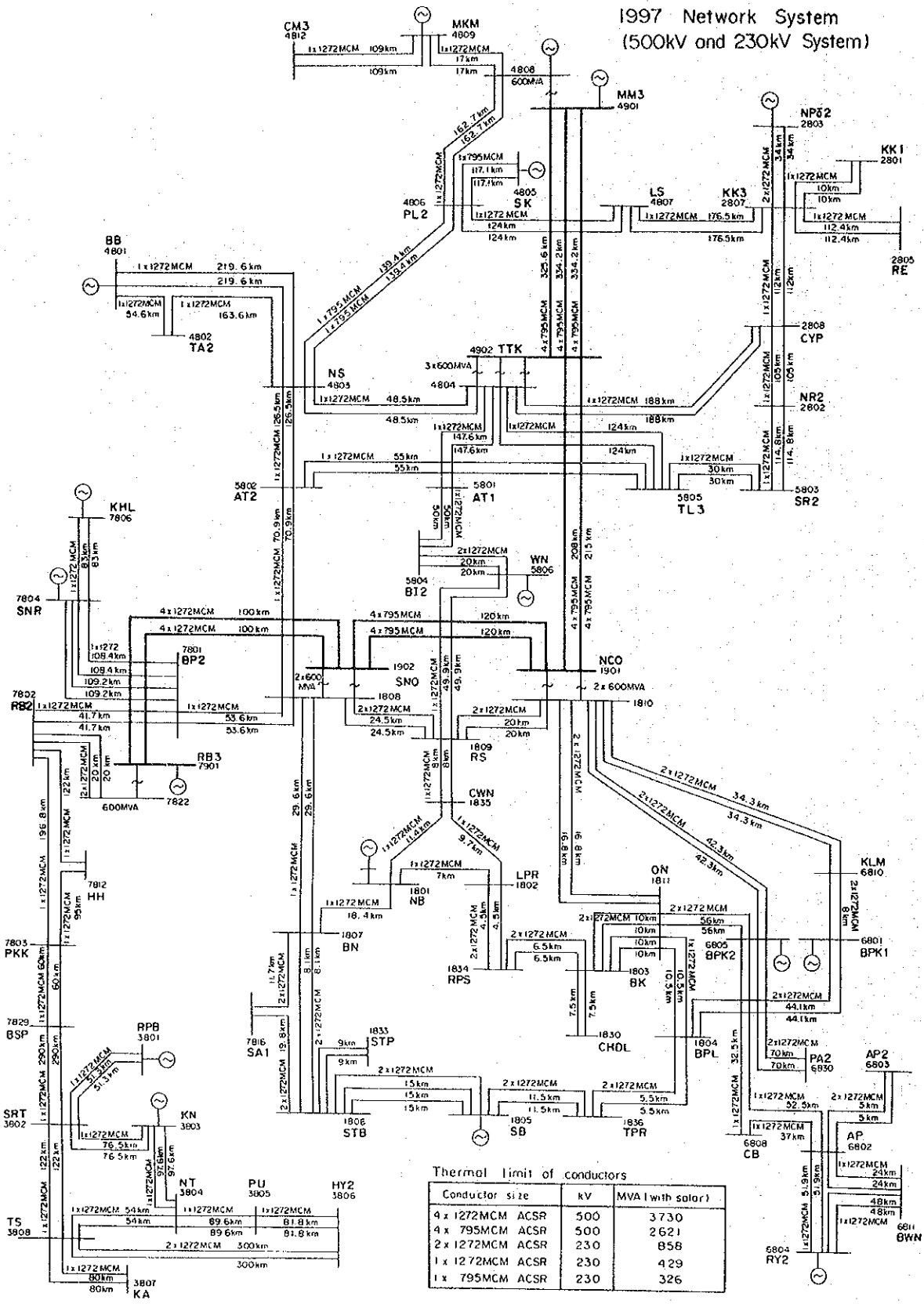
Table 6-4-1 Construction and Expansion Schedule of transmission line and Substation

year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
EGAT's PDP power development	KAENG KRUNG #1-2 2× 40MW MAE KHAM FBC #1-2 2×150MW SOUTH BANGKOK CC 200MW LOWER CENTRAL #1-2 2×600MW EGAT-TNB TIE LINE 300MW	LAM TAKHONG #1-2 2×250MW LOWER CENTRAL #3 600MW	SURAT THANI #1 retied -30MW AO PHAI #1-2 2x700MW MAE LAMA LUANG 2x 80MW	AO PHAI #3 700MW NEW THERMAL#1 1000MW	MAE TAENG 2x13MW REGION-3 CC 300MW NEW THERMAL#2 1000MW	LAMPANG #1-3 3x300MW LAM TAKHONG #3-4 2x250MW	LAM KRABU GT retired -140MW BANG PAKONG CC1 retired -380.3MW REGION-3 CC 300MW LAMPANG #4-6 3x300MW NEW THERMAL#3 1000MW NAM KHEK #1-2 2x150MW	BANG PAKONG CC2 retired -380.3MW NORTH BANGKOK retired - 237.5MW MAE MOH #1-2 retired - 2x 75MW NEW THERMAL #4-5 2x1000MW	LAMPANG #7-8 2x300MW NEW THERMAL#6 1000MW	NUCLEAR #1-2 2x1000MW
transmission system expansion		AO PHAI - NONG CHOK T-junction		NEW THERMAL - LOWER CENTRAL CC 4x1272MCM 500KV 2cct 180km NEW THERMAL - SAI NOI 4x1272MCM 500KV 4cct 375km LAMPANG - MAE MOH T-junction termination of 500KV THA TAKO - NONG CHOK lines and 500KV SAI NOI - NONG CHOK lines at WANG NOI S/Y LAMPANG - THA TAKO 4x795MCM 500KV 1cct 351km THA TAKO - WANG NOI 4x 795MCM 500KV 1cct 168km (line string only) NEW THERMAL - SAI NOI 4x1272MCM 500KV 2cct 375km NUCLEAR - NEW THERMAL 4x1272MCM 500KV 2cct 125km				
transmission system construction schedule	RANGSIT - CHAENG WATTHANA 10km 1x1272MCM ACSR 230KV ⇩ 500KV designed 4x1272 2cct 230KV 4x1272MCM 2cct	NONG CHOK - ON NUCH 16.8km 230KV 2x1272MCM 2cct ⇩ 230KV 2x1272MCM 4cct	BANGKOK NOI - SAI NOI 29.6km 230KV 1x1272MCM 2cct ⇩ 500KV designed 4x1272 2cct	NORTH BANGKOK -BANGKOK NOI 18.4km 230KV 1x1272 1cct ⇩ 500KV desined 4x1272 2cct	NORTH BANGKOK - LAT PHRAO 230KV 1x1272 1cct 7km NORTH BANGKOK - CHAENG WATTHANA 230KV 1x1272 1cct 9km LAT PHRAO - CHAENG WATTHANA 230KV 1x1272 1cct 12km ⇩ NORTH BANGKOK - A s/s (4.4km) 500KV designed 4x1272 2cct 230KV 4x1272 2cct LAT PHRAO - A s/s (2.7km) 230KV 4x1272 2cct CHAENG WATTHANA - A s/s(7.1km) 500KV designed 4x1272 2cct 230KV 2x1272 2cct and underground cable	RANGSIT - WANG NOI 50km 230KV 1x1272 2cct ⇩ 230KV 2x1272 4cct BANGKOK NOI - SAN PHRAN 11.7km 230KV 2x1272 1cct ⇩ 230KV 4x1272 2cct	BANGKOK NOI - SAI NOI 500KV operation	RANGSIT - SAI NOI 24.5km 230KV 2x1272 2cct ⇩ 500KV designed 4x1272 2cct SOUTH THON BURI - SAN PHRAN 1 19.8km 230KV 2x1272 1cct ⇩ 230KV 4x1272 2cct SOURT THON BURI - BANGKOK NOI 8.1km 230KV 2x1272 2cct ⇩ 230KV 4x1272 1cct	NORTH BANGKOK - SAI NOI lines (36.0km) and NORTH BANGKOK - BANGKOK NOI lines (18.4km) 500KV operation BANG PHLI - ON NUCH 10.5km 230KV 1x1272 2cct ⇩ 230KV 2x1272 2cct	
500/230KV transformer bank number	NONG CHOK 600MVA 2-unit	600MVA 2-unit	600MVA 2-unit 750MVA 1-unit	600MVA 2-unit 750MVA 1-unit	600MVA 2-unit 750MVA 1-unit	600MVA 2-unit 750MVA 1-unit	600MVA 2-unit 750MVA 1-unit	600MVA 2-unit 750MVA 2-unit	600MVA 2-unit 750MVA 2-unit	600MVA 2-unit 750MVA 2-unit
	SAI NOI 750MVA 2-unit	750MVA 2-unit	750MVA 3-unit	750MVA 3-unit	750MVA 4-unit	750MVA 4-unit	750MVA 3-unit	750MVA 3-unit	750MVA 3-unit	750MVA 3-unit
	BANGKOK NOI						750MVA 3-unit	750MVA 4-unit	750MVA 4-unit	750MVA 4-unit
	NORTH BANGKOK								750MVA 3-unit	750MVA 4-unit
	WANG NOI					600MVA 2-unit		600MVA 3-unit	600MVA 3-unit	600MVA 3-unit

Fig. 6-1-1



Thermal limit of conductors

Conductor size	kV	MVA (with solar)
4 x 1272MCM ACSR	500	3730
4 x 795MCM ACSR	500	2621
2 x 1272MCM ACSR	230	858
1 x 1272MCM ACSR	230	429
1 x 795MCM ACSR	230	326

Fig. 6-1-2

1997 Impedance Map
(Positive Sequence)

R1+jX1(Y1) : % at 100MVA

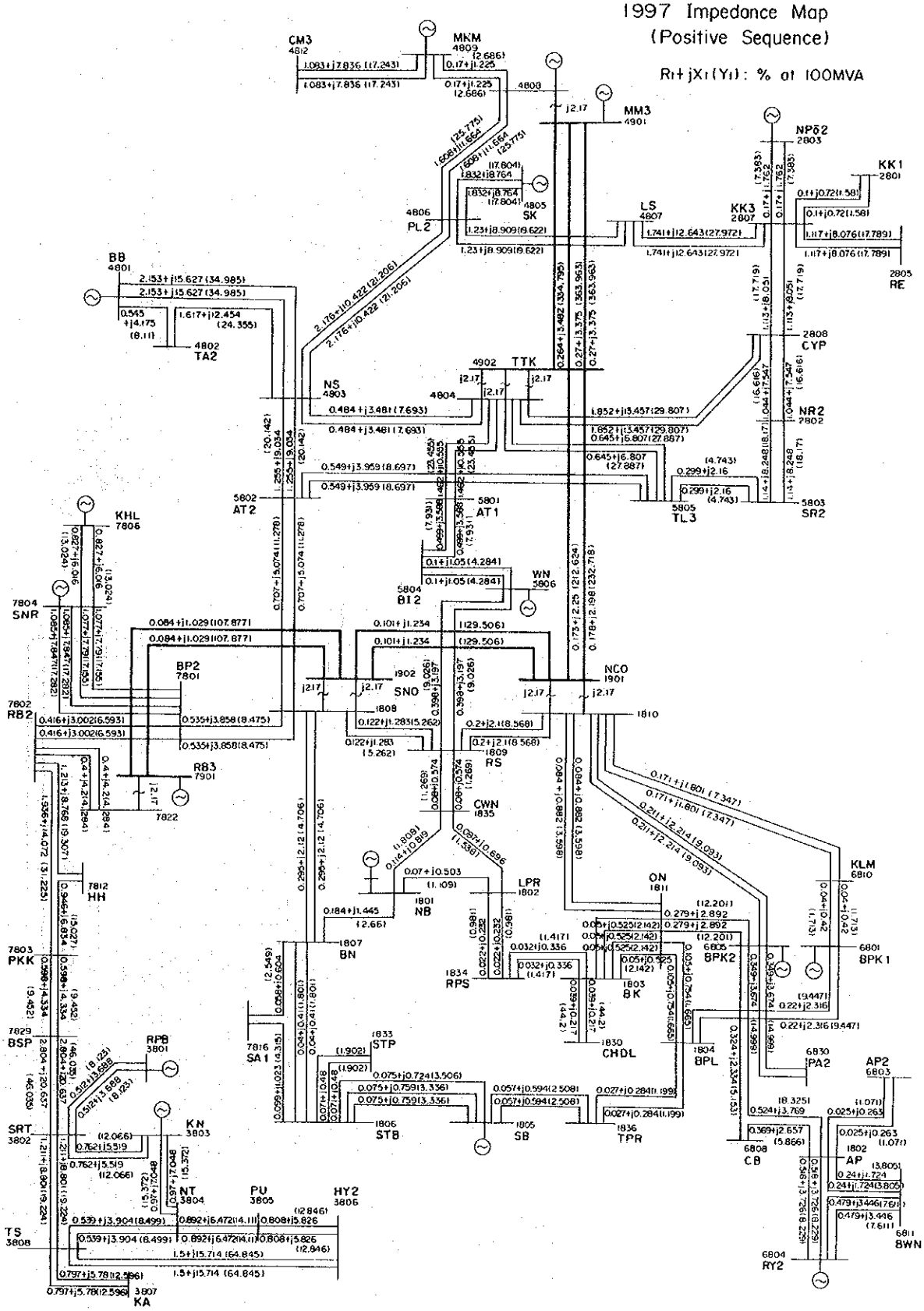


Fig. 6-1-3

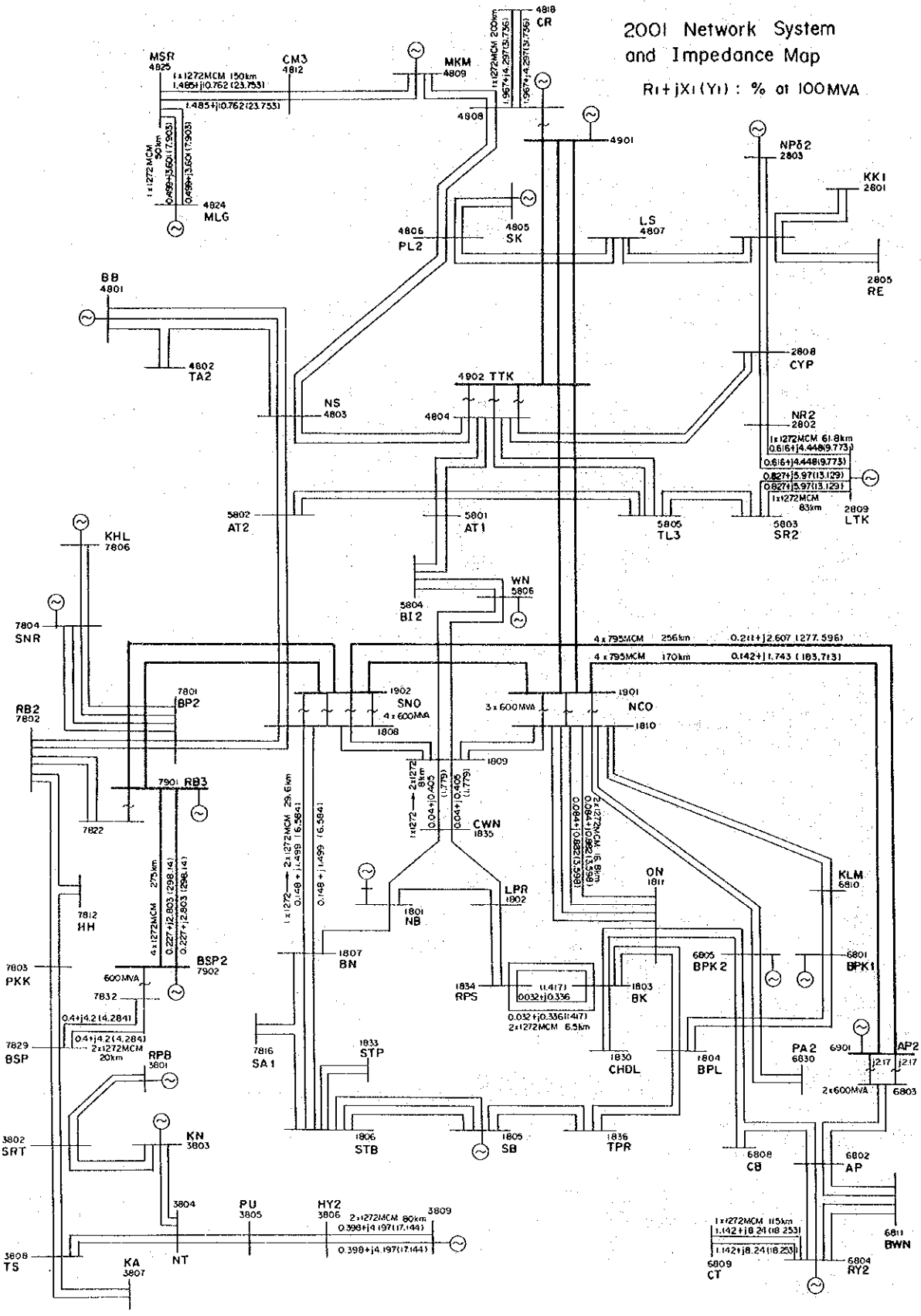

2001 Network System
and Impedance Map
R1+jX1(Y1) : % at 100MVA
MSR 4825
CM3 4812
MKM 4809
CR 4818
4808
4901
NP82 2803
KKI 2801
2805 RE
4824 MLG
4806 PL2
4805 SK
LS 4807
BB 4801
4802 TA2
4902 TTK
NS 4803
4804
2808 CYP
NR2 2802
2809 LTK
5802 AT2
5801 AT1
5805 TL3
5803 SR2
KHL 7806
WN 5806
5804 BI2
7804 SNR
4 x 795MCM 256km 0.211+j2.607 (277.596)
4 x 795MCM 170km 0.142+j1.743 (185.713)
RB2 7802
7801 BP2
1902 SNO 4 x 600MVA
1901 NCO 3 x 600MVA
1808
1810
1809
7901 RB3
7822
CWN 1835
ON 1811
KLM 6810
7812 HH
LPR 1802
1801 NB
7803 PKK
BSP2 7902
600MVA
1807 BN
6805 BPK2
6801 BPK1
1834 RPS
1803 BK
7832
7829 BSP
RPB 3801
7816 SA1
1833 STP
1830 CHDL
1804 BPL
PA2 6830
6901 AP2
2x600MVA
6803
3802 SRT
KN 3803
1806 STB
1805 SB
1836 TPR
6808 CB
6802 AP
3804
PU 3805
HY2 3806
3809
3808 TS
KA 3807
NT
6811 BWN
6809 CT
6804 RY2

Fig. 6-1-4

2006 Network System and Impedance Map

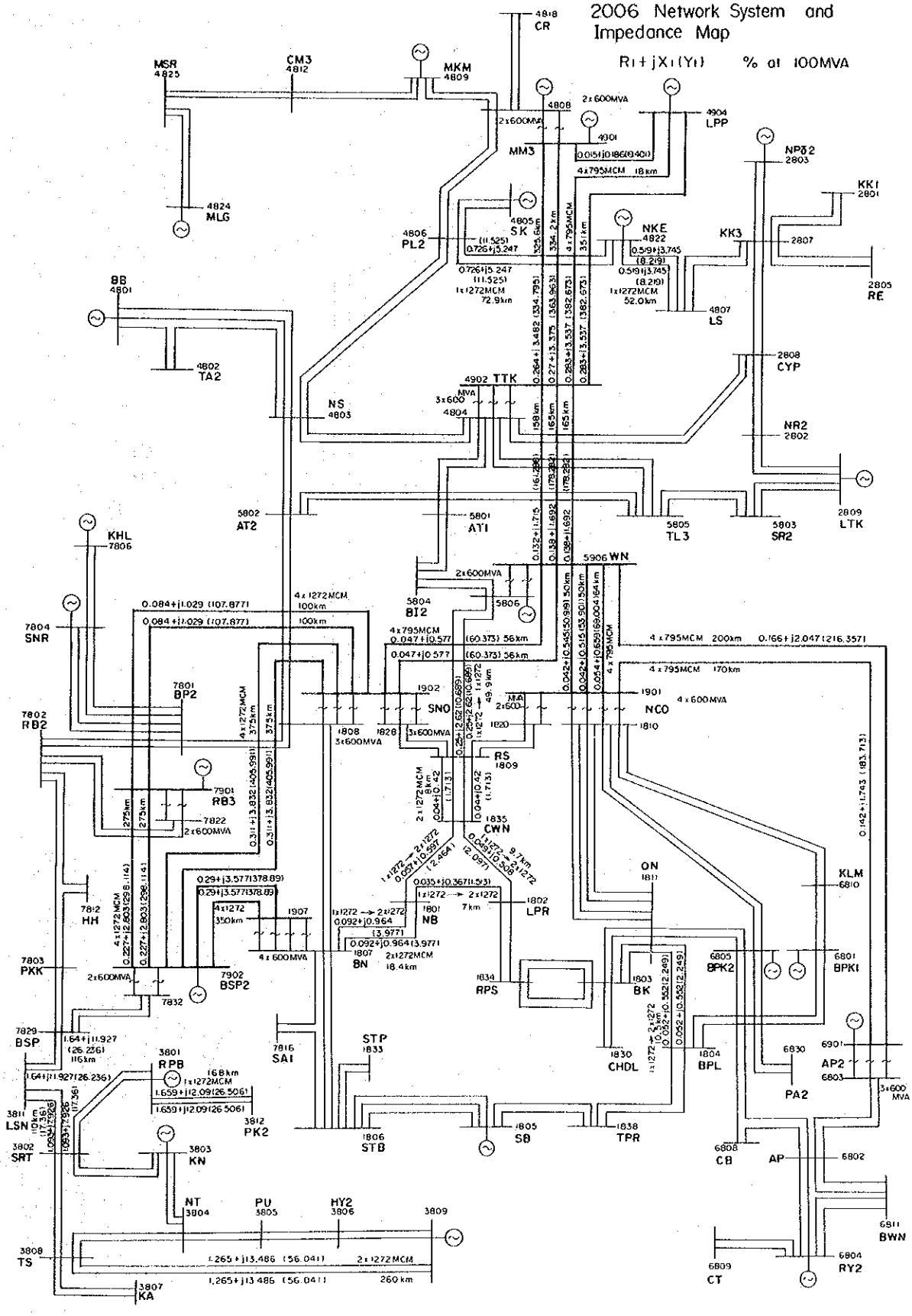


Fig. 6-2-1

1997 Power Flow (System Peak)

V∠θ : %∠deg, P+jQ : MW+jMVar

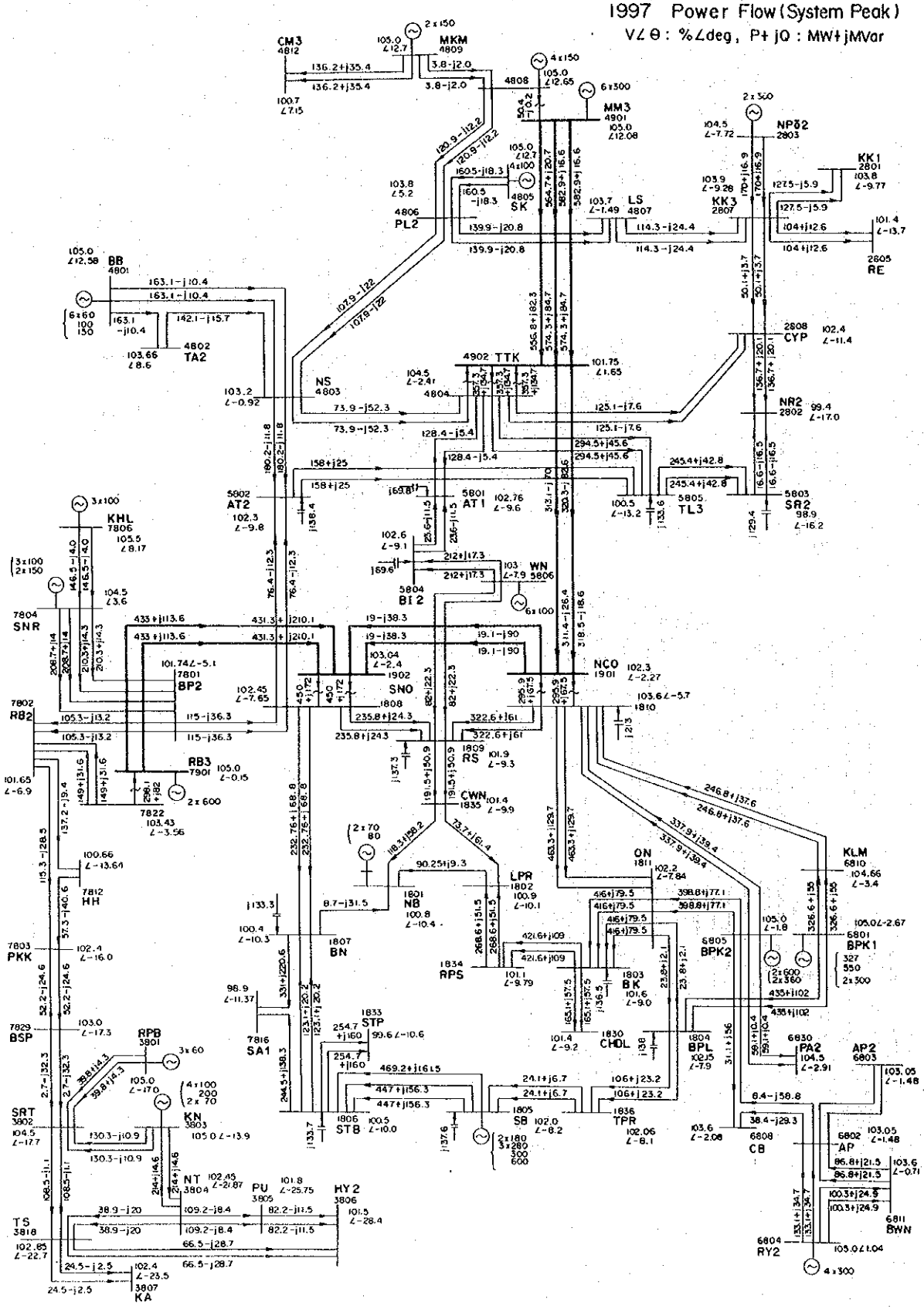
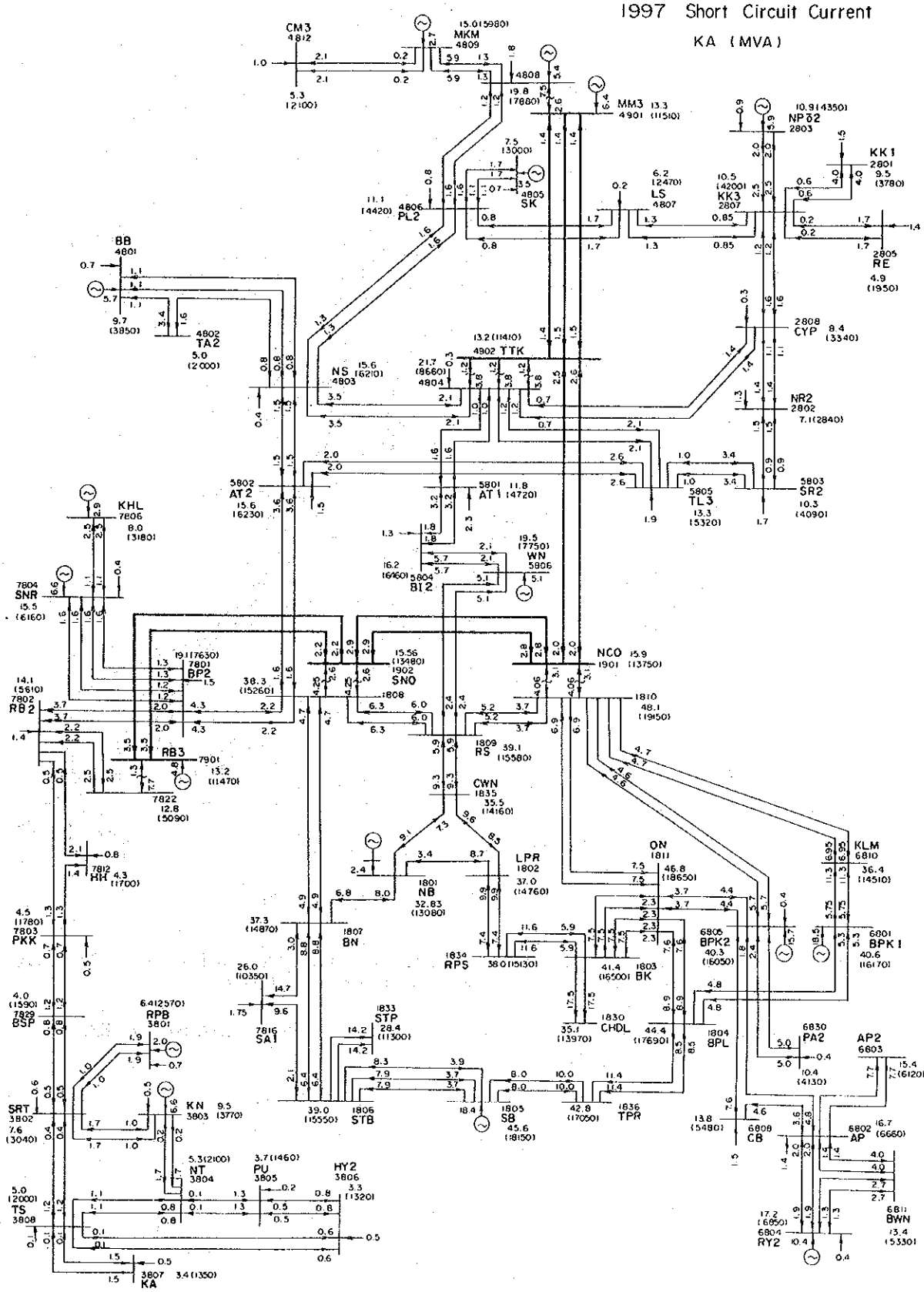


Fig. 6-2-2


1997 Short Circuit Current
KA (MVA)
CM3 4812
MKM 4809
MM3 4901
NP32 2803
KK1 2801
LS 4807
KK3 2807
SK 4805
PL2 4806
BB 4801
TA2 4802
RE 2805
CYP 2808
TTK 4802
NS 4803
NR2 2802
AT2 5802
AT1 5801
TL3 5805
SR2 5803
KHL 7806
WN 5806
BI2 5804
SNR 7804
BP2 7801
SNO 1902
NCO 1901
RB2 7802
RB3 7901
RS 1809
CWN 1835
LPR 1802
NB 1801
ON 1811
KLM 6810
BPK2 6805
BPK1 6801
PKK 7803
BN 1807
RPS 1834
BK 1803
HH 7812
RPB 3801
BSP 7829
SA1 7816
STP 1833
CHDL 1830
BPL 1804
PA2 6830
AP2 6803
SRT 3802
KN 3803
STB 1806
SB 1805
TPR 1836
CB 6808
AP 6802
NT 3804
PU 3805
HY2 3806
TS 3808
BWN 6811
RY2 6804
KA 3807

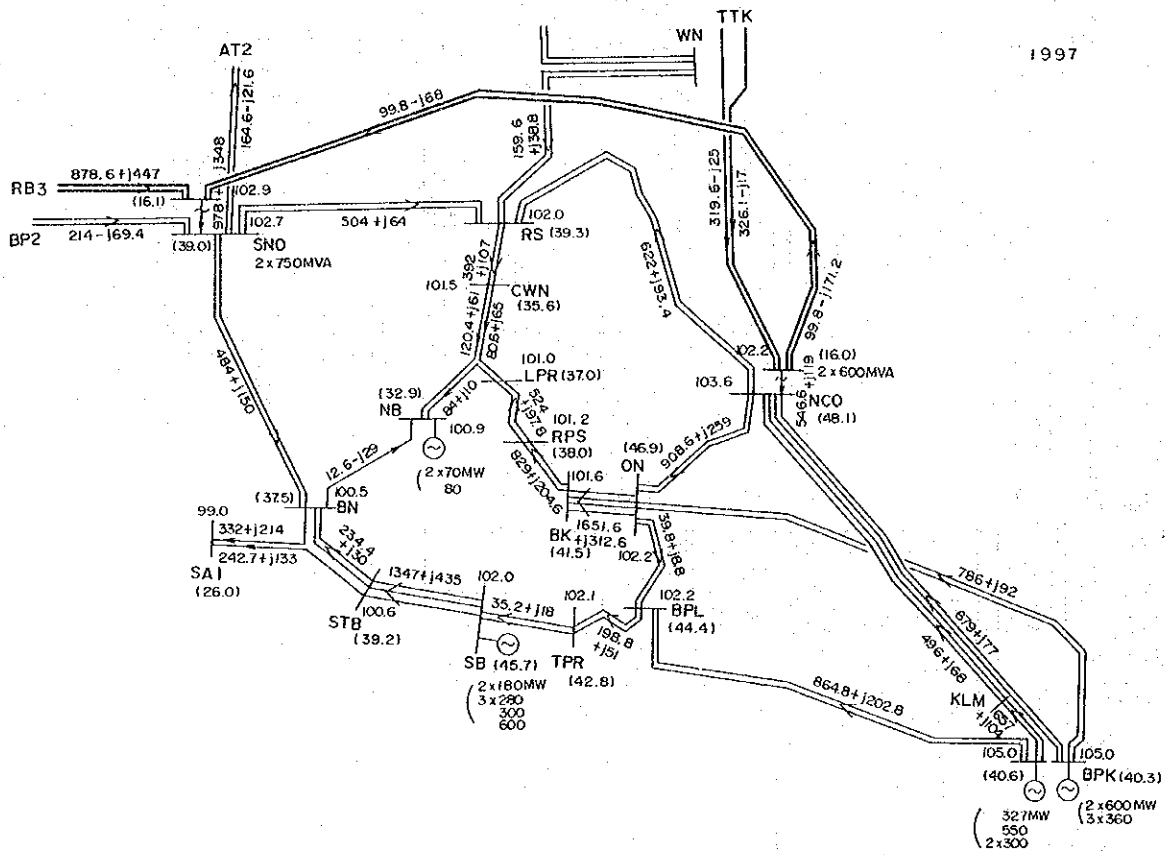
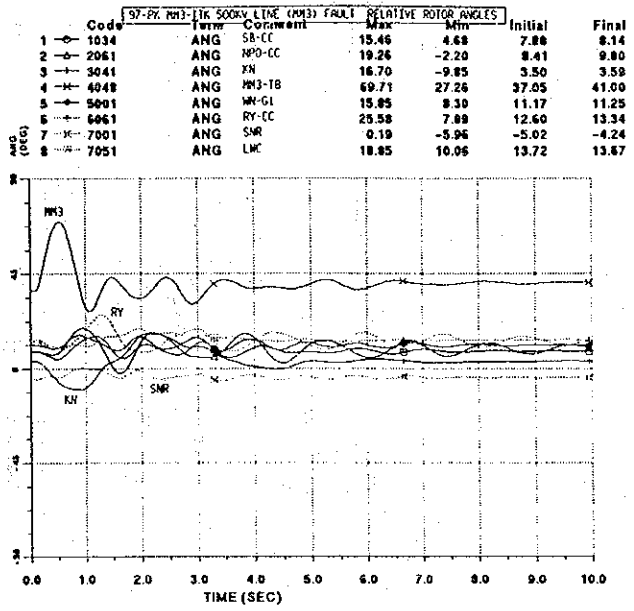


