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Prototype Design of a Central Control System for KODAS

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ABSTRACT

This paper summerizes a prototype central control system of distribution automation system, which is a result of project carried out by KERI and 6 companies. Of the many possible systems, feeder automation oriented system is described. Control hardware system is composed of one super-mini and 2 workstations. Two kinds of commercial softwares, DBMS and graphic tools, are adopted. Three component system of the hardware has its own role, host system for DB managent, F.A. program running, communication scheduling, and etc., two workstations for communication node and graphic interface node. System management program, feeder automation program including load forcasting, communication scheduling and supervisory contorl functions are developed on the basis of above hardware and properly designed protocol, communication system and terminals.

1. Power Distibution System in Korea

Electric Power System consists of three layers. The first layer is power plant, which includes generator, turbine, boiler, step-up transformer and etc.. The second layer is transmission system, which is long power cable carrying high voltage (154kv or 345kv) power to substations. The last layer is distribution system, which is usually located in customer's area and composed of lower than 22.9kv power lines. In KODAS, 22.9kv main distribution line and customer facility are considered to be controlled automatically. Fig 1. shows a typical power distribution system.

2. Automation Strategy

In most of the practical distribution automation system design, the user asks the followings:

- minimum change of given distribuion system
- friendly user interfaced system with powerful functions
- reliable with reasonable expenses

From the basic design stage, a minimum change concept is adopted.

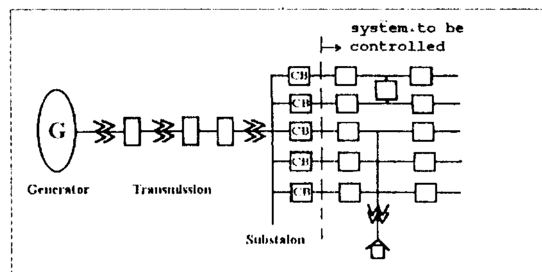


Fig 1. Typical Configuration of Power System

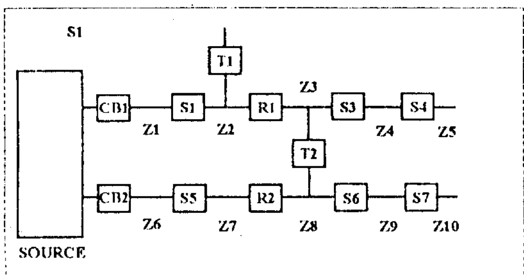
3. Needs for automation

Main functions of distribution automation can be summerized as

- automatic control of feeders when a fault occurs in the system or severe unbalanced load is applied,
- telemetering of customer's load status including kwh, power factor, maximum load and etc.,
- load control of space heating and airconditioning.

But the three big functions are not integrated in a typical system. In the U.S. system, telemetering and load control is considered to be the most important functions.[1] But in Japan system, feeder automation is the key function of D.A.S..[2]

In KODAS, the three functions can be integrated into one central control system. But this paper limits its range to feeder automation. To explain the function of feeder automation, the working status of current distribution system is described. Fig 2. shows a simple distribution system. A fault in z1 or z2 makes CB1 open and all the zones (z1, z2 . . . z5) connected to CB1 are incapable of receiving power until switches are controlled manually, which takes about 1 - 2 hours. When the fault zone is repaired, the switch connection should be changed to the original status. Also this takes time and makes customer inconvenient. In automation system, reducing 1 or 2 hours dead time to several minutes is possible. Another important function is load balancing. If CB1 has a heavy load, while CB2 has a very light load, load balancing can be done by automatic operation of switches.



C/B : Circuit Breaker
R : Recloser
T : Tie Switch (normally open)
S : Remotely Controlled Switches
Z : zone

Fig 2. Simple Distribution System

To be controlled automatically, the following informations are necessary.

- switch status (C/B, R/C, A/S)
- fault indicator's counter
- load information

Another function of distribution automation is to help operator's handling of distribution facilities' status and other information such as history. So many kinds of data such as transformer, distribution line, switches, location and etc. are surveyed and managed in D.A.S.. Graphic interface system is the best way for the operation check of the topological relation of feeder's status. With the aids of graphic tools, distribution system can be overlapped over a map to reduce repairing time by easy indentification of fault location.

