IEE ELECTRICITY AUTHORITY

CHULALONGKORN UNIVERSITY

APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND

COOPERATIVE RESEARCH PROGRAMME NO. 28

POWER SYSTEM ANALYSIS

SYNOPTIC REVIEW NO. 1
CUMULATIVE SUMMARY
OF RESEARCH TO MAY 1969

ASRCT, BANGKOK 1969

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F O R E W O R D

This synoptic review summarizing research activities and results from Cooperative Research Programme No. 28, has been prepared by Mr. Wiwat Trutasnawint (Electrical Engineering Unit, TRI, ASRCT).

The research programme originated with Dr. J.K. Lubbock, then head of a Colombo Plan team from the United Kingdom involved in introducing advanced studies in electrical and mechanical engineering at Chulalongkorn University. Dr. Lubbock wished to see a continuing research interest at Chulalongkorn University in problems of industrial significance.

Negotiations with Yanhee Electricity Authority and ASRCT resulted in the present cooperative research programme as a joint venture between YEA, Chulalongkorn University, and ASRCT. YEA agreed to provide a grant to finance the work.

The outcome has been fruitful in producing analyses of the YEA power system which have been of value in defining optimum operating configurations and in minimizing the repercussions from fault occurrences as well as in assisting the planning of system development. At the same time it has had a catalytic effect in interesting YEA in the use of the computer in other phases of its operations to the extent that a decision has been taken to obtain a computer for the sole use of YEA.

CUMULATIVE SUMMARY OF RESEARCH TO MAY 1969

I. COOPERATIVE ARRANGEMENTS FOR RESEARCH ON POWER SYSTEM ANALYSIS

The origins of this programme and the partners in the joint venture have been mentioned in the foreword of this report.

A Steering Committee has been established to guide the activities of the cooperative research programme. The Committee is composed of representatives of the several agencies involved in the work. At present the Steering Committee is composed of the following members (or their representatives):

Mr. Frank G. Nicholls, Special Governor (ASRCT)
Dr. C. Lewis Wrenshall, Research Director-General, TRI (ASRCT)
Mr. Pratin Pathanaporn (YEA)
Mr. Danai Manophars (YEA)
M.R.Chirideja Kitiyakara (ASRCT)
Mr. Wiwat Trutasnawint (ASRCT)

II. ANALYTICAL FACILITIES

Computing devices are essential to the carrying out of this programme. Initially the devices available were a small d-c analyser board at YEA, which was found to be insufficiently accurate, and a small digital computer at Chulalongkorn University (an IBM 1620 with 20k digit cores). Later the work was transferred to the IBM 360 Model 40 (64 k byte core) at the National Statistical Office. YEA now plans to rent an IBM 360 Model 30 (64 k byte storage) for its own use.

III. DEVELOPMENT OF THE WORK

The initial research team formed in October 1966 consisted of:

Mr. H.C. Porter (Colombo Plan) as Co-ordinator
Mr. Pratin Pathanaporn (YEA)
Mr. Payack Rathnarathorn (YEA)
Mr. Manoo Ordeedolchest (ASRCT)

M.R. Chirideja Kitiyakara (Graduate Student at CU)
Mr. Wiwat Trutasnawint (Graduate Student at CU)

In the absence of suitable existing computer programmes in Thailand, the work started in October 1966 with M.R. Chirideja and Mr. Wiwat developing a load-flow programme and short circuit programmes using FORTRAN II language on the IBM 1620. The matrix method suggested by Gupta and Davies (1960) and by Brameller and Deanmead (1962) was used to represent a power system.

In November 1966, Mr. Manoo obtained a load-flow programme written in SPS (the IBM 1620 machine-oriented language) from the IBM Service Bureau in Bangkok. Mr. Manoo started to adapt the programme to be run under the available SPS processor. He finished his task in March 1967 and handed the programme over to Mr. Payack to be used in the study of the YEA system. It was able to handle a maximum of 125 busbars.

In January 1967, Mr. Danai Manophars, a YEA officer just graduated from post-graduate study at University of Texas, joined the group. In March 1967, Mr. Porter returned to U.K. and his place was taken by Mr. A.C. Sensicle, a new Colombo Plan adviser.

In April 1967, M.R. Chirideja completed his 6-busbar load-flow programme which was provided with automatic control of MVA generation and transformer tap setting. Mr. Wiwat completed a three-phase short circuit programme (20 busbars) and a single-line short circuit programme (15 busbars); these programmes calculated fault MVA, current and voltage distributions. Both investigators used these programmes to study the 230 kV transmission system of YEA in 1968 configuration. These various studies were presented in their M.Eng. theses which were accepted and their degrees granted in June 1967.

Several changes took place in the research group in mid-1967. M.R. Chirideja and Mr. Wiwat became research associates on the staff of ASRCT. Mr. Manoo commenced part-time employment with the IBM Service Bureau in Bangkok, and was available only part-time to work with the group. No further candidates for M.Eng. degrees become available and, as no staff members of CU were available to participate, the programme continued largely as an ASRCT - YEA joint venture. Mr. John Mayne, a Canadian Universities Service Overseas (CUSO) volunteer, was attached

to ASRCT in July 1967 and joined the group. From this time on the work has been centred at YEA under the supervision of Mr. Pratin Pathanaporn.