Fig. 6-2-3
load flow and short circuit current in the case of 750MVA 500kV/230kV 2-bank at Sai Noi substation in 1997

short circuit current levels are shown in parentheses (KA)

Fig. 6-2-4
results of system stability
1997 network system in Thailand

CASE-97-MTM
relative rotor angles :
three phase 4-cycles fault at MAE MOH 500KV bus
MAE MOH - THA TAKO 500KV line tripped upon fault clearing



CASE-97-SRR
relative rotor angles :
three phase 4-cycles fault at RATCHABURI 3 500KV bus
SAI NOI - RATCHABURI 3 500KV line tripped upon fault clearing

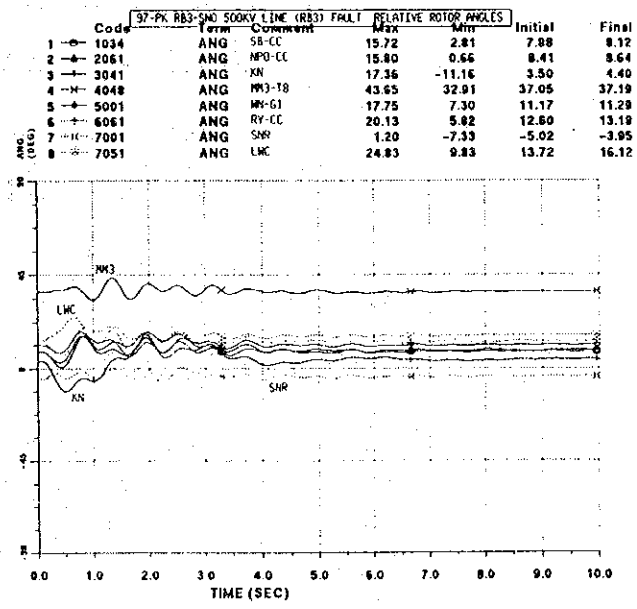
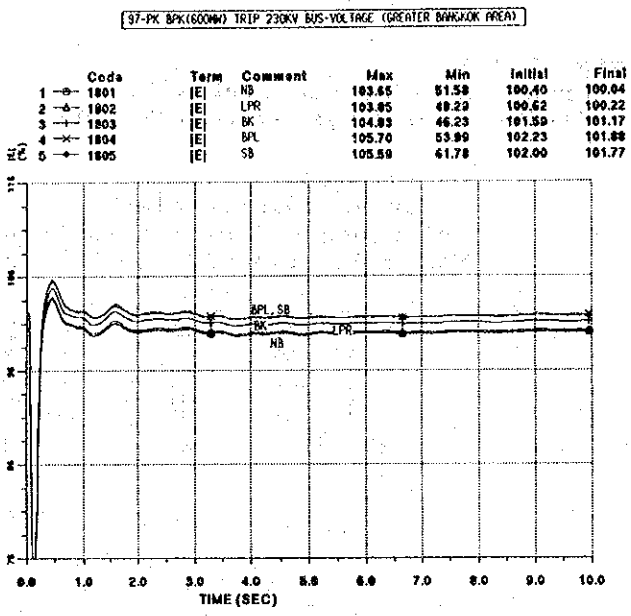
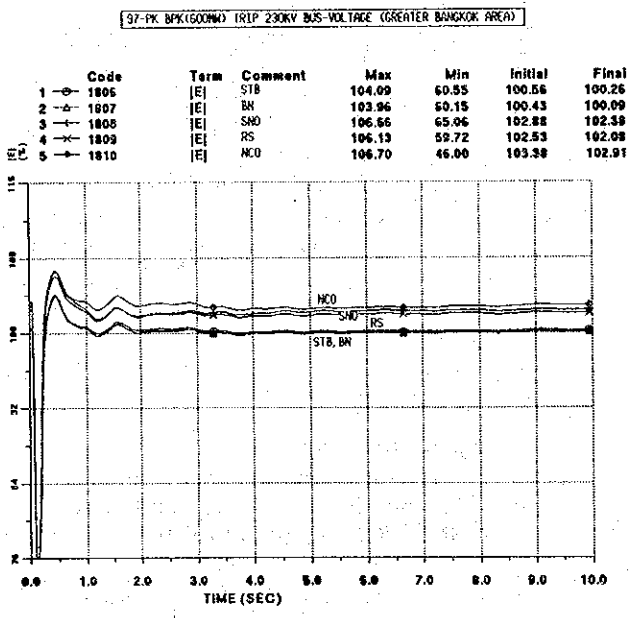


Fig. 6-2-5
the fluctuation of 230kV bus voltage in the Greater Bangkok Area
fault condition :
Bang Pakong 230kV bus 3LG - 3LO
Bang Pakong thermal unit (600MW) trip

NB : North Bangkok
LPR: Lat Phrao
BK : Bang Kapi
BPL: Bang Phli
SB : South Bangkok
STB: South Thon Buri
BN : Bangkok Noi
SNO: Sai Noi
RS : Rangsit
NCO: Nong Chok
ON : On Nuch
CWN: Chaeng Watthana
RPS: Ratchadaphisek
TPR: Thepharak





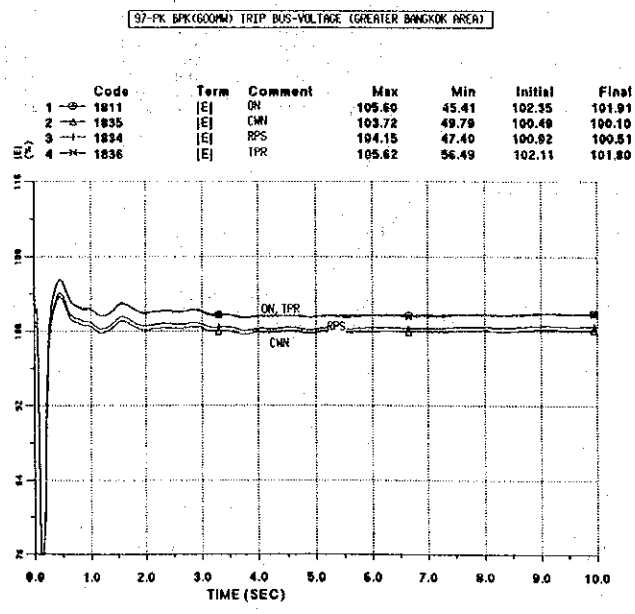


Fig. 6-3-1

2001 Power Flow (System Peak)
Base - Case

V∠θ : %∠deg P+jQ : MW+jMVar

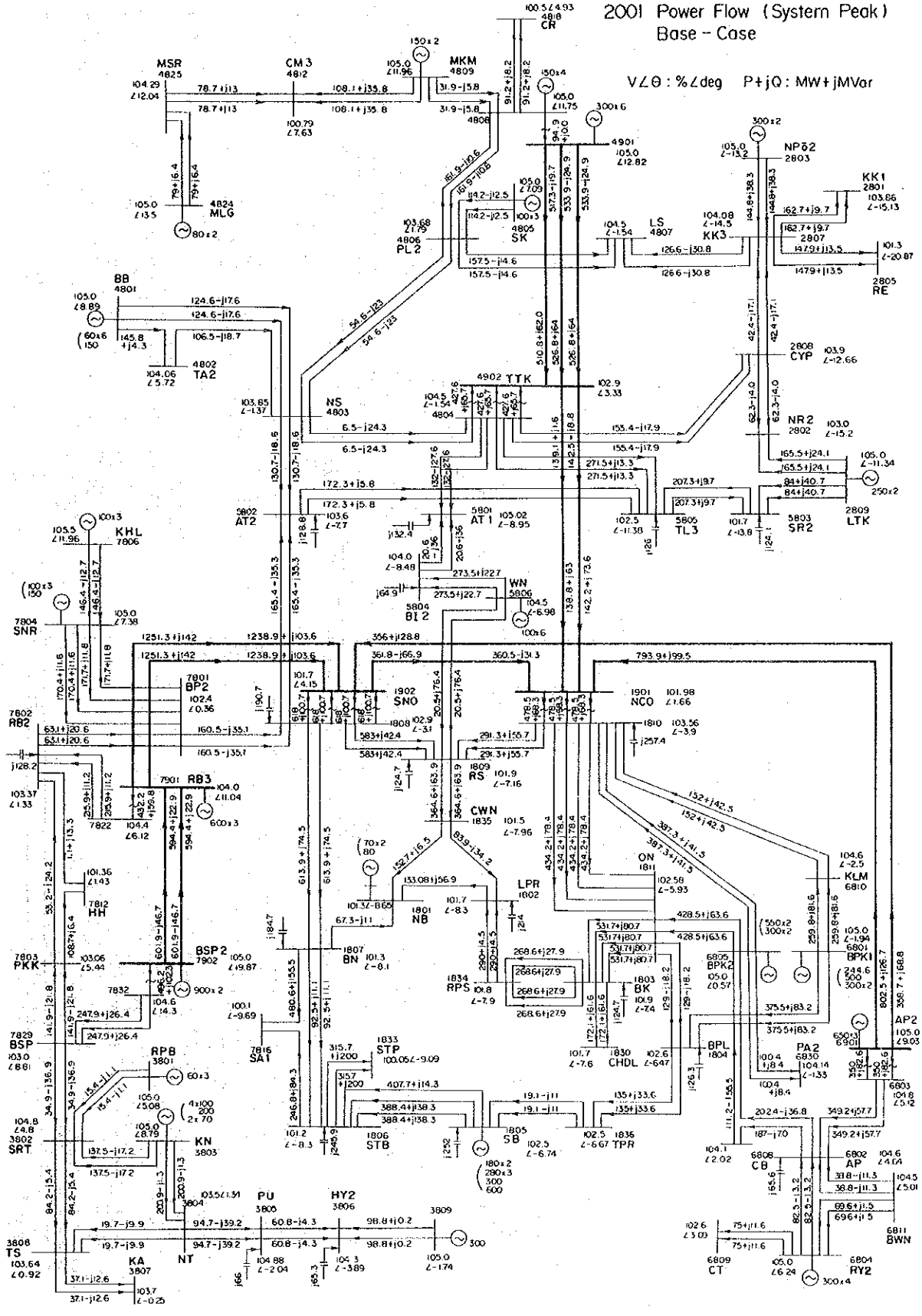


Fig. 6-3-2

2001 Power Flow (System Peak)
Sai Noi 500kV Transformer 5-unit

V∠θ : %∠deg P+jQ : MW+jMVar

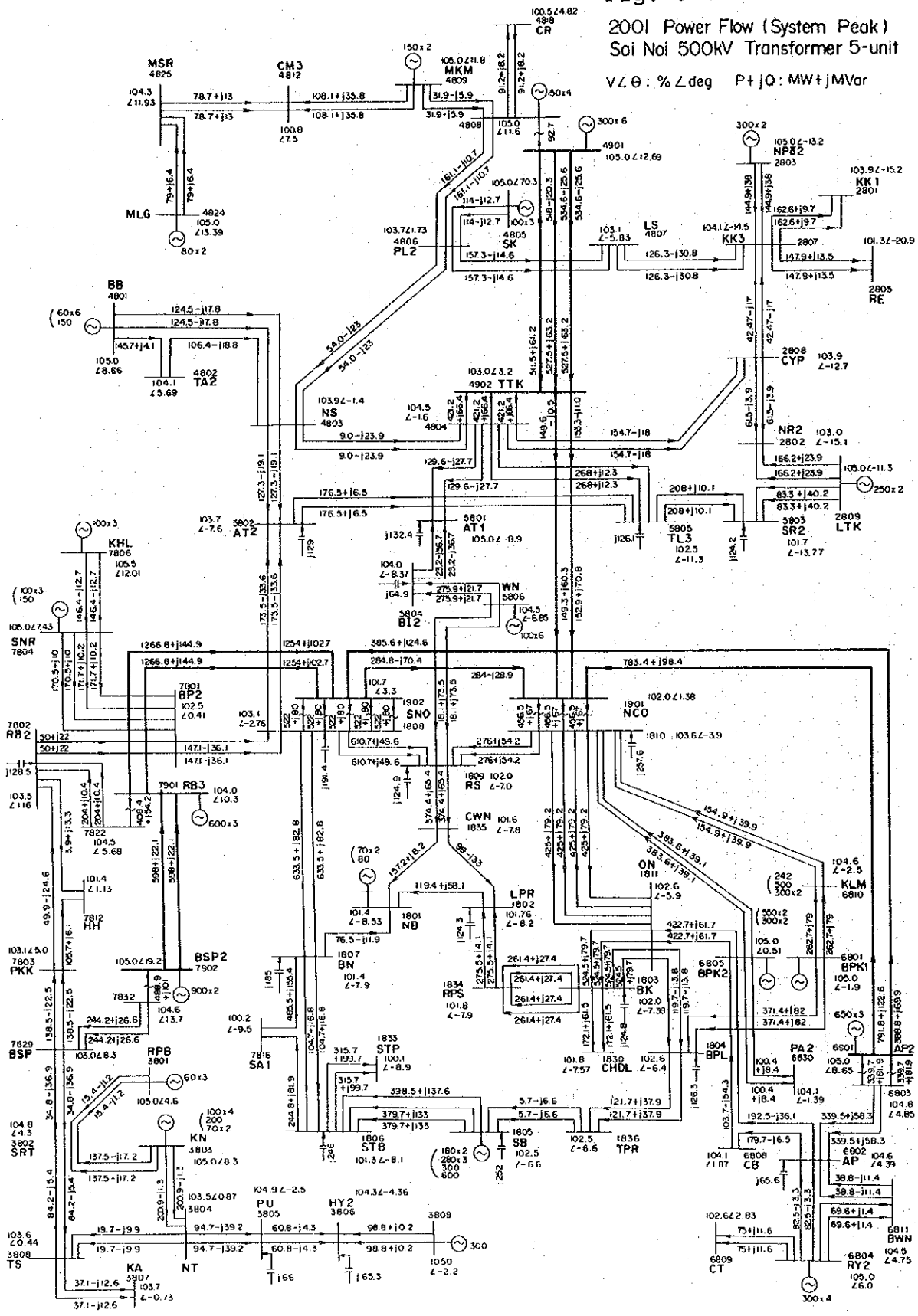
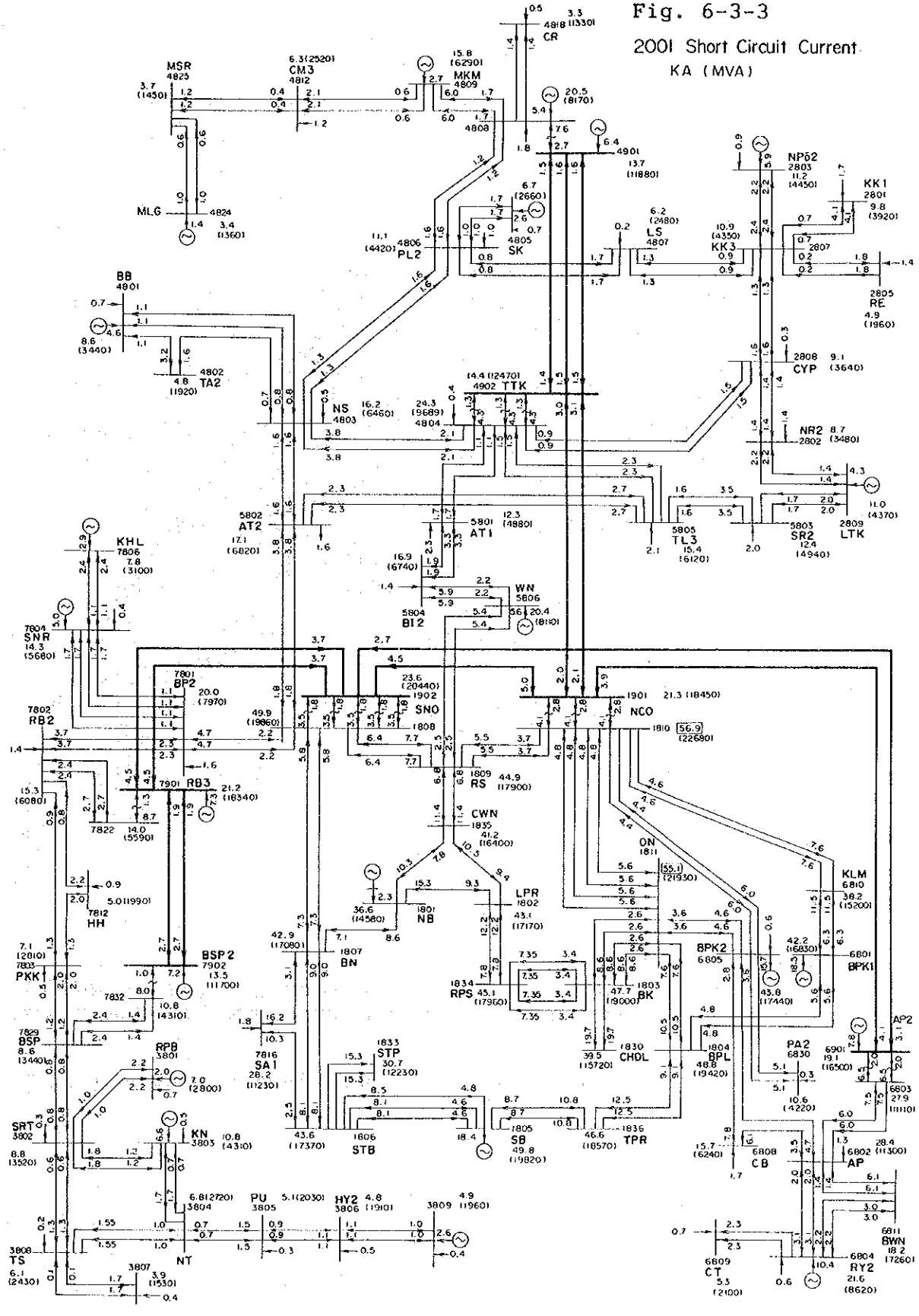


Fig. 6-3-3

2001 Short Circuit Current

KA (MVA)



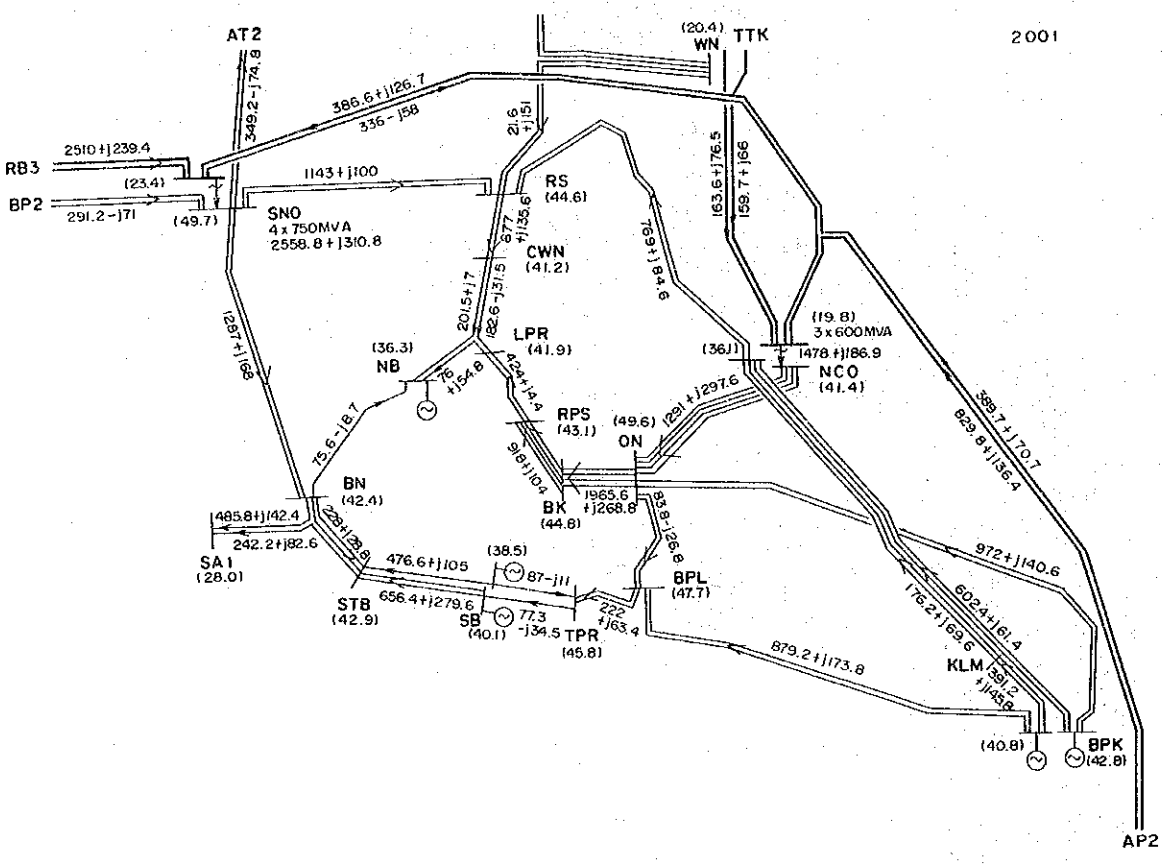


Fig. 6-3-4
the results of load flow and short circuit current in 2001's power system having been taken countermeasures for reducing short circuit current

short circuit current levels are shown in parentheses (KA)

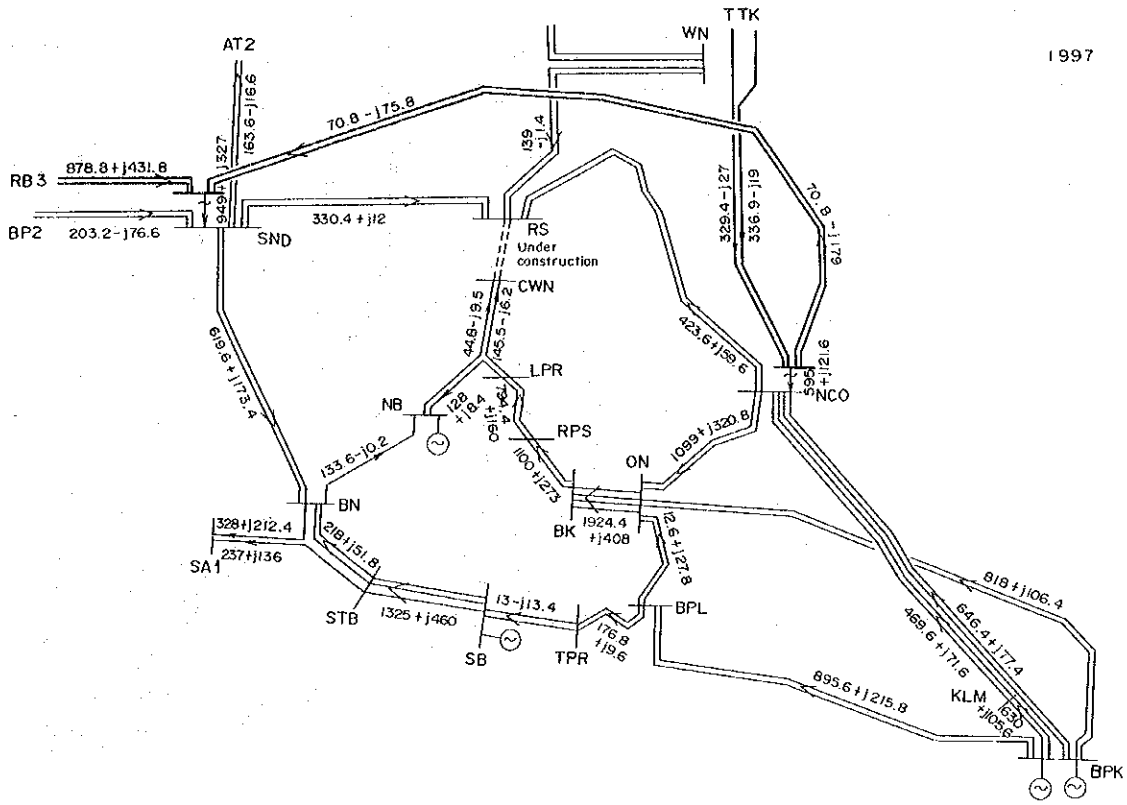


Fig. 6-3-5
the result of load flow under construction of Rangsit - Chaeng Watthana line section in 1997's network system

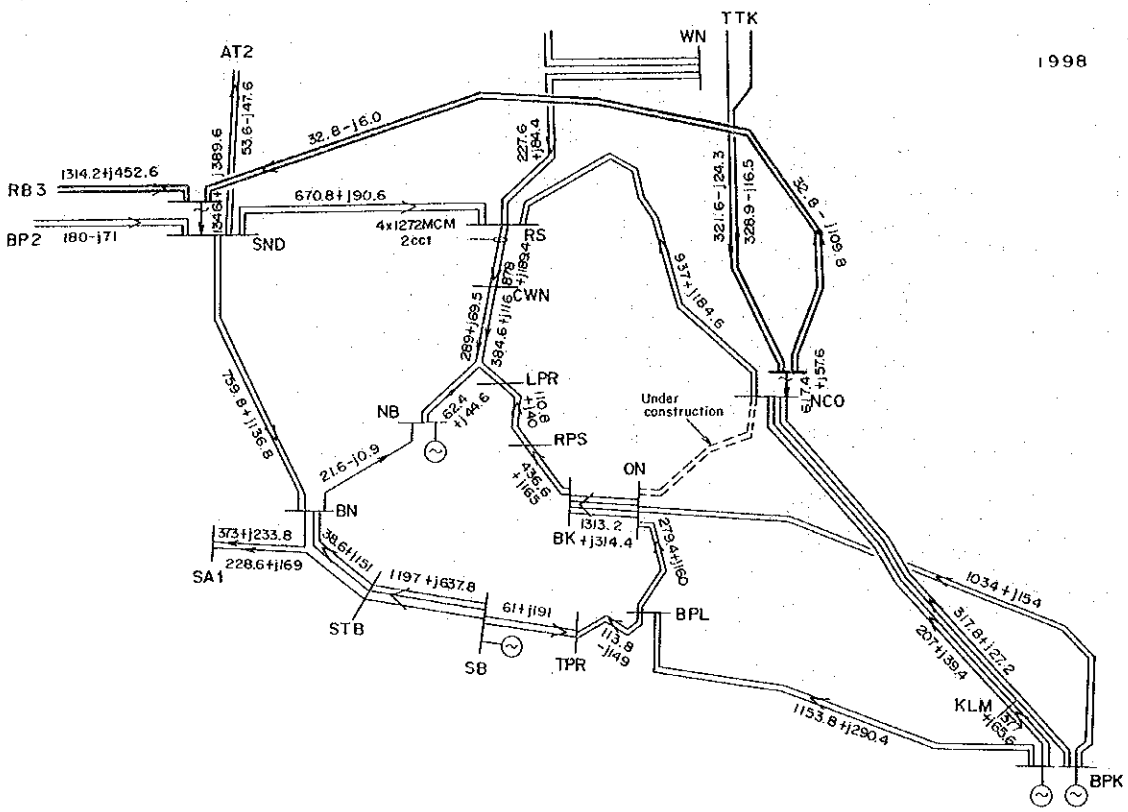


Fig. 6-3-6
result of load flow under construction of Nong Chok - On Nuch in 1998's network system

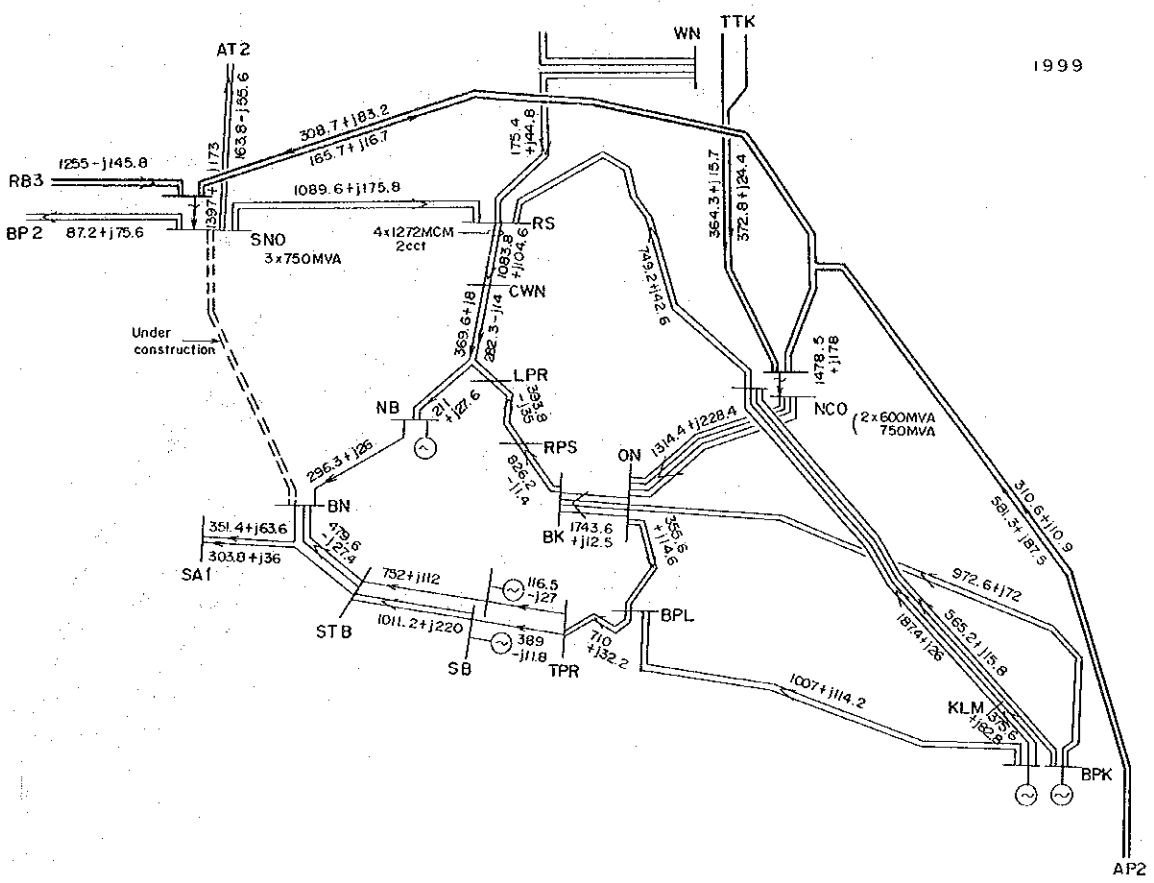


Fig. 6-3-7
the result of load flow under construction of Bangkok Noi - Sai Noi in 1999's network system

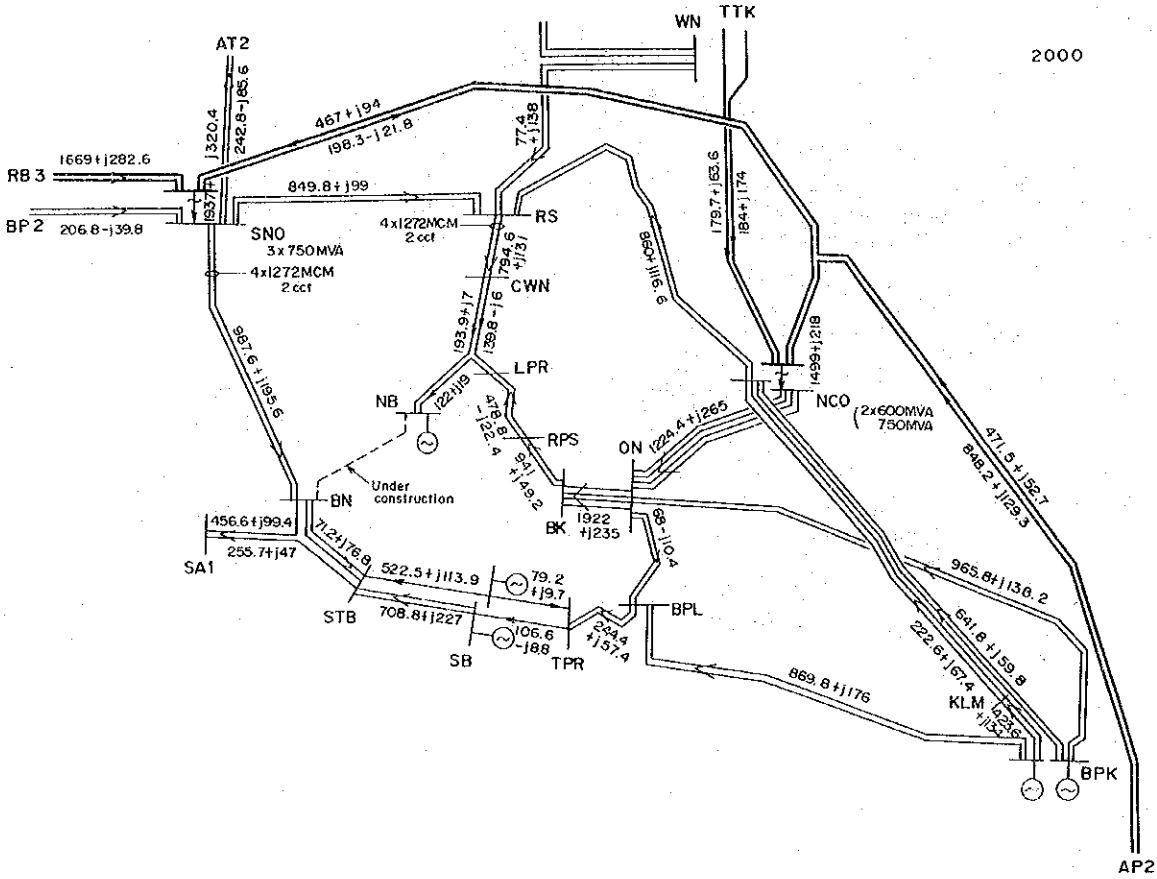


Fig. 6-3-8
result of load flow under construction of North Bangkok - Bangkok Noi in 2000's network system