4. Configuration of KODAS

Kodas consists of 3 parts in large, central control system, communication system, terminals for sensing and remote control.[3] Table 1 shows the items included in KODAS and FIG 3. shows their relational diagrams. In power distribution line, FRU (Feeder Remote Unit) is attached to CB, automated switches and reclosers. If a zone comes to fault state, quite a large fault current flows, CB / FRU pair detects fault current simultaneously and set fault indicator on. Host computer can check this situation by periodic gathering of CB's FRU data via SCCU. This fault situation excites F.A. algorithm to find exact fault zone, which is done by taking the FRU data connect serialy to the fault CB. After analysis of the data, F.A. algorithm generates switching sequence to operate the switches or suggest to the operator. Operator can change the running mode. Confirm being made, host computer orders FRUs to change on/off status of the switches. The status of distribution system is shown by a graphic terminal. Operator can also control switches through graphic terminal and decide switching sequences after a safety key operation.

Table 1. Subsystems in KODAS

system	name	main functions
Central Control System	DB/FA node	DB service Process Control FA service Reporting Operator Interface Mapboard Control Scheduled Interruption of Power Supply
	COMM node	Data Acqusition & Control DB update On-line Skeleton Diagram
	MMI node	Graphic User Interface Geographical Data Manage. Facility Data Management Seperately Switch Control
Comm. system	S.C.C.U.	Communication Control for F.R.U.
	F.C.C.U.	Communication Control for C.R.U. (PLC)
Teminals	F.R.U.	Fault Sensing On/Off Control V,I Measuring
	C.R.U	Telemetering Load Control

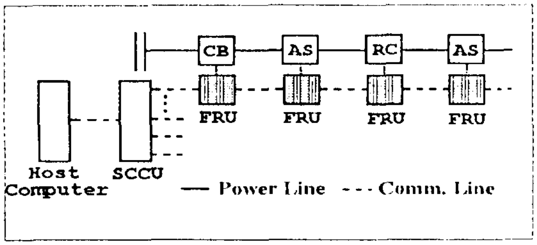


Fig 3. Example of KODAS Configuration

5. Central Control System Design

5.1 Computer System Environment

The selection of Computer systems for developing procedure and prototype design of KODAS must satisfy the following items

- multiuser, multitasking OS support
- real-time processing capability
- continuous availiability
- system upgrade compatiblity
- expansibility
- various interface support
- various developing tool support
- easy system service utilization

DEC's VAX machine was chosen for the main system. One example of signal flow in the system can be summerized by the following flow chart. During the cycle of the shown flow chart, other functions such as graphic display, keyboard operation should be performed simultaneously. To make multi-functioning possible, distrubuted processing system concept is adopted, which are FA/DB, COMM and MMI node. Data can be shared via Ethernet network using DECnet protocol. A minimum hardware system satisfying the above conditions is chosen as Table 2.

Table 2. Specification of Computer System

node	computer	specificaiton	
DB/FA	MicroVAX 3190	speed	24 VUPS
		memory	64 MB
		disk	2 GB
		os	VAX/VMS
COMM	VAXstation 4060	speed	6 VUPS
		memory	32 MB
		disk	1 GB
		os	Motif
MMI	VAXstation 4060	same as COMM	
COMM server	DECserver 700-08	8 rs-232c ports	
		LATcp protocol	
X-terminal	VXT-2000	1248x1024 resolution	

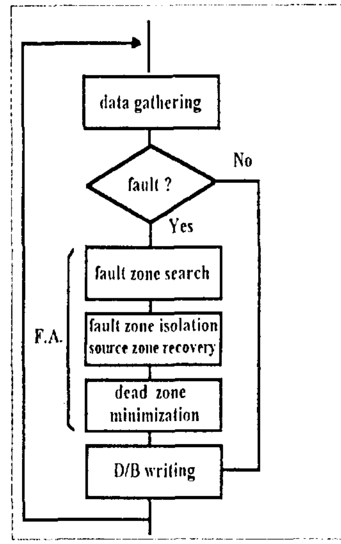


Fig 4. Auto Mode Operation Concept

Communication between SCCUs and COMM node is accomplished through DECserver by 1200 bps which supports RS-232C. Communication data packet and protocol were defined to guarantee error free data transfer.

