Minutes
of
42nd PCC meeting

Date: 10.05.2016
Eastern Regional Power Committee
14, Golf Club Road, Tollygunge
Kolkata: 700 033

EASTERN REGIONAL POWER COMMITTEE

MINUTES OF 42ND PROTECTION SUB-COMMITTEE MEETING HELD AT ERPC, KOLKATA ON 27.04.2016 (WEDNESDAY) AT 11:00 HOURS

List of participants is enclosed at **Annexure-A.**

PART – A

ITEM NO. A.1: Confirmation of minutes of 41st Protection sub-Committee Meeting held on 17th March, 2016 at ERPC, Kolkata.

The minutes of 41st Protection Sub-Committee meeting held on 17.03.16 circulated vide letter dated 28.03.16.

Members may confirm the minutes of 41st PCC meeting.

Deliberation in the meeting

Members confirmed the minutes of 41st PCC meeting.

PART – B

ANALYSIS & DISCUSSION ON GRID INCIDENCES WHICH OCCURRED IN CTU/STU SYSTEMS DURING MARCH, 2016.

Item No B.1. Disturbance in Odisha System

B.2.1: South Orissa system on 10-03-16 at 12:24 hrs to 12:31 hrs.

At 12:24hrs, 400KV Indravati - Rengali S/c line tripped from both ends on transient R-G fault. Auto reclose operation was successful at Indravati end but it was unsuccessful at Rengali end. Therefore, 400KV Indravati - Rengali S/c line (356 km) was hanging from Indravati (PG) s/s only.

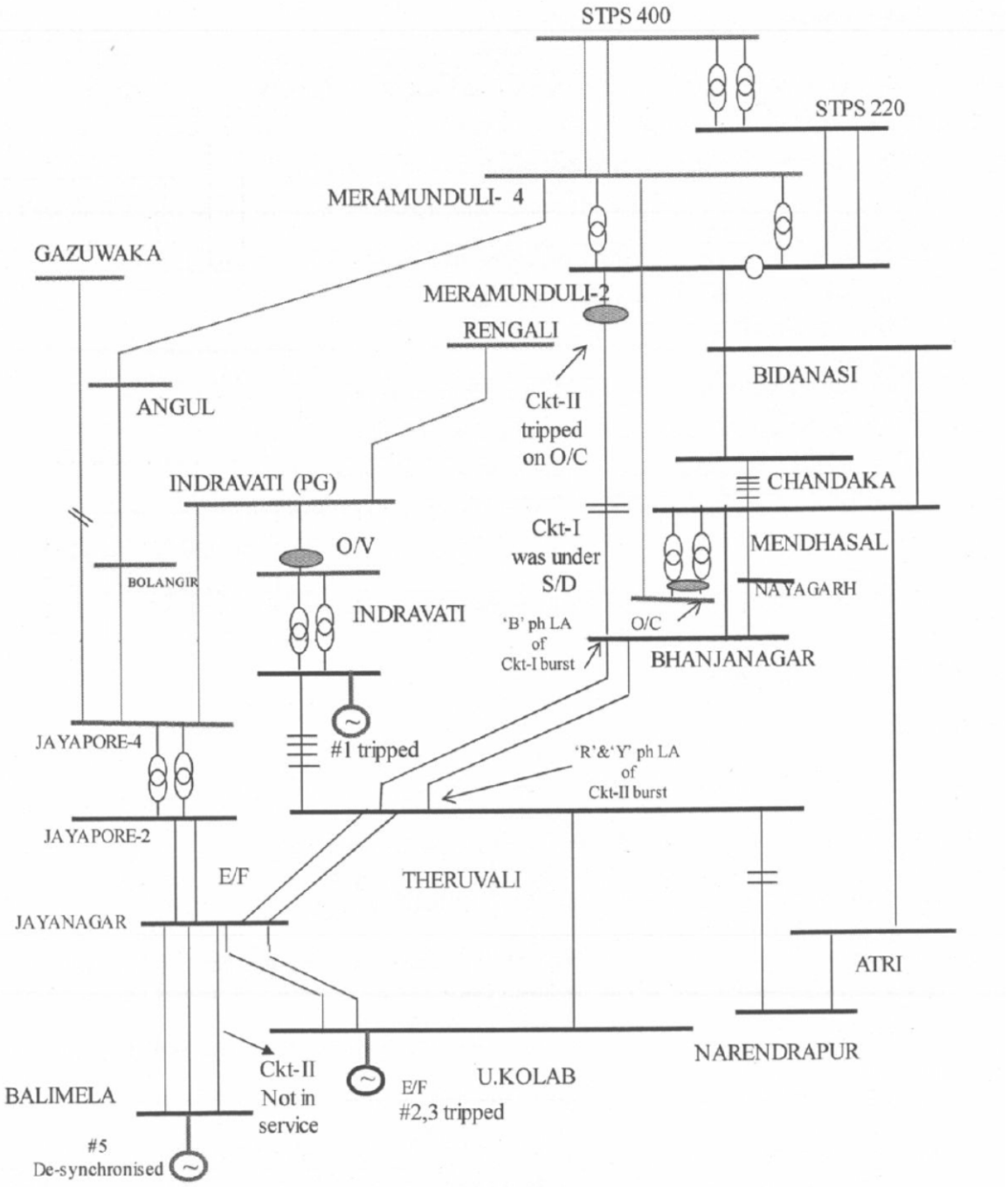
In another incidence, at 12:28:29 hrs, 400KV Bolangir-Angul S/c line tripped on transient B-G fault and auto reclose operation was successful at both the ends.

Powergrid reported that repeated power swings were observed by the relays of 400KV Angul-Bolangir line at both ends.

The following lines got tripped on over voltage:

- 400KV Jeypore-Bolangir line
- 400KV Jeypore-Gajuwaka D/C line
- 400KV Indravati-Jeypore line
- 400KV Indravati(PG)-Indravati(OHPC) line

From the SCADA data, it was observed that after tripping of 400kV Rengali- Indravati S/c line, power flow on 220kV Meramundali- Bhanjanagar-II and 315 MVA ICTs at Mendhasal has increased and tripped on overload. Subsequently, heavy jerk was observed in South Odisha system which resulted in tripping of the running units of Indravati, U.Kolab & Balimela HPS.



Relay indications are as follows:

Time	Name of the Line	Local end	Remote end
12:24:17 hrs	400KV Indravati - Rengali line	Transient Fault: 73.5Km from Indravati, 1.64kA, R-N. A/R successful at Indravati	Transient Fault: R-N A/R unsuccessful at Rengali.
12:28:29 hrs	400KV Bolangir-Angul Line	Transient Fault: 143.8Km from Bolangir, 1.13kA, B-N A/R successful	Transient Fault: B-N A/R successful
12:31:07:073 hrs	400KV Jeypore-Bolangir Line	Over Voltage Stage-1	NA
12:31:07:091 hrs	400KV Jeypore-	Over Voltage Stage-1	NA

	Gajuwaka Line - I		
12:31:07:207 hrs	400KV Jeypore-Gajuwaka Line - II	Over Voltage Stage-2	NA
12:31:13 hrs	400KV Indravati-Jeypore Line	Over Voltage Stage-1	NA
12:35 hrs	400KV Indravati(PG)-Indravati(OHPC) line at their end	Over Voltage Stage	At Indravati(O) O/V
12:29 hrs	220kV Theruvali-Indravati-II	At Theruvali Did Not Trip	At Indravati DP, Zn-I
	220kV Bhanjanagar-Meeramandali-II	At Bhanjnagar Did Not Trip	At Meeramandali O/C
	220kV Narendrapur-Mendhasal-I	At Narendrapur Zn-I, O/C	AT Mendhasal Did Not Trip
	220kV Theruvali-Narendrapur-I	AT Theruvali Did Not Trip	At Narendrapur Zn-I, O/C
	220kV Theruvali-Narendrapur-II	AT Theruvali Did Not Trip	At Narendrapur Master Trip
	400/220kV. 315 MVA ICT-I & II at Mendhasal	Tripped from 400kV side on O/C	
	220/132kV ATR-I,II & III at Narendrapur	Tripped from both side (o/f from 220kV side)	
	Indravati U #1 & Balimela U #5	Tripped	
	U.Kolab U# 2 & 3	Tripped	

Analysis of PMU data:

At 12:24 hrs,

- From Jeypore PMU plot 60kV voltage dip has been observed in R-Ph at 12:24 hrs.
- Fault clearance time was less than 100 ms and after 1000 ms Autorecloser operation was successful. This gives the clear indication of successful Autorecloser operation of 400kV Rengali- Indravati S/c line at Indravati end.

At 12:28 – 12:30 hrs,

- From Jeypore PMU plot 70kV voltage dip has been observed in B-Ph at 12:28 hrs. And after 1000 ms AR operation was successful.
- Thereafter heavy voltage oscillations was observed from Jeypore PMU plot. Voltage had drastically reduced to 250 kV.
- After 2 min Jeypore voltage had started building and it went upto 450kV.

Status of Reporting:

- PGCIL has given the tripping report on 10/03/16.
- OPTCL has given the report on 16/03/16.

Powergrid and OPTCL may explain the following:

- Powergrid may explain the reason for unsuccessful auto reclose operation at 400kV Rengali end.
- OPTCL may explain the tripping of 220kV Theruvali- Indravati line-II from Indravati end on

zone-1 distance protection.

- OPTCL may explain the tripping of 220kV Theruvali- Narendrapur D/C line from Narendrapur.
- Powergrid reported that 400kV Jeypore- Gajuwaka -II tripped on operation of over voltage Stage-II. However, from the Jeypore PMU plot voltage at Jeypore has momentarily increased up to 450 KV. Powergrid may place the overvoltage settings at 400kV Jeypore end.
- From Jeypore PMU plot and SCADA plot, ERLDC observed that the voltage at 400kV Jeypore had reduced drastically during decrease in Gajuwaka power order from 700 MW to 331 MW. Thereafter, voltage had started building with increase in Gajuwaka power order from 331 MW to 500 MW. Powergrid may explain.

Deliberation in the meeting

Powergrid explained that

- *At 12:24hrs, 400KV Indravati - Rengali S/c line tripped from both ends on transient R-G fault.*
- *During autoreclose operation, another fault (Ph-E) was occurred in the line reactor and REF protection at Rengali end operated and tripped the line.*
- *During investigation in NGR bypass system of REF the NCT-earth polarity was found reversed which is now rectified.*
- *Indravati end failed to trip as autorecloser lockout relay contact was burnt and 400KV Indravati - Rengali S/c line was hanging from Indravati end.*
- *In another incidence, at 12:28:29 hrs, 400KV Bolangir-Angul S/c line tripped on transient B-G fault and auto reclose operation was successful at both the ends.*

PCC felt that after tripping of 400KV Indravati - Rengali S/c line from Rengali end and during the auto reclose operation of 400KV Bolangir-Angul S/c line, the power flow was diverted to 220kV network of OPTCL and it caused low voltage in OPTCL system. Power flow on 220kV Meramundali-Bhanjanagar-II and 315 MVA ICTs at Mendhasal has increased and tripped on overload.