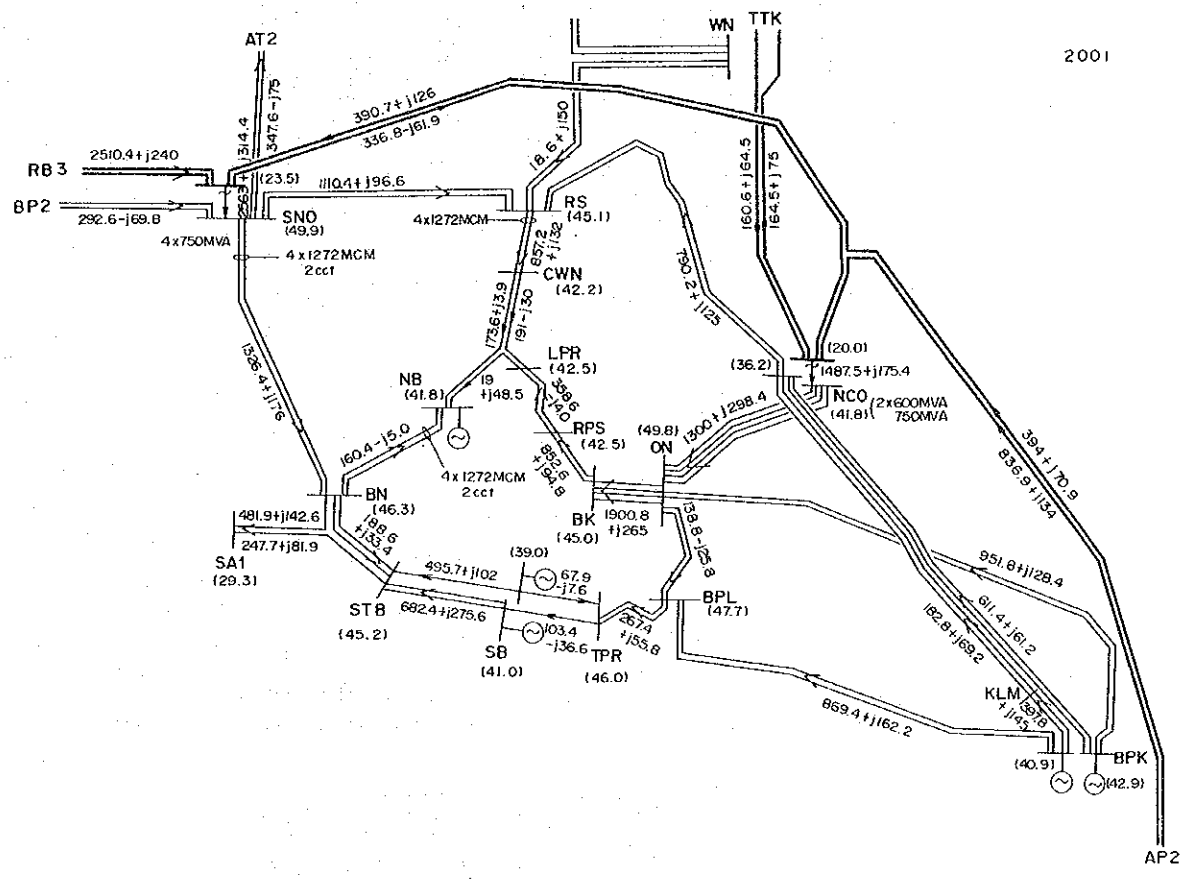
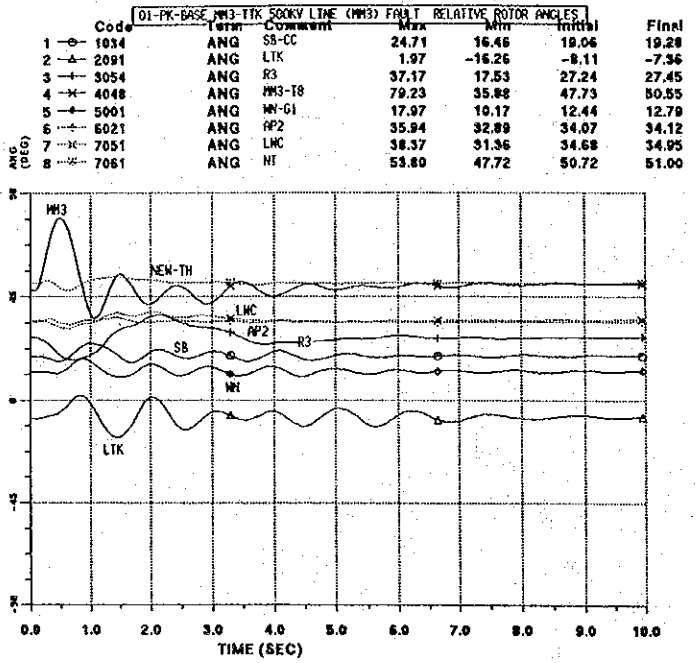


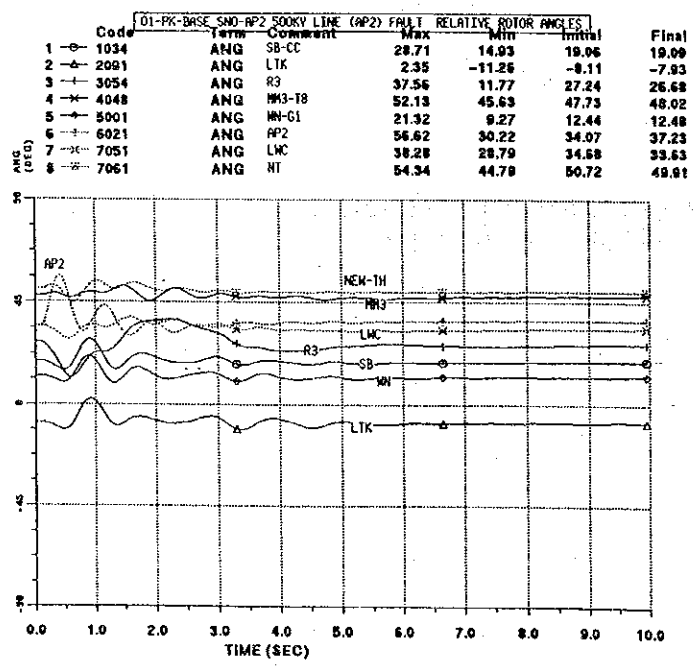
Fig. 6-3-9
result of load flow and short circuit current under normal condition in 2001's network system

Fig. 6-3-10
results of system stability
year 2001 network system in Thailand

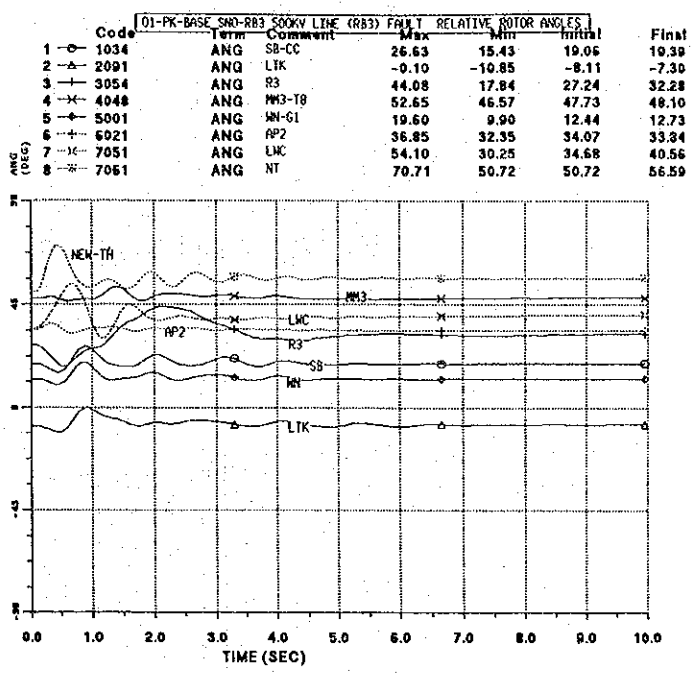
CASE-01-MTM
relative rotor angles :
three phase 4-cycles fault at MAE MOH 500KV bus
MAE MOH - THA TAKO 500KV line tripped upon fault clearing



CASE-01-SAA
relative rotor angles :
three phase 4-cycles fault at AO PHAI 2 500KV bus
SAI NOI - AO PHAI 2 500KV line tripped upon fault clearing



CASE-01-RBB
relative rotor angles :
three phase 4-cycles fault at BANG SAPHAN 500KV bus
RATCHABURI 3 - BANG SAPHAN 500KV line tripped upon fault clearing



CASE-01-SRR
relative rotor angles :
three phase 4-cycles fault at RATCHABURI 3 500KV bus
SAI NOI - RATCHABURI 3 500KV line tripped upon fault clearing

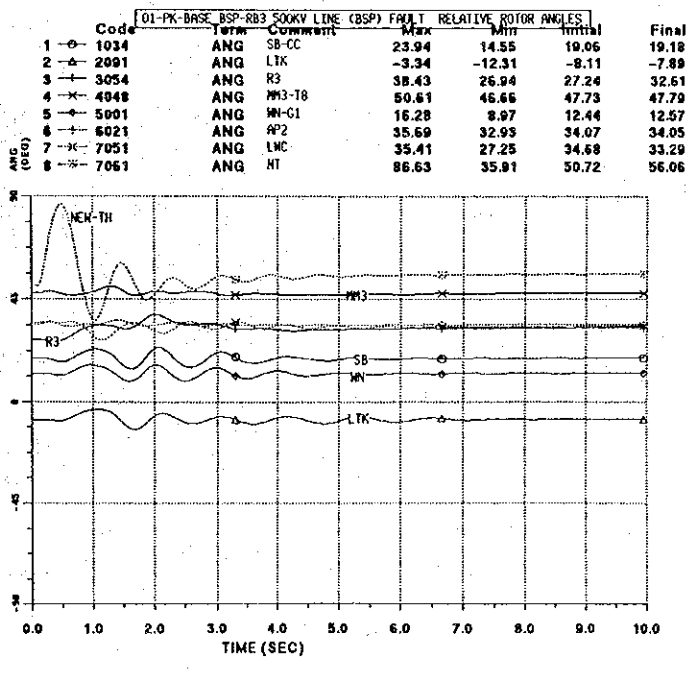


Fig. 6-4-1

2006 Power Flow (System Peak)

V∠θ : % ∠ deg P+jQ : MW+jMVar

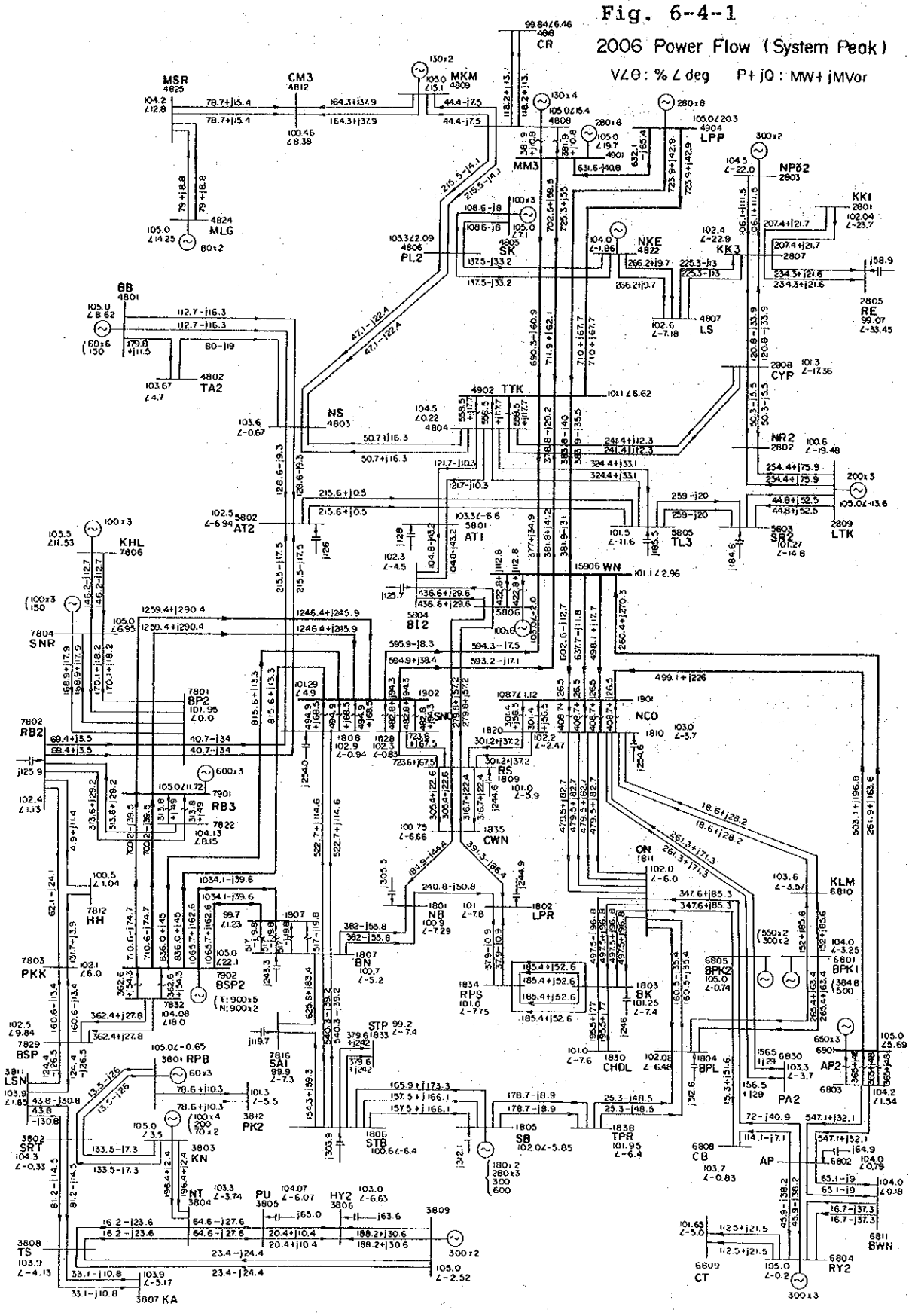
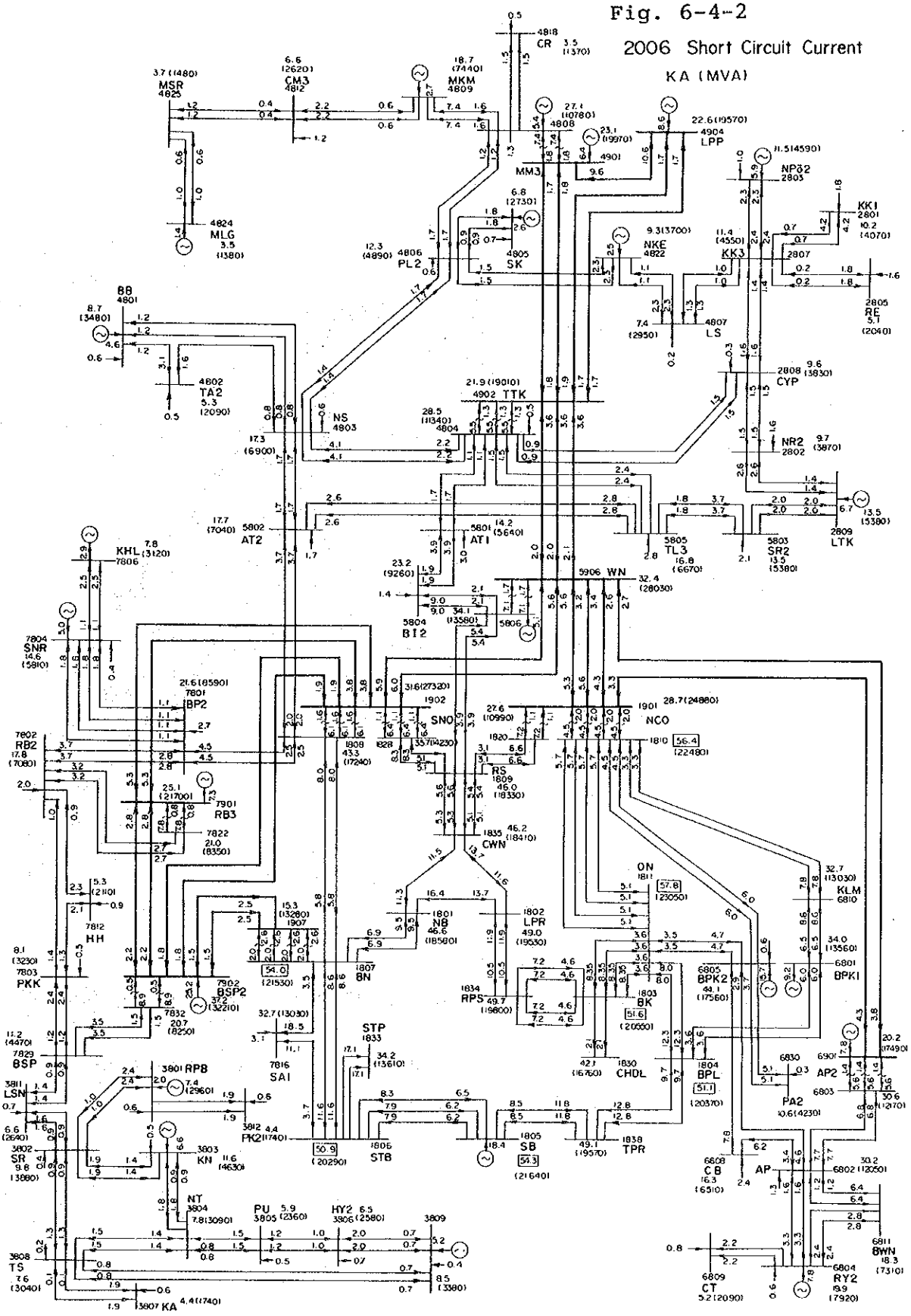


Fig. 6-4-2

2006 Short Circuit Current

KA (MVA)



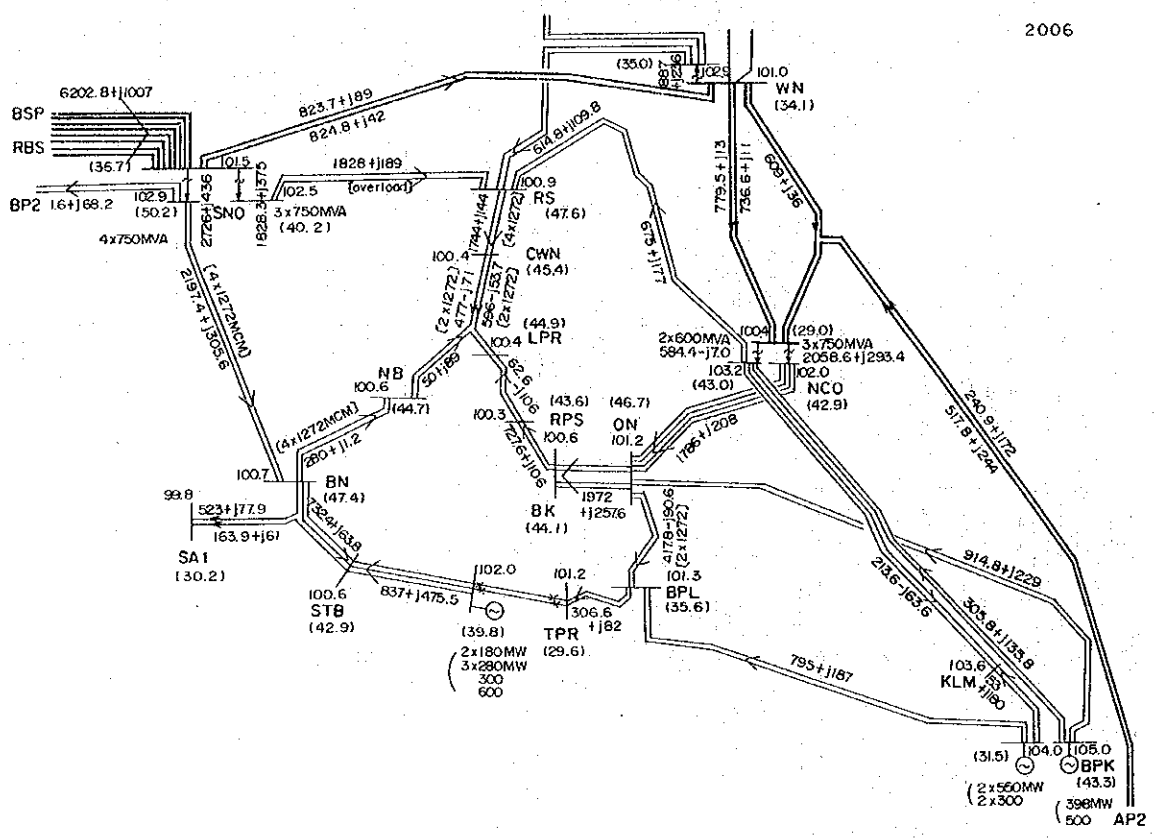


Fig. 6-4-3
the result of load flow and short circuit current in 2006's modified power system

short circuit current levels are shown in parentheses (KA)

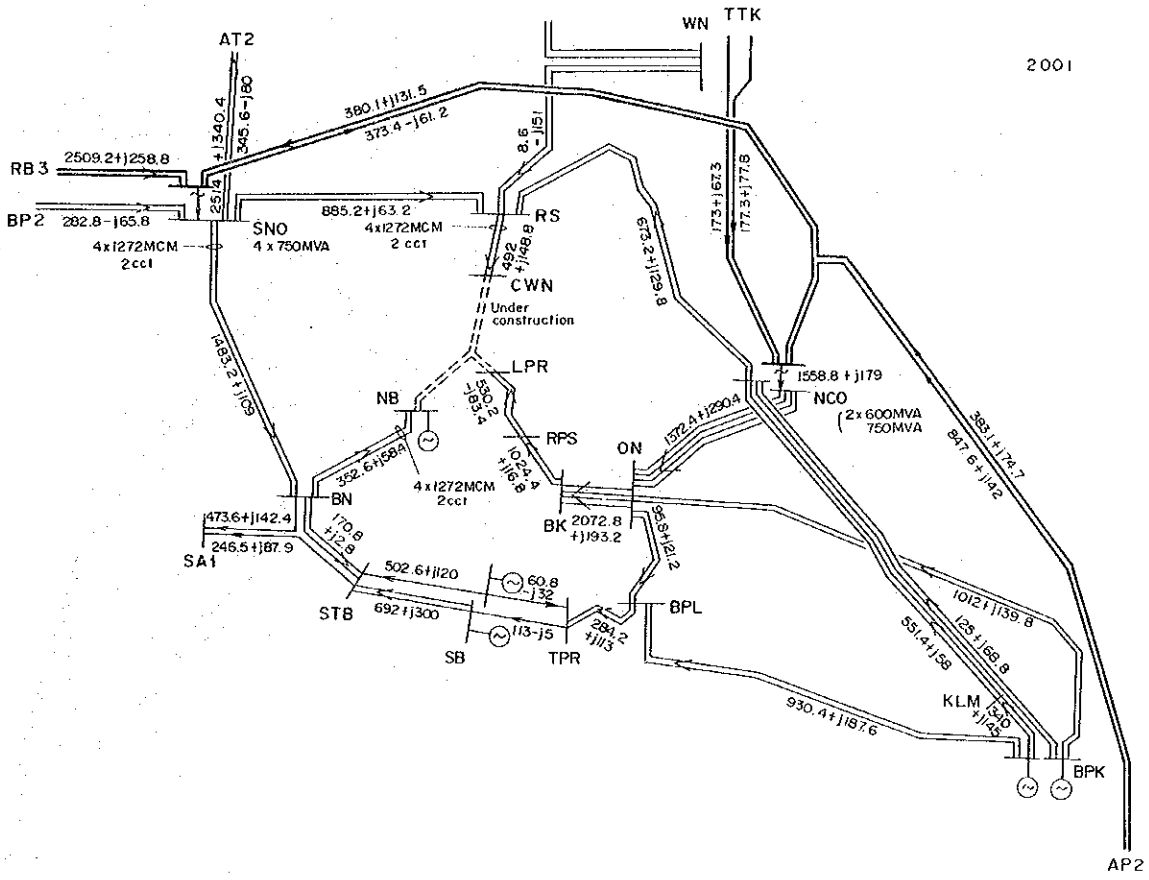


Fig. 6-4-4
result of load flow under construction of North Bangkok - Lat Phrao - Chaeng Watthana in 2001's network system

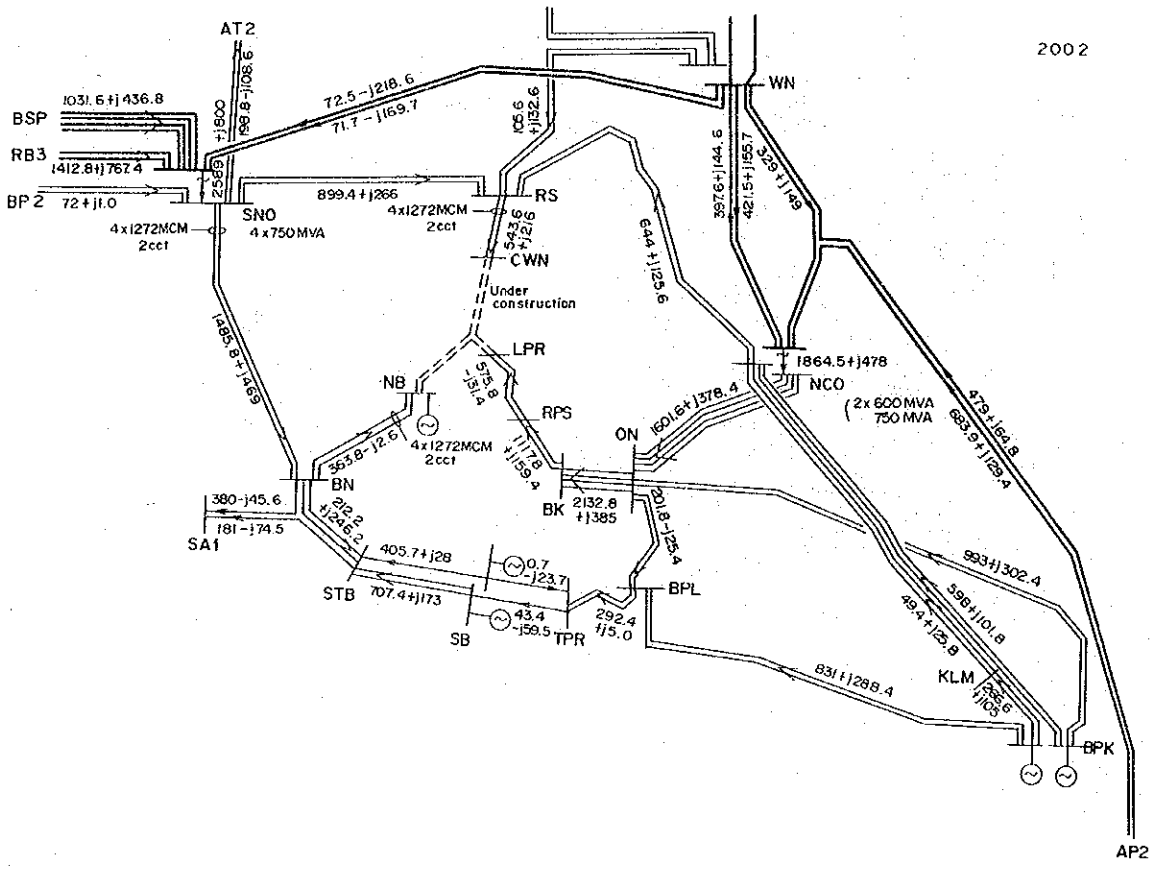


Fig. 6-4-5
result of load flow under construction of North Bangkok - Lat Phrao - Chaeng Watthana in 2002's network system

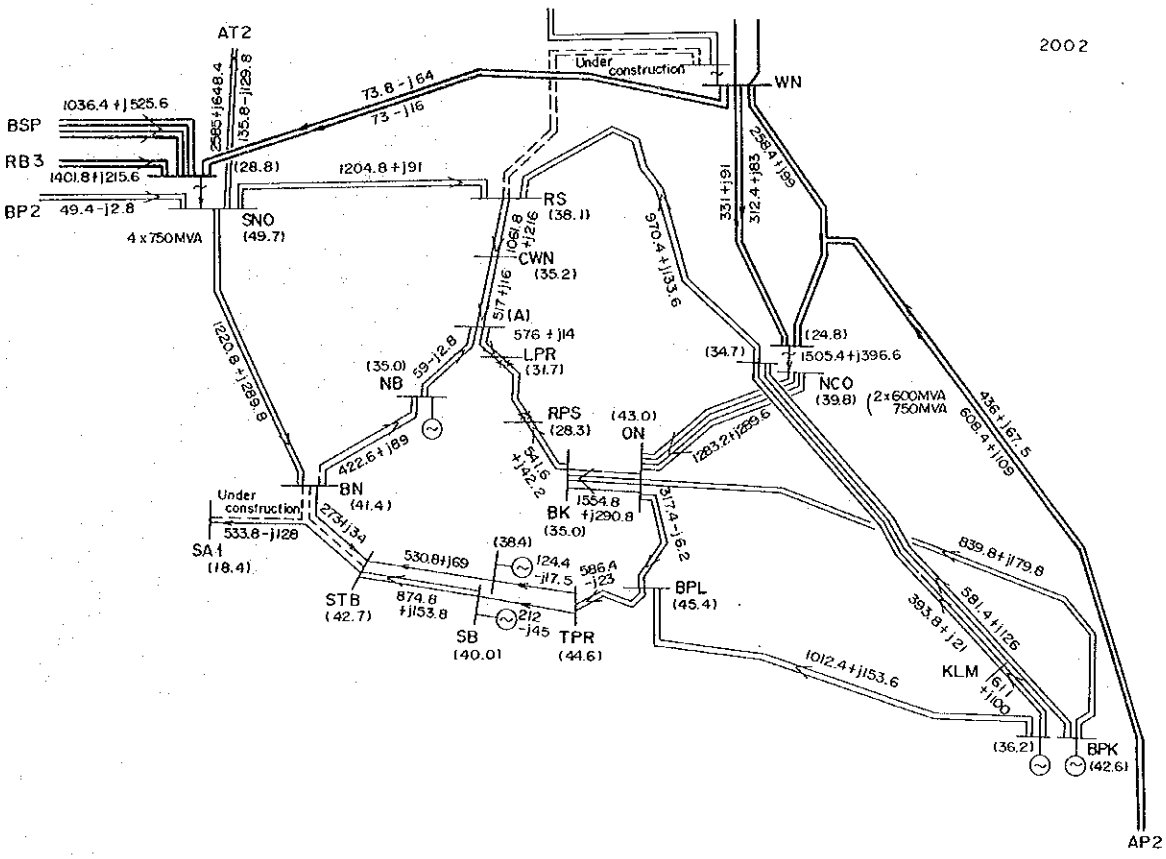


Fig. 6-4-6
result of load flow and short circui current under construction of Rangsit - Wang Noi and Bangkok Noi - Sam Phran 1 in 2002's network system

short circuit current levels are shown in parentheses (KA)

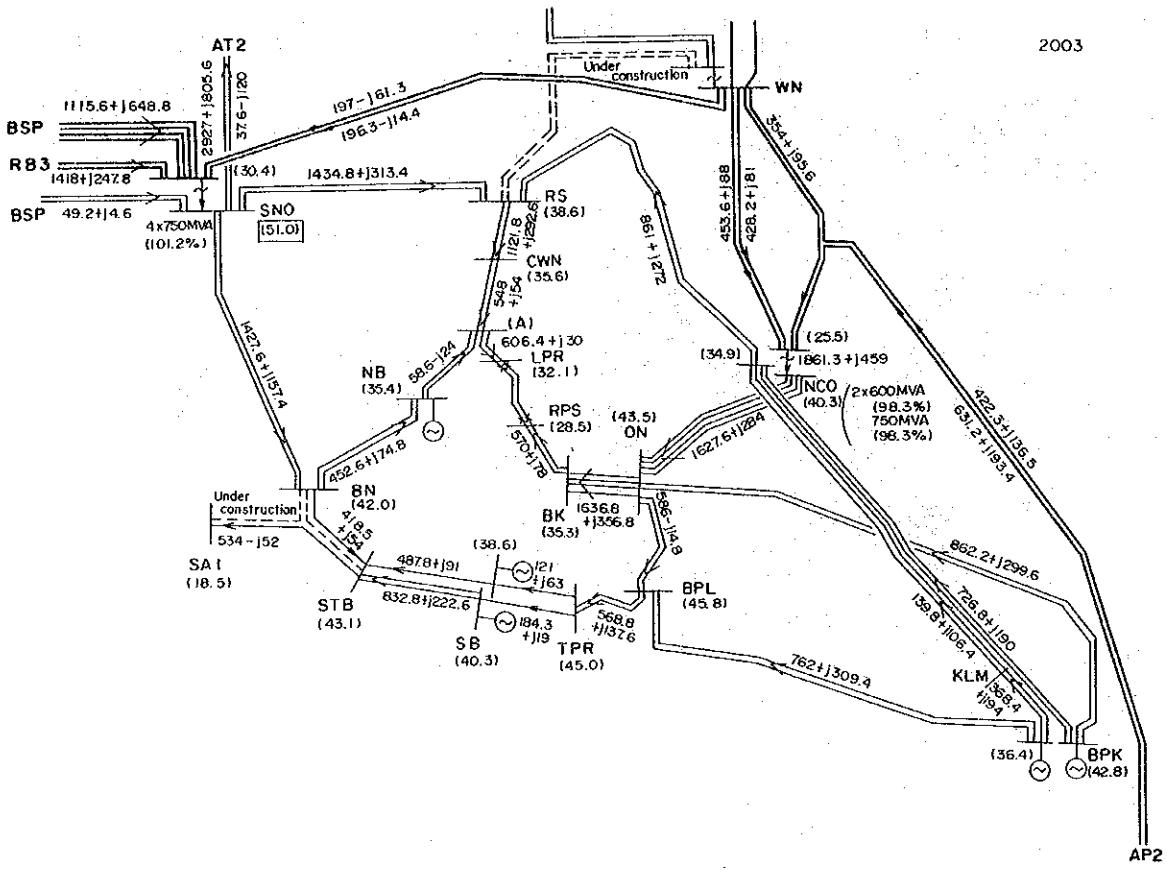


Fig. 6-4-7
result of load flow and short circui current under construction of Rangsit - Wang Noi and Bangkok Noi - Sam Phran 1 in 2003's network system in the case of Bangkok Noi - Sai Noi transmission line with 230kV operation

short circuit current levels are shown in parentheses (KA)