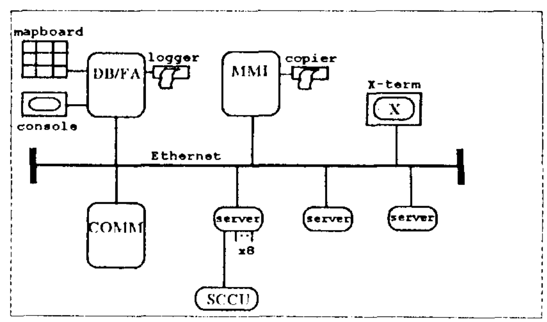


Fig 5. Configuration of Computer System

5.2 Software Design

Software in KODAS consists of several modules, which is sets of processes. Some modules use special tools which make system efficient. Each process is linked by process synchronizing technique, and network programming. Inter-process communication is accomplished by 'mail box' and 'event flag' which are terminology of VMS. 'Client-Server' design technique was used in design stage to minimize design error as well as to increase the efficiency of system maintence.[4]

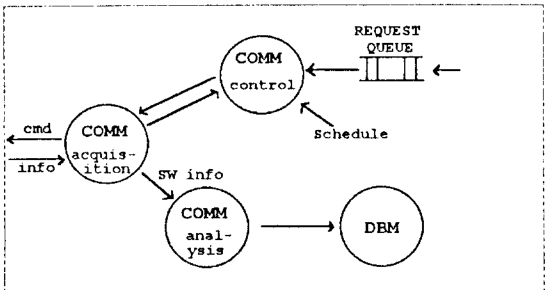


Fig 6. The Example of DFD of Auto Operating Mode

5.2.1 DB Module

KODAS DB has management informations about devices, substations, transformer, power distribution lines, switches and description about their physical or logical relationship. When data is gathered from FRU such as switch status, voltage, current, these are updated in database, and translated to be used by the other program (FA,MMI). DB was built using Relational DBMS based on SQL (Structured Query Language) and C language. The same DB is linked with graphic tool to represent distribution system status on the map through graphic terminal. As using RDBMS makes much disk i/o operation, some problems remain on real-time processing. The major specifications of RDBMS are followings;

- ANSI SQL support,
- distributed DB support,
- tools for form generating and report support,
- several major network protocol support,
- c language interface support.

5.2.2 FA Module

FA(Feeder Automation) program consists of 4 submodules, rule base, inference engine, database, and numeric calculation. Rule base is module storage of standardization in recover strategy of power failure. This consists of grouping, group modification, feasibility checking, violation resolution, and switching sequence program. Inference engine can select rules and execute. Database stores several data while recovering plan is being set. Calculation module is for load flow operation and load forecasting.

Operation is performed by the following steps

1) Assign outage area to backup feeder in grouping and group modification step.
2) Calucate terminal voltage in feasibility checking step, if violate, resolve it.
3) Switching sequence is selected not to power failure of good region when recover operation performs.

Shortly speaking, our F.A. algorithm uses expert based heuristic approach instead of numerical optimization and can easily satisfy the field operators requirements such as not to violate the given protective coordination rules.[5]

5.2.3 COMM Module

This module consists of 3 parts in large,

- communication scheduler,
- data acquisition,
- data analysis.

Communcation scheduler decides priority between informations of data acquisition plan and communication request of processes. Time interval of data acquisition via communcation is shown in table 3. Data acquistion module performs control operation of FRU, acquisition of current status. Data analysis module analyze acquired data to check illegal operation of terminal units and interruption of power failure in power distribution system. If any power failure detected, this module excites the F.A. algorithm to perform recover operation. A skeleton diagram is displayed in X terminal, which can monitor current C/B status, voltage, current and etc. before accessing to D.B..

Table 3. Interval of Data Acquisition

informations	interval
Fault Indicator of CB	15 sec
Analog Data of CB	30 min
Status of Automatic Switch	1 day

5.2.4 MMI Module

GIS (Graphic Information System) has been developed to display the status of distribution power line facilities with background geographical map informations (eg. address, street, railway and buildings). It provides various menu screen that can be handled easily. Its principal functions are

- various geographical information display,
- display of facility information,
- supervisory display of facility information and background geographic information,
- facility information search,
- facility control interface.

In KODAS, we seperate facility data into two parts, graphic data and non-graphic data. Schema is defined to implement facility data. Table 4 is an example of developed schema.