Thereafter, the Gajuwaka-Jeypore HVDC power order was reduced and it resulted in sudden severe high voltage in 400kV and 220kV network in Odisha. The following lines were tripped on high voltage:

- *400KV Jeypore-Bolangir line tripped from Jeypore end*
- *400KV Jeypore-Gajuwaka D/C line tripped from Jeypore end*
- *400KV Indravati-Jeypore line tripped from Indravati end*
- *400KV Indravati(PG)-Indravati(OHPC) line tripped from Indravati(PG) end*

OPTCL informed that that the following elements tripped

- *220/132kV ATR-I,II & III at Narendrapur were tripped on over flux protection*
- *220kV Upper Kolab-Jeynagar tripped on over voltage from Jeynagar*
- *Balimela Unit#5 was hand tripped.*
- *Upper Kolab unit#2 & 3 also tripped*

OHPC informed that after tripping of 400KV Indravati(PG)-Indravati(OHPC) line, Indravati Unit#1 was tripped on over speed protection.

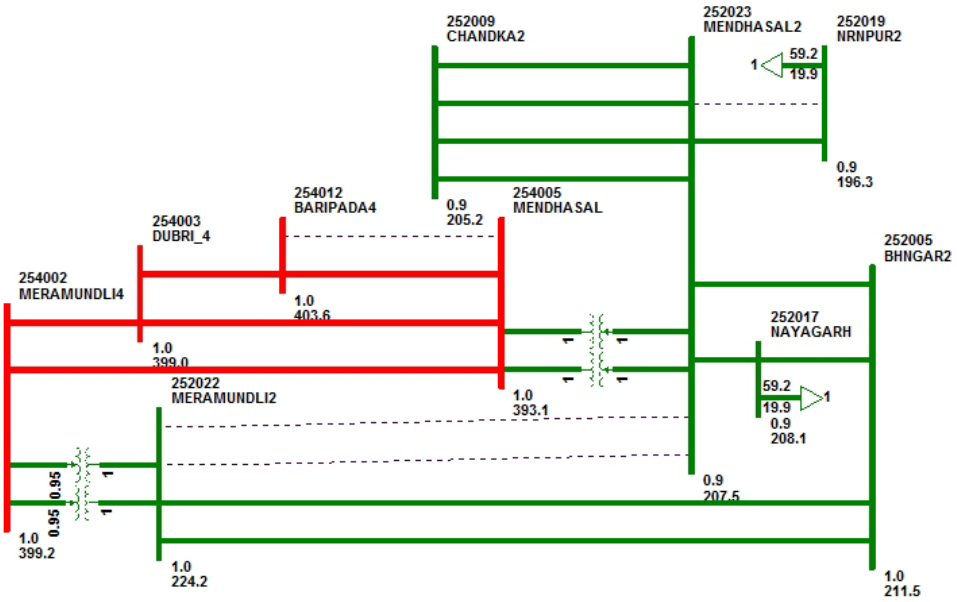
B.2.2: Total power failure at 400kV Mendhasal S/s of OPTCL system on 30-03-16 at 16:59 hrs.

At 16:59 hrs, 400kV Meeramandali- Mendhasal S/c tripped due to occurrence of SLG fault (i.e. R-N fault) from Meeramandali end.

Simultaneously, other 400kV lines emanating from Mendhasal s/s such as Mendhasal- N .Duburi S/c & Mendhasal- Baripada S/c were also tripped (relay indications not available).

After tripping of above mentioned lines, MW flow on both 400/220kV, 315 MVA ICTs at Mendhasal became zero.

400kV bus became dead at Mendhasal S/s and approx. 400 MW load loss occurred at Chandaka and its surrounded area.



Following elements tripped:

- 400kV Meeramandali- Mendhasal S/c
- 400kV Mendhasal- N. Duburi S/C
- 400kV Mendhasal - Baripada S/C
- 400/220kV , 315 MVA ICT-I & II at Mendhasal (not tripped only flow became zero)

Analysis of PMU plots:

- From the Talcher PMU plot ,15 kV voltage dip has been observed in R-Ph at 16:59:10 hrs.
- Fault clearance time was 380 ms.

Status of Reporting:

- Tripping reports are yet to be received from OPTCL.

OPTCL may explain the following:

- OPTCL may place the relay indications of all the elements.
- OPTCL may explain the tripping of 400kV Mendhasal- New Duburi S/C & Mendhasal-Baripada S/c lines.
- OPTCL may explain the status of 220kV lines during the incidence.
- Fault clearance time of approx. 380 ms is a gross violation of Clause 3(e) of CEA Grid Standards, 2010, which stipulates that any fault 400kV level should be cleared within 100 ms.

Deliberation in the meeting

OPTCL explained that

- *400kV Meeramandali- Mendhasal S/c line tripped from Meramundali end on zone 1, R-N fault and tripped from Mendhasal end on Zone 2 R-N fault.*
- *OPGW cable slang was observed at Location-272 of this line, which was causing the frequent tripping of the line. The same has been rectified.*

- *Since PLCC was not in service, the fault was cleared in zone 2 time.*
- *Thereafter, 400kV Mendhasal- N. Duburi S/C and 400kV Mendhasal - Baripada S/C lines got tripped from Mendhasal end on over voltage.*
- *OPTCL informed that they are replacing the relays at Mendhasal. The new relays have been reached to site and it will be replaced soon.*
- *OPTCL informed that no 220kV line tripped during the incidence.*

OPTCL explained that the presently the voltage is being measured from Phase to earth which might have measured high voltage during fault and caused for tripping of 400kV Mendhasal- N. Duburi S/C and 400kV Mendhasal - Baripada S/C lines on over voltage. Therefore, they have changed the relay input voltage from ph-earth to ph-ph voltage.

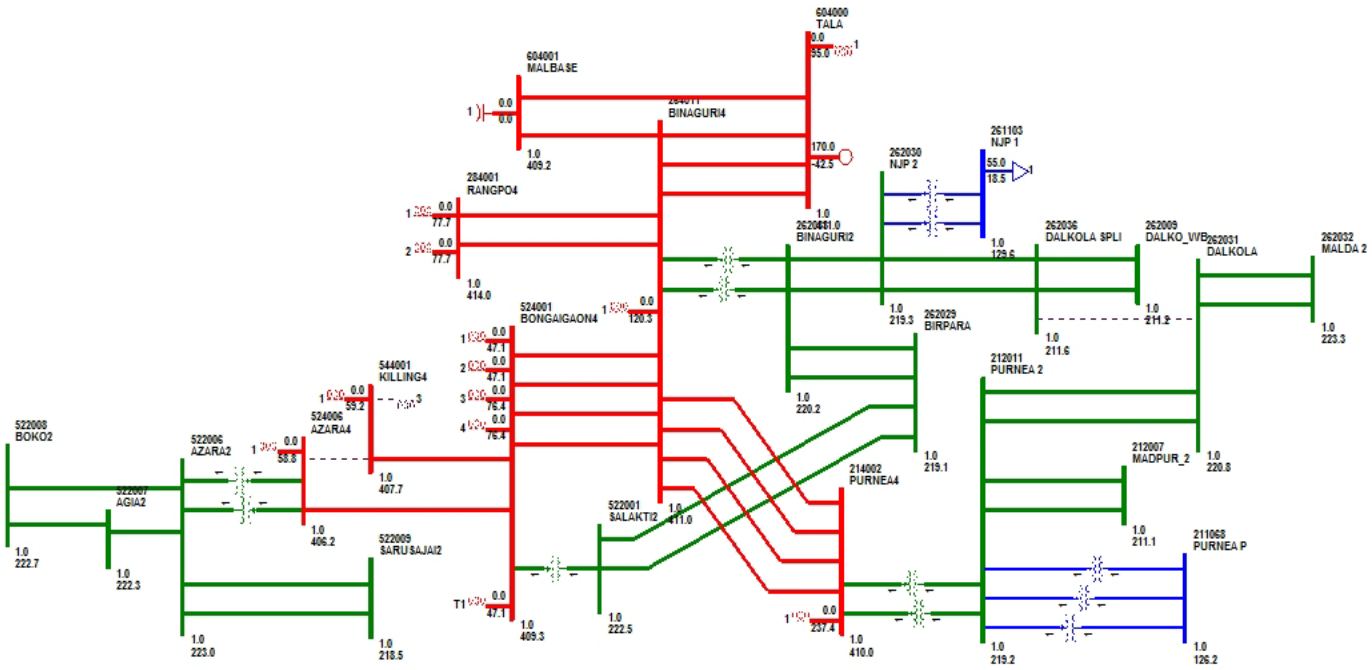
PCC felt that the voltage of other phases would increase during line-to-ground fault, if earthing of CVT secondary is improper.

PCC advised OPTCL to check the CVT secondary earthing.

OPTCL agreed.

Item No B.2. Disturbances in West Bengal System

B.2.1: Total power failure in North Bengal, Bhutan & Sikkim system on 16-03-16 at 18:09 hrs & 18:17 hrs



At 18:09 hrs, 400/220kV, 315 MVA ICT-I at Binaguri tripped from HV side due to operation of B-Ph back up over-current protection.

After tripping of 315 MVA ICT –I at Binaguri, load on 2nd ICT went upto 450 MW and tripped on actuation of over-current protection.

Subsequently following elements tripped:

Time (Hrs)	Details of tripping	Relay at local end	Relay at remote end
18:09 hrs	400/220kV, 315 MVA ICT-I at Binaguri	DIR O/C B-Phase HV Side Opt 86 B Gr B relay	

18:17 hrs	220kV Dhalkola Bus Coupler	Tripped on overcurrent
	400/220kV, 315 MVA ICT-II at Binaguri	DIR O/C B-Phase HV Side Opt 86 B Gr B relay
	Rangit U# 1, 2 & 3	Emergency shutdown & Gen. 115 % over speed
	Chukha U#1	Tripped
	All the 132kV lines emanating from Rangit S/s tripped	Tripped
Following lines were hand tripped		
	220kV Birpara- Salakati I & II	Hand tripped
	220kV Chukha- Birpara-II	
	220kV Birpara- Binaguri-I & II	
	220kV Siliguri- Binaguri –I & II	
	220kV Kishanganj- Dhalkola –I & II	
	220kV Kishanganj- Siliguri –I & II	
	220kV Birpara- NJP	
	220kV Purnea- Dhalkola D-I & II	

As per information received from NERLDC, 400/220 kV, 315 MVA ICT at Bongaigaon had also tripped on over-current protection and thereafter entire power supply to Dhaligaon & adjacent areas of Assam shifted to 220kV Azara – Agia and 220 kV Azara – Boko lines which resulted in tripping of both lines on overload.

Due to tripping of ICTs at Binaguri & Bongaigaon, significant amount of power interruption occurred in Bhutan system & North Bengal. On subsequent tripping of 132kV lines emanating from Rangit S/s along with of running units of Rangit HPS, Sikkim system was also affected.