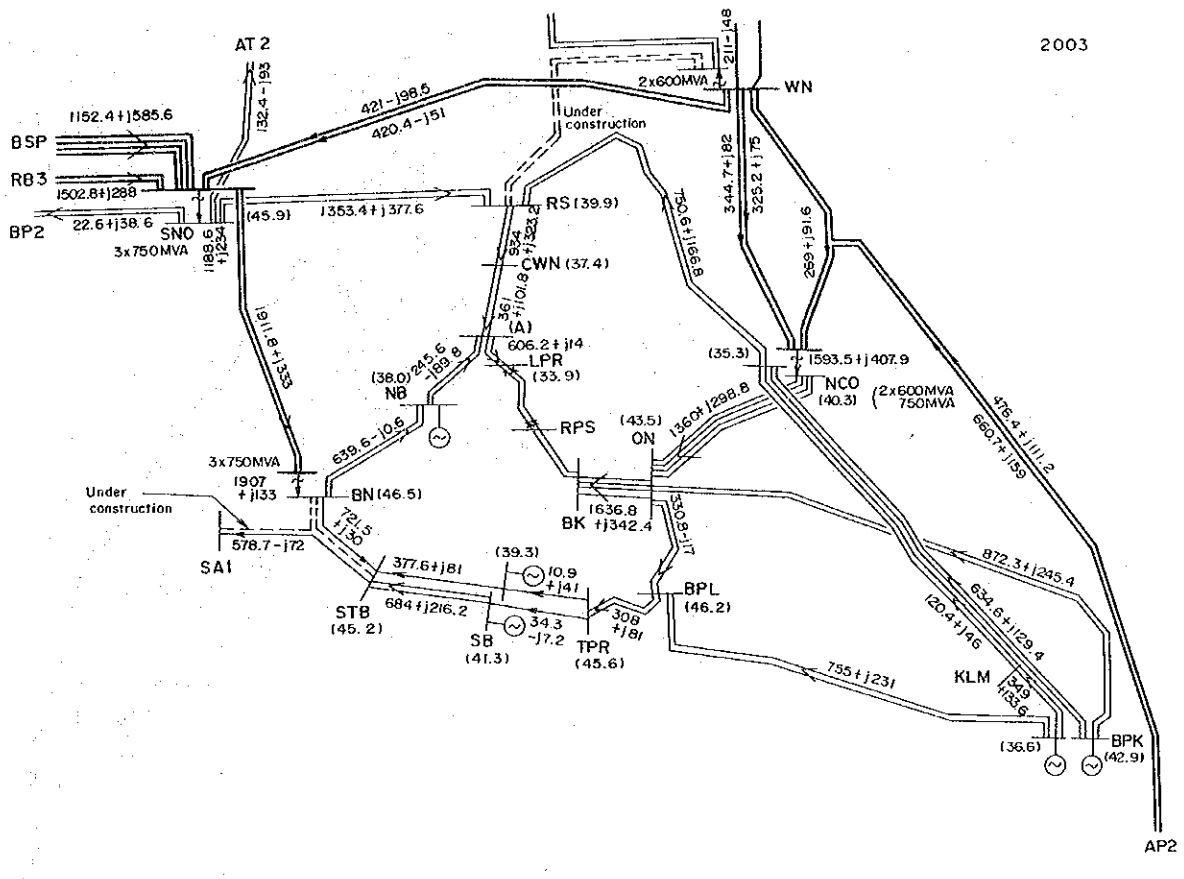


Fig. 6-4-8
result of load flow and short circui current under construction of Rangsit - Wang Noi and Bangkok Noi - Sam Phran 1 in 2003's network system in the case of Bangkok Noi - Sai Noi transmission line with 500kV operation

short circuit current levels are shown in parentheses (KA)

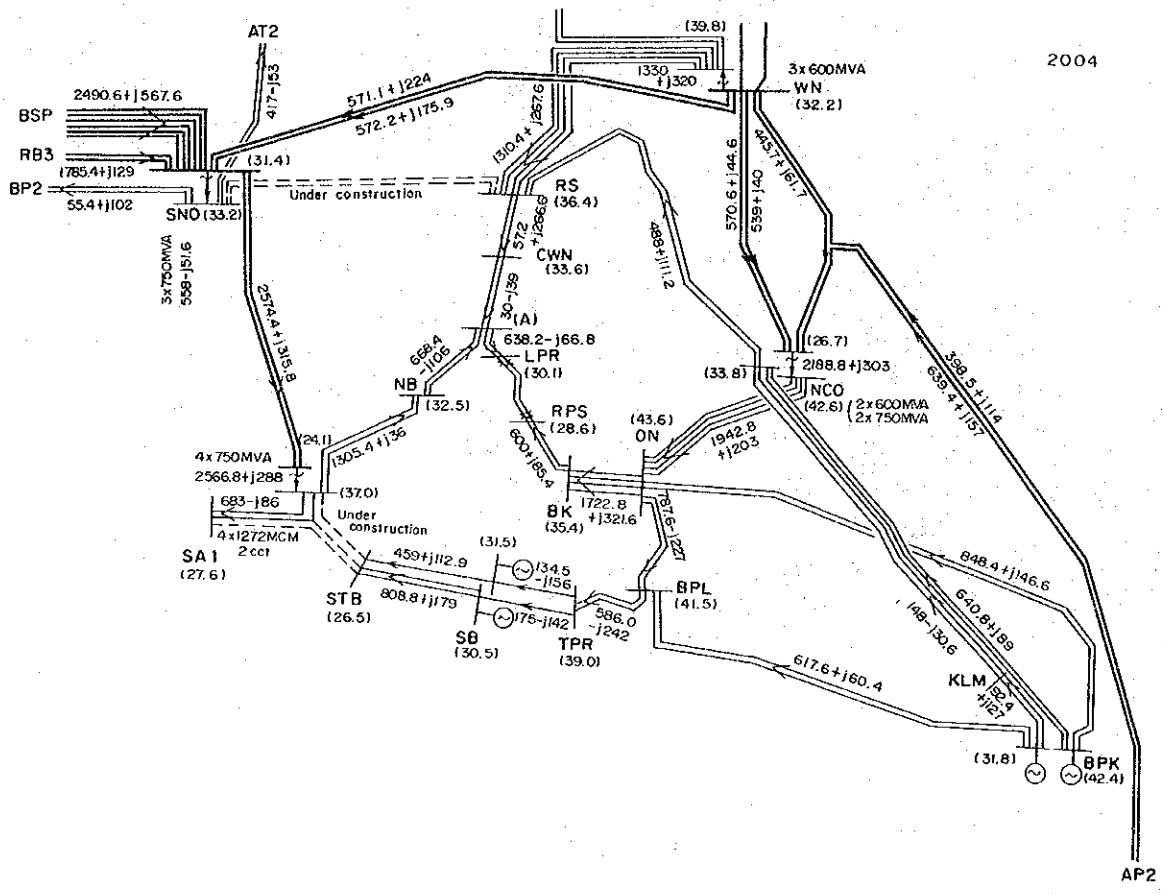


Fig. 6-4-9
result of load flow and short circuit current under construction of Sai Noi - Rangsit in 2004's network system

short circuit current levels are shown in parentheses (KA)

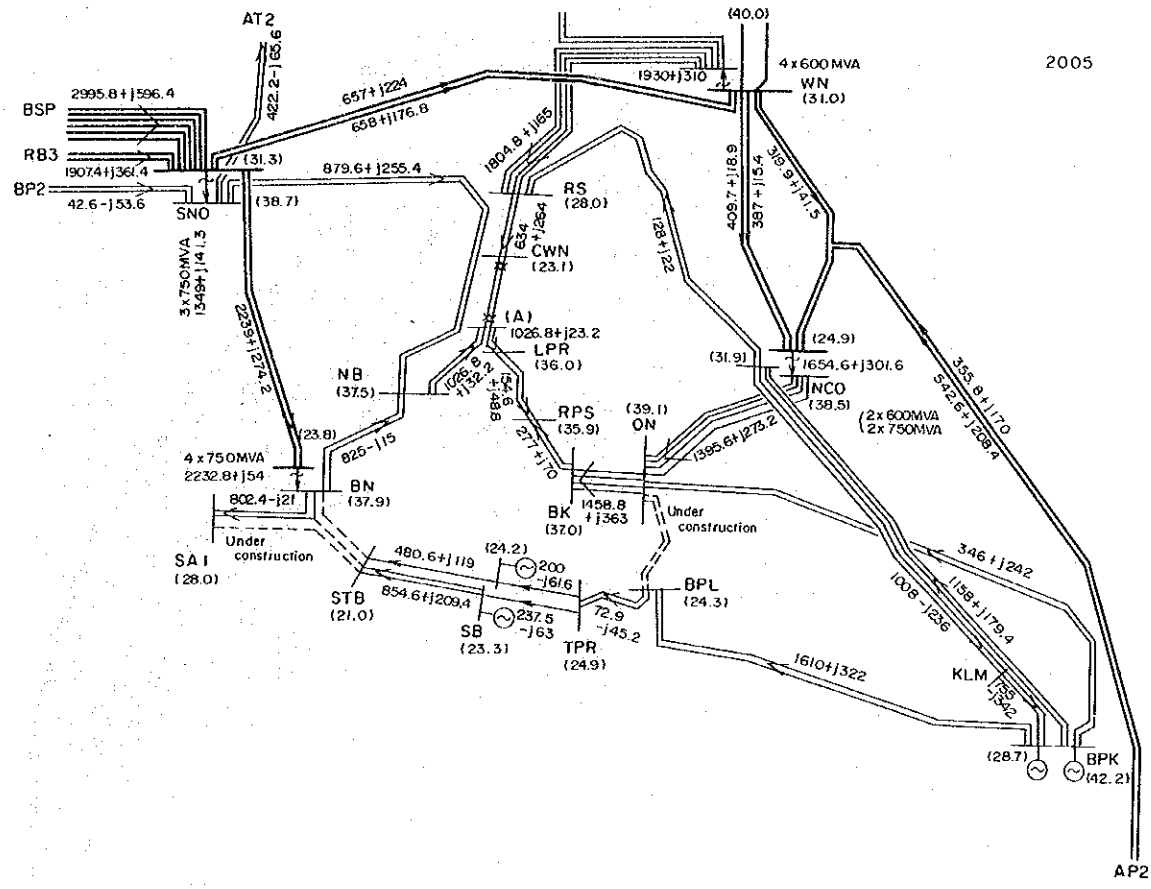


Fig. 6-4-10
result of load flow and short circuit current under construction of South Thon Buri - Sam Phran 1 - Bangkok Noi and Bang Phli - On Nuch in 2005's network system

short circuit current levels are shown in parentheses (KA)

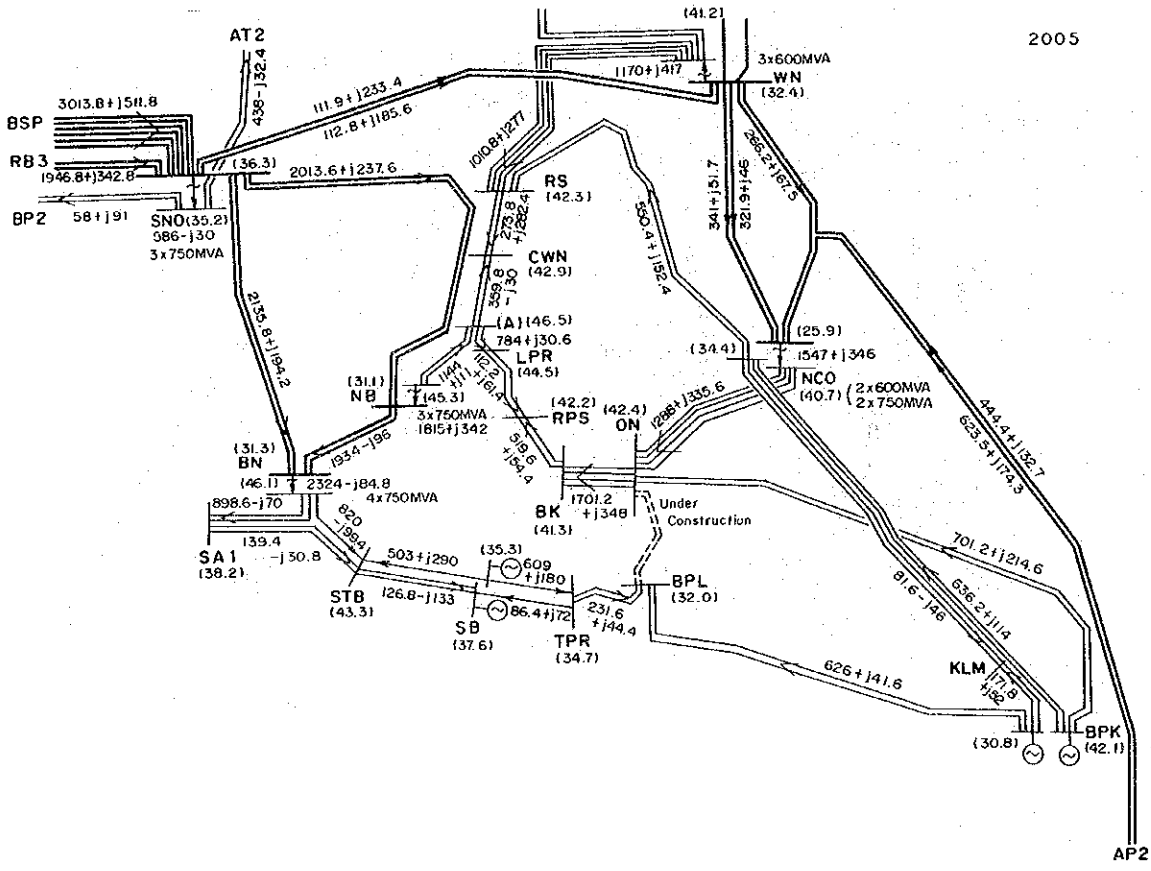


Fig. 6-4-11
result of load flow and short circuit current under construction of Bang Phli - On Nuch in 2005's network system

short circuit current levels are shown in parentheses (KA)

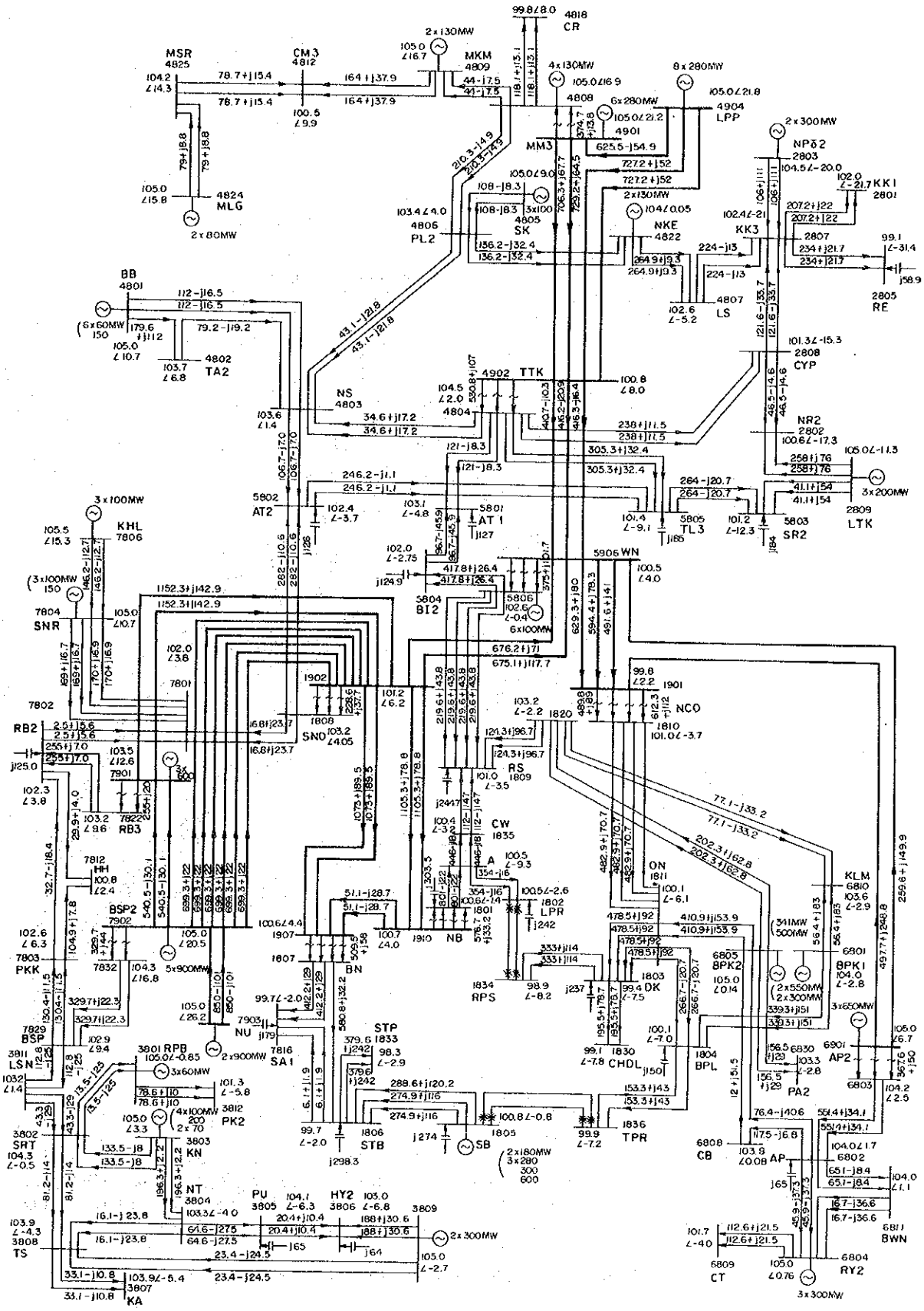


Fig. 6-4-12
result of load flow under normal condition in 2006's network system
South Bangkok - Theparak transmission lines are put into scheduled outage without South Bangkok bus-split and Lat Phrao - Ratchadaphisek transmission lines are put into scheduled outage due to reducing short circuit current

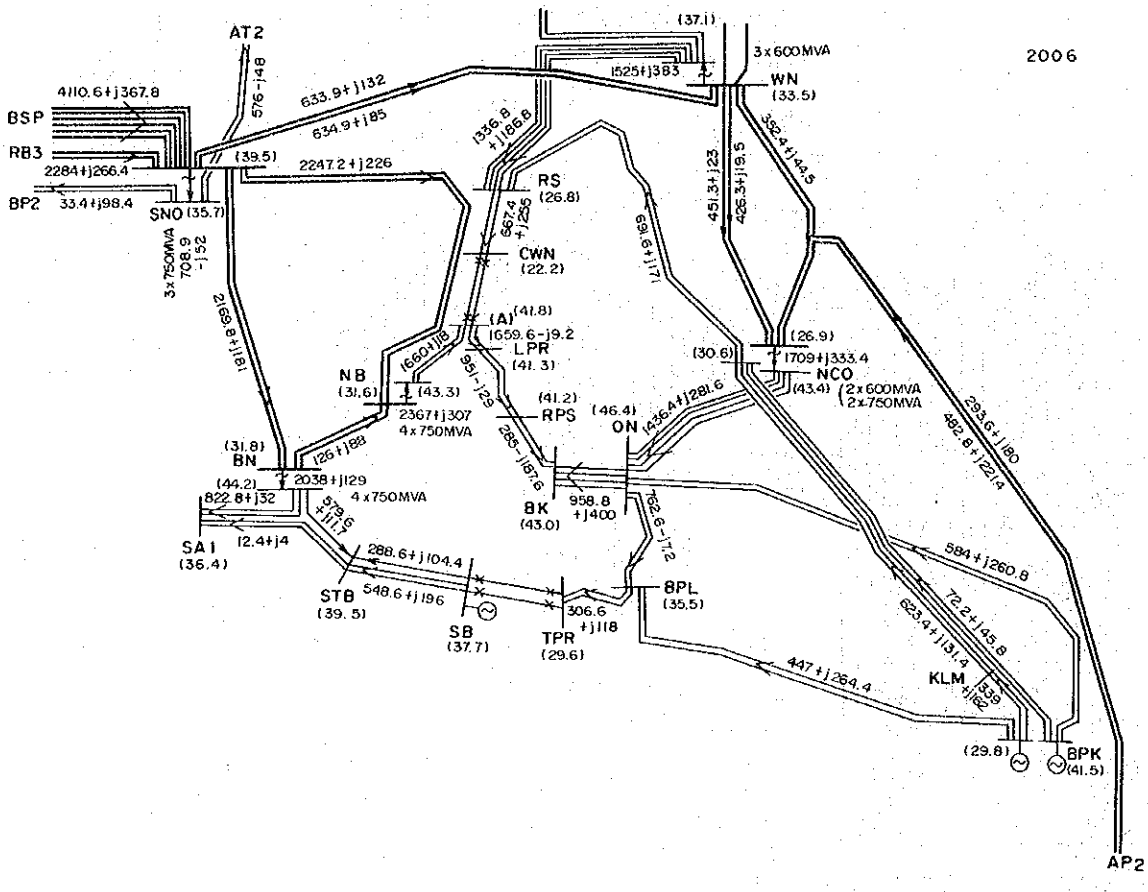
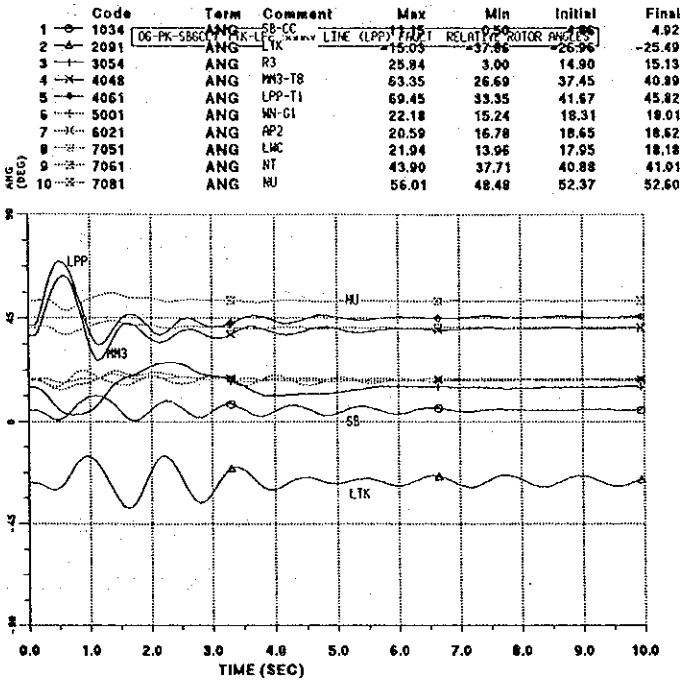


Fig. 6-4-13
result of load, flow and short circuit current under normal condition in 2006's network system
South Bangkok - Theparak transmission lines are put into scheduled outage without South Bangkok bus-split and Chaeng Watthana - new substation "A" transmission lines are put into scheduled outage due to reducing short circuit current

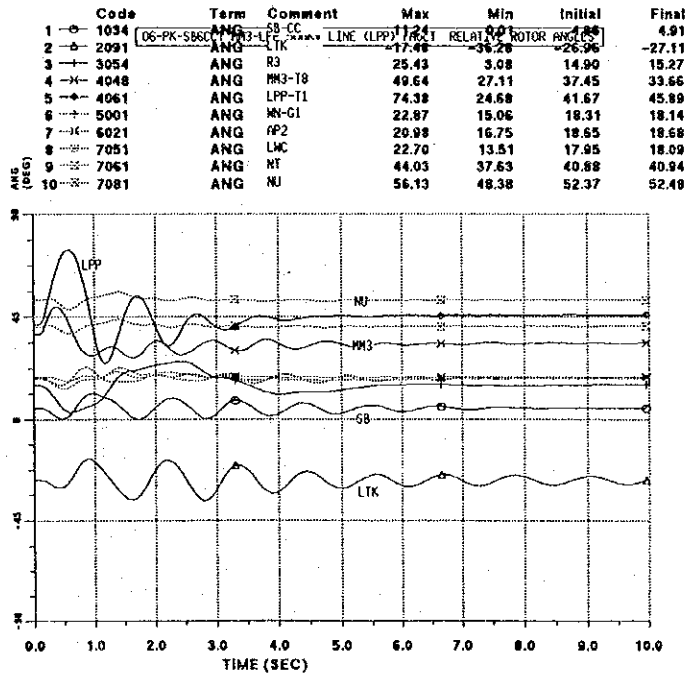
short circuit current levels are shown in parentheses (KA)

Fig. 6-4-14
results of system stability
2006's network system in Thailand

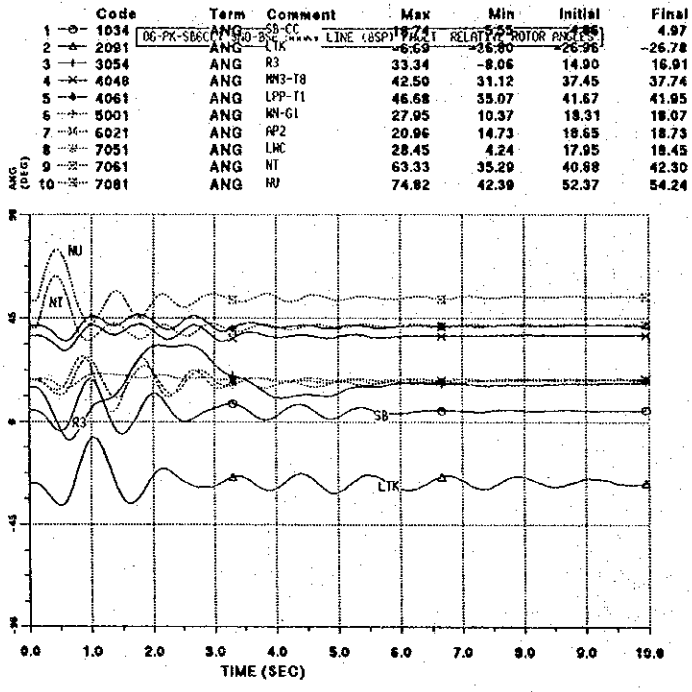
CASE-06-TLL
relative rotor angles
three phase 4-cycles fault at LAMPANG 500KV bus
LAMPANG - THA TAKO 500KV line tripped uopn fault clearing



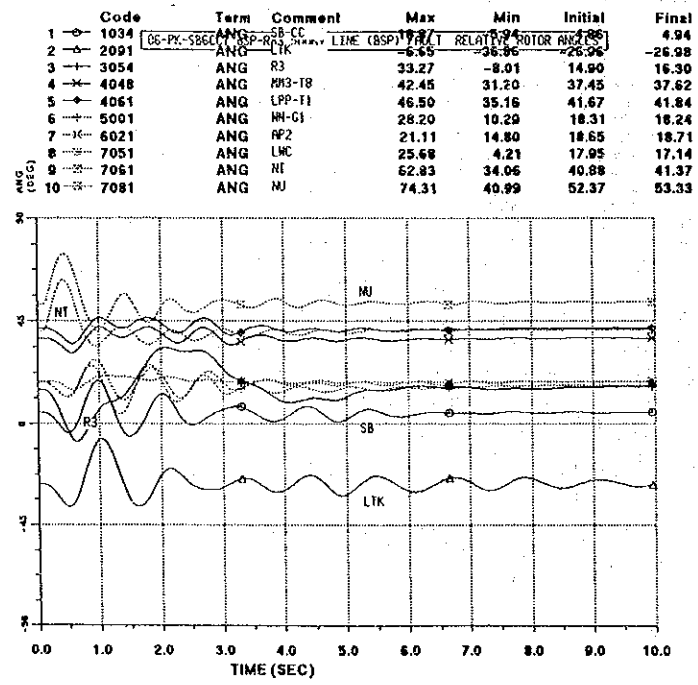
CASE-06-MLL
relative rotor angles :
three phase 4-cycles fault at LAMPANG 500KV bus
MAE MOH - LAMPANG 500KV line tripped upon fault clearing



CASE-06-SBB
relative rotor angles :
three phase 4-cycles fault at BANG SAPHAN 500KV bus
SAI NOI - BANG SAPHAN 500KV line tripped upon fault clearing



CASE-06-RBB
relative rotor angles :
three phase 4-cycles fault at BANG SAPHAN 500KV bus
RATCHABURI 3 - BANG SAPHAN 500KV line tripped upon fault clearing



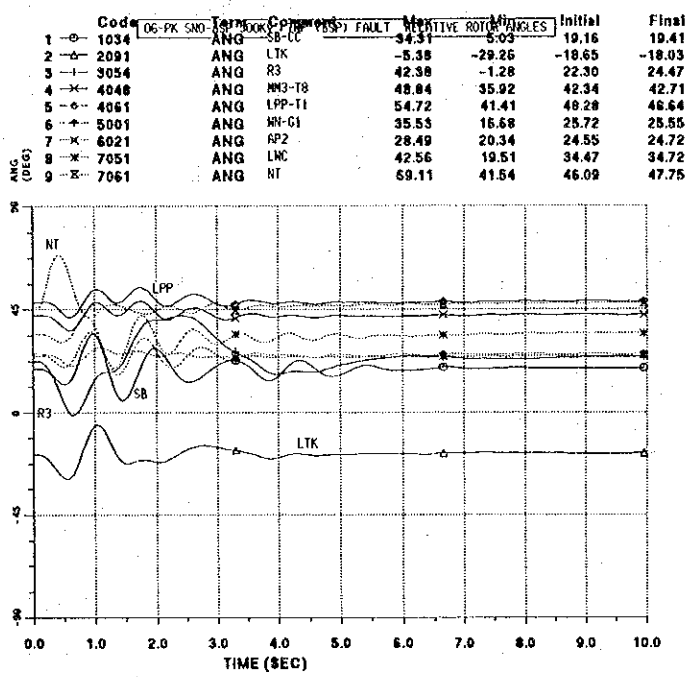
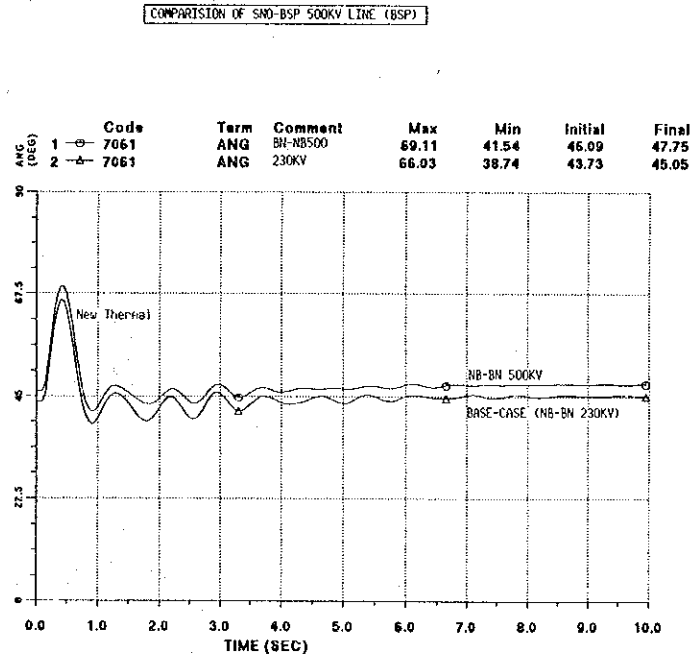


Fig. 6-4-15
the result of system stability in the expanded power system
three phase 4-cycles fault at BANG SAPHAN 500KV bus
SAI NOI - BANG SAPHAN 500KV line tripped upon fault clearing

relative rotor angles

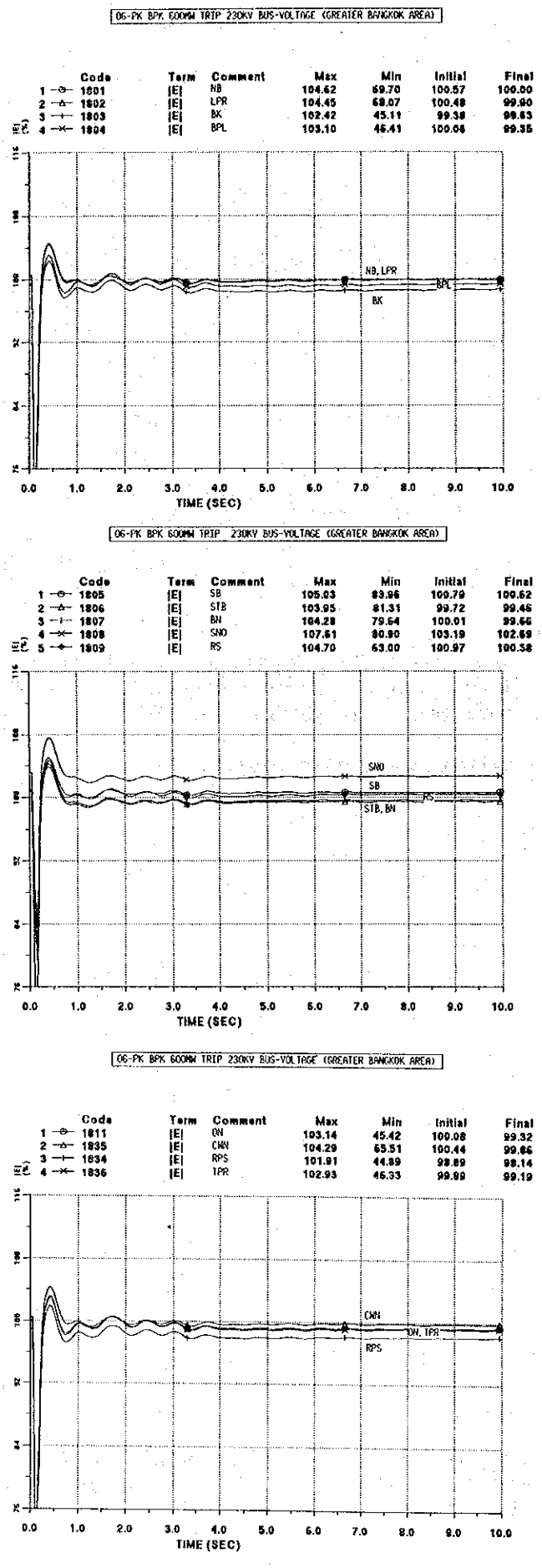


comparision of system stability between EGAT's plan and power system augmentated North Bangkok and Bangkok Noi with 500kV substation

Fig. 6-4-16
fluctuation of 230kV bus voltage in the Greater Bangkok Area

fault condition
Bang Pong bus fault
Bang Pong thermal unit (600MW) trip

NB : North Bangkok
LPR: Lat Phrao
BK : Bang Kapi
BPL: Bang Phli
SB : South Bangkok
STB: South Thon Buri
BN : Bangkok Noi
SNO: Sai Noi
RS : Rangsit
NCO: Nong Chok
ON : On Nuch
CWN: Chaeng Watthana
RPS: Ratchadaphisek
TPR: Theparak