The IBM 360 Model 40 computer was installed at the National Statistical Office and 12 hours per week of computer time became available for the programme. The existing computer programmes were modified for the new computer. M.R. Chirideja modified the load-flow programme using the matrix method to handle 70 busbars on the IBM 360 and this was available in October 1967. Mr. Wiwat modified both his three-phase short circuit and single-line short circuit programmes to handle problems of 70 and 40 busbars respectively; this was completed in November 1967. He went on to develop a transient stability programme using matrix representation of a power system and convention representation of synchronous machines. This programme which was completed in January 1968 can handle a symmetrical disturbance problem of 70 busbars and 40 machines, and on unsymmetrical disturbance with 40 busbars and 20 machines.

By mid-1967, the only other computer programmes received from other authorities were some manuals from Associated Electrical Industries Ltd. in the U.K. Mr. Manoo decided that the conversion of the IBM 1620 load-flow programme which had been written in machine-oriented language was not warranted, and he decided to look for other library programmes. By the end of 1967, a new load-flow programme (in machine-oriented language) and a critical path scheduling programme (in FORTRAN) were received from the IBM 1130 library, and other programmes were known to be available.

At that time the catalogue of programmes in the IBM 360 library were quite limited, although a load-flow programme and a project control system programme became available later. Anticipating that the IBM 360 would be the main computing device, YEA ordered a number of IBM 1130 programmes and had them converted for use on the IBM 360.

By November 1968 many computer programmes were available, there was a continuous supply of problems from within YEA and trained staff were becoming available. Accordingly YEA decided to rent (from October 1969) an IBM 360 Model 30. Mr. Danai became responsible for the establishment of a computer centre in YEA. Mr. Mayne assisted Mr. Danai to increase

the programme library by obtaining programmes from IBM and elsewhere and converting them for use on the IBM 360. Mr. Payack and Mr. Wiwat Pleuksawan (YEA engineers) started to develop computer programmes for YEA reservoir operation. M.R. Chirideja and Mr. Wiwat have continued work to increase the capability of their programmes.

The stage has now been reached when YEA now has computer programmes available covering problems encountered in construction, planning, reservoir operation, administration, and computer language conversion as well as for power system analysis.

IV. PROGRAMME SUB-DIVISION

Research Programme No. 28 has been divided into projects as follows:

Research Project No. 28/1. Load flow in power systems.
Research Project No. 28/2. Short circuit faults in power systems.
Research Project No. 28/3. Transient stability of power systems.
Research Project No. 28/4. Interconnection of power systems.
Research Project No. 28/5. Specific studies in YEA power system.
Research Project No. 28/6. Economic operation of power systems.

An outline of the activities in these projects is given below:

(1) Research Project No. 28/1. M.R. Chirideja developed a 70-busbar load-flow programme using matrix method. He is now using matrix partitioning technique in the programme so that it can handle problems of 400 busbars on a 64 k byte memory IBM 360 computer. The new programme is expected to be completed by July 1969. The reports produced are:

- Electric load-flow programme by matrix method for IBM system 360/40 computer (a programme manual reproduced at YEA in 1968).
- Report No. 1 on Research Project No. 28/1. Load flow analysis programme by matrix method.

(2) Research Project No. 28/2. Mr. Wawat developed a 70-busbar three-phase short-circuit programme and a 40-busbar single-line to ground short-circuit programme. The programmes have been rewritten to handle 400 busbar problems. The only report produced on this project is:

- Report No. 1 on Research Project No. 28/2. Short-circuit analysis programmes by matrix method.

(3) Research Project No. 28/3. Mr. Wiwat developed a transient stability programme for a 70-busbar problem of symmetrical disturbance and a 40-busbar problem of unsymmetrical disturbance. The programme capacity is being increased to handle 400 busbar 50 machine problems and to be able to be used in studying the behaviour of synchronous machines in the dynamic stability region. The new programme is expected to be completed by July 1969. The reports produced on the project are:

- Transient stability programme by matrix method for IBM system 360/40 computer (a programme manual reproduced at YEA in 1968).
- Report No. 1 on Research Project No. 28/3. Transient stability analysis programme by matrix method.

(4) Research Project No. 28/4. Mr. Somkiet Paloprakarn (YEA engineer) studied the load-flow conditions and stability of YEA and NEEA power systems after the interconnection of the two power system by a double circuit 115 kV transmission line from Ang Thong to Nakhon Ratchasima substation. The results of the studies were reported in:

- รายงานการวิเคราะห์กำลังไฟฟ้าสายส่งเชื่อมโยง ๑๑๕ เควี อ่างทอง - นครราชสีมา และระบบไฟฟ้าในภาคตะวันออกเฉียงเหนือ.
  (Report on analysis of load flow and stability of the 115 kV transmission line from Ang Thong to Nakhon Ratchasima, and the *power systems of the north-east.*)

(5) Research Project No. 28/5. A number of problems in YEA system were studied as a joint venture by the research group and the System Planning Division of YEA, as follows:

- The possibility of using series capacitor compensation in the northern transmission system.
- Determination of fault current distribution in YEA 230 and 69 kV transmission systems in 1968 for relay setting.
- Determination of transferred power limit of the Bhumibol-Nakhon Sawan 230 kV double transmission circuit.
- Study of the YEA system in 1968, 1971, and 1977.

- Determination of excessive fault levels at north Bangkok switch yard (report reproduced at YEA in 1968).
- Design of Phasom-Nakhon Sawan 230 kV transmission system (report reproduced at YEA in 1968).
- Selection of transmission voltage for Yasothon-Surin transmission system (NEEA problem).
- Effects of MEA loop network on YEA system in 1985.
- Studies of the northern, eastern, and western transmission systems of YEA (reports reproduced at YEA in 1969).

(6) Research Project No. 28/6. Mr. John Mayne has developed two programmes, one of which finds the optimum distribution of plant generators in a system and the other of which calculates the system loss coefficients from load flow study data. Reports on this work are being reproduced.