Due to tripping of above mentioned elements approx. 550 MW load loss occurred in North Bengal, Bhutan & Sikkim system and generation loss of approx. 180 MW occurred at Chukha & Rangit HPS. But due to non-availability of details from both Sikkim & Bhutan, actual load loss and generation loss in their system could not be apprehended.

Analysis of PMU plots:
At 18:09 hrs & 18:17 hrs

- From the Binaguri PMU plot no signature of fault has been observed during the said period.

Status of Reporting:

- PGCIL has given the tripping report along with DR & EL on 17/03/16.
- NHPC (Rangit) has given the tripping report on 17/03/16.
- Reports are yet to be received from WBSETCL, Bhutan & Sikkim.

Powergrid, WBSETCL, Bhutan and Sikkim may explain the following:

- Reason for tripping of 315 MVA ICT-I at Binaguri on operation of back up over-current protection may be explained by PGCIL.

- Reason for tripping of 400/220 kV, 315 MVA ICT at Bongaigaon.
- Over-current setting of 220kV Dhalkola bus coupler may be explained by PGCIL.
- Bhutan & Sikkim may also explain how much load loss and generation loss had actually occurred in their system.
- West Bengal, Sikkim may furnish the amount of energy unserved during the incident.

Deliberation in the meeting

Powergrid explained that

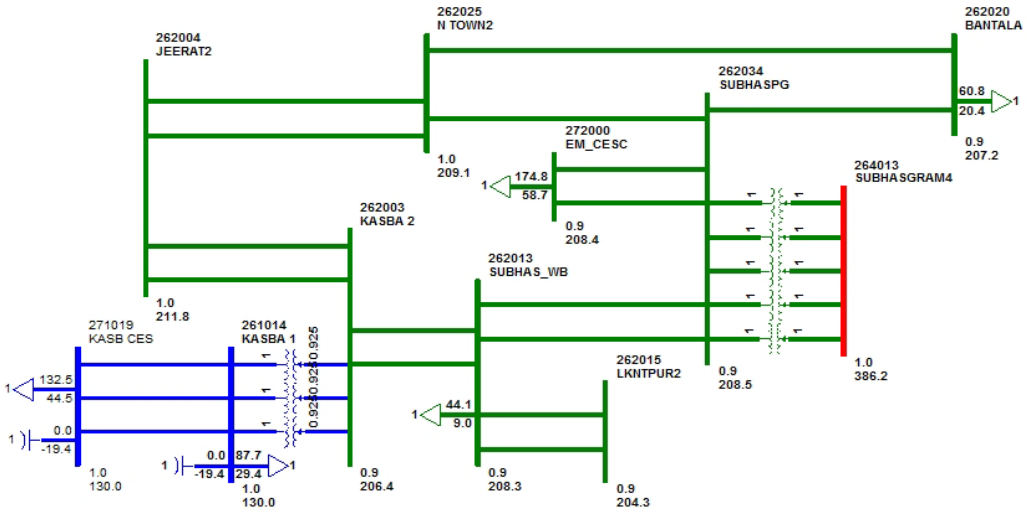
- *315 MVA, 400/220kV ICT at Malbase was tripped on B-N fault at 16:05 hrs and at 18:03 hrs bus coupler at 220kV Dalkhola was opened.*
- *This resulted in over loading of 400/220kV, 315 MVA ICT-I at Binaguri and tripped on B-ph static back up over current relay at 18:09 hrs.*
- *Powergrid explained that the setting of over current relay is at 110% of full load current.*
- *After tripping of ICT-I, the loading of ICT-II increased to 450 MW and it was tripped on actuation of over current protection at 18:17 hrs.*
- *Powergrid explained that the over current setting of ICT-II is 150% hence it was sustained for more time than ICT-I.*
- *Powergrid mentioned that the over current setting of 220kV Dhalkola bus coupler is PMS = 0.25, CTR = 600/1.*

WBSETCL informed that the backup over current setting of 400/220kV, 315 MVA ICT-I may be increased for sustained operation during emergencies.

Powergrid agreed to look into it.

B.2.2: Disturbance in 220kV WBSETCL & CESC on 01-03-16 at 09:31 hrs.

At 09:31 hrs, all the 220kV lines connected to Main Bus-I of Subhasgram (PG) S/s (i.e. 220kV Subhasgram (PG) - Subhasgram (WB) D/C, Subhasgram (PG) - CESC-II & Subhasgram (PG) - New Town S/c) tripped due to mal-operation of LBB protection. At 09:39 hrs, 220kV Jeerat- Kasba line-I tripped on zone 1, Y-ph fault from both ends but 220kV Jeerat- Kasba line-II was tripped from Jeerat end only on indication of Z-I, Y-Ph.



After tripping of 220kV Subhasgram(PG)-Subhasgram (WB) D/c and 220kV Jeerat-Kasba D/c lines, part of WBSETCL network along with CESC system got isolated from the ER grid and around 180 MW power was being exported to the part of WBSETCL network from CESC's EM Substation through 132 KV EMSS (CESC) – Kasba (WBSETCL) circuits.

Hence, the frequency of the CESC System sharply dipped to 47.7 Hz leading to load shedding of

around 200 MW within CESC's network through UFR operation at various Substations.

At the same time, 132 kV Bus Coupler- I at EMSS tripped through SPS for Islanding Scheme (triggered by U/F relay at 47.8 Hz) by which the CESC system has finally isolated from WBSETCL System.

Due to loss of 200 MW (load shedding through U/F relays) & 180 MW of WBSETCL load (due to final isolation of WBSETCL Kasba S/S from CESC system) caused sudden rise of frequency in islanded CESC system which was arrested by reduction of Budge-Budge generation through operation of HP/LP bypass system. Later CESC System was synchronized at WBSETCL Howrah Point at 09:46 hrs.

The following elements were tripped during the disturbance:

Time (Hrs)	**Details of tripping**	**Relay at local end**	**Relay at remote end**
09:31 hrs	220kV Subhasgram (PG)- Subhasgram (WB) D/C	Due to Maloperation of LBB at 220kV Main Bus- I of Subhasgram(PG)	
	220kV Subhasgram-CESC –II		
	220kV Subhasgram-Newtown S/c		
09:39 hrs	220kV Jeerat- Kasba-I	At Jeerat 186A,186B,86T-(3 nos.),AUXILIARY RELAY-A,86, 86ABC, Y-Ph, 40k.m.	At Kasba Y-Ph, Z-1,86,10.6 K.M.
	220kV Jeerat- Kasba-II	At Jeerat 86B (2Nos.),186(3Nos), Z-1,Y-ph, 35.40K.M.	At Kasba Did Not Trip

Analysis of PMU plots:

At 09:39:34 hrs

- From the Durgapur PMU plot 5kV voltage dip was observed in Y-Ph.
- Fault clearance time was less than 100 ms.

At 09:39:35 hrs

- From the Durgapur PMU plot 4kV voltage dip was observed in both Y & B-Ph respectively.
- After 1000 ms further 4kV dip has been observed in both Y & B-Ph respectively.
- Fault clearance time was less than 100 ms.

Status of Reporting:

- WBSETCL has given the preliminary tripping report on 03/03/16.
- CESC has given the detailed tripping report along with DR status on 03/03/16.
- Tripping reports are yet to be received from PGCIL.

Powergrid, WBSETCL and CESC may explain the following:

- Powergrid may explain the reason for mal-operation of LBB protection of 220kV Main Bus-I

at Subhasgram (PG).

- WBSETCL may explain the tripping of 220kV Jeerat- Kasba D/C line.
- Moreover, from the Durgapur PMU plot signature of Y-B Ph-Ph fault has been observed at 09:39:35:400 hrs and after 1000 ms further dip has been observed in both Y & B-Ph. This shows the clear indication of Auto-recloser lock out. WBSETCL may explain whether Auto-recloser scheme has also enabled for Ph-Ph fault in their system for particular lines.
- CESC may explain the operation of islanding of CESC system.
- WBSETCL and CESC may furnish the amount of energy un-served due to this incident.

Deliberation in the meeting

Powergrid informed that this incidence was happened while carrying out the DCRM testing of line circuit breaker at 400kV Subhasgram S/s. Powergrid explained that only line isolator was opened and they kept the bus isolator in closed while carrying out the testing.

Regarding tripping of 220kV Jeerat- Kasba D/c lines, WBSETCL explained that 220kV Jeerat-Kasba Line-I tripped from both ends on zone 1, Y-N fault. Thereafter, 220kV Jeerat- Kasba Line-II tripped from Jeerat end only on B-ph Zone 1 protection. WBSETCL informed that even though the B-ph PT fuse failed, the Micom P442 is showing 20 V secondary voltage and this resulted in tripping of the line-2. WBSETCL added that the issue of malfunction of Micom P442 has been referred to relay manufacturer.

PCC felt that bus isolator should also kept open while carrying out the line maintenance and the LBB link of particular breaker should also kept open in order to avoid the unwanted operation of LBB during breaker maintenance. Moreover, Powergrid kept both the 220kV Subhasgram (PG)-Subhasgram (WB) D/C lines in Main Bus-I which resulted in isolation of CESC system from 220kV Subhasgram (PG) on operation of LBB protection.

PCC viewed that such operating practice followed by Powergrid needs to be avoided and advised Powergrid to take care in future.

Powergrid assured.

ERLDC informed that after tripping of 220kV Subhasgram (PG)- Subhasgram (WB) D/C at 09:31 hrs, WBSETCL should have reduced the load in around 220kV Kasba S/s so that CESC system could survive with 220kV Kasba S/s.

WBSETCL agreed to take in future.

B.2.3: Total Power failure at 220kV Kasba S/s of WBSETCL system on 19-03-16 at 16:53 hrs.

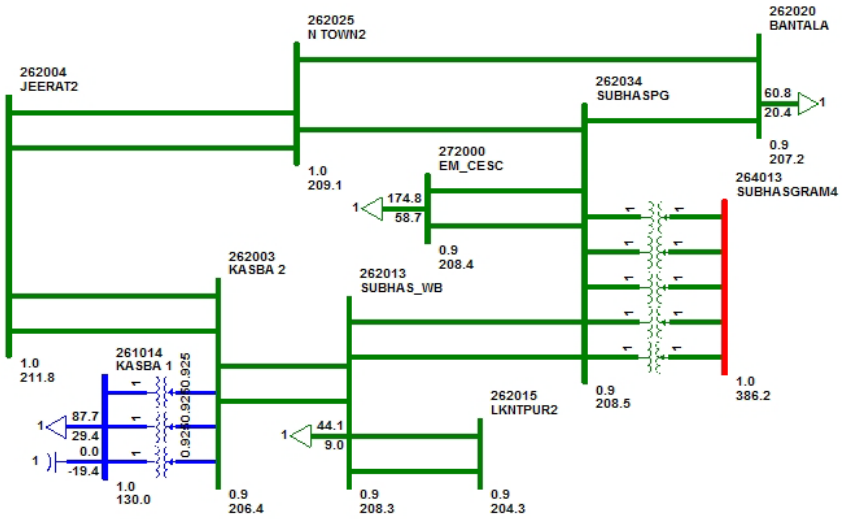
At 16:53 hrs, SLG (i.e R-N) fault occurred in 220kV Jeerat- Kasba –II near to Kasba but Kasba end failed to clear the fault. Subsequently, 220kV Jeerat-Kasba-I, Subhasgram (PG)- Subhasgram (WB) D/C & Subhasgram (PG)- Bantala S/C lines tripped on directional earth fault relay.