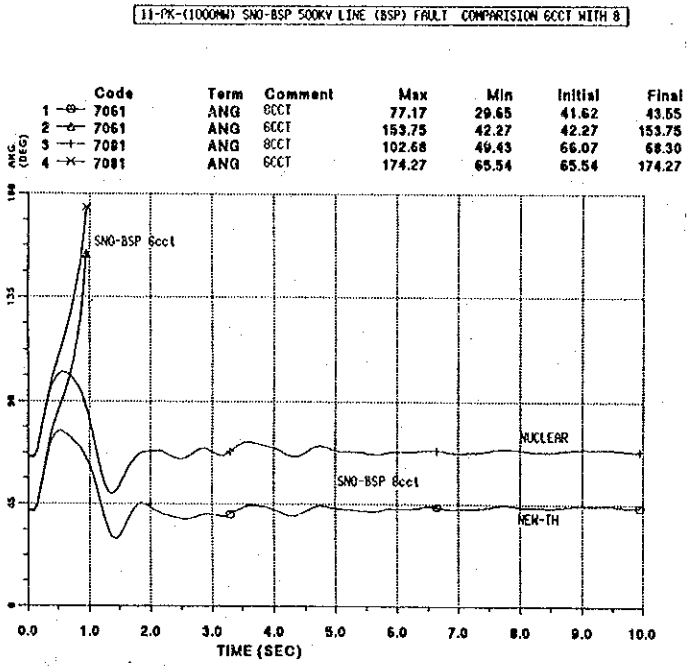


Fig. 6-5-1
comparision of system stability between 6cct and 8cct on SAI NOI - BANG SAPHAN line
fault condition:
three phase 4-cycles fault at BANG SAPHAN 500KV bus
SAI NOI - BANG SAPHAN 500KV line tripped upon fault clearing

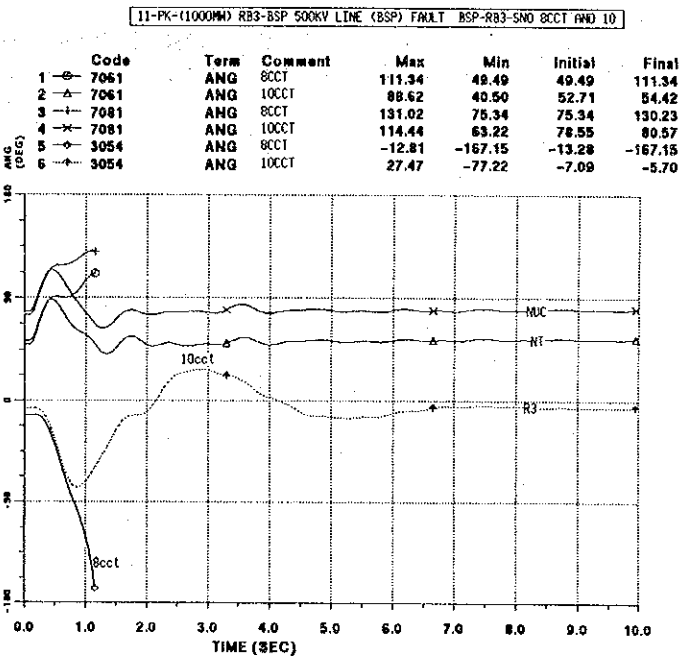


Fig. 6-5-2
comparision of system stability between 8cct and 10cct on RATCHABURI 3 - BANG SAPHAN line
fault condition:
three phase 4-cycles fault at BANG SAPHAN 500KV bus
RATCHABURI 3 - BANG SAPHAN 500KV line tripped upon fault clearing

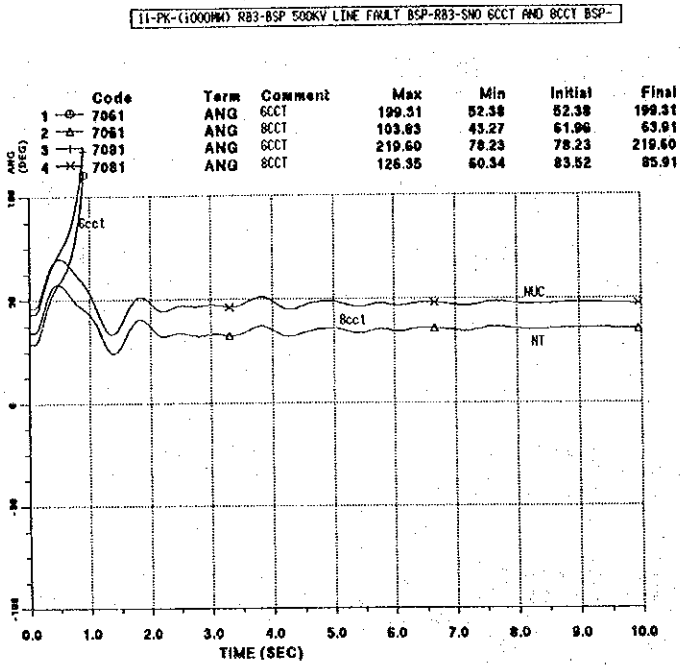


Fig. 6-5-3
comparision of system stability between 6cct and 8cct on RATCHABURI 3 - BANG SAPHAN line in the case of interconnection between BANG SAPHAN and SURAT THANI (region-3) with 500kV

fault condition :
three phase 4-cycles fault at BANG SAPHAN 500KV bus
RATCHABURI 3 - BANG SAPHAN 500KV line tripped upon fault clearing

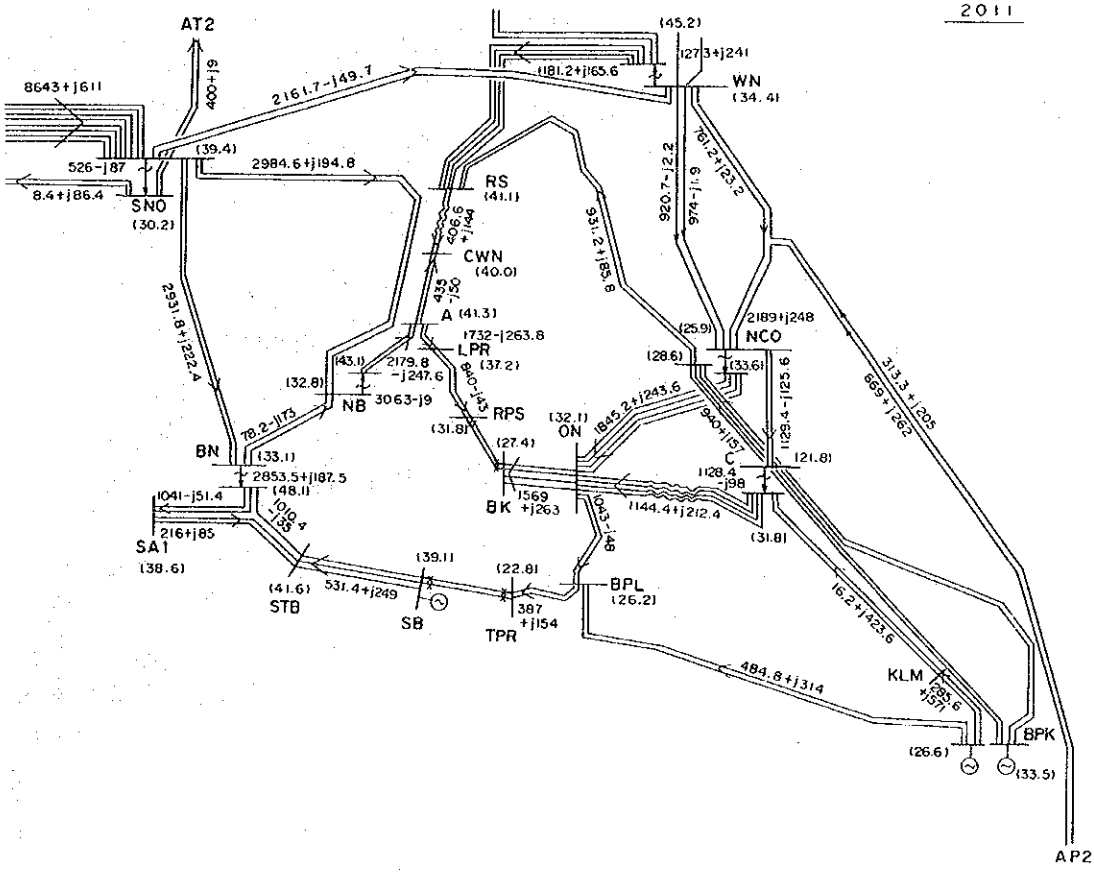


Fig. 6-5-4
the result of load flow and short circuit current in 2011's power system

short circuit current levels are shown in parentheses (KA)

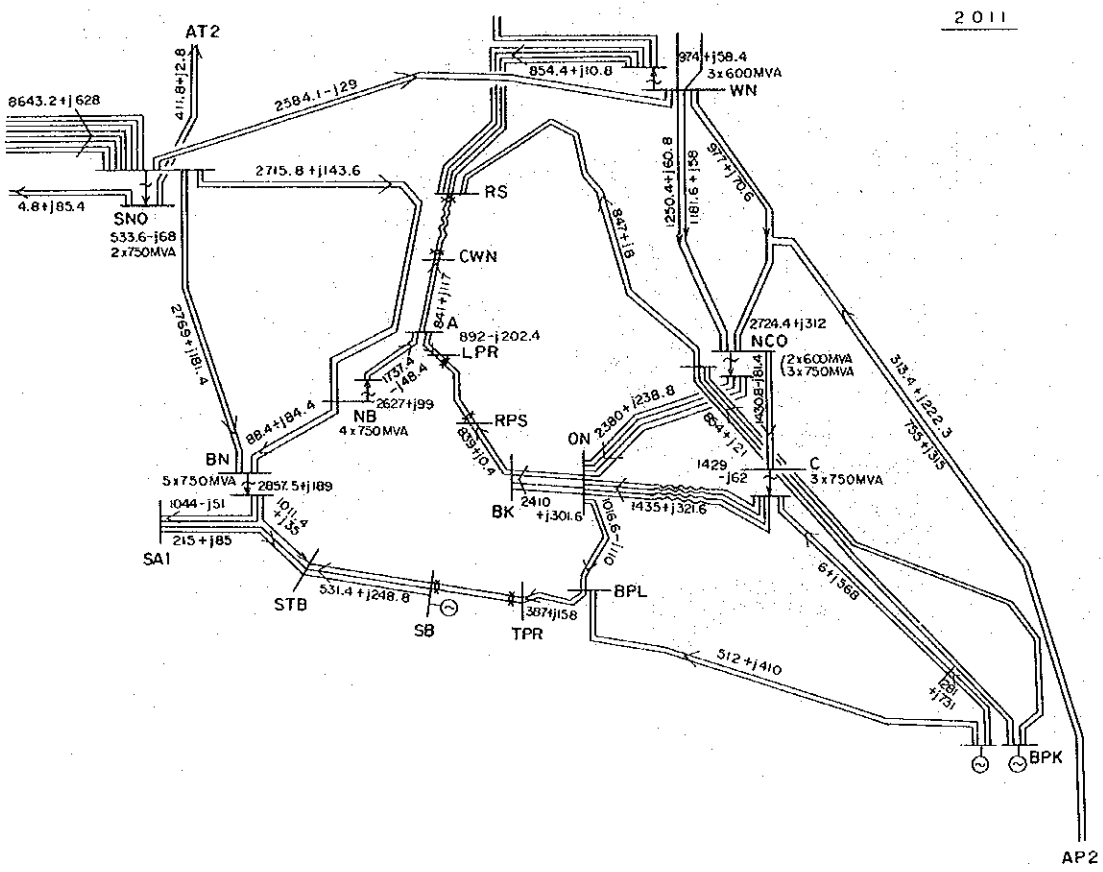


Fig. 6-5-5
the result of load flow in 2011's power system
Rangsit - Chaeng Watthana line and Lat Phrao - Ratchadaphisek line are put into scheduled outage due to control load flow on North Bangkok - new substation "A" line

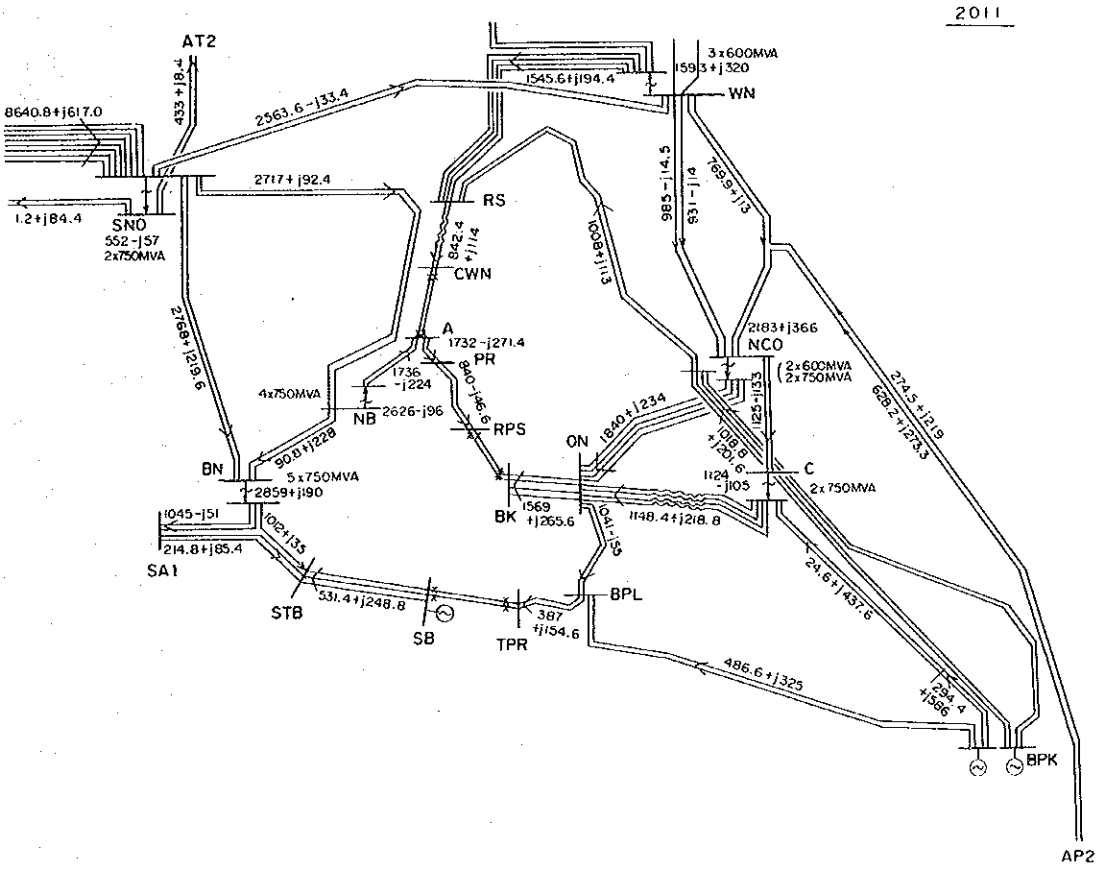


Fig. 6-5-6
the result of load flow in 2011's network system
Chaeng Watthana - new substation "A" line and Bang Kapi - Ratchadaphisek line are put into scheduled outage due to control load flow on North Bangkok - new substation "A" line

CHAPTER 7

BASIC DESIGNS

CHAPTER 7 BASIC DESIGN

7.1 Power System Configulation of Planned Years

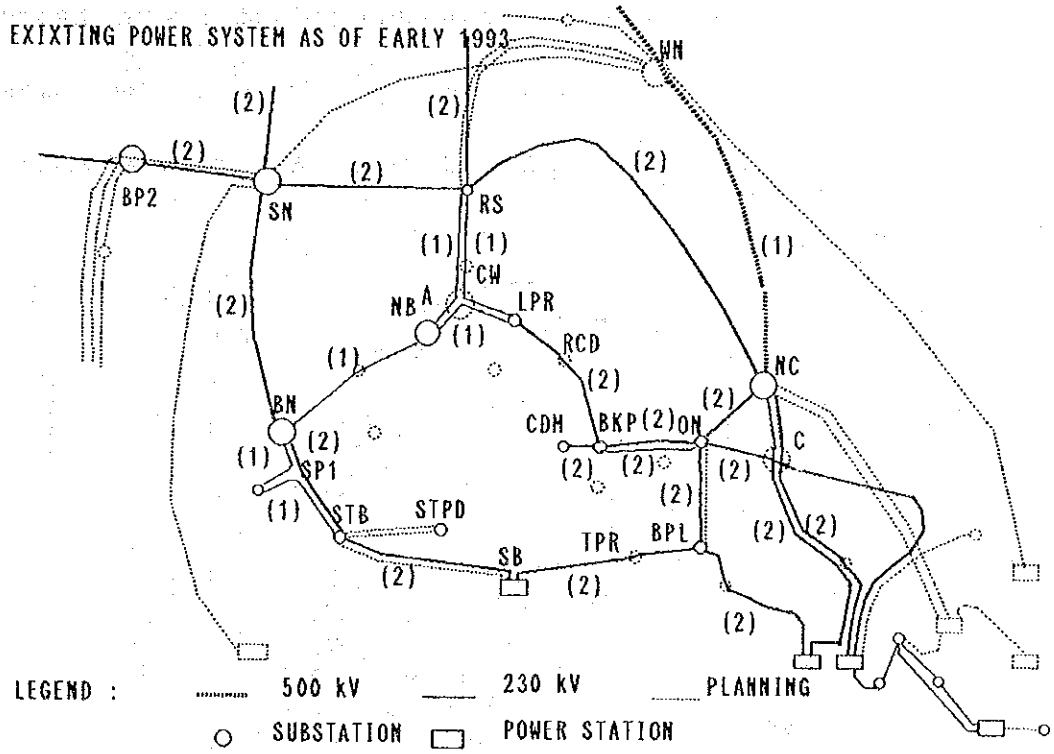
In accordance with the result of optimal power system plan and analysis in the previous chapter 5 and 6, and construction scheduling in chapter 8, power system configulation of planned years are drawn as shown in Figures 7-2,7-3,7-4 and 7-5.

Planned years are, 1997, 2001, 2006 and 2011.

Existing power system as of early 1993 is as shown below (Fig.7-1).

The outline of power system configulation in each planned year is described from next page.

Fig.7-1



(1) Up to 1997

a) New 500 kV double lines between SAI NOI and NONG CHOK via WANG NOI. (1995)

b) New 500 kV double lines to SAI NOI from lower central seaboard via BAN PONG 2.

c) New 500 kV double lines to SAI NOI from western seaboard.

d) 230 kV double lines replaced by 500/230 kV 4 lines between RANGSIT and CHAENG WATTHANA and operated at 230 kV (1997).

e) Tap to TEPARAK of existing 230 kV double lines (SOUTH BANGKOK-BANG PHLI- 1996).

f) New 230 kV double lines with four circuit tower between RANGSIT and WANG NOI (1995).

g) New 230 kV triple lines (Underground Cable) from BANG KAPI to KHRONG TOEY (1996).

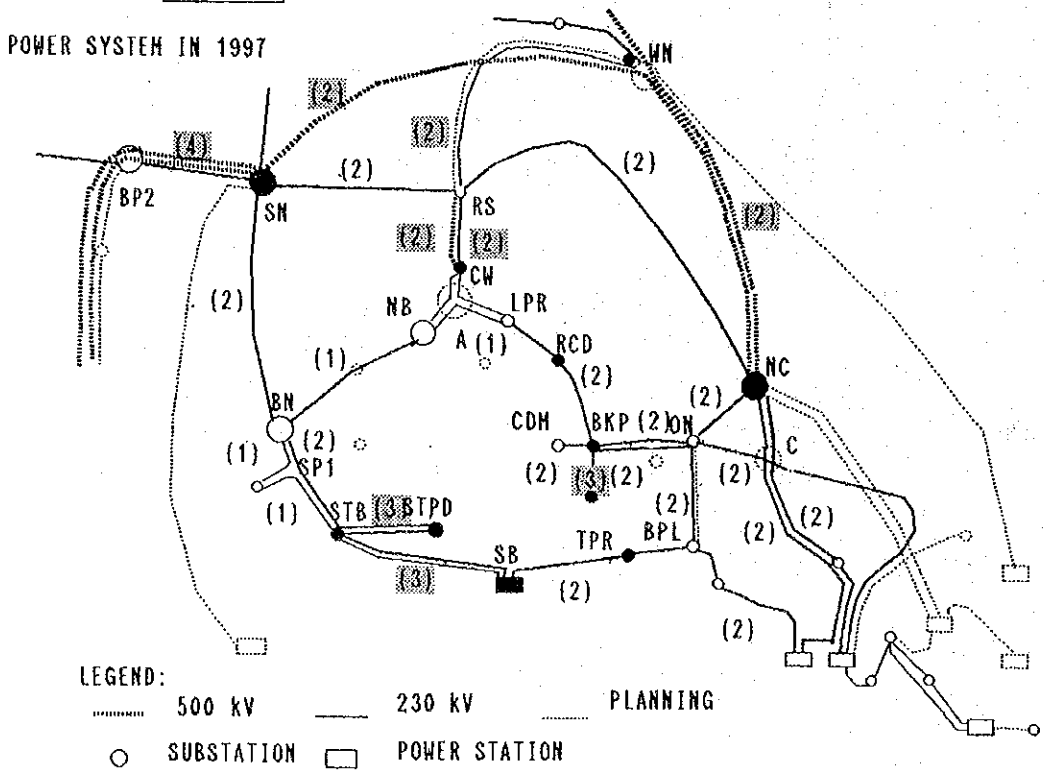
h) New 230 kV triple lines (Underground Cable) from SOUTH THONBURI to SATU PRADIT by 1996.

i) New 230 kV single line from SOUTH BANGKOK to SOUTH THONBURI by 1997.

j) Tap to RAICHADAPISEK of existing 230 kV double lines (LATPRO -BANG KAPI, 1994).

k) New substations; 230 kV WANG NOI, CHAENG WATHANA (1997), TEPARAK (1997).

Fig.7-2



(2) Up to 2001

a) New 500 kV double lines to NONG CHOK from AO PHAI.

b) 230 kV double lines replaced by 500 kV double lines between SAI NOI and BANGKOK NOI and operated at 230 kV (2000).

c) 230 kV single line replaced by 500 kV double lines between NORTH BANGKOK and BANGKOK NOI and operated at 230 kV (2000).

d) 230 kV double lines replaced by 500/230 kV 4 lines between <A> and NORTH BANGKOK and between <A> and CHAENG WATTHANA (2002).

e) 230 kV double lines replaced by 4 conductor double lines between <A> and LAT PHRAO (2002).

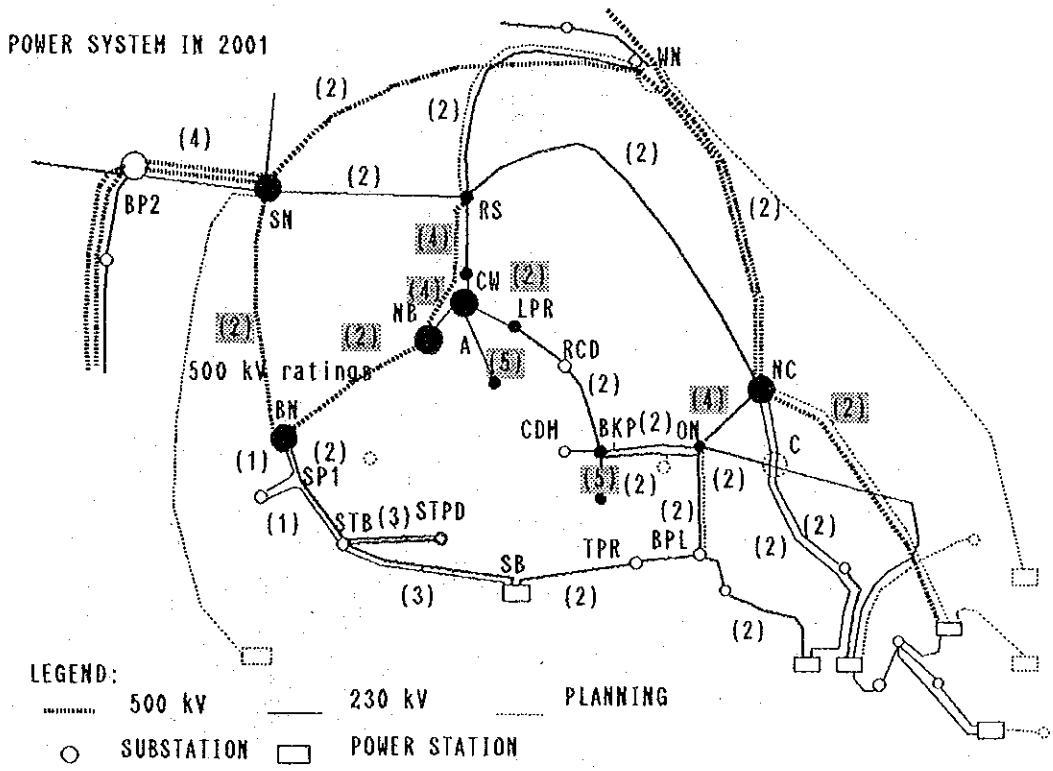
f) 230 kV double lines replaced by 230 kV 4 lines between NONG CHOK and ON NUCH (1998).

g) Lay additional 230 kV double lines (Underground Cable) from BANG KAPI to KHRONG TOEY (2000).

h) New 230 kV five lines (Underground Cable) from <A> to SANANPAO (2000).

i) New substation; <A> (2001).

Fig.7-3



(3) Up to 2006

a) Operate SAI NOI-BANGKOK NOI lines at 500 kV (2002).

b) 230 kV double lines replaced by 500 kV double lines between SAI NOI and RANGSIT site (2004).

c) Operate SAI NOI-NORTH BANGKOK lines via RANGSIT site and NORTH BANGKOK-BANGKOK NOI lines at 500 kV (2005).

d) String additional 230 kV double lines between RANGSIT and WANG NOI (2003).

e) 230 kV triple lines replaced by 230 kV 4 conductor triple lines between BANGKOK NOI and tap point to SAM PHRAN 1, two of which tap to SAM PHRAN 1 (2003).

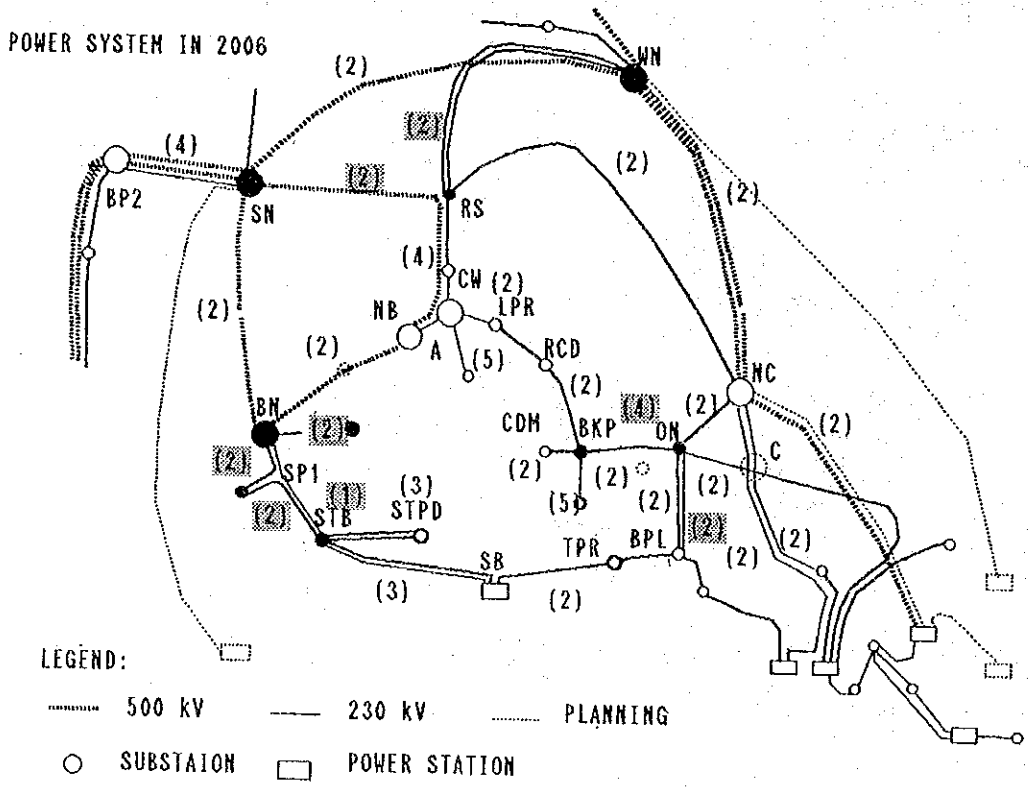
f) 230 kV triple line replaced by 230 kV 4 conductor triple lines between SOUTH THONBURI and tap point to SAM PHRAN 1, two of which tap to SAM PHRAN 1 and the other to BANGKOK NOI line (2004).

g) Existing 230 kV lines replaced by 230 kV 4 lines between ON NUCH and BANG KAPI (2005).

h) New 230 kV double lines from BANGKOK NOI to THONBURI (2005).

i) New 230 kV double lines between ON NUCH and BANG PHLI (2005).

Fig.7-4



(4) Up to 2011

a) New 500 kV double lines to NONG CHOK from AO PHAI.

b) Tap to <C> of existing 230 kV lines (NONG CHOK - BANG PAKONG, ON NUCH - BANG PAKONG, 2009).

c) 230 kV double overhead lines replaced by 230 kV 4 lines (underground cable crossing airport area and overhead line in the other area) between <C> and ON NUCH (2007).

d) Existing 230 kV lines replaced by 230 kV 4 lines between <C> and NONG CHOK (2009).

e) New 500 kV double lines between <C> and NONG CHOK (2010).

f) Tap to TALINGCHAN just below the line (500/230 kV line from NORTH BANGKOK, 2009)

g) Lay additional 230 kV single line (Underground Cable) from BANGKOK NOI to THONBURI (2011)

h) Lay additional 230 kV single line (Underground Cable) from BANG KAPI to KHRONG TOEY (2010).

i) Lay additional 230 kV single line (Underground Cable) from SOUTH THONBURI to SATU PRADIT (2010)

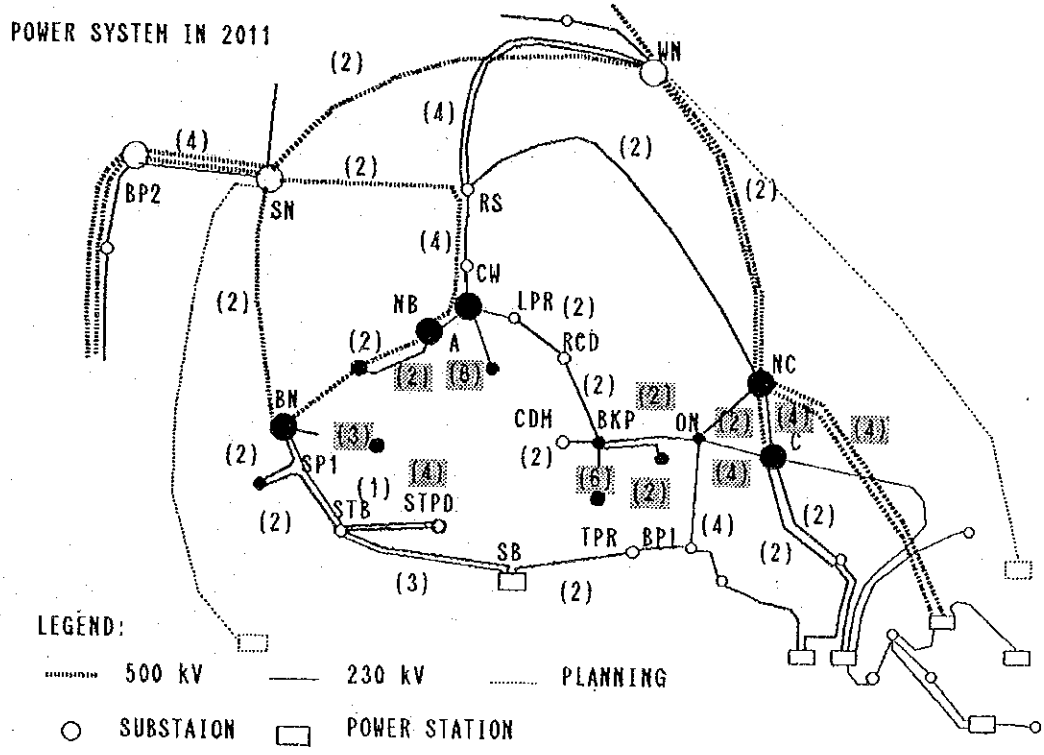
j) Lay additional 230 kV single line (Underground Cable) from <A> to SANAMPAO

k) 230 kV double lines replaced by 230 kV 4 lines between BANG KAPI and tap point to PATANAKAN, 2 of which tap to PATANAKAN (2010).

l) Tap to KHLONG MAI of existing 230 kV double lines (<C> - BANG PAKONG, 2009)

m) New substation; <C> (2008).

Fig.7-5



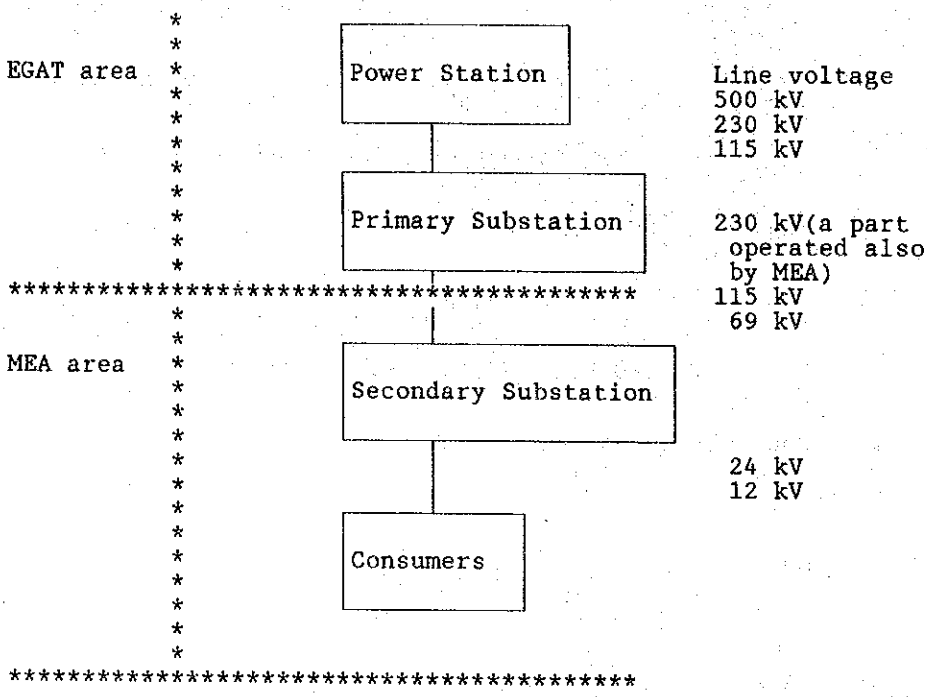
7.2 Transmission Line

7.2.1 Outline of On-site Survey

(1) Present Status of Transmission System

For the transmission system in the Greater Bangkok Area of the Kingdom of Thailand, which is the subject area of this project, the Electricity Generating Authority of Thailand (EGAT) constructs the transmission trunk lines to supply the its electricity generated to the Metropolitan Electricity Authority (MEA).