Table 4. The Example of Schema

HIFEEDER	50	G50	N50	5	STI	ST2	High Voltage Feeder
POLE	56	G56	N56	4	STI	ST2	Pole
TRANSFRM	57	G57	N57	4	STI	ST2	Transformer
CB	73	G73	N73	4	STI	ST2	Circuit Breaker

6. Prototype System

To evaluate our design concept, we assumed a small scale mixed distribution plant. The mixed plant contains 3 22.9kv testing feeders as well as part of Chang-Won distribution plant in a expermental scale form. The aim of this plant is to check the functional status of softwares developed. And, we also constructed a real distribution plant to check hardware oriented reliability related with noise, communication problem, which has 3 feeders with 22. 9kv loaded.

This system can satisfy the following potential specifications :

- 2 minutes for identication of fault and fault zone
- 3 minutes for isolation/recovering of fault feeder
- semi-auto display of fault on graphic display terminal with background geographical map
- display of skeleton diagram with on-line analog data

7. References

[1] "EMETCON Automated Distribution System Manual", Westinghouse Electric Co. , Mar, 1987.

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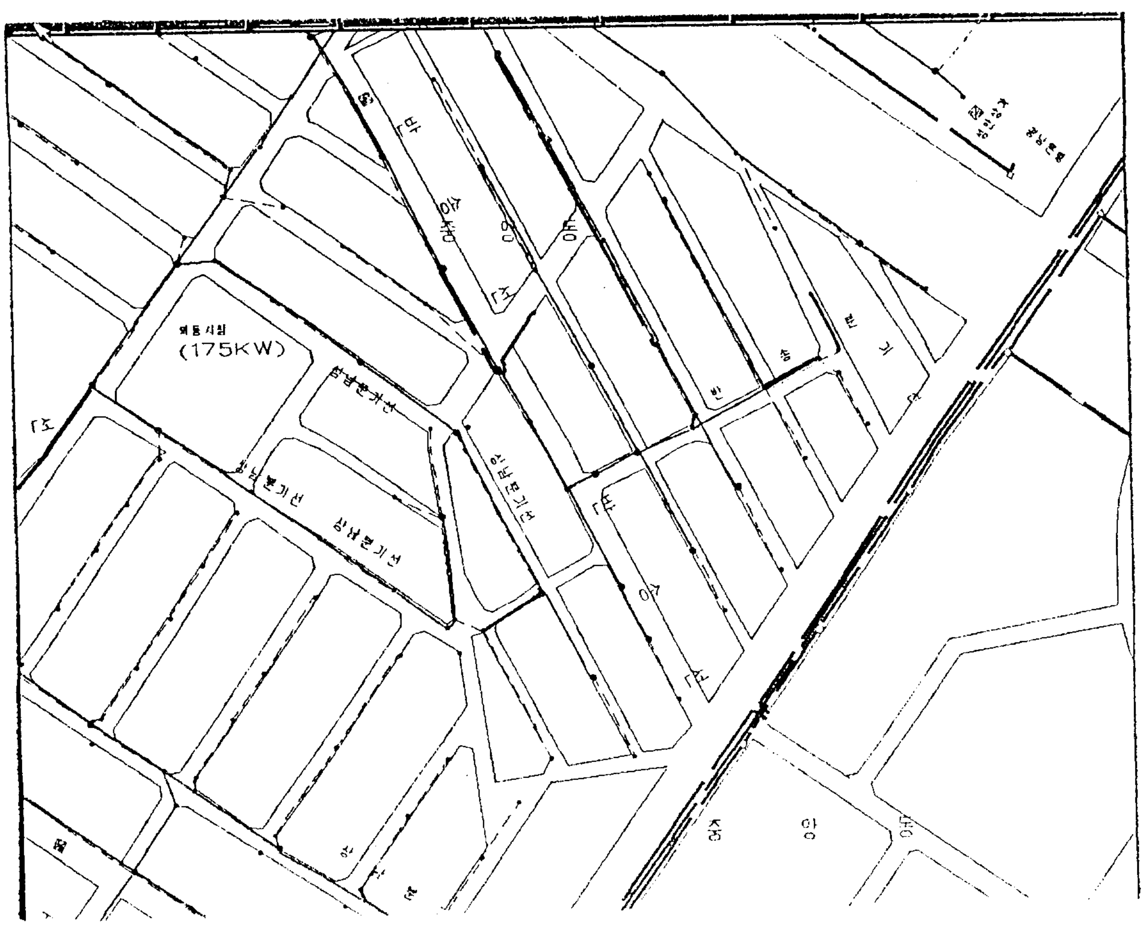

Fig 7. Example of Geographical Display