CESC got separated from West Bengal system and later it was synchronized at Howrah Point at 17:03 hrs.

Relay indications are as follows:

Time (Hrs)	Details of tripping	Relay at local end	Relay at remote end

16:53 hrs	220kV Jeerat- Kasba-II	<u>At Jeerat</u> Fault location from Jeerat 58.26 km towards Kasba, Fault Current- 2.24 KA, R-N fault, Fault Duration - 344.06 Ms (informed by PGCIL)	<u>At Kasba</u> Information not available
	220kV Jeerat- Kasba-I	Tripped (But from which end not mentioned)	
	220kV Subhasgram (PG)- Subhasgram (WB) D/C	<u>At Subhasgram (PG)</u> directional earth fault relay picked up	<u>At Subhasgram (WB)</u> Did Not trip
	220kV Subhasgram(PG)- Bantala S/c	<u>At Subhasgram (PG)</u> directional earth fault relay picked up	<u>At Bantala</u> Did Not trip



Analysis of PMU plots:

- 12kV voltage dip has been observed in R-Ph at 16:53:24 hrs from the Durgapur PMU plot.
- Fault persistence time was 340 ms.

Status of Reporting:

- PGCIL has given the preliminary tripping report through mail on 23/03/16.
- Reports are awaited from both WBSETCL & CESC.

Powergrid, WBSETCL and CESC may explain the following:

- WBSETCL may explain any delayed clearance of the fault in 220kV Jeerat- Kasba Ckt-II from Kasba end.
- WBSETCL may place the status of 220kV Subhasgram (WB)- Kasba D/c line at Subhasgram (WB) end which was supposed to clear the fault in zone 3.
- Powergrid may place the relay settings of backup earth fault protection of 220kV Subhasgram (PG) - Subhasgram (WB) D/C and 220kV Subhasgram(PG)- Bantala at Subhasgram (PG) end. Powrgrid may explain the tripping of above lines on backup protection as the fault clearance time was 340 ms.
- CESC may explain separation of their system from WBSETCL system at Kasba.
- WBSETCL may also explain how much load loss had actually occurred in their system and also furnish the energy unserved data during the said period.
- Fault clearance time of approx. 340 ms is a gross violation of Clause 3(e) of CEA Grid Standards, 2010, which stipulates that any fault at 220/132KV level should be cleared within

160 ms.

Deliberation in the meeting

WBSETCL informed that 220kV Kasba-Subhasgram(WB) D/C lines were tripped from Subhasgram(WB) on zone 2 distance protection.

PCC felt that the 220kV Subhasgram (PG)- Subhasgram (WB) D/C and 220kV Subhasgram(PG)-Bantala S/c should not trip on directional earth fault protection as the fault was already cleared from Subhasgram(WB) end. Proper relay coordination between Powergrid, WBSETCL and CESC is necessary to avoid such unwanted tripping of the lines.

PCC decided to convene a separate meeting with Powergrid, WBSETCL and CESC at ERPC Conference Hall on 3rd May, 2016 at 11:30 hrs.

Powergrid, WBSETCL and CESC agreed to attend the meeting with necessary details.

B.2.4: Multiple elements tripping at 400kV Bidhannagar S/s of WBSETCL system on 30-03-16 at 16:25 hrs.

At 16:25 hrs, R-Ph CT connected to Bus-A of bus coupler bay at 400kV Bidhannagar S/s busted due to the inclement weather condition. All the elements connected to the Bus-A were tripped from remote end. Simultaneously, the bus differential protection of Bus-B had operated and tripped all the elements connected to Bus-B of 400kV Bidhannagar S/s from local end. 400kV bus became dead at Bidhannagar.

Disposition of feeders at 400kV Bidhannagar S/s

Bus-A
400KV BIDHANNAGAR- PPSP-1
400KV BIDHANNAGAR-DURGAPUR-1
315MVA TR-1

Bus-B
50MVAR REACTOR
400KV BIDHANNAGAR-ARAMBAG
400KV BIDHANNAGAR-DURGAPUR-2
400KV BIDHANNAGAR-PPSP-2
315MVA TR-2

400KV BUS COUPLER: ON

The relay indications are as follows:

Time	Name of Bay/ Line	Local end relay	Remote end Relay
16:25 hrs	BUS COUPLER	i)87M2R(Main Bus 2 differential protection relay) ii)87 CR (check Zone protection relay)	_
	315MVA TR-1	67XAB(O/C ,E/F) 67R-LV (time) DIR B/U O/C PRTN	DIR O/C OPERTED
	400kV Bidhannagar- -Durgapur -2	96 relay operated	DIRECT TRIP
	315MVA TR-2	96 OPERATED (HV side)	--
	400kV Bidhannagar- -PPSP-2	96 OPERATED	Did not Trip
	400kV Bidhannagar-Arambagh	96 OPERATED	Did not Trip
	50MVAR BUS REACTOR	96 OPERATED	_
	400kV Bidhannagar-	Did not Trip (hand trip)	R-N, 100%, dist-185Km, Z-II & III ,

	PPSP-1		FD1, 86A
	400kV Bidhannagar-Durgapur-1	Did not Trip (hand trip)	Main -1:- Dist-13.36km, R-7.809KA, Y-7.9KA, B-1.28KA Main –II: dist 11KM, 7.9KA, R-phase E/F

Analysis of PMU plots:

- 40 kV voltage dip has been observed in R-Ph at 16:25:04 hrs from the Jamshedpur PMU plot.
- Fault clearance time was 380 ms.

Status of Reporting:

- WBSETCL has given the tripping report on 02/04/16.
- Tripping reports are yet to be received from PGCIL.

WBSETCL may explain the following:

- Non-operation of bus-bar protection of Bus-A at 400kV Bidhannagar S/s.
- Operation of bus differential protection of Bus B instead of Bus A at 400kV Bidhannagar S/s
- Load loss and generation loss occurred due to the incident.

Deliberation in the meeting

WBSETCL informed that R-Ph CT of bus coupler bay at 400kV Bidhannagar S/s busted due to the inclement weather condition. The bus differential protection of Bus-B was operated and all the elements connected to the Bus-A were tripped from remote end.

PCC felt that since the fault was in common zone of the bus differential protection, the differential protection for both Bus-A & B should have operated to clear the fault immediately.

PCC advised WBSETCL to check the bus differential scheme at 400kV Bidhannagar S/s.

Item No B.3. Disturbance at 220/132kV Waria S/s of DVC system on 09-03-16 at 23:47 hrs

At 23:47 hrs, Y-Ph pole of GT CB was stuck while desynchronizing of Waria (DTPS) U#4 due to boiler tube leakage. In order to isolate the unit (to prevent motoring mode operation), 220kV Bus at Waria S/s was made dead by opening the following elements manually:

- 220kV Waria- Mejia D/C (manually opened)
- 220kV Waria- Parulia D/C (manually opened)
- 220kV Waria- Bidhannagar D/C (manually opened)
- 220/132kV ATRs-I,II & III at Waria (manually opened)

Due to above mentioned incident, industrial load of approx. 40 MW of ASP got interrupted as well as 20 MW local loads at 33kV level. Traction power of approx. 20 MW at Waria had also interrupted but it was immediately normalized by feed extension from respective remote ends of Kalyaneswari & Burdwan S/s.

Status of Reporting: DVC has given the preliminary tripping report through mail on 11/03/16.

DVC may explain.

Deliberation in the meeting

DVC informed that Y-Ph pole of GT CB was stuck while desynchronizing of Waria (DTPS) U#4 due to boiler tube leakage. The LBB and Bus Bar protections were not available due to some problem in VAJC relays, which are under replacement. 220kV Bus at Waria S/s was made dead by opening the connected lines.

DVC informed that GT CB has been tested found satisfactory.

Item No B.4. Total power failure at 400/220kV Muzaffarpur S/s of PGCIL on 01-03-2016 at 17:55 hrs.

At 17:55 hrs, 400/220kV, 315 MVA ICT-II at Muzaffarpur tripped due to mal-operation of auxiliary trip relay. This lead to subsequent tripping of 500 MVA ICT- III on over current due to overloading which resulted in total power interruption at 400/220/132kV Muzaffarpur S/S & its surrounded area. As observed from SCADA data 315 MVA ICT-I at Muzaffarpur (PG) was under shutdown and power flow in ICT-II & III was 600 MW just before the incidence. The relay indications are as follows:

Time (Hrs)	Details of tripping	Relay at local end	Relay at remote end
17:55 hrs	400/220kV , 315 MVA ICT-II	Maloperation of Auxiliary Trip relay (Verbally informed by PG)	
	400/220kV , 500 MVA ICT-III	Overcurrent from HV side (Verbally informed by PG)	

Analysis of PMU plots: No fault was observed in Biharshariff PMU plot.

Status of Reporting: Tripping report is yet to be received from Powergrid.

Powergrid may explain.

Deliberation in the meeting

Powergrid informed that 400/220kV, 315 MVA ICT-II at Muzaffarpur was tripped due to mal-operation of auxiliary trip relay. The relay has been tested and no abnormality found.

PCC advised Powergrid to replace the auxiliary relay.

Item No B.5. Multiple elements tripping due to heavy fire hazard at 765kV Jharsuguda S/s of PGCIL on 10-03-16 at 06:49 hrs.

At 06:49 hrs, control supply (AC & DC) failed at 765kV Jharsuguda S/s due to heavy fire in cable trench. Hence all the 765kV lines emanating from Jharsuguda S/s along with 765/400kV, 1500 MVA ICT –I & II at Jharsuguda were switched off manually.

Following elements were tripped manually:

- 765kV Angul- Jharsuguda D/C
- 765kV Jharsuguda- Dharamjaygarh D/C
- 765/400kV , 1500 MVA ICT-I & II at Jharsuguda

Due to opening of above mentioned feeders neither load loss nor generation loss had reported at Jharsuguda S/s and its surrounded area.

Status of Reporting: Tripping report is yet to be received from Powergrid.

Powergrid may explain.

Deliberation in the meeting

Powergrid informed that the control cables were damaged due heavy fire in cable trench. The damaged cables have been replaced.

Item No B.6. Tripping of 400kV Subhasgram(PG)-Haldia Line I & II due to over voltage.

CESC vide letter dated 12.04.16 informed that 400kV Subhasgram(PG)-Haldia Line I & II tripped on 9-02-2016 at 03:37 hrs due to over voltage at 400kV Subhasgram(PG) S/s. This has caused tripping of both HEL units. However, 400kV Sagardhigi-Subhagram(PG) line was not tripped for the over voltage.