MEA distributes the electricity into the Greater Bangkok Area, which major transmission system is as follows:



(2) Present Status of Transmission Line Facilities

Present status of transmission line facilities as of July, 1992 is as follows:

Line voltage	Total Circuit Length (km)	Note
500 kV	533	
230 kV	7,022	15 km for MEA
115 kV	10,058	
69 kV	484	536 km for MEA

(3) Present Status of Number of Circuits of Transmission line Facilities

Although the basic facilities of EGAT transmission lines has been based on the one circuit policy, they have been multiplied because of the situation change in electricity demand and the difficulty of securing the right-of-way.

Voltage	Total Line Length (km)		
	Double Circuit	Single Circuit	Total
500 kV	26	507	533
230 kV	6,788	236	7,022
115 kV	4,569	5,489	10,058

(4) Future Expansion Plan of Transmission Facilities

With the steep increase of electricity demand due to the development of economy and improvement in living standard, EGAT has established a generation, transmission and substation facilities expansion program, and is carrying out the facility expansion and improvement program which is planned to be completed in the year 1997.

Line Voltage	Total Line Length (km)	Note
500 kV	660	
230 kV	1,080	
115 kV	1,000	

(5) Number of Conductors of Transmission Line

The general standard of the cross section and number of conductors for transmission lines of EGAT is as follows:

Voltage	Single Conductor	Double Conductor	4 Bundle Conductor
500 kV	--	--	795MCM ACSR x 4
500 kV	--	--	1,272MCM ACSR x 4
230 kV	1,272MCM ACSR x 1	1,272MCM ACSR x 2	
115 kV	795MCM ACSR x 1		
115 kV	477MCM ACSR x 1		

7.2.2 Development Plan of Transmission Line for Each Fiscal Year

Major issues of problem are as follows:

(1) By 1997

It is not necessary to increase or improve the transmission lines because the necessary transmission line capacity can be secured if the transmission lines are completed under the present capacity expansion and improvement plan of EGAT.

Taking into account the electricity supply status in 2001, the following plan shall be adopted:

- The section between RANGSIT and CHAENG WATTANA is converted to 500/230 kV, 2/2 cct., 4 x 1272MCM with underground cable
- The section between WANG NOI and NONG CHOK is converted to 500 kV, 2 cct., 4 x 1272 MCM
- The section between SAI NOI and WANG NOI is converted to 500 kV, 2 cct., 4 x 1272 MCM
- The section between WANG NOI and RANGSIT is converted to 230 kV, 2 cct., 2 x 1272MCM
- The section between SOUTH THONBURI and I(THANONTOK) is converted to 230 kV, 3 cct., underground cable
- The section between BANG KAPI and H(KLONG TOEY) is converted to 230 kV, 3 cct., underground cable

(2) By 2001

The capacity expansion and improvement plan for the transmission line until 2001 is as follows:

a) The sections where the capacity expansion and improvement plans are implemented on transmission lines which will be converted to 500 kV:

- The section between BAN PONG 2 and SAI NOI is converted to 500 kV, 2 cct., 4 x 1272MCM
- The section between SAI NOI and BANGKOK NOI is converted to 500 kV, 2 cct., 4 x 1272MCM
- The section between BANGKOK NOI and F (TALINGCHAN) is converted to 500 kV, 2 cct., 4 x 1272MCM
- The section between F (TALINGCHAN) and NORTH BANGKOK is converted to 500 kV, 2 cct., 4 x 1272MCM with to 230 kV, 2 cct., 2x1272MCM

b) The sections where the capacity expansion and improvement plan is implemented on the 230 kV transmission lines:

- The section between NONG CHOK and ON NUCH is converted to 230 kV, 4 cct., 2 x 1272MCM

c) The section where the 230 kV transmission line is converted to underground cable:

- The section between "A" substation and G (SANAMPAO) is converted to 230 kV, 5 cct., underground cable
- The section between BANG KAPI and H(KLONG TOEY) is converted to 230 kV, 2 cct., underground cable

(3) By 2006

The capacity expansion and improvement plan for the transmission line by 2006 is as follows:

a) The sections where the capacity expansion and improvement plan is implemented on transmission lines which are to be upgraded to 500 kV:

- The section between SAI NOI and RANGSIT is converted to 500 kV, 2 cct., 4 x 1272MCM
- The section between CHEANG WATTANA and Site "A" is converted to 500/230 kV, 2/2 cct., 4 x 1272MCM
- The section between Site "A" and NORTH BANGKOK is convered to 500/230 kV, 2/2 cct., 4 x 1272MCM

b) The section where capacity expansion and improvement plan is implemented on the 230 kV transmission lines:

- The section between ON NUCH and BANG PHLI is converted to 230 kV, 2 cct., 2 x 1272MCM
- The section between ON NUCH and BANG KAPI is converted to 230 kV, 4 cct., 2 x 1272MCM
- The section between Site "A" and LAT PHRAO is converted to 230 kV, 2 cct., 4 x 1272MCM
- The section between WANG NOI and RANGSIT is converted to 230 kV, 2 cct., 2 x 1272MCM
- The section between BANGKOK NOI and Junction near BANGKOK NOI is converted to 230 kV, 2 cct., 2 x 1272MCM
- The section between Junction near BANGKOK NOI and SAM PHRAN 1 is converted to 230 kV, 4 cct., 4 x 1272MCM
- The section between Junction near BANGKOK NOI and SOUTH THONBURI is converted to 230 kV, 2 cct., 4 x 1272MCM
- The section between BANGKOK NOI and SOUTH THONBURI is converted to 230 kV, 2 cct., 4 x 1272MCM
- The section between WANG NOI and RANGSIT IS converted to 230 kV, 2 cct., 2 x 1272MCM

c) The section where 230 kV transmissions are converted to underground cables:

- The section between BANGKOK NOI and J(THONBURI) is converted to 230 kV 2 cct., underground cable

(4) By 2011

The capacity expansion and improvement plan for the transmission lines by 2011 is as follows:

a) The sections where the capacity expansion and improvement plan is implemented on transmission lines which will be upgraded to 500 kV:

- The section between NONG CHOK and Site "C" is converted to 500 kV, 2 cct., 4 x 1272MCM

b) The sections where the capacity expansion and improvement plan is implemented on the 230 kV transmission lines:

- The section between NONG CHOK and Site "C" is converted to 230 kV, 2 cct., 4 x 1272MCM

- The section between NONG CHOK and Site "C" is converted to 230 kV, 4 cct., 2 x 1272MCM (with cable)

- The section between F (TALINGCHAN) and NORTH BANGKOK is additional stringing 230 kV, 2 cct., 2 x 1272MCM

c) The section where 230 kV transmission lines are converted to underground cables:

- The section between Site A and G(SANAMPAO) is converted to 230 kV 6 cct., underground cable

- The section between SOUTH TONBURI and(THANONTOK) is converted to 230 kV, 4 cct., underground cable

- The section between BANGKOK NOI and J(THONBURI) is converted to 230 kV, 3 cct., underground cable

- The section between BANK KAPI and H(KLONG TOEY) is converted to 230 kV, 6 cct., underground cable

7.2.3 Basic Design of Transmission Line

(1) Selection of Transmission Lines Route

As it is getting difficult to secure the transmission line right-of-way, and it is nearly impossible to construct a new transmission line, it has been planned to utilize the grounds under the existing transmission lines as far as possible for the capacity expansion and improvement of transmission lines.

(2) Conditions in Selecting Transmission Lines

In the planning the transmission system for the Greater Bangkok Area, it is necessary to pay particular attention to the following conditions.

- Expansion of the transmission capacity to the Greater Bangkok Area:

  The expansion of the transmission capacity for the Greater Bangkok Area shall be dealt with by adopting multiple circuit lines and multiple conductors.

- Difficulty in securing the right-of-way for new transmission line routes (especially, it is impossible within the 230 kV loop system):

  Such capacity expansion measures that utilize the existing transmission line routes are to be considered.

- Underground cables, etc. are to be considered for the transmission lines to the Greater Bangkok Area.

- Minimization of short circuit current of each substation:

  In order to minimize the short circuit current, the 500 kV transmission system is to be planned in the Greater Bangkok Area.

With considerations on the above conditions, the capacity expansion and improvement of the 500 kV transmission lines leading to the Greater Bangkok Area are planned as described below:

- Introduction of the 500 kV transmission line into the Bangkok Noi Substation.
- Introduction of the 500 kV transmission line into the North Bangkok Substation.
- Introduction of the 500 kV/230 kV transmission line into the C Substation.
- Securing of transmission line route by division of the bus of Rangsit Substation.
- Construction of underground cables by constructing substations (G, H, I, J) in the center of the city.

(3) Electricity Supply in the Greater Bangkok Area and Future Plan

Currently, the electricity is being supplied to the Greater Bangkok Area by means of 230 kV transmission networks from North Bangkok and South Bangkok fossil fuel power stations, and the 500 kV and 230 kV transmission lines from Region 1 hydro power station and Region 2 fossil fuel power station which are linked to the 230 kV networks.

At present, it is necessary to reinforce the transmission network to supply electricity to the Greater Bangkok Area in order to cope with the growth in the electricity demand.

Large scale electric power development projects are now being planned, including Mae Moh and Lampang fossil fuel power stations in the northern district, those in the eastern seaboard area and western seaboard area of Region 1, and those in Region 3. Thee electricity generated in these areas can be supplied to the Greater Bangkok Area by 500 kV or 230 kV transmission lines.

(4) Prediction of Demand and Supply in the Greater Bangkok Area

As for projection of demand and supply in the Greater Bangkok Area, the electricity demand is estimated by EGAT and JICA team as below:

Fiscal Year	EGAT Demand Prediction	JICA Demand Prediction	Note
1997	6,089 MW	6,089 MW	
2001	7,952 MW	7,952 MW	
2006	10,264 MW	10,264 MW	
2011	13,569 MW	13,569 MW	

(5) Presumed Transmission Capacity of Transmission Lines

The transmission capacity of multiple circuit (N circuit) transmission line is presumed to be N-1 times that of single circuit transmission line.

Voltage (kV)	No. of Conductors (ACSR)	Transmission Capacity of Multiple Circuit (N-circuits) Line (MVA)			Note
		Single circuit	Double circuit	4 circuit	
500	795MCM x 4	(0) 2,830	(2,830) 5,660	(8,490) 11,320	
	1,272MCM x 4	(0) 3,730	(3,730) 7,460	(11,190) 14,920	
230	795MCM x 1	(0) 330	(330) 660	(990) 1,320	
	1,272MCM x 1	(0) 430	(430) 860	(1,290) 1,720	
	795MCM x 2	(0) 650	(650) 1,300	(1,950) 2,600	
	1,272MCM x 2	(0) 860	(860) 1,720	(2,580) 3,440	
	795MCM x 4	(0) 1,300	(1,300) 2,600	(2,900) 5,200	
	1,272MCM x 4	(0) 1,720	(1,720) 3,440	(5,160) 6,880	
115	477MCM x 1	(0) 180	(180) 360	(540) 720	
	795MCM x 1	(0) 330	(330) 660	(990) 1,320	
	1,272MCM x 1	(0) 430	(430) 860	(1,290) 1,720	

(6) Selection of Each Transmission Line Route

Selection of each transmission line routes in the expansion plan of transmission and substation facilities in the Greater Bangkok Area have been selected as below:

a) Selection of Transmission Route Up To 1997

Selection of routes for transmission lines required by 1997 is as described below:

- Transmission line route is not required until 1997 if the transmission lines now being constructed by EGAT are completed.

Section	Power Flow under Normal Condition	Power Flow under Contingency Condition
NONG CHAK - ON NUCH 230 kV, 2cct. 2x1272MCM	463 MW/cct	673 MW
BANG KAP1-RATCHADA PHISEK 230 kV, 2cct. 2x1272MCM	421 MW/cct	764 MW
BANGKOK NOI-SAI NOI 230 kV, 2cct. 1x1272MCM	233 MW/cct	323 MW
BANG KHLI-BANG PAKONG 230 kV, 2cct. 2x1272MCM	435 MW/cct	619 MW
Thermal Limit of Conductors	: 1x1272MCM = 2X1272MCM =	429 MW 858 MW

- In order to minimize the short circuit current at each substation, it is recommended to change the transmission line Plan for the following section.

Section	Total Length	Present Scale	Changed Scale
RANGSIT - CHAENGWATIANA	10.0 km	230 kV, 2 cct., 1 x 1272MCM	500/230 kV, 2/2 cct., 4 x 1272MCM with cable
WAN NOI - NONG CHOK	64 km	-	500 kV, 2 cct., 4 x 1272MCM
SAI NOI - WAN NOI	56 km	-	500 kV, 2 cct., 4 x 1272MCM

b) Selection of Transmission Route from 1997 to 2001

The routes of transmission lines required from 1997 to 2001 have been selected as below:

- In order to minimize the short circuit current at each substation, it is recommended to change the transmission line plan for the following sections.

Section	Total Length	Present Scale	Changed Scale
NONG CHOK - ON NUCH	16.8km	230 kV, 2 cct, 2x1272MCM	230 kV, 4 cct, 4x1272MCM
BANGKOK NOI - SAI NOI	29.6km	230 kV, 2 cct, 1x1272MCM	500 kV, 2cct, 4x1272MCM
NORTH BANGKOK - F (TALINGCHAN)	9.2km	230 kV, 2 cct, 1x1272MCM	500/230 kV, 2/2cct, 4/2x1272MCM design
F (TALINGCHAN) - BANGKOK NOI	9.2km	230 kV, 2 cct, 1x1272MCM	500 kV, 2cct, 4x1272MCM

c) Selection of Transmission Route from 2001 to 2006

The routes of transmission lines required from 2001 to 2006 have been selected as below:

- In order to minimize the short circuit current at each substation, it is recommended to change the transmission line plan for the following sections.

Section	Total Length	Present Scale	Changed Scale
CHAENG WATTANA NORTH BANGKOK	4.4 km	230 kV, 2 cct, 1 x 1272MCM	500/230 kV, 2/2 cct 4 x 1272 MCM
	2.7 km		230 kV, 2 cct 4 x 1272 MCM
	7.1 km		500/230 kV, 2/2 cct 4 x 1272 MCM
RANGSIT - WANG NOI	50.0 km	230 kV, 2 cct 1 x 1272MCM	230 kV, 4 cct 2 x 1272MCM
BANGKOK NOI - SAN PHRAN 1	11.7 km	230 kV, 1 cct 2 x 1272MCM	230 kV, 2 cct 4 x 1272MCM
RANGSIT - SAI NOI	24.5 km	230 kV, 2 cct 2 X 1272MCM	500 kV, 2 cct 4 x 1272MCm
SOUTH THON BURI - SAN PHRAN 1	13 km	230 kV, 1 cct 2 x 1272MCM	230 kV, 2 cct 4 x 1272MCM
SOUTH THON BURI - BANGKOK NOI	19.8 km	230 kV, 2 cct 2 x 1272MCM	230 kV, 2 cct 4 x 1272MCM
BANG PHLI - ON NUCH	10.5 km	230 kV, 2 cct 1 x 1272MCM	230 kV, 2 cct 2 x 1272MCM

d) Selection of Transmission Route from 2006 to 2011

The routes of transmission lines required from 1997 to 2001 have been selected as below:

i) In order to minimize the short circuit current at each substation, it is recommended to change the transmission line plan for the following sections.

Section	Total Length	Present Scale	Changed Scale
NONG CHOK - SITE C	19.0 km	230 kV, 2 cct, 2 x 1272MCM	500 kV, 2 cct 4 x 1272 MCM
NONG CHOK - SITE C	19.0 km	230 kV, 2 cct, 2 x 1272MCM	230 kV, 2 cct 4 x 1272MCM
ON NUCH - SITE C	22.0 km	230 kV, 2 cct, 2 x 1272MCM	230 kV, 4 cct 2 x 1272MCM with cable
NORTH BANGKOK - F (TALINGCHAN)	9.2 km	-	230 kV, 2 cct 2 x 1272MCM additional stringing

• Reinforcement of 500 kV transmission lines:

The following sections of 500 kV transmission lines are to be reinforced:

Section	Total Length	Present Scale 230 kV	Changed Scale 500 kV
SAI NOI - BANGKOK NOI	29.6 km	2cct, 2x1272MCM	2cct, 4x 1272MCM
SAI NOI - BANGSIT	24.5 km	2cct, 2x1272MCM	2cct, 4x1272MCM
BANGSIT - NORTH BANGKOK	19.4 km	2cct, 2x1272MCM	2cct, 4x1272MCM
SAI NOI - BAN PONG 2	53.6 km	2cct, 2x1272MCM	2cct, 4x1272MCM
NON CHOK - SITE C	19.0 km	2cct, 2x1272MCM	2cct, 4x1272MCM
SAI NOI - WANG NOI	56.0 km	-	2cct, 4x1272MCM
WANG NOI - NON CHOK	64.0 km	-	2cct, 4x1272MCM

(7) Basic Design of Transmission Lines

a) Basic Design

The basic design for the transmission lines of this plan is based on the following design concept:

For new transmission lines and lines to be expanded or improved, changes from the existing facilities are to be minimized as much as possible, and the plan is to be established according to the standards and criteria which are presently in use in the Kingdom of Thailand.

The transmission line designs in the power system renovation plans and future plans shall be so developed that they can be applied to the power systems in the time sections of 1997, 2006 and 2011.

In cases where it is found difficult to secure new transmission line routes in future based on the site surveys, the reinforcement and improvement of existing transmission lines (conversion to multiple circuit lines and multiple conductor lines) shall be considered.

In cases where the width of the transmission line right-of-way can not be further expanded, the adoption of the towers having narrow conductor separation and the underground cables shall be considered, and the designs shall be developed appropriately.

The following rules shall be applied to cases where the existing

transmission lines are to be reinforced by converting them to extra-high voltage designs or to multiple circuit designs.

i) Conversion of transmission line to double circuit, 500 kV line.

ii) Stringing of double circuit 500 kV line and double circuit 220 kV lines on the same tower.

iii) Conversion of 220 kV line to multiple circuit line (4 circuits) or multiple conductor lines.

b) Transmission Line Voltage

The standard voltages in use in the Kingdom of Thailand are 500 kV, 230 kV, 115 kV and 69 kV, which conform to international standard. In this plan, therefore, the following voltage classes are used for the transmission lines.

Main Transmission Lines	Voltage
Trunk Transmission Lines	500 kV
Major Linked Transm'n Lines	230 kV
Other Transmission Lines	115 kV

c) Number of Circuits of Transmission Lines

The number of circuits commonly used in the Kingdom of Thailand are; typically circuit for 500 kV lines, typically double circuit for 230 kV lines, and single circuit and double circuits are used for 115 kV lines in equal proportions.

For the expansion plan in future, it is difficult to secure the right of way for construction of transmission lines because of the rapid economic development and regional development around the metropolitan area of the Kingdom of Thailand over the past several years, and it is necessary to construct the lines with multi-circuit and multi-conductor designs. For the transmission lines under this plan, it is necessary to adopt multiple circuit, multiple conductor designs. The following numbers of circuits are recommended in order to utilize the ground under the existing transmission lines as far as possible.

Present Scale	Future Scale
230 kV, 2 cct	To be converted to 500 kV, 2 cct. To be converted to 500 kV, 2cct and 230 kV, 2cct on the same support structures. To be converted to 230 kV, 4cct.
115 kV, 2 cct	To be converted to 230 kV, 2cct. To be converted to 230 kV, 2cct and 115 kV, 2cct on the same support structure. To be converted to 115 kV, 4cct.

Note: If an overhead line can not be constructed, underground cable shall be planned.

d) Number of Conductors Used for Transmission Lines

As the transmission lines of this plan are comparably short (10 - 30 km), and the transmission capacity is determined by heat capacity of conductors thereof, it is recommended that the capacity expansion is implemented by adoption of multiple conductor designs, for which the recommended number of conductors are as follows:

As corona noises and radio disturbances are apt to be generated by single conductor lines, surface potential gradient of the conductor shall be minimized.

Single Conductor Area	Number of Conductors
1272MCM ACSR	1, 2, and 4 Bundle Conductors
795MCM ACSR	1, 2, and 4 Bundle Conductors
477MCM ACSR	1

When underground cables are planned, transmission capacity per circuit shall be planned to be capable of transmitting the bank capacity of substation, as follows:

Voltage used	Transmission Capacity of Underground Cable
230 kV	300 MVA/cct, or 200MVA/cct
115 kV	200 MVA/cct, or 100MVA/cct

e) Support Structure of Transmission Line

The self-sustaining steel towers are recommended for the support structures of the transmission lines of this plan because many lines are to be converted in future to multiple circuit or multiple conductor lines having heavy design loads.

In cases where the strength of the towers made of X-section angles is insufficient, steel pipe towers must be considered.

As the support structure of transmission lines of this plan, the self-supporting steel towers are recommended since it is required to support multiple numbers of circuits and conductors with the heavy load transmission line design.

For the steel tower members, it may be required to consider the pipe steel towers when the combination of X-cross sections angles are not sufficient in strength.

The ground clearance of conductor of transmission line is determined by electric field intensity on the ground, and the ground clearance must be determined by taking into account the environmental conditions.

As the lands under the existing transmission lines is utilized, it is necessary to consider the tower design with narrow offset between conductors when it is not possible to install additional circuits below the existing circuits.

In case of underground cable, it should be planned to use the burial method with concrete duct instead of direct burial, since the nature of the soil around the metropolitan area is generally soft.

In having the new cable route cross existing cable ducts, the new cables must be brought above the ground surface to install them on the overhead bridging ducts.

f) Transmission Line Insulators

The V-type or strain-type insulator strings shall be used in order to reduce the magnitude of lateral swing of conductors and thereby to reduce the right-of-way under conductors where the transmission line right-of-way is limited.

As for the insulators, the "V-shaped suspension" string device must be planned for suspension of conductors, which will often be strung above the existing right of ways, to prevent the conductors from swinging as much as possible. The "strain type insulator device" and the "suspension device with jumper swing stopper" must also be considered in combination, since the narrow right of ways of the existing lines are utilized.

Many of present insulators of transmission lines of EGAT lack the arc horn or shield ring. In order to quickly eliminate the fault current arc in the event of lightning stroke, the arc horns or shield rings should be included in the design of insulators of the future transmission lines to decrease the rate of faults.

g) Foundation Type of Transmission Tower

As the transmission lines of this plan pass many of soft soil grounds, there is the risk of uneven settlement of tower foundations. Therefore, pile foundation should be used for the transmission tower foundations in order to remove the uncertainty in the tower strength.

Where the load of the foundation of the tower is large, the combination of pile foundation and mat foundation is to be adopted.

EGAT at present uses pre-fabricated concrete pile. As the foundation load tends to be large, it should be planned to determine the pile diameter and number of piles which are appropriate for the foundation load by using the on-place casting pile method.

h) Power Line Conductors

The power line conductors shall be selected based on the Optimal Power System Plan. The selection of conductors shall be planned with due consideration on the adoption of the multiple conductor systems such as the double conductor design or 4-conductor design. The standard of the transmission line and substation facilities of the Kingdom of Thailand, which sets forth the ACSR (aluminum conductor steel reinforced) 1,272 MCM cables as the standard conductor, may be revised when the power system plan is completed.

The conductors shall be selected by the following conditions.

i) The required transmission line capacity (thermal capacity) is assured.

ii) The maximum voltage gradient at the conductor surface is appropriate.

iii) The corona noise level is permissible.

iv) The mechanical strength of the conductor is sufficient.

v) Corrosion resistance and vibration suppression performance are sufficient.

* When the right-of-way under transmission line can not be secured:

When the right-of-way under transmission line can not be secured, the adoption of underground cable shall be studied. The type of the underground cables shall be selected from the following types.

i) Oil-filled cable (OF cable).

ii) Interlinked polyethylene cable (XPLE cable).

iii) Gas insulated cable (SF6 cable).

Although the performance of the oil-filled cable is established today, the use of the interlinked polyethylene cable and the gas insulated cable shall be considered in view of the technology development in future and the environmental restraints.

* Environmental Technology Survey

With the expansion of extra-high voltage transmission systems and their development to higher voltage, larger capacity systems, transmission line facilities could provide environmental effect on the surrounding area. Therefore, sufficient studies including the countermeasures must be studied beforehand, including the following items.

i) Prevention of electrostatic and magnetic inductions.

ii) Survey of television reception.

iii) Survey of radio reception.

iv) Survey of wind noise.

* Survey of Surrounding Areas of Transmission Lines

As the conditions of the surrounding areas of the transmission lines have large impacts on the maintenance and management of transmission line facilities, easiness of construction works, and the economic values of the transmission lines, these conditions must be sufficiently surveyed and analyzed beforehand.

i) Geographical and geological surveys (presence of faults, soft grounds, rivers, etc.)

ii) Meteorological surveys (wind, salt pollution, lightning, etc.)

i) Restrictions by Environmental Factors of Transmission Line

i) Electric Field Intensity

In determining the ground of clearance of transmission lines, it shall be so determined that the electricity field strength is below the threshold intensity of 50 V/cm.

ii) Corona Noise

In order to prevent the generation of corona noise, multiple conductor designs and/or corona shied rings on the insulator device must be considered.

The potential gradient at the conductor surface must be below 15 V/cm.

iii) Wind Noise

Wind noise is generated when wind blows through the conductor configuration. The spiral rod, etc. for wind noise prevention must be adopted for the transmission lines to prevent the wind noise problems.

ix) Aviation Hazard

In the area where the aviation hazard is anticipated, the height of transmission tower must be restricted below 60 m, or the tower must be painted with aviation marking indicating the restriction of flight.

Balloons must be attached to the overhead ground wires.

v) Miscellaneous

Where environmental hazards due to the shapes and other aspects of transmission towers are anticipated, the "aesthetic" support structure designs must be carefully considered.

j) Compensation for Land under Transmission Lines

Compensation for the land under transmission lines is being made by EGAT according to the following practice. As there are many places which are anticipated to be urbanized in the future, it would be required to consider the compensation of the lands under the transmission line conductors.

Land Scope	Compensation Scope	
	Present Compensation	Future Compensation
Land for Steel Tower	Land only is compensated.	Land only is compensated
Land for the ground under transmission lines	Without Compensation	Lump sum Compensation (%) of Land Price or Leased Land Compensation (every 3-5 years)

7.3 Substation

To meet the optimal power system configualtion in each planned year, substations are to be renovated or newly constructed, the outline of which is summalized in one sheet per substation as enclosed in appendix.

Brief explanations of renovation and construction works are given below.

7.3.1 Renovation and Construction Work to be Performed

(1) NONG CHOK

Refer to appendix.

In addition to existing 500 kV single line and two 600 MVA banks, new 500 kV lines of 7 are to be tapped-off and three 750 MVA banks are to be added to this substation by 2011.

500 kV line feeders to be tapped-off are;

-By 1997, additional single line for THA TAKO
-By 1997, double lines for SAI NOI
-By 2001, double lines for AO PHAI
-By 2011, double lines for <C> substation
-By 2011, additional double lines for AO PHAI

As for 500 kV transformer bank, one bank (500/230 kV,750 MVA each) are to be installed by 2001 and aditional one by 2006.

Of 8 existing 230 kV line feeders,

-ON NUCH lines(double) are to be replaced by 4 lines by 1999
-BANG PAKONG lines (4 lines) are to be disconnected and tap to <C> substation by 2009.

In response to MEA demand,one bank (230 kV,300 MVA) will be added by 1997 and another one by 2006.

For the renovation work above mentioned, the following equipment is necessary.

-500 kV GIS (one and a half CB, 4 bays)	1 lot
-Take-off structure(500 kV, 4 lines)	1 lot
-Transformer(single phase,500/230 kV,250 MVA)	6 sets
-Transformer(three phase,230/115 kV,300 MVA)	2 sets
-Steel structure, conductor, strings, hardware and misceleneous materials	1 lot

(2) SAI NOI

Refer to appendix.

By 1997, 500 kV double lines for NONG CHOK via WANG NOI, double lines from Lower Central and double lines from western seaboard will be tapped-off to this station.

By 2001, existing 230 kV double lines for BANGKOK NOI will be replaced by double lines of 500 kV ratings and operated at 230 kV, and at 500 kV by 2002.

Also, by 2005, existing 230 kV double lines for RANGSIT will be relpaced by double lines of 500 kV ratings and operated at 500 kV.

Of 8 existing 230 kV lines (2 for BANG PONG 2, 2 for BABGKOK NOI, 2 for RANGSIT and 2 for ANGTHONG 2), 6 (including BANG PONG 2 line) are replaced by 500 kV lines.

Two banks (500 kV, 750 MVA) will be necessary by 1997 and additional 2 by 2001.

Only 2 feeders of 230 kV for ANGTHONG 2 will be operated by 2011.

In response to MEA demand,one bank (230 kV, 300 MVA) will be added by 1997, 2001 and 2011.

For the renovation work above mentioned, the following equipment is necessary.

-500 kV switchyard equipment (Alminum pipe bus, one and a half CB, 8 bays)	1 lot
-Take-off structure(500 kV,8 lines)	1 lot
-Transformer(single phase,500/230 kV,250 MVA)	12 sets
-Transformer(three phase,230/115 kV,300 MVA)	4 sets
-Steel structure, conductor, strings, hardware and misceleneous material	1 lot

(3) NORTH BANGKOK

Refer to appendix.

By 2001, existing 230 kV single line for BANGKOK NOI will be replaced by double lines of 500 kV ratings and operated at 230 kV, and at 500 kV by 2005.

By 2002, existing 230 kV double lines for RANGSIT and LAT PHRAO will be replaced by 500/230 kV 4 lines and tap to <A> substation and operated at 230 kV, and at 500 kV by 2005.

By 2006, four banks (500 kV, 750 MVA) will be necessary.

By 2001, three 230 kV line feeders for TALINJAN will be tapped-off.

One bank (230 kV, 300 MVA) will be added by 1997 and by 2006.

For the renovation work above mentioned, the following equipment is necessary.

-500 kV GIS (one and a half CB, 4 bays)	1 lot
-Take-off structure(500 kV,4 lines)	1 lot
-Transformer(single phase,500/230 kV,250 MVA)	12 sets
-230 kV GIS (double bus, 10 bays)	1 lot
-take-off structure(230 kV,5 lines)	1 lot
-Transformer(three phase,230/115 kV,300 MVA)	2 sets
-230 kV power cable and it's accesories	1 lot
-Steel structure, conductor, strings, hardware and misceleneous material	1 lot

(4) BANGKOK NOI

Refer to appendix.

By 2001, existing 230 kV double lines for SAI NOI will be replaced by double lines of 500 kV ratings and operated at 230 kV, and at 500 kV by 2002.

Also, by 2001, existing 230 kV single line for NORTH BANGKOK will be replaced by double lines of 500 kV ratings and operated at 230 kV, and at 500 kV by 2005.

By 2006, new four banks (500 kV, 750 MVA) will be necessary and addtional one by 2011.

By 2004, 230 kV triple lines up to the tap point to SANPHRAN 1 will be replaced by 4 conductor triple lines, two of which tap to SANPHRAN 1.

New 230 kV double lines for THONBURI will be tapped-off by 2006 and additional one for THONBURI by 2009.

In response to MEA demand,three more banks (230 kV, 300 MVA) will be necessary by 1997 and another one by 2001.

For the renovation work above mentioned, the following equipment is necessary.

-500 kV GIS (one and a half CB, 5 bays)	1 lot
-Take-off structure (500 kV,4 lines)	1 lot
-Transformer(single phase,500/230 kV,250 MVA)	15 sets
-230 kV GIS (double bus,9 bays)	1 lot
-take-off structure (230 kV,3 lines)	1 lot
-Transformer(three phase,230/115 kV,300 MVA)	4 sets
-230 kV power cable and it's accessories	1 lot
-Steel structure, conductor, strings, hardware and misceleneous material	1 lot

(5) RANGSIT

Refer to appendix.

By 1996, new 230 kV double line feeders for WANG NOI will be constructed and existing double lines for ANGTHONG 1 will be dismantled, and another 230 kV double line feeders for WANG NOI will be constructed by 2004.

By 1998, existing 230 kV lines for NORTH BANGKOK and LAT PHRAO will be replaced by 500/230 kV 4 lines and tapped to CHAENG WATHANA.

By 2005, existing 230 kV double lines for SAI NOI will be replaced by new 500 kV double lines.

In response to MEA demand, three banks (230 kV,300 MVA) will be added by 1997, one by 2001 and two by 2006, totaling twelve banks by 2011.

For the renovation work above mentioned, the following equipment is necessary.

-230 kV switchyard equipment(Aluminun pipe, one and a half CB,1 bay)	1 lot
-Take-off structure(230 kV, 2 lines)	1 lot
-Transformer(three phase,230/115 kV,300 MVA)	6 sets
-Steel structure, conductor, strings, hardware and misceleneous material	1 lot

(6) SOUTH BANGKOK

Refer to appendix.

New 230 kV single feeder for SOUTH THONBURI will be added by 1997.

In response to MEA demand,two more banks (230 kV,300 MVA) will be necessary by 1997 and another one by 2006.

For the renovation work above mentioned, the following equipment is necessary.

-230 kV switchyard equipment (Aluminum pipe, one and a half CB, 3 bays)	1 lot
-Take-off structure (230 kV, 1 line)	1 lot
-Transformer (three phase 230/115 kV,300 MVA)	3 sets
-Steel structure, conductor, strings, hardware and misceleneous material	1 lot

(7) SAMPHRAN 1

Refer to appendix.

By 2004, existing 230 kV single line for BANGKOK NOI and another single line for SOUTH THONBURI will be replaced by double lines(4cct tower).

For the renovation work above mentioned, the following equipment is necessary.