CESE requested for review of over voltage relay setting of 400kV Subhasgram(PG)-Haldia Line I & II at Subhasgram(PG) to avoid simultaneous tripping of both the lines.

Present setting: 110% with 5 sec delay for both the lines
Revised setting: 112% and 110% with 5 sec delay for line I & II respectively.

Powergrid and CESC may explain and Members may decide.

Deliberation in the meeting

Powergrid and CESC informed that the settings have been revised.

Item No B.7. Frequent Blackouts at Kanti TPS

On 7th April, 2016, total station power failure (Blackout) incident has occurred at Kanti TPS. There was some fault at 220KV Gopalganj side from Kanti TPS Switchyard and 220kV Muzaffarpur-Kanti D/C line tripped on Zone 3 before fault was cleared from Kanti TPS end. This had resulted in total power failure at Kanti TPS leading to Emergency situation with hot turbine coasting down without normal lub oil supply.

A special meeting was convened at ERPC, Kolkata on 18-04-2016 and the following decisions were taken:

a) As a temporary measure, zone 1 and zone 2 time setting of all 220kV and 132kV lines at Kanti TPS end should be changed to instantaneous and zone 3 time setting as 200ms in order to clear the downstream faults from Kanti TPS end.
b) Powergrid was advised to change the zone 3 time settings at Muzaffarpur (PG) end as per protection philosophy of ERPC.
c) NTPC and Powergrid were advised to activate the PLCC scheme for 220kV Muzaffarpur-Kanti D/C by 26th April, 2016 and give feedback in 42nd PCC Meeting.
d) On activation of PLCC system, Powergrid is to change the zone 2 time setting at Muzaffarpur (PG) end as per protection philosophy of ERPC.
e) BSPTCL was advised to check the clearance between cross arm and jumper and rectify if required.
f) BSPTCL was advised to review the protection system and relay coordination of 220kV Gopalgunj, Darbhanga and Begusarai and all 132kV feeders in around Kanti. Therefore, BSPTCL was advised to submit their relay details to Powergrid by 22nd April, 2016 for review. Powergrid was requested to study the details and give feedback in 42nd PCC Meeting scheduled to be held on 27th April, 2016.
g) It was decided that the above temporary measure will be followed, till BSPTCL protection

system is full proof.

h) Further course of action will be decided in PCC Meeting for relay coordination in BSPTCL system in and around Kanti TPS.

Members may update.

Deliberation in the meeting

Kanti TPS, NTPC informed that zone settings at their end have been revised as per the recommendation. Regarding activation of PLCC scheme for 220kV Muzaffarpur-Kanti D/C line NTPC informed that cabling has been done but some parts in PLCC panels were defective and needs to be replaced.

Powergrid informed that they have not yet revised the zone 3 time setting at Muzaffarpur (PG) end.

PCC advised Powergrid to revise the zone 3 time setting at Muzaffarpur (PG) end as per protection philosophy of ERPC at the earliest.

PCC also advised Powergrid to implement the PLCC scheme for 220kV Muzaffarpur-Kanti D/C line at the earliest.

Item No B.8. Tripping incidences in the month of March, 2016

Other tripping incidences occurred in the month of March, 2016 which needs explanation from constituents of either of the end is given at **Annexure- B.8.**

Members may discuss.

Deliberation in the meeting

Members explained the tripping incidences. Updated list is enclosed at **Annexure- B.8***.*

Item No B.9. Protection Committee visit to BSPTCL and JUSNL Sub-stations

In view of repeated uncoordinated trippings in BSPTCL and JUSNL systems, a committee of following protection engineers was formed to review the situation:

- Shri Sabyasachi Roy, ACE, WBSETCL,
- Shri L Nayak, GM, OPTCL
- Shri Jayanta Datta, SE, DVC
- Shri Surajit Bannerjee Asst GM, ERLDC,
- Shri S. K. Singh, DGM, PGCIL (in place of Shri J. Das, PGCIL)
- Shri S. B. Prasad, ESE, BSPTCL
- Shri Vidyasagar Singh, ESE, JUSNL

PCC needs the following information in respect of Chandil, Ramchandrapur, Adityapur and adjoining substations in Jharkhand and New Purnea, Madhepura, Biharshariff and adjoining substations in Bihar.

1. SLD of all the affected and surround Sub-station (with CT location)
2. Year of manufacture of all equipments
3. Comprehensive CT details along with name plate (with connected/adopted ratio)
4. VT details
5. Fault level- 3-phase as well as 1-phase (line length, conductor details and Transformer details for computing fault level)
6. Transformer detail (Rating, impedance)

7. Availability of Auto-Reclosure feature
8. Availability of carrier protection
9. Availability of Bus- differential and LBB Protection
10. Junction Box (JB) details
11. Cable details used for CT connections (Cross section/core of cable, Junction Box (JB) details & length of cable between JB & control panel)
12. Grid earthing resistance (With latest test report)
13. Breaker details (operating time)
14. CT/PT earthing details
15. Relay details (Relay type, model, settings, manufacturing, basis of settings)
16. Scheme adopted for protection settings for lines and transformers
17. DC system details with charger and battery

In a special meeting held on 8th December, 2015 and PCC meetings, BSPTCL and JUSNL advised to submit the pending details.

BSPTCL and JUSNL have submitted the details.

In 41st PCC, the Protection team has presented a preliminary study report regarding the data as submitted by JUSNL and BSPTCL.

As decided in PCC, a special Meeting was convened on 29th Mar, 2016 to review the data submitted by BSPTCL & JUSNL and also to discuss the road map for the site visit.

JUSNL and BSPTCL had submitted all the requisite data as desired by the Protection Team. The observations as submitted by Protection team in its preliminary study were discussed in detail. The remedial action taken by JUSNL and BSPTCL was reviewed by the protection team and recommendations were advised. The minutes of the meeting is already available at ERPC website.

The protection team advised JUSNL and BSPTCL to initiate the implementation of the recommendations however, the final report with recommendations will be given after the complete study and site visit of the listed sub-stations. It was also decided that the team will start the site visit from the month of April, 2016. The site visit plan will be formulated in consultation with the team members and will be intimated to JUSNL and BSPTCL in due course.

BSPTCL and JUSNL may update.

Deliberation in the meeting

PCC decided that the protection committee members will carry out the site visit of JUSNL substations during 11th to 14th May, 2016 to review the protection system in respect of Chandil, Ramchandrapur, Adityapur and adjoining substations.

Item No B.10. PROTECTION PHILOSOPHY OF EASTERN REGION

The Protection Philosophy finalized in special PCC meeting held on 20th July, 2015 is as given below:

Sl. No.	Zone	Direction	Protected Line Reach Settings	Time Settings (in Seconds)	Remarks
1	Zone-1	Forward	80%	Instantaneous (0)	As per CEA
2a	Zone-2	Forward	For single ckt- 120 % of the protected line	0.5 to 0.6 - if Z2 reach overreaches the 50% of the shortest line ; 0.35- otherwise	As per CEA
			For double ckt- 150 % of the protected line		As per CEA
2b	Zone-2	Forward	120 % of the protected line, or	0.35	As per CEA with

	(for 220 kV and below voltage Transmission lines of utilities)		100% of the protected line + 50% of the adjacent shortest line		minor changes
3	Zone-3	Forward	120 % of the (Protected line + Next longest line)	0.8 - 1.0	As per CEA
4	Zone-4	Reverse	10%- for long lines (for line length of 100 km and above) 20%- for shot lines (for line length of less than 100 km)	0.5	As per CEA

Note:

1) **Zone-2:- Z2 Reach should not encroach the next lower voltage level.**
2) **Zone-3:- If Z3 reach encroaches in next voltage level (after considering "in-feed"), then Z3 time must be coordinated with the fault clearing time of remote end transformer.**
3) **Zone-4:- If utility uses carrier blocking scheme, then the Z4 reach may be increased as per the requirement. It should cover the LBB of local bus bar and should be coordinated with Z2 time of the all other lines.**
4) **The above settings are recommended primarily (exclusively) for uncompensated lines.**

All the constituents agreed on the principles read with notes as above.

Till date DVC, WBSETCL, JUSNL, OPTCL, Powergrid (ER-I, ER-II & Odisha-Projects), NTPC, BSPTCL, NHPC, Vedanta and GMR had submitted the zone settings.

PCC advised all the other constituents to implement the revised zone philosophy and submit the settings to ERPC at the earliest.

IPPs may submit the revised zone settings data at the earliest.

Deliberation in the meeting

PCC advised all the IPPs to implement the revised zone philosophy and submit the settings to ERPC at the earliest.

Item No B.11. Third Party Protection Audit

1. Status of 1st Third Party Protection Audit:

The compliance status of 1st Third Party Protection Audit observations is as follows:

Name of Constituents	Total Observations	Complied	% of Compliance
Powergrid	54	37	68.52
NTPC	16	14	87.50
NHPC	1	1	100.00
DVC	40	26	65.00
WB	68	27	39.71
Odisha	59	38	64.41
JUSNL	34	16	47.06
BSPTCL	16	5	31.25
IPP (GMR, Sterlite and MPL)	5	5	100.00

The substation wise status of compliance are available at ERPC website (Observations include

PLCC rectification/activation which needs a comprehensive plan).

Members may update.

Deliberation in the meeting

PCC advised all the constituents to comply the pending observations at the earliest.

2. Schedule for 2nd Third Party Protection Audit:

The latest status of 2nd Third Party Protection audit is as follows:

1)	Jeerat (PG)	Completed on 15th July 2015
2)	Subashgram (PG)	Completed on 16th July 2015
3)	Kolaghat TPS (WBPDCL)-	Completed on 7th August 2015
4)	Kharagpur (WBSETCL) 400/220kV -	Completed on 7th August 2015
5)	Bidhannagar (WBSETCL) 400 &220kV	Completed on 8th September, 2015
6)	Durgapur (PG) 400kV S/s	Completed on 10th September, 2015
7)	DSTPS(DVC) 400/220kV	Completed on 9th September, 2015
8)	Mejia (DVC) TPS 400/220kV	Completed on 11th September, 2015
9)	400/220/132kV Mendhasal (OPTCL)	Completed on 2nd November, 2015
10)	400/220kV Talcher STPS (NTPC)	Completed on 3rd November, 2015
11)	765/400kV Angul (PG)	Completed on 4th November, 2015
12)	400kV JITPL	Completed on 5th November, 2015
13)	400kV GMR	Completed on 5th November, 2015
14)	400kV Malda (PG)	Completed on 23rd February, 2016
15)	400kV Farakka (NTPC)	Completed on 24th February, 2016
16)	400kV Behrampur(PG)	Completed on 25th February, 2016
17)	400kV Sagardighi (WBPDCL)	Completed on 25th February, 2016
18)	400kV Bakreswar (WBPDCL)	Completed on 26th February, 2016

Members may note.

Deliberation in the meeting

Members noted.

Item No B.12. Implementation of Protection Database Management System Project.

ERPC proposal for "Creation & Maintenance of web based protection database management system and desktop based protection calculation tool for Eastern Regional Grid" has been approved by the Ministry of Power for funding from Power System Development Fund (PSDF) vide No-10/1/2014-OM dated 07.03.2016. Subsequently, the LOA was given to PRDC and the first implementation meeting was held on 12.04.2016.

Operational load flow requisite data format is available in ERPC website.

All the constituents are requested to submit the filled formats at the earliest and co-operate for smooth implementation of the project in time bound manner.

Members may note and co-operate.

Deliberation in the meeting

PCC advised all the constituents to submit the filled formats at the earliest.

Item No B.13. Presentation on Fault Current Limiter (FCL)

A brief presentation on Fault Current Limiters (FCL) by Applied Materials**.**

Members may participate.

Deliberation in the meeting

Applied materials delivered a presentation on Fault Current Limiter. Presentation is enclosed at ***Annexure-B.13****.*

PART- C

FOLLOW-UP OF DECISIONS OF THE PREVIOUS PROTECTION SUB-COMMITTEE MEETING(S)

(The status on the follow up actions is to be furnished by respective constituents)

ITEM NO. C.1: Total power failure at 220kV Chandil S/s of JUSNL system on 24/02/16 at 16:59hrs

At 16:59hrs, the R-ph jumper of 220kV side main bus to isolator of 100 MVA, ICT-IV burnt and grounded which caused a bus fault at 220kV Chandil S/s. The following elements tripped:

Time (Hrs)	Details of tripping	Relay at local end	Relay at remote end
16:59 hrs	220 KV Chandil - Santaldih S/C	AT Chandil Zone –IV distance protection	At Santaldih Did not Trip
	220 KV Chandil – Ramchandrapur S/C	AT Chandil Zone –IV distance protection 1.184 km	At Ramchandrapur Zone-II distance protection
	220/132kV , 100 MVA ATR-III	At HV O/C , E/F	At LV O/C , E/F
	220/132kV , 100 MVA ATR-IV	At HV O/C , E/F	At LV O/C , E/F
	132 KV Chandil – Adityapur S/C	AT Chandil Did not Trip	At Adityapur O/C , E/F
	132 KV Chandil – Rajkharswan S/C	AT Chandil Did not Trip	AT Rajkharswan O/C , E/F
	132 KV Chandil – Manique S/C	AT Chandil U/V	At LV Did not Trip

220kV Chandil -Ranchi S/C and 132kV Chandil-Hatia S/C lines are under shutdown. Total load of 125 MW including 35 MW traction load was interrupted.

In 41st PCC, JUSNL explained that ---

- On 24.02.16 at 16:59 Hrs the R-ph jumper of 220kV side main bus to isolator of 100 MVA, ATR-I burnt and grounded which caused a bus fault at 220kV Chandil S/s.
- 220 kV Chandil-Santaldih tripped on Zone-IV from Chandil end only.
- 220 kV Chandil-Ramchandrapur tripped on Zone-II from Ramchandrapur end and on Zone-IV from Chandil end,
- There was a delayed tripping of ATR-I & II because of old EM relays.
- Due to delayed clearance of fault form ATRs,132kV Chandil- Adityapur & 132 kV Chandil-Rajkharswan tripped from remote end.
- 132 kV Chandil-Manique tripped on under voltage from Chandil end, however 132kV Chandil-Golmuri D/C line did not trip from either end.

PCC felt that 220 KV Chandil –Ramchandrapur S/C line should not trip on Zone-IV from Chandil end as the line has already been tripped from Ramchandrapur end on Zone-II and advised JUSNL to check & review the time settings of 220 KV Chandil –Ramchandrapur S/C line at both ends.

Further, PCC advised JUSNL to review the zone settings of Chandil and adjoining area as per the protection philosophy of ERPC as depicted in Item No B.6.

PCC also advised JUSNL to ensure the protection healthiness of 220/132 kV ATRs I & II by replacing the old EM relays.

On query WBPDCL informed that none of the protection has operated at Santaldih end of 220 kV Chandil –Santadih line.

PCC felt that Santaldih end has failed to detect the fault in zone-II and advised WBPDCL to check & review the zone settings of 220 kV Chandil –Santadih line at Santaldih end.

JUSNL and WBPDCL may update.

Deliberation in the meeting

WBPDCL informed that the settings of 220 kV Chandil –Santadih line at Santaldih end will be reviewed on opportunity shutdown.

ITEM NO. C.2: Restoration of PLCC system of 220 kV lines of JUSNL.

In 41st PCC, JUSNL informed that the following:

a) In 220 KV Chandil –Ramchandrapur line auto-reclosure has been enabled and linked with PLCC panels on 09.03.16.
b) In 220 KV Chandil –Ranchi line auto-reclosure has been enabled and termination done in PLCC panels (Auto-reclosure will be in service after testing of PLCC scheduled on 22.03.16)
c) In 220 KV Chandil –Santaldih line auto-reclosure has been enabled and termination done in PLCC panels at Chandil end but due to non-availability of PLCC panels at Santaldih(WBPDCL) end the A/R and PLCC scheme could not be activated.
d) Also in 220 KV Ramchandrapur-Joda line auto-reclosure has been enabled and termination done in PLCC panels at Ramchandrapur end but due to non-availability of PLCC panels at Joda (OPTCL) end the A/R and PLCC scheme could not be implemented.

Further, it was informed that JUSNL is ready to share their standby PLCC panels (BPL make) with WBPDCL (for Snataldih end) and OPTCL (for Joda end) to complete the PLCC schemes of both the above lines.

PCC advised WBPDCL and OPTCL to accept the JUSNL offer and implement the PLCC scheme at the earliest for both the 220 kV lines.

WBPDCL and OPTCL agreed and nominated their coordinators as follows to complete the work:

1) For 220 kV Chandil-Santaldih line:
   Sh. Amar Pal, DGM (Engg.), M.- 8336904021, e-mail: anpal@wbpdcl.co.in & Sh. Jaydeb Bhattacharyya, Sr, Manager(PS), M.- 8336904059, e-mail: jbhattacharyya@wbpdcl.co.in
2) For 220 kV Ramchandrapur-Joda line:
   Sh. L. Nayak, GM, OPTCL, M.- 943890780, e-mail: ele.lanayak@optcl.co.in

(ERPC Secretariat has issued a fax message vide no. 138 dated 21.03.2016 to JUSNL for taking up the issue with the above nominated coordinators for restoring the PLCC scheme of both the lines at the earliest.)

Subsequently, JUSNL vide letter dated 13.04.2016 has asked for consent of OPTCL and WBPDCL

for cost estimate details for further needful action.

JUSNL, OPTCL, WBPDCL may update.

Deliberation in the meeting

OPTCL informed that they have some queries regarding the AMC of the PLCC panels as these were purchased in 2006. They will communicate their queries to JUSNL.

WBPDCL informed that they are in receipt of the JUSNL letter and the decision of their higher authority will be communicated soon.

ITEM NO. C.3: Disturbance at 220/132kV NJP S/s of WBSETCL system on 29.02.16 at 03:55 hrs.

WBSETCL reported that at 03:55 hrs, 220/132kV, 160 MVA TR-I,II & III, 220kV NJP-TLDP (IV)- I & II and 220kV Binaguri (PGCIL)- NJP Bus Section-A & B were tripped due to over voltage. 220kV bus voltage was recorded as 254 kV and 132kV bus voltage was recorded as 148 kV ay NJP.

Powergrid reported that 125 MVAR bus reactor-2 tripped at Binaguri end on Y ph differential protection and reactor Buch relay/PRV/WT1/OTI trip. After physical inspection, it is observed that R & Y phase bushing was heavily cracked from Turret/Bottom and B phase bushing was totally burst and heavy oil leakage was observed.

The tripping details are as follows:

Time (Hrs)	**Details of tripping**	**Relay at local end**	**Relay at remote end**
03:55 hrs	220/132kV, 160 MVA TR-I,II & III at NJP	HV side:- Over flux, 86 L & LV side:- 86 L	
	220kV NJP-TLDP (IV)- I & II	<u>At NJP</u> High Speed 3-Ph Trip relay (86/LO), Autorecloser L/O	<u>At TLDP (IV)</u> 21 M, 23 Px, PLCC channel unhealthy, 27 RYB, 30 C, 30 D, 86 A,86 B, Autorecloser PTS switch relay
	220kV Binaguri (PGCIL)- NJP Bus Section-A & B	<u>At (NJP end)</u> Did Not Trip (as informed by WBSETCL)	<u>At PGCIL (end)</u> Trip Relay 96 BSA, 96 BSB (as informed by WBSETCL)
	125 MVAr Bus Reactor-II at Binaguri (PGCIL)	Y-Ph differential relay operated	

Analysis of PMU plots:

- No overvoltage has been observed from the Binaguri PMU plot
- From the Binaguri PMU plot 175kV dip has been in Y-Ph at around 03:55:39 hrs.
- 1.1 KA rise in line current of 400kV Binaguri- Purnea has been observed during the incident.
- Fault clearance time was approximately 80 ms.

In last PCC, WBSETCL informed that there was a high voltage at 220 kV Binaguri and NJP due to which all the ICT and 220kV Binaguri (PGCIL)- NJP Bus Section-A & B were tripped.

However, the exact cause of tripping of 220kV NJP-TLDP (IV)- I & II could not be ascertained.

Powergrid informed that as per their record there was no over voltage at Binaguri side and all equipments are intact.

PCC advised WBSETCL to get the tripping details of 220kV NJP-TLDP (IV)- I & II and submit a report on the incidence.

WBSETCL may explain.

Deliberation in the meeting

PCC advised WBSETCL to submit the report.

ITEM NO. C.4: Disturbance at 400kV Sagardighi S/s (WBPDCL) on 08/05/15 at 11:00hrs.

In 33rd PCC, it was informed that the over current settings of Powergrid feeders from Sagardighi was kept at 200 % with instantaneous trip settings which was provided by Powergrid. WBPDCL requested Powergrid to review the existing settings and advice if there is a need to change.

PCC felt that the O/C settings need to be reviewed and advised Powergrid to check the settings and provide the reviewed settings to WBPDCL for implementation of the same.

Powergrid agreed.

In 34th PCC, WBPDCL informed that they have sent the relay settings to Powergrid. PCC advised Powergrid to review the settings and send to WBPDCL.

In 36th PCC, WBPDCL informed that they received the revised settings from Powergrid.

In 37th PCC, WBPDCL informed that the revised settings will be incorporated on opportunity shutdown.

In 40th PCC, ERLDC informed that 400 kV Sagardighi- Bahrampore D/C line is an important link for power transfer to Bangladesh and in case of undesired tripping of this line the power transfer to Bangladesh may get affected.

PCC advised WBPDCL to implement the revised settings at the earliest keeping in view of un-interrupted power transfer to Bangladesh.

In last PCC, WBPDCL informed that the revised settings will be incorporated by April, 2016.
Further, WBPDCL inquired that whether the stub protection can be kept in service for this line.
PCC expressed that stub protection may be kept in service.

WBPDCL may update.