-230 kV GIS (double bus, 2 bays)	1 lot
-Take-off structure (230 kV, 2 lines)	1 lot
-Transformer(three phase 230/115 kV,300MVA)	1 set
-Steel structure, conductor, strings, hardware and misceleneous material	1 lot

(8) SOUTH THONBURI

Refer to appendix.

By 1997, 230 kV single line feeder for SOUTH BANGKOK will be added.

By 1997, 230 kV triple lines feeders for THANONTOK will be tapped-off and additional one by 2011.

By 2004, 230 kV triple lines for SANPHRAN 1 and BANGKOK NOI will be replaced by 4 conductor triple lines, two of which tap to SANPHRAN 1.

Two more banks (230 kV, 300 MVA) will be necessary by 1997.

For the renovation work above mentioned, the following equipment is necessary.

-230 kV GIS (double bus, 3 bays)	1 lot
-Take-off structure (230 kV, 2 lines)	1 lot
-Transformer (three phase, 230/115 kV,300 MVA)	2sets
-Steel structure, conductor, strings, hardware and misceleneous material	1 lot

(9) RATCHADAPISEK

Refer to appendix.

Three banks (230 kV, 300 MVA) will be necessary by 1997, two more by 2001 and another one by 2011.

For the renovation work above mentioned, the following equipment is necessary.

-Transformer (three phase, 230/115 kV,300 MVA)	3 sets

(10) BANG KAPI

Refer to appendix.

New 230 kV triple lines for KHRONG TOEY will be tapped-off by 1997, two more by 2001 and another one by 2010.

Existing 230 kV lines for ON NUCH will be replaced by 230 kV 4 lines by 2006.

One bank (230 kV, 300 MVA) will be added by 1997, and another one by 2001.

For the renovation work above mentioned, the following equipment is necessary.

-230 kV GIS (double bus,8 bays)	1 lot
-Take-off structure(230 kV,8 lines)	1 lot
-Transformer(three phase,230/115 kV,300 MVA)	2 sets

(11) ON NUCH

Refer to appendix.

Existing 230 kV double lines for NONG CHOK will be replaced by 4 lines by 1999.

Existing 230 kV 4 lines for BANG KAPI will be replaced by 2006.

Existing 230 kV double lines for BANG PAKONG will be replaced by 4 lines up to <C> substation by 2008.

New 230 kV duble lines for BANG PHLI will be tapped-off by 2006.

Three banks (230 kV,300 MVA) will be necessary by 1997 and another one by 2006.

For the renovation work above mentioned, the following equipment is necessary.

-Transformer(three phase, 230/115 kV, 300 MVA)	4 sets

(12) LAT PHRAO

Refer to appendix.

Existing double lines for NORTH BANGKOK and RANGSIT will be replaced by 4 conductor double lines by 2002.

Existing four banks (230 kV,200 MVA) will be replaced by four 230 kV,300 MVA by 2006.

For the renovation work above mentioned, the following equipment is necessary.

-Transformer(three phase,230/115 kV,300 MVA)	4 sets

(13) BANG PHLI

Refer to appendix.

New 230 kV double lines for On Nuch will be tapped-off by 2006.

Two more banks (230 kV,300 MVA) will be necessary by 1977.

For the renovation work above mentioned, the following euipment is necessary.

-230 kV switchyard equipment(one and a half CB, Aluminum pipe, 1 bay)	1 lot
-Transformer(three phase,230/115 kV,300 MVA)	2 sets

(14) CHAENG WATHANA

Refer to appendix.

New construction.

500/230 kV 4 line feeders for RANGSIT will be tapped off by 1998 and 500/230 kV 4 line feeders for <A> substation by 2002.

Two banks (230 kV, 300 MVA) are necessary by 1997, one more by 2001 and another one by 2011.

(15) TEPARAK

Refer to appendix.

New construction.

This substation will tap to existing 230 kV double lines from SOUTH BANGKOK to BANG PHLI by 1997.

Four banks (230 kV,300 MVA) will be necessary by 1997, one more by 2006 and another by 2011.

(16) WANG NOI

Refer to page

New construction.

Eight 500 kV feeders (2 for Sai Noi, 4 for Nong Chok and 2 for Tha Tako), three banks (500 kV, 750 MVA) and six 230 kV feeders will be equipped by 2011.

(17) CHIDLOM

Refer to appendix.

No change.

(18) SATU PRADIT

Refer to appendix.

230 kV triple lines from SOUTH THONBURI and three banks (230 kV, 300 MVA) by 1997 and additional one line and bank by 2011.

(19) <A> Substation (Switching station)

Refer to appendix.

New construction.

New 230 kV six lines for Sananpao will be tapped off by 2001.

500/230 kV 4 lines for North Bangkok, 500/230 kV 4 lines for Chaeng Watthana, 230 kV 4 conductor double lines for Lat Phrao will be tapped off by 2002.

(20) <C> Substation

Refer to appendix.

New construction.

Existing 230 kV lines (Nong Chok-Bang Pakong, On Nuch-Bang Pakong) tap to <C> substation by 2008, of which the lines for On Nuch are replaced by 230 kV 4 lines by 2008, the lines for Nong Chok are replaced by 230 kV 4 lines by 2009.

500 kV double lines from NONG CHOK and four banks (500/230 kV, 750 MVA) will be equipped by 2011.

Four banks (500 kV, 750 MVA) will be necessary by 2011.

7.3.2 Determination of Number of Transformer Banks

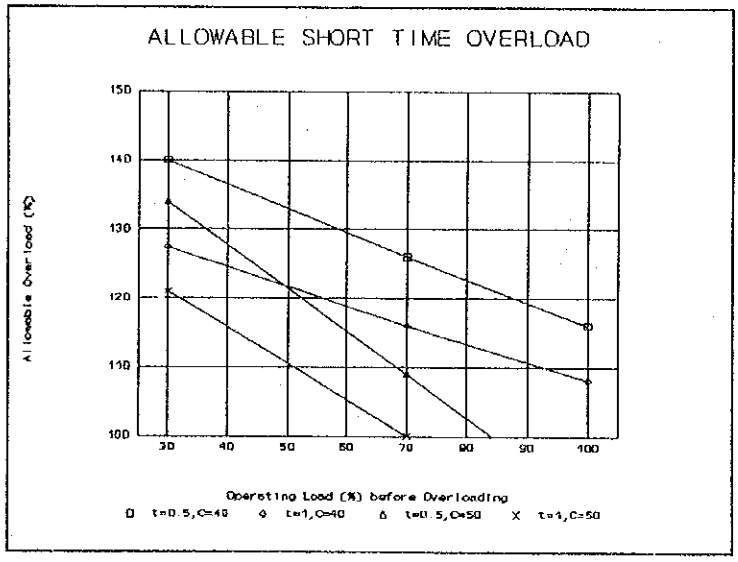
Not to shed power supply to the consumer even in the case of any one bank failure in any substation, the number of transformer banks should be determined in such a way that the sum of the capacity of sound transformers is enough to continue supplying power with one transformer out of service.

To pursue the economy, or to reduce the number of transformers the minimum under the design condition above mentioned in the other words, the concept of "short time overload" is allowed in Japan, which is reported in Technical Report Part 2, serial No.183 of Institute of Electrical Engineers of Japan titled " Operational Limit of Electrical Equipment Served for Power Transmission".

The allowable short time overloading indicated in the above report is shown in the figure below.

From the figure, it can be understood that 116% load (16% overload) for the duration of 30 minutes is allowed for the transformer of oil forced type which is operated at rated capacity (100% load) continuously prior to overloading at ambient temperature of 40 degree celsius

The less the operating load before overloading is, the more the allowable short time overload is.



When a conservative value of 115 % is adopted for short time overload, the relation of required number of transformers and the maximum power demand of the substation is expressed in the following formula.

$$\frac{115\%}{100} \times \{300 \times (N-1) + 200 \times N''\} > \frac{P}{\cos Q}$$

where,

N : Required number of 300 MVA transformer

N": Number of existing 200 MVA transformer

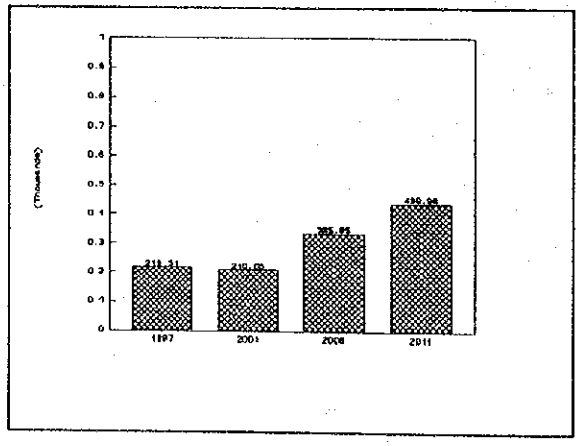
P : Maximum demand of substation (MW)

cos$Q$:Power factor = 0.85

In accordance with the criteria for selection of required number of transformer banks above mentioned, the required number of transformer banks for each substation is calculated as follows.

(1) NONG CHOK

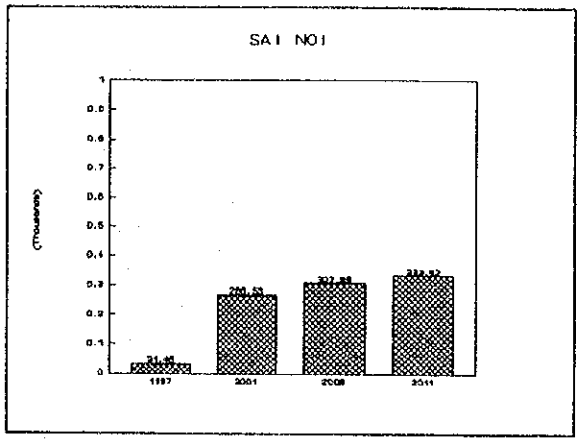
Existing: 1 bank



Total number of banks	2	2	3	3

(2) SAI NOI

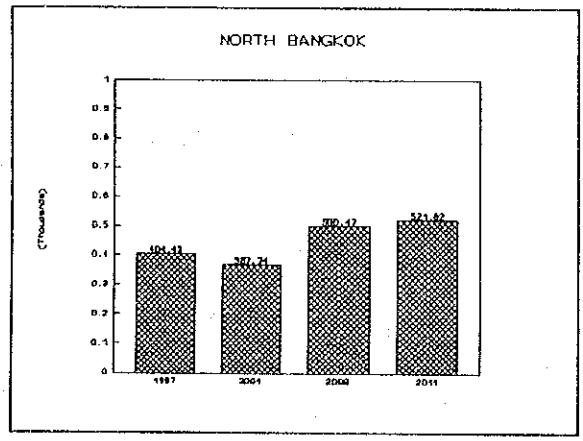
Existing: 0 bank



Total number of banks	2	2	2	3
		(3)	(3)	(4)

(3) NORTH BANGKOK

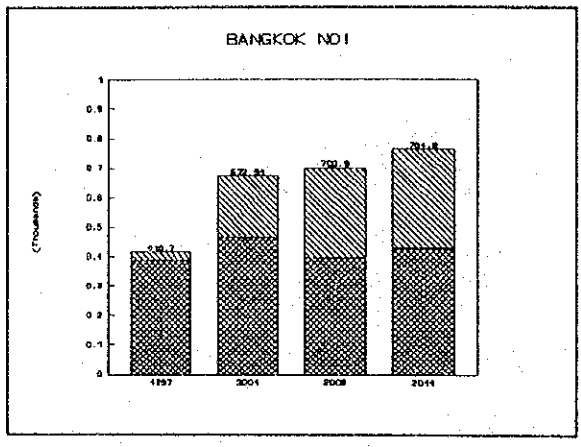
Existing: 3 banks



Total number of banks	4	4	4	4
			(5)	(5)

(4) BANGKOK NOI

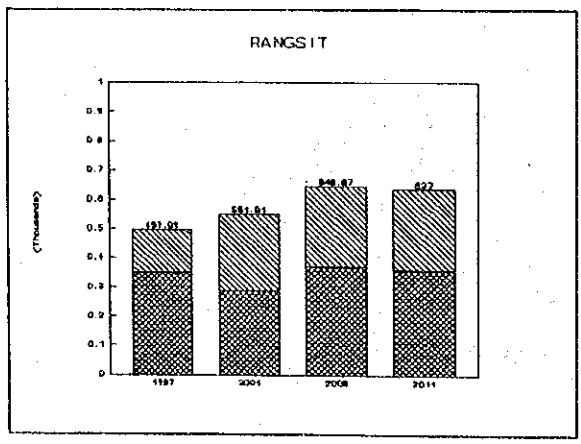
Existing: 4 banks



Total number of banks	230/115 kV:	4	4	4	4
	230/ 69 :	2	2	2	3
		(7)	(8)	(8)	(8)
		29.38	205.67	304.19	334.65
		387.32	467.27	396.61	430.15

(5) RANGSIT

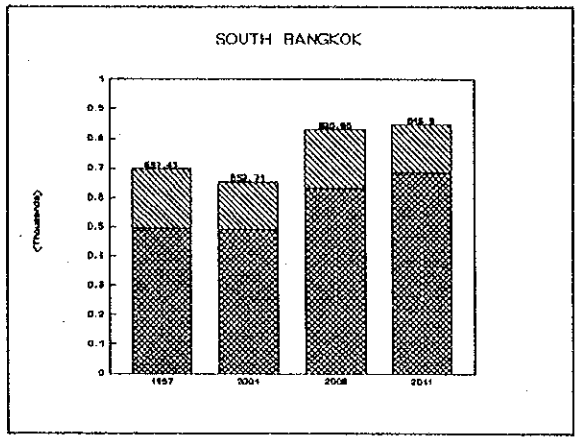
Existing: 6 banks



Total number of banks	230/115 kV:	4	4	4	4
	230/ 69 :	3	3	3	3
		(9)	(10)	(12)	(12)
		145.06	264.47	276.82	278.54
		352.03	286.54	369.85	358.46

(6) SOUTH BANGKOK

Existing: 5 banks

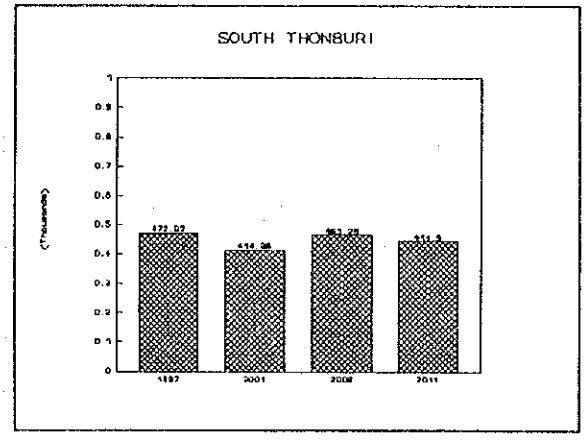


Total number of banks	230/115 kV:	4	4	5	5
	230/ 69 kV:	3	3	3	3
		200.19	163.17	197.7	160.19
		497.26	490.54	633.16	686.71

(7) SAMPHRAN 1

(8) SOUTH THONBURI

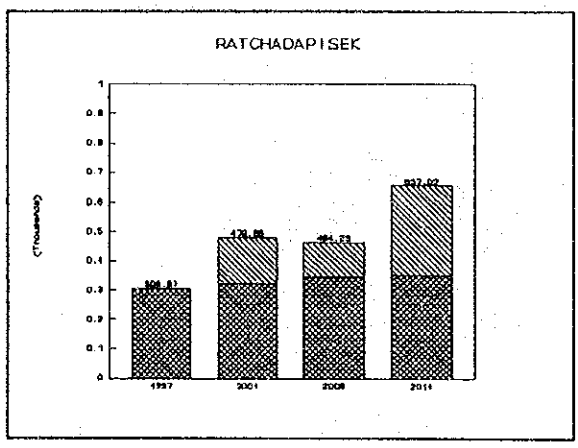
Existing: 2 banks



Total number of banks	4	4	4	4

(9) RATCHADAPISEK

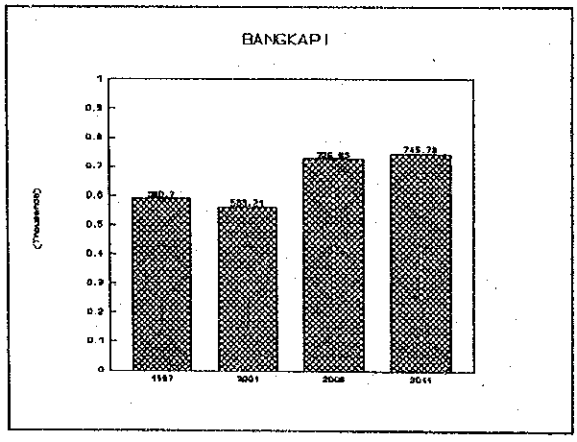
Existing: 0 bank



Total number of banks	230/115 kV:	2	3	3	3
	230/ 69 :	1	2	2	2
					(6)
		-	160.1	116.3	305.69
		306.87	319.56	347.93	351.33

(10) BANG KAPI

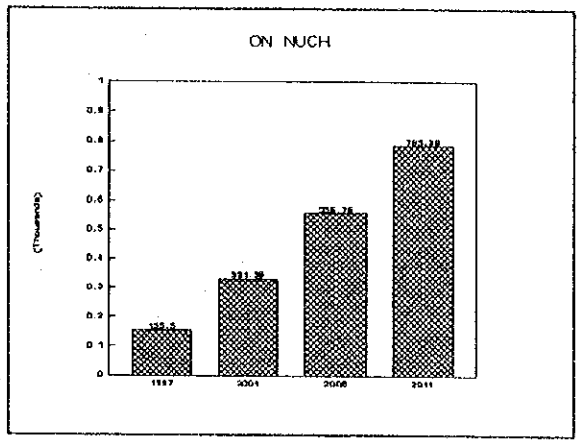
Existing: 4 banks



Total number of banks		5	5	5	5
					(6) (6) (6)

(11) ON NUCH

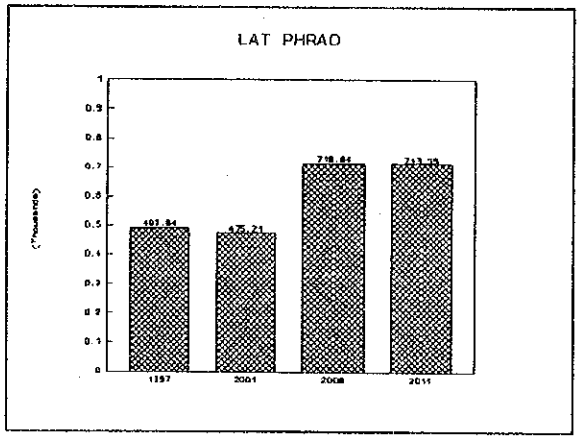
Existing: 0 bank



Total number of banks	2	3	3	4
		(3)		(4)

(12) LAT PHRAO

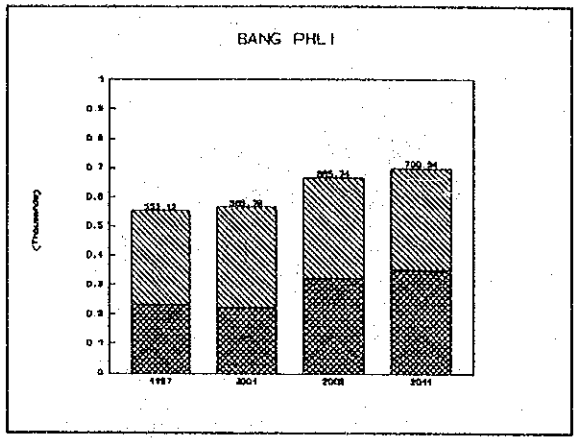
Existing: 4 banks



Total number of banks	4	4	5	5
			(6)	(6)

(13) BANG PHLI

Existing: 4 banks

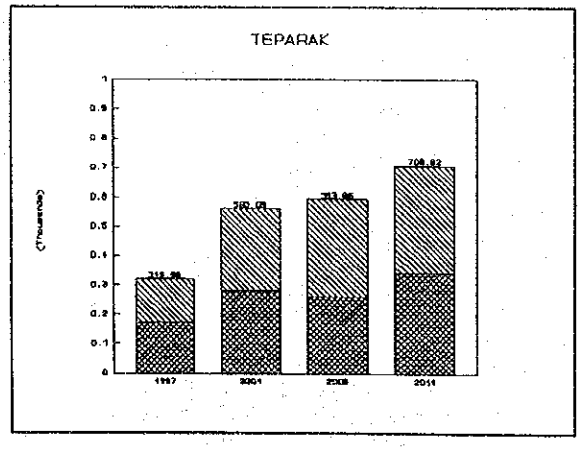


Total number of banks	230/115 kV:	3	3	3	3
	230/ 69 :	3	3	3	3

322.5	346	343.34	350.68
230.62	219.78	322.4	349.66

(14) TEPARAK

Existing: 0 bank

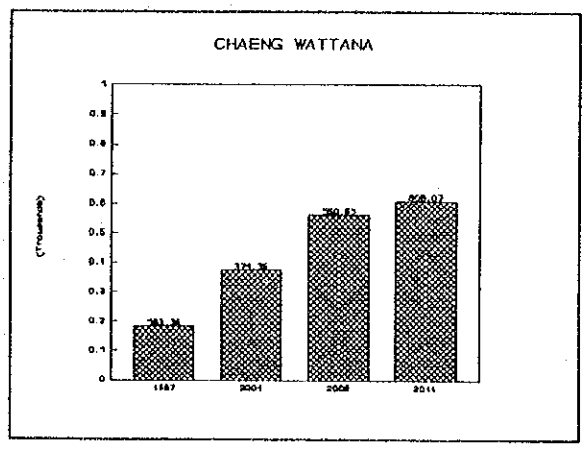


Total number of banks	230/115 kV:	2	2	2	3
		2	2	3	3

149.48	280.82	336.65	365.12
170.5	279.27	257.21	343.5

(15) CHAENG WATHANA

Existing: 0 bank

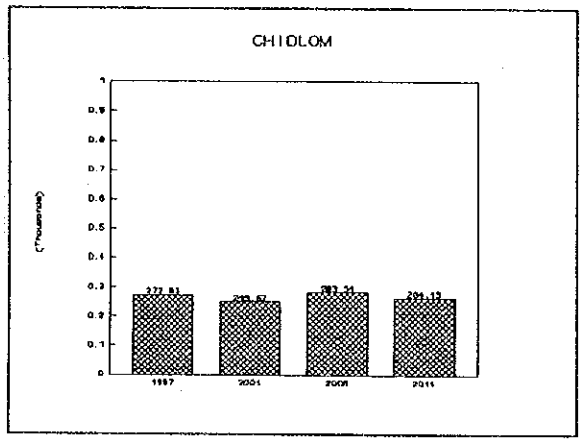


Total number of banks	2	3	3	4

(16) WANG NOI

(17) CHIDLOM

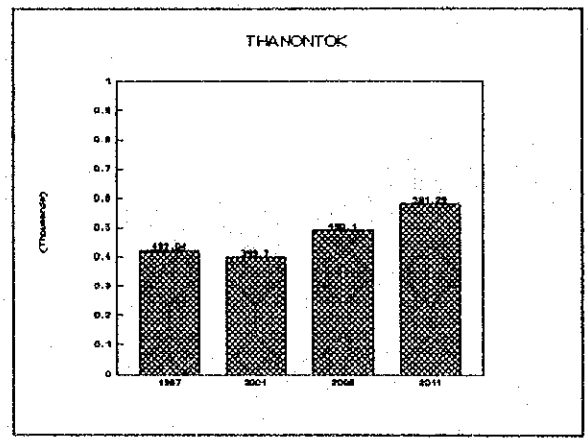
Existing: 2 banks



Total number of banks	3	3	3	3
	(2)	(2)	(2)	(2)

(18) SATU PRADIT (THANONTOK)

Existing: 0 bank

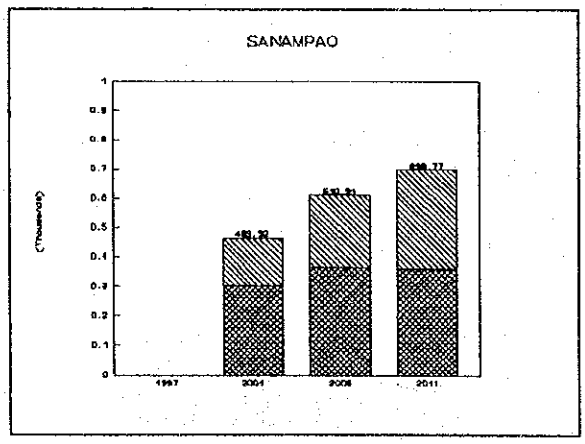


Total number of banks	3	3	3	3

(4)

(19) SANAMPAO

Existing: 0 bank

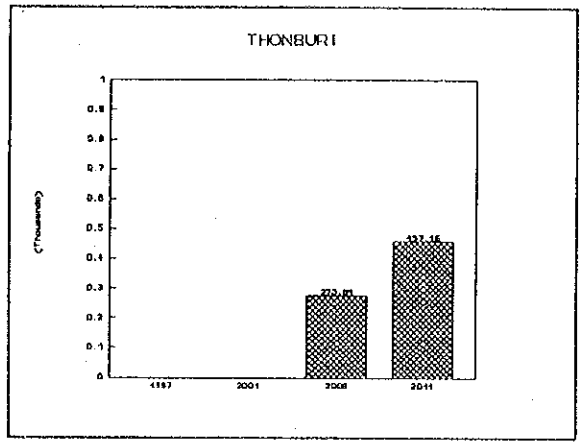


Total number of banks 230/115 kV:
230/ 69 :

-	162.04	247.88	337.15
-	301.28	363.06	359.62

(20) THONBURI

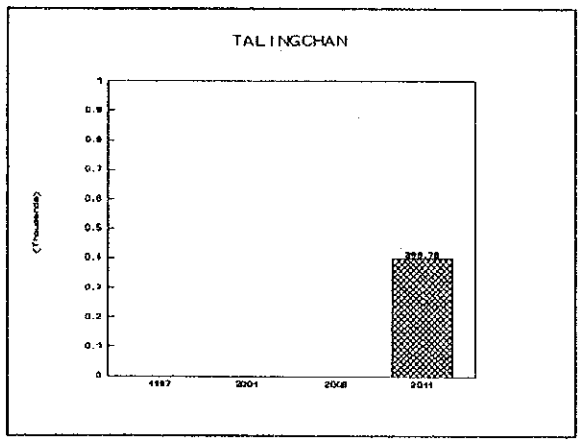
Existing: 0 bank



Total number of banks 2 3

(21) TALINGCHAN

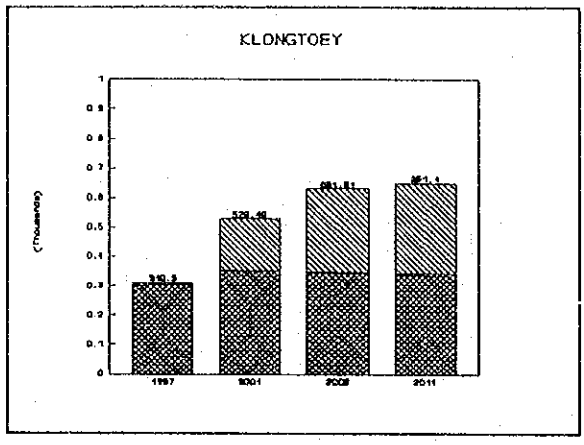
Existing: 0 bank



Total number of banks 3

(22) KHRONG TOEY

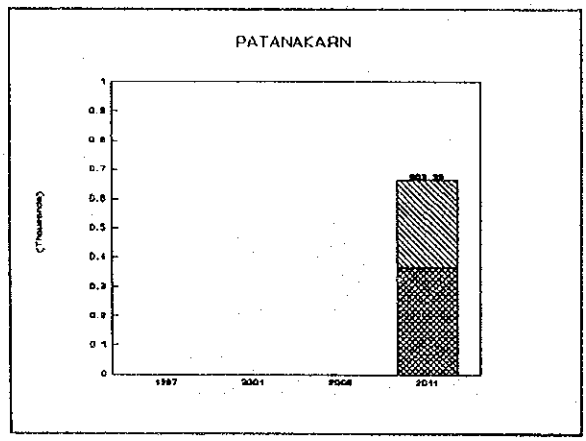
Existing: 0 bank



Total number of banks	230/115 kV:	3	3	3	3
	230/ 69 :	1	2	2	3
		0	180.79	284.98	309.08
		310.3	348.7	346.83	342.02

(23) PATANAKARN

Eisting: 0 bank



Total number of banks	230/115 kV:	3
	230/ 69 :	2
		296
		367.39

CHAPTER 8

COST ESTIMATION AND CONSTRUCTION SCHEDULING

CHAPTER 8 COST ESTIMATION AND CONSTRUCTION SCHEDULING

8.1 Cost Estimation

8.1.1 Approach to Cost Determination

Based on the basic design in Chapter 7, which are prepared for composing optimal power system configulation recommended in Chapter 5, all cost required for renovation and construction of transmission lines and substations are to be estimated in this clause except the expense for environmental protection.

The cost incurred for environmental protection is to be estimated in Chapter 9 "Study of Environmental Impact".

The total construction cost of each substation and transmission line is broken down into the following:

(1) SUBSTATION

1) Land Acquisition

2) Land Improvement

3) Foundation Work

4) Control Building

5) Equipment (supply & installation)

- Steel Structure including Take-off Structure and Support Structure of DS, CT, CCPD and BUS
- Miscellaneous Hardware
- Power Transformer
- Power Circuit Breaker including Support Structure
- Disconnecting Switch
- Instrument Transformer
- Control & Station Service
- Others

6) Miscellaneous Facilities

7) Miscellaneous Expenses

8) Engineering and Supervision

9) Contingencies

10) Import Duties

11) Value Added Tax

(2) TRANSMISSION LINE

1) Line Route Survey and Soil Investigation

2) Right-of-way

3) Preliminary Work

4) Tower Footing

5) Equipment (supply & installation)

- Tower bodies
- Insulator String
- Conductor
- Overhead Ground Wire
- Line Accessories
- Grounging Material
- Others

6) Miscellaneous Expense

7) Engineering & Supervision

8) Contingencies

9) Import Duties

10) Value Added Tax

Items 1) to 7) of substation and items 1) to 6) of transmission line above are categorized in direct cost, and the remainder indirect cost.

Each value of indirect cost is determined as follows;

- Miscellaneous Expense	5% of direct cost excluding and in case of substation and route survey and soil investigation and right-of-way in case of transmission line
- Engineering & Supervision	7% of direct cost
- Contiengency	10% of direct cost
- Import Duty	incurred individually by products

- Value Added Tax	7% of the sum of import duty and direct cost excluding land related cost, route survey and soil investigation and right-of-way

Interest during construction, which is included in indirect cost, is to be determined in Chapter 11 "Financial Analysis" when the total cost of the project has been estimated and the overall time-related division of the works has been established.

The prices of various items above are based on EGAT's recent experience which is reported on "TRANSMISSION SYSTEM COST ESTIMATE CATALOG".

Price escalation rate of 5 % per anumm will be considered in Chapter 11 "Financial Analysis", taking into account the year of renovation or construction.

All unit prices and lump sum is devided into local and foreign currency components.

8.1.2 Summary

The construction cost is tabulated in the following pages, expressed in the price level in 1992.

Much importance was placed on the use the existing right of way in planning transmision line routes on account of dificulties in acquiring new right of way in the Gtreater Bangkok Area and together with the expectation to minimize the construction cost.

Eventhough overhead line is preferable to underground cable from economical point of view, some sections which are not wide enough to reconstruct new lines required or deemed to obstruct aviation or others, are planned by underground cables as listed below.

- RANGSIT to CHAEWG WATTHAN (EGAT)
- SOUTH THONBURI to THANONTOK (MEA)
- BANG KAPI to KHLONG TOEY (MEA)
- <A> S.S. to SANAMPAO (MEA)
- BANGKOK NOI to THONBURI (MEA)
- ON NUCH to <C> S.S. (EGAT)

The construction cost of transmission line much differs depending on the cost for tower footing for overhead line or that for tunnel excavation for underground cable owing to the nature of soil (poor or fair) of the route.

As it is considered that the poor soil covers most of the Greater Bangkok Area, the estimation in case of poor soil will give a rather realistic value for the construction cost of transmission line.

As for substation, pad or pile type foundation will be adopted depending on the nature of soil for bus support, steel structure or

equipment such as transformer, circuit breaker, disconnecting switch and others, but it has less affect on the total construction cost of substations, of which the foundation cost occupies small part.