Deliberation in the meeting

WBPDCL informed that the revised settings have been incorporated.

ITEM NO. C.5: Members may update the following:

1. Powergrid informed that Bus-bar protection at 220kV Birpara S/s will be installed within 2-3 months.

In 40th PCC, Powergrid informed that Bus-bar protection at 220kV Birpara S/s will be installed by 2nd week of March 2016.

In last PCC, Powergrid informed that the testing of Bus-bar protection is expected by 25.03.2016.

Powergrid may update.

Deliberation in the meeting

Powergrid informed that the testing of Bus-bar protection is in progress.

2. OPTCL may please update the latest status on following substations:

In last PCC, OPTCL informed that

- The issue of LBB maloperation at 220kV Meeramundali S/s at 04:59hrs on 18/09/15 has been taken up with Siemens: *Siemens has checked the LBB logic and found ok*
- OPTCL informed that they will review the logic of all the newly installed LBB protection: *Exploring for improvement in logic for tripping of single bus in case of LBB operation*
- Old distance protection relays in 132kV system at 220kV Tarkera S/s will be replaced after replacing old relays at 220kV level*: The replacement work of relays at Tarkera is in progress*

OPTCL may update.

Deliberation in the meeting

OPTCL informed that the work is in progress.

Meeting ended with vote of thanks to the chair

****

Participants in 42nd PCC Meeting of ERPC

Venue: ERPC Conference Room, Kolkata Time: 11:00 hrs Date: 27.04.2016 (Wednesday)

Sl No	Name	Designation/ Organization	Contact Number	Email	Signature
1	A K Bandyopadhyay	M S, ERPC	9433068533	mserpc-power@nic.in	[signature]
2	U.K. Verma	GM, ERLDC	8902496220	ujwalkumar.verma@gmail.com	[signature]
3	P. P. BANDYOPADHYAY	DGM(SO), ERLDC	7044083323	parth_bany@yahoo.co.in	[signature]
4	P.S. Das	Asl GM(SO), ERLDC	9433041837	psdas_psd@yahoo.com	[signature]
5	S. BANERJEE	DGM (SS) ERLDC	9433041823	surajitb@gmail.com	[signature]
6	S. NAG.	DCE, CTC, DVC	9477865520	sumita.nag@dvc.gov.in	[signature]
7	P. Ghosh	A.E, CLD, DVC	9674299618	preetoshonly@gmail.com	P. Ghosh.
8	R.V. Patnaik	AGM(OS), ER-II, NTPC	9438233243	rvpatnaik@ntpc.co.in	[signature]
9	S. K. Rai	Sr Mgr (OS) ER-I NTPC	9473400272	skrai02@ntpc.co.in	[signature]
10	PURUSHOTTAM CHAUDHARY	DY. MANAGER(E) RANGIT POWER STATION, NHPC Ltd	9800936867	Chaudhary3986@gmail.com	[signature] 27/04/2016
11	Nima Tshering	Engineer NLDC, BPCL	0097517416847	nimatshering@bpc.bt	[signature]
12	Ugyen Tshering	Manager SMD, BPCL	0097517613039	tshering.ugyen@yahoo.com	[signature]
13	Saurav K Sahay	Sr Engg, ERLDC	9432013173	sahay.saurav@gmail.com	Sahay
14	Bramhanand Verma	Engg, ERLDC	9903180731	bramhanand180@gmail.com	[signature]
15	M.K. Thakur	Dy. Manager, ERLDC	9432351832	mkzelect@gmail.com	[signature]
16	A. De.	AEE, ERPC	9681932906	alikpantha@gmail.com	Alikpantha De.
17	S. MAITI	EE, CRITL, DVC	8986824841	sudipta.maiti77@gmail.com	S. Maiti
18	Rajesh	Ch. Mgr (AM), PG	9431821127	rajeshos@powergridindia.com	[signature]
19	Lenin. B	AEE, ERPC	8335905837	lenin.nitc@gmail	[signature]
20	SVS Sathyanarayan	CM, POWERGRID	9434740038	svs@powergridindia.com	[signature]

"Coming together is a beginning, staying together is progress, and working together is success." –Henry Ford

Participants in 42nd PCC Meeting of ERPC

Venue: ERPC Conference Room, Kolkata Time: 11:00 hrs Date: 27.04.2016 (Wednesday)

Sl No	Name	Designation/ Organization	Contact Number	Email	Signature
21	D.K. Bauri	EE, ERPC	9883617236	eeop.erpc@gov.in	[signature]
22	G. Rao	EE, ERPC	9547891353	eseb_cea@yahoo.co.in	[signature]
23	S. KEJRIWAL	EE, ERPC	9831919509	eecom2.erpc@gov.in	[signature]
24	Rambaboo Singh	EEE, CRITL/BSPTCL	7763817723	eeecritl@gmail.com	[signature]
25	Dharmbeer Singh	AEE, SLDC/JUSNL	9771850485	sldcranchi@gmail.com	[signature]
26	Arun Kumar	ESE, CRITL /JUSNL	7070816390	arunjusnl@gmail.com	[signature]
27	Rajendra Prasad	AEE. TVNL	9631049936	r.p.ttps@gmail.com	[signature]
28	Kamales Maiti	Addl. CE, WBSETCL	9434910282	acectd16@gmail.com	[signature]
29	P. K. Kundu	AEE, SLDC, WBSETCL	9434910263	pkundu_1961@yahoo.co.in	[signature]
30	Bhaswati Nath	Sr. Mgr, WBPDCL	8336903703	b.nath@wbpdcl.co.in	[signature]
31	Nikhilesh De	Manager	9831562898	nikhilesh.de@rpsg.in	[signature]
32	PK Mishra	G.M., SLDC Odisha	9438907402	ele.pkmishra@sldcorissa.org.in	[signature]
33	L. Nayak	GM (O&M)	9438907801	ele.lanayak@optcl.co.in	[signature]
34	S.K. Harichandan	DGM OPTCL	9438907042	ele.skharichandan.	[signature]
35	H.P. Mahapatra	Mgr OHPC	9861164943	hpm.ohpc@gmail.com	[signature]
36	PRASHANT KUMAR DAS	DGM(E), SLDC, OPTCL BBSR	9438907408	prashant_das@yahoo.co.in	[signature]
37	SUDIPTA GHOSH	AM (PS), WBPDCL	9474363864	g_sudiptas@rediffmail.com	[signature]
38	Neha Srivastva	AEE, BSPTCL	7033092547	nehasrivastva08@gmail.com	[signature]
39	Anjali Anand	AEE, BSPTCL	7033092546	anjalianand290@gmail.com	[signature]
40	Akash Bajpai	TATA POWER (MPL)	9204757804	akash.bajpai@tatapower.com	[signature]
41	S. K. Naik	Chief Mgr, [illegible]	9437962169.	[illegible]@gmail.com	[signature]

"Coming together is a beginning, staying together is progress, and working together is success." –Henry Ford

42. Shankar Kodle Applied Materials 990164234 Shankar_Kodle@amat.com [signature]

Annexure-B8

220kV & above Intra Region Transmission Lines												
S.NO	LINE NAME	TRIP DATE	TRIP TIME	RESTORATION DATE	RESTORATION TIME	Fault Clearance time in msec	Relay Indication LOCAL END	Relay Indication REMOTE END	Auto Recloser status	DR/EL received within 24 Hrs	DR/EL received after 24 Hrs	Remarks/Deliberation in the meeting
Fault clearing time is violating protection standard (As per PMU data)												
1	400 KV BARIPADA-MENDHASAL	01.03.16	13:54	01.03.16	21:10	approx 520 ms	Z-II, 257 km from Baripada F/C 2.18 KA	Z-I, 0.5 km from Mendasal, 9.74 KA	--	No	No	Y-B FAULT, Multi ckt tower ph-ph fault.
2	220 KV MUZAFFARPUR-MTPS	02.03.16	13:22	02.03.16	13:40	240 ms approx	Zone III, Y-B, 75.54 KM from Muzzafarpur Iy:2.5 KA; Ib: 2.1 KA	No information received	No autorecloser operation observed in PMU data	No	No	Y-B FAULT (at same time, 220 kV MTPS-Gopalganj-I tripped from MTPS end (fault distance 215 km from MTPS end) which resulted in tripping of MTPS-Gopalgunj II due to overloading. Same type of tripping incident was observed in the month of Jan,16 also)
3	400 KV STERLITE - MERAMUNDALI- II	12.03.16	14:09	13.03.16	18:23	120 ms approx	R-N, Z-I, 2.85 KA, 15 KM from SEL	R-N, Z-I, 2.17 KA, 183.2 KM from Meramundali	No autorecloser operation observed in PMU data	No	No	R-N FAULT (BREAK DOWN))
4	400 KV STERLITE - MERAMUNDALI- I	12.03.16	14:58	13.03.16	18:50	200 ms approx	B-N, Z-I, 1.81 KA, 138.5 KM from SEL	B-N, Z-I, 1.42 KA	No autorecloser operation observed in PMU data	No	No	B-N FAULT(BREAK DOWN)
5	400KV MERAMUNDALI-MENDHASHAL	17.03.16	14:59	17.03.16	15:47	approx 480 ms	Z-II 4.29 KA, 95.2 km from Meramundali.	Z-1	No autorecloser operation observed in PMU data	No	No	R-N FAULT
6	220 KV NEW PURNEA - MADHEPURA - II	25.03.16	12:44	25.03.16	13:24	approx 280 ms	No information received	No information received	No autorecloser operation observed in PMU data	No	No	B-N FAULT
7	400 KV MERAMANDLI - MENDASHAL	27.03.16	11:29	27.03.16	11:57	approx 320 ms	R-N, F/C 4.26 kA, 94.3 km from Meramundali	No information received	No autorecloser operation observed in PMU data	No	No	R-N FAULT
8	400 KV MERAMANDLI - MENDASHAL	27.03.16	12:18	27.03.16	20:46	approx 320 ms	R-N, F/C 4.25 kA, 95.7 km from Meramundali	No information received	No autorecloser operation observed in PMU data	No	No	R-N FAULT
9	400KV MERAMANDALI-MENDHASHAL	28.03.16	05:13	28.03.16	16:14	approx 450 ms	R-N ,Z-I, F/C 30.6 kA, 1.2 km from Meramundali	R-N, Z-II, F/C 2.7 kA, 94.3 km from Mendasal	No autorecloser operation observed in PMU data	No	No	R-N FAULT
10	400KV MENDHASHAL-BARIPADA	28.03.16	07:01	28.03.16	17:36	approx 450 ms	No information received	No information received	--	No	No	Y-B FAULT
11	400KV JEYPORE-BOLANGIR	30.03.16	09:08	30.03.16	12:57	appros 400 ms	No information received	No information received	--	Yes	No	R Y B FAULT, DT recived from Bolangir end
12	400 KV MERAMUNDALI - MENDASAL	30.03.16	15:33	30.03.16	16:52	approx 360 ms	No information received	No information received		No	No	R-N FAULT
13	400 KV MERAMUNDALI - MENDASAL	30.03.16	16:59	still out		approx 360 ms	No information received	No information received		No	No	R-N FAULT (400 Kv Baripada-Mendasal-New Duburi tripped on same time due to over voltage)