CONSTRUCTION COST DISBUESEMENT (TOTAL-PRICE LEVEL IN YEAR 1992) UNIT: mill.US$

From	To	kV/ km/ cct/ cond.	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	TOTAL	EGAT	MEA
NONG CHOK						36.003				9.231					9.046					16.815	71.095	71.095	0
	- ON NUCH	230/ 16.8/ 4/ 2					14.85														14.85	14.85	0
	- <C>	230/ 19.0/ 4/ 2																16.79			16.79	16.79	0
	- <G>	500/ 19.0/ 2/ 4																	13.75		13.75	13.75	0
	- WANG NOI	500/ 64.0/ 2/ 4		59.24																	59.24	59.24	0
SAI NOI						53.755				44.377					0.139					2.218	100.489	100.489	0
	- BANGKOK NOI	500/ 29.6/ 2/ 4							21.42												21.42	21.42	0
	- RANGSIT	500/ 24.5/ 2/ 4											17.73								17.73	17.73	0
	- WANG NOI	500/ 56.0/ 2/ 4		51.84																	51.84	51.84	0
NORTH BANGKOK						2.218				33.805					29.529					4.527	70.079	70.079	0
	- BANGKOK NOI																						
	(NB-TAL)	500/230 /9.2/ 2/ 2							17.3												17.3	17.3	0
	(TAL-BN)	500/ 9.2/ 2/ 4							6.65												6.65	6.65	0
	- <A>	500/230 /4.4/ 2/2 / 4/4									8.28										8.28	8.28	0
BANGKOK NOI						6.654				71.424					34.102					6.882	119.062	119.062	0
	(- SAI NOI)																				0	0	0
	(- NORTH BANGKOK)																				0	0	0
	- SAMPHRAN 1	230/ 0.3/ 2/ 4										0.15									0.15	0.15	0
		230/ 11.7/ 4/ 4										14.93									14.93	14.93	0
	- SOUTH THONBURI	230/ 8.1/ 1/ 4											4.1								4.1	4.1	0
	- THONBURI	230/ 11.0/ 3/ CABLE												117.46						28.29	145.75	0	145.75
RANGSIT						6.654				2.218					4.436						13.308	13.308	0
	- CHAENG WATTHAMA	500/230 / 5/ 2/2/ 4/4				9.41															9.41	9.41	0
		500/ 4.0/ 2/ 4				2.9															2.9	2.9	0
		230/ 4.0/ 2/ CABLE				69.1															69.1	69.1	0
	- WANG NOI	230/ 50.0/ 4/ 2		50.2								0									50.2	50.2	0
	(- SAI NOI)																				0	0	0
SOUTH BANGKOK						15.645									2.218						17.863	17.863	0
SAMPHRAN 1						2.218									7.949					0.109	10.276	10.276	0
	(- BANGKOK NOI)																				0	0	0
	- SOUTH THONBURI	230/ 8.1/ 2/ 4											4.1								4.1	4.1	0
SOUTH THONBURI						4.653															4.653	4.653	0
	- THANONTOK	230/ 10.0/ 4/ CABLE			136.22														25.96		162.18	0	162.18
	(- SAMPHRAN 1)																				0	0	0
	(- BANGKOK NOI)																				0	0	0
RATCHADAPISEK										4.436										2.218	6.654	6.654	0
	- LAT PHRAO	230/ 0.5/ 2/ 2	0.15																		0.15	0.15	0
	- BANG KAPI	230/ 0.5/ 2/ 2	0.15																		0.15	0.15	0
BANG KAPI						7.497				7.484										0.054	15.035	15.035	0
	- KHLONG TOEY	230/ 8.0/ 6/ CABLE			110.08				41.49										20.75		172.32	0	172.32
	(- RATCHADAPISEK)																				0	0	0
	- ON NUCH	230/ 10.0/ 4/ 2												8.83							8.83	8.83	0
	- PATANAKAN	230/ 5.0/ 2/ 2																	2.35		2.35	0	2.35
ON NUCH						6.654				0.109					2.218						8.981	8.981	0
	(- NONG CHOK)																				0	0	0
	(- BANG KAPI)																				0	0	0
	- BANG PHLI	230/ 10.5/ 2/ 2												3.68							3.68	3.68	0
	- <C>	230/ 10.0/ 4/ CABLE														164.58					164.58	164.58	0
	- <C>	230/ 12.0/ 4/ 2														10.6					10.6	10.6	0
	(- PATANAKAN)																				0	0	0
LAT PHRAO															8.872						8.872	8.872	0
	(- RATCHADAPISEK)																				0	0	0
	- <A>	230/ 2.7/ 2/ 4									1.36										1.36	1.36	0
BANG PHLI						4.436														2.521	6.957	6.957	0
	- BANG BOR	230/ 1.0/ 2/ 2							0.47												0.47	0	0.47
(BANG PAKONG)-BANG BOR		230/ 1.0/ 2/ 2							0.47												0.47	0	0.47
	(- ON NUCH)																				0	0	0
TEPARAK						26.343									2.218					2.218	30.779	30.779	0
CHAENG WATTHANA						14.413				2.218										2.218	18.849	18.849	0
	(- RANGSIT)																				0	0	0
	- <A>	500/230 / 7.1/ 2/2 / 4/2									13.36										13.36	13.36	0
WANG NOI						19.852									71.061						90.913	90.913	0
	(- NONG CHOK)																				0	0	0
	(- SAI NOI)																				0	0	0
	(- RANGSIT)																				0	0	0
<A> S.S.										18.607											18.607	18.607	0
	- SAMAMPAO	230/ 9.0/ 6/ CABLE							174.18										23.36		197.54	0	197.54
	(- NORTH BANGKOK)																				0	0	0
	(- LAT PHRAO)																				0	0	0
	(- CHAENG WATTHANA)																				0	0	0
<C> S.S.																				72.738	72.738	72.738	0
	- BANG PAKONG 2	230/ 2.0/ 2/ 2																0.7			0.7	0.7	0
	- BANG PAKONG 2	230/ 2.0/ 2/ 2																0.7			0.7	0.7	0
	(- NONG CHOK)																				0	0	0
	(- NONG CHOK)																				0	0	0
	(- ON NUCH)																				0	0	0
	(- ON NUCH)																				0	0	0
	- KHLONG MAI	230/ 2.0/ 2/ 2																0.94			0.94	0	0.94
TOTAL			0.3	161.28	246.3	288.405	14.85	0	261.98	193.909	23	15.08	25.93	129.97	171.788	175.18	0	19.13	86.17	140.808	1954.08	1272.06	682.02
EGAT PORTION			0.3	161.28	0	288.405	14.85	0	45.37	193.909	23	15.08	25.93	12.51	171.788	175.18	0	18.19	13.75	112.518	1272.06		
MEA PORTION			0	0	246.3	0	0	0	216.61	0	0	0	0	117.46	0	0	0	0.94	72.42	28.29	682.02		

VALUE ADDED TAX DISBURSEMENT (PRICE LEVEL IN YEAR 1992) UNIT: mill.US$

From	To	kV/ km/ cct/ cond.	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	TOTAL	EGAT	MEA
NONG CHOK						1.98136				0.50676					0.49616					0.9366	3.921	3.921	0
	- ON NUCH	230/ 16.8/ 4/ 2					0.763581														0.764	0.764	0
	- <C>	230/ 19.0/ 4/ 2																8.635732			8.636	8.636	0
	- <C>	500/ 19.0/ 2/ 4																	0.699773		0.7	0.7	0
	- WANG NOI	500/ 64.0/ 2/ 4	2.357126																		2.357	2.357	0
SAI NOI						2.95732				2.44116					0.0078					0.12156	5.528	5.528	0
	- BANGKOK NOI	500/ 29.6/ 2/ 4							1.090172												1.09	1.09	0
	- RANGSIT	500/ 24.5/ 2/ 4											0.902339								0.902	0.902	0
	- WANG NOI	500/ 56.0/ 2/ 4	2.062485																		2.062	2.062	0
NORTH BANGKOK						0.12156				1.86092					1.61984					0.2488	3.851	3.851	0
	- BANGKOK NOI																						
	(NB-TAL)	500/230 /9.2/ 2/ 2							0.918056												0.918	0.918	0
	(TAL-BN)	500/ 9.2/ 2/ 4							0.338837												0.339	0.339	0
	- <A>	500/230 /4.4/ 2/2 / 4/4									0.43907										0.439	0.439	0
BANGKOK NOI						0.36476				3.92588					1.87148					0.37764	6.54	6.54	0
	(- SAI NOI)																				0	0	0
	(- NORTH BANGKOK)																				0	0	0
	- SAMPHRAN 1	230/ 0.3/ 2/ 4										0.007488									0.007	0.007	0
		230/ 11.7/ 4/ 4										0.783482									0.783	0.783	0
	- SOUTH THONBURI	230/ 8.1/ 1/ 4											0.202210								0.202	0.202	0
	- THONBURI	230/ 11.0/ 3/ CABLE												0.006464						0.001596	0.008	0	0.008
RANGSIT						0.36468				0.12156					0.24312						0.729	0.729	0
	- CHAENG WATTHANA	500/230 / 5/ 2/2/ 4/4				0.498943															0.499	0.499	0
		500/ 4.0/ 2/ 4				0.147319															0.147	0.147	0
		230/ 4.0/ 2/ CABLE				0.0038															0.004	0.004	0
	- WANG NOI	230/ 50.0/ 4/ 2	2.272557									0									2.273	2.273	0
	(- SAI NOI)	\																			0	0	0
SOUTH BANGKOK						0.85904									0.12156						0.981	0.981	0
SAMPHRAN 1						0.12156									0.4372					0.00608	0.565	0.565	0
	(- BANGKOK NOI)																				0	0	0
	- SOUTH THONBURI	230/ 8.1/ 2/ 4											0.202210								0.202	0.202	0
SOUTH THONBURI						0.25528															0.255	0.255	0
	- THANONTOK	230/ 10.0/ 4/ CABLE			0.007532														0.001464		0.009	0	0.009
	(- SAMPHRAN 1)																				0	0	0
	(- BANGKOK NOI)																				0	0	0
RATCHADAPISEK										0.24312										0.12156	0.365	0.365	0
	- LAT PHRAO	230/ 0.5/ 2/ 2	0.008201																		0.008	0.008	0
	- BANG KAPI	230/ 0.5/ 2/ 2	0.008201																		0.008	0.008	0
BANG KAPI						0.41188				0.41116										0.00304	0.826	0.826	0
	- KHLONG TOEY	230/ 8.0/ 6/ CABLE			0.006076				0.00234										0.001172		0.01	0	0.01
	(- RATCHADAPISEK)																				0	0	0
	- ON NUCH	230/ 10.0/ 4/ 2												4.544912							4.545	4.545	0
	- PATANAKAN	230/ 5.0/ 2/ 2																	0.082001		0.082	0	0.082
LAT PHRAO															0.48632						0.486	0.486	0
	(- RATCHADAPISEK)																				0	0	0
	- <A>	230/ 2.7/ 2/ 4									0.067402										0.067	0.067	0
BANG PHLI						0.24312														0.13872	0.382	0.382	0
	- BANG BOR	230/ 1.0/ 2/ 2							0.016402												0.016	0	0.016
(BANG PAKONG)-BANG BOR		230/ 1.0/ 2/ 2							0.016402												0.016	0	0.016
	(- ON NUCH)																				0	0	0
TEPARAK						1.43796									0.12156					0.12156	1.681	1.681	0
CHAENG WATTHANA						0.79192				0.12156										0.12156	1.035	1.035	0
	(- RANGSIT)																				0	0	0
	- <A>	500/230 / 7.1/ 2/2 / 4/2									0.708501										0.709	0.709	0
WANG NOI						1.08232									3.90804						4.99	4.99	0
	(- NONG CHOK)																				0	0	0
	(- SAI NOI)																				0	0	0
	(- RANGSIT)																				0	0	0
<A> S.S.										1.02184											1.022	1.022	0
	- SANAMPAO	230/ 9.0/ 6/ CABLE							0.009684										0.001316		0.011	0	0.011
	(- NORTH BANGKOK)																				0	0	0
	(- LAT PHRAO)																				0	0	0
	(- CHAENG WATTHANA)																				0	0	0
<C> S.S.																				3.98756	3.988	3.988	0
	- BANG PAKONG 2	230/ 2.0/ 2/ 2																0.032802			0.033	0.033	0
	- BANG PAKONG 2	230/ 2.0/ 2/ 2																0.032802			0.033	0.033	0
	(- NONG CHOK)																				0	0	0
	(- NONG CHOK)																				0	0	0
	(- ON NUCH)																				0	0	0
	(- ON NUCH)																				0	0	0
	- KHLONG MAI	230/ 2.0/ 2/ 2																0.032801			0.033	0	0.033
TOTAL			0.016	6.692	0.014	12.008	0.764	0	2.392	10.66	1.215	0.791	1.307	4.724	9.435	0.555	0	8.734	0.786	6.186	66.275	66.09	0.185
EGAT PORTION			0.016	6.692	0	12.008	0.764	0	2.347	10.66	1.215	0.791	1.307	4.718	9.435	0.555	0	8.701	0.7	6.184	66.093		
MEA PORTION			0	0	0.014	0	0	0	0.045	0	0	0	0	0.006	0	0	0	0.033	0.086	0.002	0.186		

IMPORT DUTY DISBURSEMENT (PRICE LEVEL IN YEAR 1992) UNIT: mill.US$

From	To	kV/ km/ cct/ cond.	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	TOTAL	EGAT	MEA
NONG CHOK						2.38704				0.55392					0.443					1.15116	4.535	4.535	0
	- ON NUCH	230/ 16.8/ 4/ 2					0.3216														0.322	0.322	0
	- <C>	230/ 19.0/ 4/ 2																0.36372			0.364	0.364	0
	- <C>	500/ 19.0/ 2/ 4																	0.47396		0.474	0.474	0
	- WANG NOI	500/ 64.0/ 2/ 4		1.59644																	1.596	1.596	0
SAI NOI						4.23444				3.45868					0.0078					0.1022	7.803	7.803	0
	- BANGKOK NOI	500/ 29.6/ 2/ 4							0.73836												0.738	0.738	0
	- RANGSIT	500/ 24.5/ 2/ 4											0.61116								0.611	0.611	0
	- WANG NOI	500/ 56.0/ 2/ 4		1.39688																	1.397	1.397	0
NORTH BANGKOK						0.1022				2.28836					1.4654					0.38784	4.244	4.244	0
	- BANGKOK NOI																						
	(NB-TAL)	500/230 /9.2/ 2/ 2							0.35004												0.35	0.35	0
	(TAL-BN)	500/ 9.2/ 2/ 4							0.22948												0.229	0.229	0
	- <A>	500/230 /4.4/ 2/2 / 4/4									0.1674										0.167	0.167	0
BANGKOK NOI						0.30664				4.28392					1.94492					0.3482	6.884	6.884	0
	(- SAI NOI)																				0	0	0
	(- NORTH BANGKOK)																				0	0	0
	- SAMPHRAN 1	230/ 0.3/ 2/ 4										0.00584									0.006	0.006	0
		230/ 11.7/ 4/ 4										0.4388									0.439	0.439	0
	- SOUTH THONBURI	230/ 8.1/ 1/ 4											0.15816								0.158	0.158	0
	- THONBURI	230/ 11.0/ 3/ CABLE												0.011256						0.005072	0.016	0	0.016
RANGSIT						0.30664				0.1022					0.2044						0.613	0.613	0
	- CHAENG WATTHANA	500/230 / 5/ 2/2/ 4/4				0.19024															0.19	0.19	0
		500/ 4.0/ 2/ 4				0.09976															0.1	0.1	0
		230/ 4.0/ 2/ CABLE				0.008164															0.008	0.008	0
	- WANG NOI	230/ 50.0/ 4/ 2		0.95712								0									0.957	0.957	0
	(- SAI NOI)																				0	0	0
SOUTH BANGKOK						1.15912									0.1022						1.261	1.261	0
SAMPHRAN 1						0.1022									0.50888					0.01484	0.626	0.626	0
	(- BANGKOK NOI)																				0	0	0
	- SOUTH THONBURI	230/ 8.1/ 2/ 4											0.15816								0.158	0.158	0
SOUTH THONBURI						0.23408															0.234	0.234	0
	- THAMONTOK	230/ 10.0/ 4/ CABLE			0.015496														0.00466		0.02	0	0.02
	(- SAMPHRAN 1)																				0	0	0
	(- BANGKOK NOI)																				0	0	0
RATCHADAPISEK										0.2044										0.1022	0.307	0.307	0
	- LAT PHRAO	230/ 0.5/ 2/ 2	0.00508																		0.005	0.005	0
	- BANG KAPI	230/ 0.5/ 2/ 2	0.00508																		0.005	0.005	0
BANG KAPI						0.44028				0.43792										0.0074	0.886	0.886	0
	- KHLONG TOEY	230/ 8.0/ 6/ CABLE			0.012372				0.007444												0.024	0	0.024
	(- RATCHADAPISEK)																				0	0	0
	- ON NUCH	230/ 10.0/ 4/ 2												0.19144							0.191	0.191	0
	- PATANAKAN	230/ 5.0/ 2/ 2																			0.051	0	0.051
ON NUCH						0.30664				0.01484					0.1022						0.424	0.424	0
	(- NONG CHOK)																				0	0	0
	(- BANG KAPI)																				0	0	0
	- BANG PHLI	230/ 10.5/ 2/ 2												0.10664							0.107	0.107	0
	- <C>	230/ 10.0/ 4/ CABLE													0.020664						0.021	0.021	0
	- <C>	230/ 12.0/ 4/ 2													0.22972						0.23	0.23	0
	(- PATANAKAN)																				0	0	0
LAT PHRAO															0.40884						0.409	0.409	0
	(- RATCHADAPISEK)																				0	0	0
	- <A>	230/ 2.7/ 2/ 4									0.05272										0.053	0.053	0
BANG PHLI						0.2044														0.23992	0.444	0.444	0
	- BANG BOR	230/ 1.0/ 2/ 2							0.01016												0.01	0	0.01
(BANG PAKONG)-BANG BOR		230/ 1.0/ 2/ 2							0.01016												0.01	0	0.01
	(- ON NUCH)																				0	0	0
TEPARAK						1.84388									0.1022					0.1022	2.048	2.048	0
CHAENG WATTHANA						1.14928				0.1022										0.1022	1.354	1.354	0
	(- RANGSIT)																				0	0	0
	- <A>	500/230 / 7.1/ 2/2 / 4/2									0.27016										0.27	0.27	0
WANG NOI						1.55952									4.45844						6.018	6.018	0
	(- NONG CHOK)																				0	0	0
	(- SAI NOI)																				0	0	0
	(- RANGSIT)																				0	0	0
<A> S.S.										1.05956											1.05956	1.05956	0
	- SANAMPAO	230/ 9.0/ 6/ CABLE							0.023228										0.004192		0.02742	0	0.02742
	(- NORTH BANGKOK)																				0	0	0
	(- LAT PHRAO)																				0	0	0
	(- CHAENG WATTHANA)																				0	0	0
<C> S.S.																				4.7562	4.756	4.756	0
	- BANG PAKONG 2	230/ 2.0/ 2/ 2																0.02032			0.02	0.02	0
	- BANG PAKONG 2	230/ 2.0/ 2/ 2																0.02032			0.02	0.02	0
	(- NONG CHOK)																				0	0	0
	(- NONG CHOK)																				0	0	0
	(- ON NUCH)																				0	0	0
	(- ON NUCH)																				0	0	0
	- KHLONG MAI	230/ 2.0/ 2/ 2																0.02032			0.02	0	0.02
TOTAL			0.01	3.95	0.028	14.635	0.322	0	1.369	12.506	0.49	0.445	0.927	0.309	9.748	0.25	0	0.425	0.537	7.319	53.27	53.092	0.178
EGAT PORTION			0.01	3.95	0	14.635	0.322	0	1.318	12.506	0.49	0.445	0.927	0.298	9.748	0.25	0	0.405	0.474	7.314	53.092		
MEA PORTION			0	0	0.028	0	0	0	0.051	0	0	0	0	0.011	0	0	0	0.02	0.063	0.005	0.178		

8.1.3 Substation

The sum of construction cost of substations during each planned year period which is expressed in price level in 1992 is summarized in the following table.

The exchange rate is 25 Baht per U.S.Dollar.

Planned Year	1997	2001	2006	2011
Period from the last	5	4	5	5
Total (mil.US$)	206.9	208.7	171.4	115.3
Annual Invest. (mil.US$)	41.4	52.2	34.3	23.1

The total substation cost accounts for 702.3 million US$ in the price level in 1992, of which 65.3% (458.7 million US$) is for 500 kV substation.

The average investment ranging from 23.1 to 52.2 million US$ per anum (576.5 to 1,304.3 million baht per anum), expressed in price level in 1992, is necessary for construction and renovation of substations.

Almost double to four times investment is necessary for 500 kV substation compared with that for 230 kV substation during the period around and after 2001, as can be understood from the following tables.

500 kV Substation

Planned Year	1997	2001	2006	2011
Total (mil. US$)	83.1	167.0	132.6	76.2
Foreign currency(mil. US$)	57.5	108.4	96.7	55.5
Local currency (mil. US$)	25.6	58.6	35.9	20.7

230 kV Substation

Planned Year	1997	2001	2006	2011
Total (mil. US$)	123.8	41.8	38.9	39.1
Foreign currency(mil. US$)	81.0	28.6	27.7	24.9
Local currency (mil. US$)	42.8	13.2	11.2	14.2

The cost of each substation and it's break down is indicated as follows.

CONSTRUCTION COST

TOTAL - 1000 US$

	1997	2001	2006	2011
NONG CHOK	36004	9230	9046	16815
SAI NOI	53755	59182	139	2218
NORTH BANGKOK	2218	33805	29529	4527
BANGKOK NOI	6654	71421	34102	6883
RANGSIT	6654	2218	3793	0
SOUTH BANGKOK	15645	0	2218	0
SAMPHRAN 1	2207	0	8236	85
SOUTH THONBURI	4584	0	0	0
RATCHADAPISEK	0	4413	0	2207
BANG KAPI	7497	7484	0	54
ON NUCH	6654	108	2218	0
LAT PHRAO	0	0	8872	0
BANG PHLI	4436	0	0	2522
TEPARAK	26343	0	2218	2218
CHAENG WATTHANA	14413	2218	0	2218
WANG NOI	19852	0	71080	0
CHIDLOM	0	0	0	0
SATU PRADIT	0	0	0	0
<A> S.S.	0	18606	0	0
<C> S.S.	0	0	0	75558
	206916	208685	171431	115305

Foreign Currency-1000 US$
1 US$ = 25 BAHT

	1997	2001	2006	2011
NONG CHOK	26012	6547	6588	12230
SAI NOI	36293	30069	69	1587
NORTH BANGKOK	1587	24436	21590	2956
BANGKOK NOI	4761	51978	24438	5028
RANGSIT	4727	1576	3151	0
SOUTH BANGKOK	10511	0	1587	0
SAMPHRAN 1	1576	0	5880	30
SOUTH THONBURI	3212	0	0	0
RATCHADAPISEK	0	3151	0	1576
BANG KAPI	5500	5493	0	15
ON NUCH	4727	30	1576	0
LAT PHRAO	0	0	6302	0
BANG PHLI	3151	0	0	1559
TEPARAK	15898	0	1576	1576
CHAENG WATTHANA	9356	1576	0	1576
WANG NOI	11217	0	51628	0
CHIDLOM	0	0	0	0
SATU PRADIT	0	0	0	0
<A> S.S.	0	12084	0	0
<C> S.S.	0	0	0	52267
	138528	136940	124385	80400

Local Currency-1000 US$

	1997	2001	2006	2011
NONG CHOK	9992	2683	2458	4585
SAI NOI	17462	29113	70	631
NORTH BANGKOK	631	9369	7939	1571
BANGKOK NOI	1893	19443	9664	1853
RANGSIT	1927	642	642	0
SOUTH BANGKOK	5134	0	631	0
SAMPHRAN 1	631	0	2356	55
SOUTH THONBURI	1372	0	0	0
RATCHADAPISEK	0	1262	0	631
BANG KAPI	1997	1991	0	39
ON NUCH	1927	78	642	0
LAT PHRAO	0	0	2570	0
BANG PHLI	1285	0	0	963
TEPARAK	10445	0	642	642
CHAENG WATTHANA	5057	642	0	642
WANG NOI	8635	0	19432	0
CHIDLOM	0	0	0	0
SATU PRADIT	0	0	0	0
<A> S.S.	0	6522	0	0
<C> S.S.	0	0	0	23291
	68388	71745	47046	34905

500 kV SUBSTATION COST

Foreign Currency-1000 US$

	1997	2001	2006	2011
NONG CHOK	24428	5069	5001	12230
SAI NOI	33119	28482	69	0
NORTH BANGKOK	0	24436	20003	0
BANGKOK NOI	0	50391	20003	5001
RANGSIT	0	0	0	0
SOUTH BANGKOK	0	0	0	0
SAMPHRAN 1	0	0	0	0
SOUTH THONBURI	0	0	0	0
RATCHADAPISEK	0	0	0	0
BANG KAPI	0	0	0	0
ON NUCH	0	0	0	0
LAT PHRAO	0	0	0	0
BANG PHLI	0	0	0	0
TEPARAK	0	0	0	0
CHAENG WATTHANA	0	0	0	0
WANG NOI	0	0	51598	0
CHIDLOM	0	0	0	0
SATU PRADIT	0	0	0	0
<A> S.S.	0	0	0	0
<C> S.S.	0	0	0	38230
	57544	108378	96674	55461

Local Currency-1000 US$

	1997	2001	2006	2011
NONG CHOK	9361	1898	1827	4585
SAI NOI	16200	28482	70	0
NORTH BANGKOK	0	9369	7308	0
BANGKOK NOI	0	18812	7308	1827
RANGSIT	0	0	0	0
SOUTH BANGKOK	0	0	0	0
SAMPHRAN 1	0	0	0	0
SOUTH THONBURI	0	0	0	0
RATCHADAPISEK	0	0	0	0
BANG KAPI	0	0	0	0
ON NUCH	0	0	0	0
LAT PHRAO	0	0	0	0
BANG PHLI	0	0	0	0
TEPARAK	0	0	0	0
CHAENG WATTHANA	0	0	0	0
WANG NOI	0	0	19354	0
CHIDLOM	0	0	0	0
SATU PRADIT	0	0	0	0
<A> S.S.	0	0	0	0
<C> S.S.	0	0	0	14277
	25561	58561	35867	20689

230 kV SUBSTATION COST

Foreign Currency-1000 US$

	1997	2001	2006	2011
NONG CHOK	1587	1478	1587	0
SAI NOI	3174	1587	0	1587
NORTH BANGKOK	1587	0	1587	2956
BANGKOK NOI	4761	1587	4435	27
RANGSIT	4727	1576	3151	0
SOUTH BANGKOK	10511	0	1587	0
SAMPHRAN 1	1576	0	5880	30
SOUTH THONBURI	3212	0	0	0
RATCHADAPISEK	0	3151	0	1576
BANG KAPI	5500	5493	0	15
ON NUCH	4727	30	1576	0
LAT PHRAO	0	0	6302	0
BANG PHLI	3151	0	0	1559
TEPARAK	15898	0	1576	1576
CHAENG WATTHANA	9356	1576	0	1576
WANG NOI	11217	0	30	0
CHIDLOM	0	0	0	0
SATU PRADIT	0	0	0	0
<A> S.S.	0	12084	0	0
<C> S.S.	0	0	0	14037
	80984	28562	27711	24939

Local Currency-1000 US$

	1997	2001	2006	2011
NONG CHOK	631	785	631	0
SAI NOI	1262	631	0	631
NORTH BANGKOK	631	0	631	1571
BANGKOK NOI	1893	631	2356	28
RANGSIT	1927	642	642	0
SOUTH BANGKOK	5134	0	631	0
SAMPHRAN 1	631	0	2356	55
SOUTH THONBURI	1372	0	0	0
RATCHADAPISEK	0	1262	0	631
BANG KAPI	1997	1991	0	39
ON NUCH	1927	78	642	0
LAT PHRAO	0	0	2570	0
BANG PHLI	1285	0	0	963
TEPARAK	10445	0	642	642
CHAENG WATTHANA	5057	642	0	642
WANG NOI	8635	0	78	0
CHIDLOM	0	0	0	0
SATU PRADIT	0	0	0	0
<A> S.S.	0	6522	0	0
<C> S.S.	0	0	0	9014
	42827	13184	11179	14216

(2) NONG CHOK

Construction Cost except Interest during Construction (Cost in 1992, thousand baht)

Nong Chok		1997	2001	2006	2011
230 kV	FC	39677	36955	39677	0
	LC	15769	19636	15769	0
500 kV	FC	610617	126736	125017	305752
	LC	234019	47439	45678	114624
TOTAL		900082	230765	226141	420376

Direct Cost (Cost in 1992, thousand baht)

Nong Chok		1997	2001	2006	2011
230 kV	FC	35934	33340	35934	0
	LC	4929	6535	4929	0
500 kV	FC	554279	114792	113275	277764
	LC	53127	12762	11979	24252
TOTAL		648269	167429	166117	302016

Indirect Cost (Cost in 1992, thousand baht)

Nong Chok	1997	2001	2006	2011
230 kV	14583	16716	14583	0
500 kV	237230	46621	45441	118360
TOTAL	251813	63337	60024	118360

(3) SAI NOI

Construction Cost except Interest during Construction (Cost in 1992, thousand baht)

Sai Noi		1997	2001	2006	2011
230 kV	FC	79354	39677	0	39677
	LC	31540	15769	0	15769
500 kV	FC	1012148	858722	1719	0
	LC	375737	318013	1762	0
TOTAL		1498779	1232181	3481	55446

Direct Cost (Cost in 1992, thousand baht)

Sai Noi		1997	2001	2006	2011
230 kV	FC	71867	35934	0	35934
	LC	9859	4929	0	4929
500 kV	FC	918945	779563	1517	0
	LC	83702	71476	783	0
TOTAL		1084373	891902	2300	40863

Indirect Cost (Cost in 1992, thousand baht)

Sai Noi	1997	2001	2006	2011
230 kV	29168	14583	0	14583
500 kV	385238	325696	1181	0
TOTAL	414406	340279	1181	14583

(4) NORTH BANGKOK

Construction Cost except Interest during Construction (Cost in 1992, thousand baht)

North Bangkok		1997	2001	2006	2011
230 kV	FC	39677	0	39677	73908
	LC	15769	0	15769	39277
500 kV	FC	0	610892	500073	0
	LC	0	234226	182704	0
TOTAL		55446	845118	738223	113185

Direct Cost (Cost in 1992, thousand baht)

North Bangkok		1997	2001	2006	2011
230 kV	FC	35934	0	35934	66680
	LC	4929	0	4929	13073
500 kV	FC	0	554529	453102	0
	LC	0	53177	47914	0
TOTAL		40863	607706	541879	79753

Indirect Cost (Cost in 1992, thousand baht)

North Bangkok	1997	2001	2006	2011
230 kV	14583	0	14583	33432
500 kV	0	237412	181761	0
TOTAL	14583	237412	196344	33432

(5) BANGKOK NOI

Construction Cost except Interest during Construction (Cost in 1992, thousand baht)

Bangkok Noi		1997	2001	2006	2011
230 kV	FC	119031	39677	110863	670
	LC	47314	15769	58911	689
500 kV	FC	0	1259853	500073	125017
	LC	0	470305	182704	45678
TOTAL		166345	1785604	852551	172054

Direct Cost (Cost in 1992, thousand baht)

Bangkok Noi		1997	2001	2006	2011
230 kV	FC	107801	35934	100020	591
	LC	14789	4929	19607	309
500 kV	FC	0	1142979	453102	113275
	LC	0	111551	47914	11979
TOTAL		122590	1295393	620643	126154

Indirect Cost (Cost in 1992, thousand baht)

Bangkok Noi	1997	2001	2006	2011
230 kV	43755	14583	50147	459
500 kV	0	475628	181761	45441
TOTAL	43755	490211	231908	45900

(6) RANGSIT

Construction Cost except Interest during Construction (Cost in 1992, thousand baht)

Rangsit		1997	2001	2006	2011
230 kV	FC	118164	39388	78777	0
	LC	48181	16058	32117	0
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		166345	55446	110894	0

Direct Cost (Cost in 1992, thousand baht)

Rangsit		1997	2001	2006	2011
230 kV	FC	107013	35671	71342	0
	LC	15577	5192	10384	0
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		122590	40863	81726	0

Indirect Cost (Cost in 1992, thousand baht)

Rangsit	1997	2001	2006	2011
230 kV	43755	14583	29168	0
500 kV	0	0	0	0
TOTAL	43755	14583	29168	0

(7) SOUTH BANGKOK

Construction Cost except Interest during Construction (Cost in 1992, thousand baht)

South Bangkok		1997	2001	2006	2011
230 kV	FC	262787	0	39677	0
	LC	128346	0	15769	0
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		391133	0	55446	0

Direct Cost (Cost in 1992, thousand baht)

South Bangkok		1997	2001	2006	2011
230 kV	FC	237387	0	35934	0
	LC	41919	0	4929	0
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		279306	0	40863	0

Indirect Cost (Cost in 1992, thousand baht)

South Bangkok	1997	2001	2006	2011
230 kV	111827	0	14583	0
500 kV	0	0	0	0
TOTAL	111827	0	14583	0

(8) SAMPHRAN 1

Construction Cost except Interest during Construction (Cost in 1992, thousand baht)

Samphran 1		1997	2001	2006	2011
230 kV	FC	39388	0	147009	760
	LC	16058	0	51704	1959
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		55446	0	198713	2719

Direct Cost (Cost in 1992, thousand baht)

Samphran 1		1997	2001	2006	2011
230 kV	FC	35671	0	133431	655
	LC	5192	0	10064	1145
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		40863	0	143495	1800

Indirect Cost (Cost in 1992, thousand baht)

Samphran 1	1997	2001	2006	2011
230 kV	14583	0	55218	919
500 kV	0	0	0	0
TOTAL	14583	0	55218	919

(9) SOUTH THONBURI

Construction Cost except Interest during Construction (Cost in 1992, thousand baht)

South Thonburi		1997	2001	2006	2011
230 kV	FC	80299	0	0	0
	LC	36033	0	0	0
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		116332	0	0	0

Direct Cost (Cost in 1992, thousand baht)

South Thonburi		1997	2001	2006	2011
230 kV	FC	72653	0	0	0
	LC	12673	0	0	0
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		85326	0	0	0

Indirect Cost (Cost in 1992, thousand baht)

South Thonburi	1997	2001	2006	2011
230 kV	31006	0	0	0
500 kV	0	0	0	0
TOTAL	31006	0	0	0

(10) RATCHADAPISEK

Construction Cost except Interest during Construction (Cost in 1992, thousand baht)

Ratchadapisek		1997	2001	2006	2011
230 kV	FC	0	78777	0	39388
	LC	0	32117	0	16058
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		0	110894	0	55446

Direct Cost (Cost in 1992, thousand baht)

Ratchadapisek		1997	2001	2006	2011
230 kV	FC	0	71342	0	35671
	LC	0	10384	0	5192
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		0	81726	0	40863

Indirect Cost (Cost in 1992, thousand baht)

Ratchadapisek	1997	2001	2006	2011
230 kV	0	29168	0	14583
500 kV	0	0	0	0
TOTAL	0	29168	0	14583

(11) BANG KAPI

Construction Cost except Interest during Construction (Cost in 1992, thousand baht)

Bang Kapi		1997	2001	2006	2011
230 kV	FC	137502	137318	0	381
	LC	49914	49777	0	978
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		187416	187095	0	1359

Direct Cost (Cost in 1992, thousand baht)

Bang Kapi		1997	2001	2006	2011
230 kV	FC	124742	124575	0	328
	LC	11418	11385	0	572
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		136160	135960	0	900

Indirect Cost (Cost in 1992, thousand baht)

Bang Kapi	1997	2001	2006	2011
230 kV	51256	51135	0	459
500 kV	0	0	0	0
TOTAL	51256	51135	0	459

(12) ON NUCH

Construction Cost except Interest during Construction (Cost in 1992, thousand baht)

On Nuch		1997	2001	2006	2011
230 kV	FC	118164	760	39388	0
	LC	48181	1959	16058	0
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		166345	2719	55446	0

Direct Cost (Cost in 1992, thousand baht)

On Nuch		1997	2001	2006	2011
230 kV	FC	107013	655	35671	0
	LC	15577	1145	5192	0
500 kV	FC	0	0	0	0
	LC	0	0	0	0
TOTAL		122590	1800	40863	0

Indirect Cost (Cost in 1992, thousand baht)

On Nuch	1997	2001	2006	2011
230 kV	43755	919	14583	0
500 kV	0	0	0	0
TOTAL	43755	919	14583	0