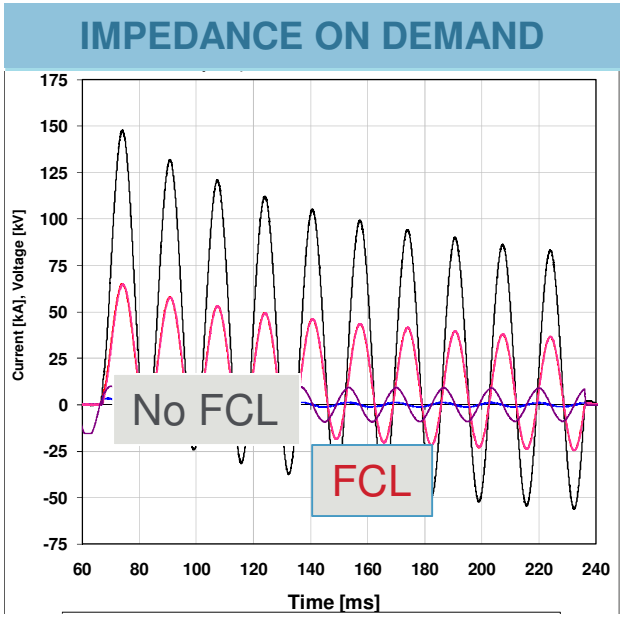
S.NO	LINE NAME	TRIP DATE	TRIP TIME	RESTORATION DATE	RESTORATION TIME	Fault Clearance time in msec	Relay Indication LOCAL END	Relay Indication REMOTE END	Auto Recloser status	DR/EL received within 24 Hrs	DR/EL received after 24 Hrs	Remarks/Deliberation in the meeting
No autorecloser operation observed in PMU data												
1	400 KV ARAMBAG-BIDHANNAGAR	09.03.16	16:40	09.03.16	16:52	<100	No information received	No information received	No autorecloser operation observed in PMU data	No	No	R-N FAULT
2	400 KV MERAMUNDALI - MENDASHAL	11.03.16	12:38	11.03.16	13:10	<100	4.73 KA, 80 KM from Meramundali	2.01 KA. 60 KM from Mendasal	No autorecloser operation observed in PMU data	No	No	B-N FAULT
3	400 KV SASARAM NABINAGAR-I	14.03.16	05:22			<100	R-N, Z-I, 7.5 KA, 29.8 KM from Sasaram	No information received	No autorecloser operation observed in PMU data	No	No	R-N FAULT, The line was Idle charged, zone time is zero.
4	400 KV Ind-Bharat -Jharsuguda	14.03.16	07:52	14.03.16	15:13	<100	Y-N , 5.2 KA	Y-N , Z-1, 5.8 KA, 47.8 km from jguda	No autorecloser operation observed in PMU data	No	No	Y-N Fault (400 Kv Raigarh Indbharat tripped from Raigarh end at Same time) DT recieved from Ind-bharat
5	400 KV BIHARSARIF - MAZAFARPUR-I	14.03.16	17:43	14.03.16	22:20	<100	No information received	Y-N, Zone-1 11.15 KA 8.2 KM from MZF	No autorecloser operation observed in PMU data	No	No	Y-N FAULT, A/R was out of service at the time of incidence
6	400 KV PATNA-KISHANGANJ-II	15.03.16	09:37	15.03.16	11:32	<100	Z-I, 1F/C 1.5 kA 259.5 kM from Patna	No information received	No autorecloser operation observed in PMU data	No	No	R-N FAULT, CB problem at Kishanganj end
7	400 KV PATNA-KISHANGANJ-II	16.03.16	11:59	17.03.16	10:43	<100	B-N F/C -14KA, 4.69 KM from Patna	B-N F/C- 0.75KA 316 KM from Kishangunj	No autorecloser operation observed in PMU data	No	No	B-N FAULT
8	400KV KOLAGHAT-KAHARAGPUR-I	19.03.16	15:58	20.03.16	21:14	<100	Z-I, R-N F/C 8.72 KA, 15.04 KM from KTPP	Z-I, R-N F/C: 2.8 KA, 57.8 KM from KGP	No autorecloser operation observed in PMU data	No	Yes	R- N FAULT
9	400KV KOLAGHAT-KAHARAGPUR-II	19.03.16	16:06	19.03.16	16:10	<100	Z-I, R-N F/C 8.64 KA, 23.92 KM from KTPP	Z-I, R-N F/C : 2.9 KA, 68.63 KA from KGP	No autorecloser operation observed in PMU data	No	No	R- N FAULT
10	400KV KOLAGHAT-KAHARAGPUR-II	19.03.16	16:21	19.03.16	18:18	<100	No information received	No information received	No autorecloser operation observed in PMU data	No	No	R- N FAULT
11	400KV BAKRESWAR-JEERAT	19.03.16	17:31	19.03.16	17:40	<100	Z-II, Y-N, 141 KM from Bakreswar	Z-I, Y-N, 8.207 KM from Jeerat, F/C 10.04 KA	No autorecloser operation observed in PMU data	No	No	Y- N FAULT
12	400 KV PATNA-KISHANGANJ -II	21.03.16	11:58	22.03.16	14:58	<100	B-N, Z-I, F/C - 14.52 KA, 4.5 km from Patna	B-N, Z-I, F/C 1.1 KA, 322 km from Kishanganj	No autorecloser operation observed in PMU data	No	No	B-N FAULT
13	400 KV GAYA - KODARMA -I	22.03.16	15:04	22.03.16	16:10	<100	R-N, Z-I, F/C - 10.2 KA, 11.7 km from Gaya	No information received	No autorecloser operation observed in PMU data	Yes	No	R -N FAULT (Autoreclose was successful at Gaya end)
14	400 KV GAYA - KODARMA - II	22.03.16	15:04	22.03.16	16:15	<100	B-N, Z-I, F/C - 10.4 KA, 14.9 km from Gaya	No information received	No autorecloser operation observed in PMU data	Yes	No	B -N FAULT (Autoreclose was successful at Gaya end)
15	400 KV STERLITE - MERAMUNDALI - II	25.03.16	14:51	26.03.16	00:39	<100	B-N, Z-I, F/C - 2.05 KA 188 km from Meramundali	B-N, Z-I, F/C - 4.11 KA, 33.97 km from SEL	No autorecloser operation observed in PMU data	No	No	R-N FAULT

S.NO	LINE NAME	TRIP DATE	TRIP TIME	RESTORATION DATE	RESTORATION TIME	Fault Clearance time in msec	Relay Indication LOCAL END	Relay Indication REMOTE END	Auto Recloser status	DR/EL received within 24 Hrs	DR/EL received after 24 Hrs	Remarks/Deliberation in the meeting
16	400KV BINAGURI-BONGAIGAON-I	27.03.16	20:51	27.03.16	21:22	<100	No information received	No information received	No autorecloser operation observed in PMU data	No	No	R-N FAULT (400 kV Binaguri Rangpo tripped at same time due to DT received at Ranpo)
17	400KV BINAGURI-RANGPO-I	27.03.16	20:51	27.03.16	21:37	<100	No information received	No information received	No autorecloser operation observed in PMU data	No	No	DT RECEIVED AT RANGPO, PLCC Maloperation
18	400KV BINAGURI-KISHANGANJ-I	28.03.16	06:11	28.03.16	18:28	<100	R-N, Z-I, F/C - 9:09 KA, 11.38 km from Binaguri	R-N, Z-I, F/C - 2.97 KA, 72.6 km from Kishangunj	No autorecloser operation observed in PMU data	No	No	R-N FAULT
Others												
1	400 KV RANCHI-RTPS	09.03.16	15:16	09.03.16	16:37	<100	No information received	O/V tripped, -5.8 km from RTPS, Zone-5 start	--	Yes	No	B-N FAULT
2	400 KV RTPS-MAITHON	09.03.16	15:13	09.03.16	17:47	<100	R-B picked up,89 A/B (line trip relay) and bus bur protection operated, fault distance -1.2%	No information received	--	Yes	No	R-B FAULT
3	400 KV RTPS-ANDAL-II	09.03.16	15:13	09.03.16	17:10	<100	B-N Z-I dist 3.61 km from RTPS	No information received	--	Yes	No	B-N FAULT (At 15:16 hrs dip in B phase voltage is observed)
4	400 KV RTPS-MAITHON	20.03.16	19:15	20.03.16	22:50	--	O/C at RTPS end	No information received	--	Yes	No	As per DVC, line tripped due to overloading. Line loading as per Relay data is < 740 MW

APPLIED MATERIALS®

Fault Current Limiters

ERPC



Shankar Kodle

Apr 27th 2016

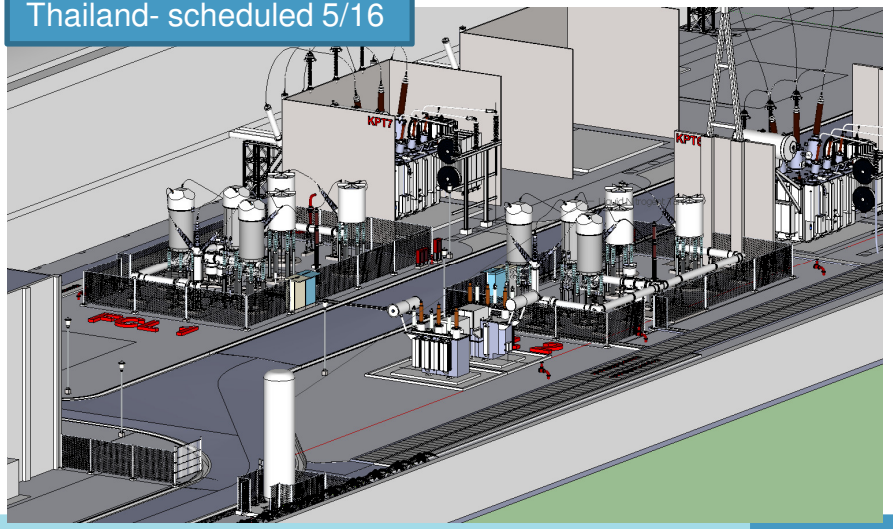
Applied Materials' FCL Systems Installed

New York- USA

Australia

Santa Clara, USA

Thailand- scheduled 5/16



Applied Materials Global Strength

Market Cap:	$29.16 billion
Fiscal 2014 Revenue:	$9.1 billion
Fiscal 2014 R&D:	$1.4 billion
Founded:	November 10, 1967
Headquarters:	Santa Clara, California
Global Presence:	84 locations in 18 countries
Fortune 500 Ranking:	302
RD&E and/or Manufacturing Centers:	China, Germany, India, Israel, Italy, Singapore, Taiwan, United States
Employees:	~13,700 worldwide
Patents:	~10,600 issued

APPLIED MATERIALS INDIA PVT LTD

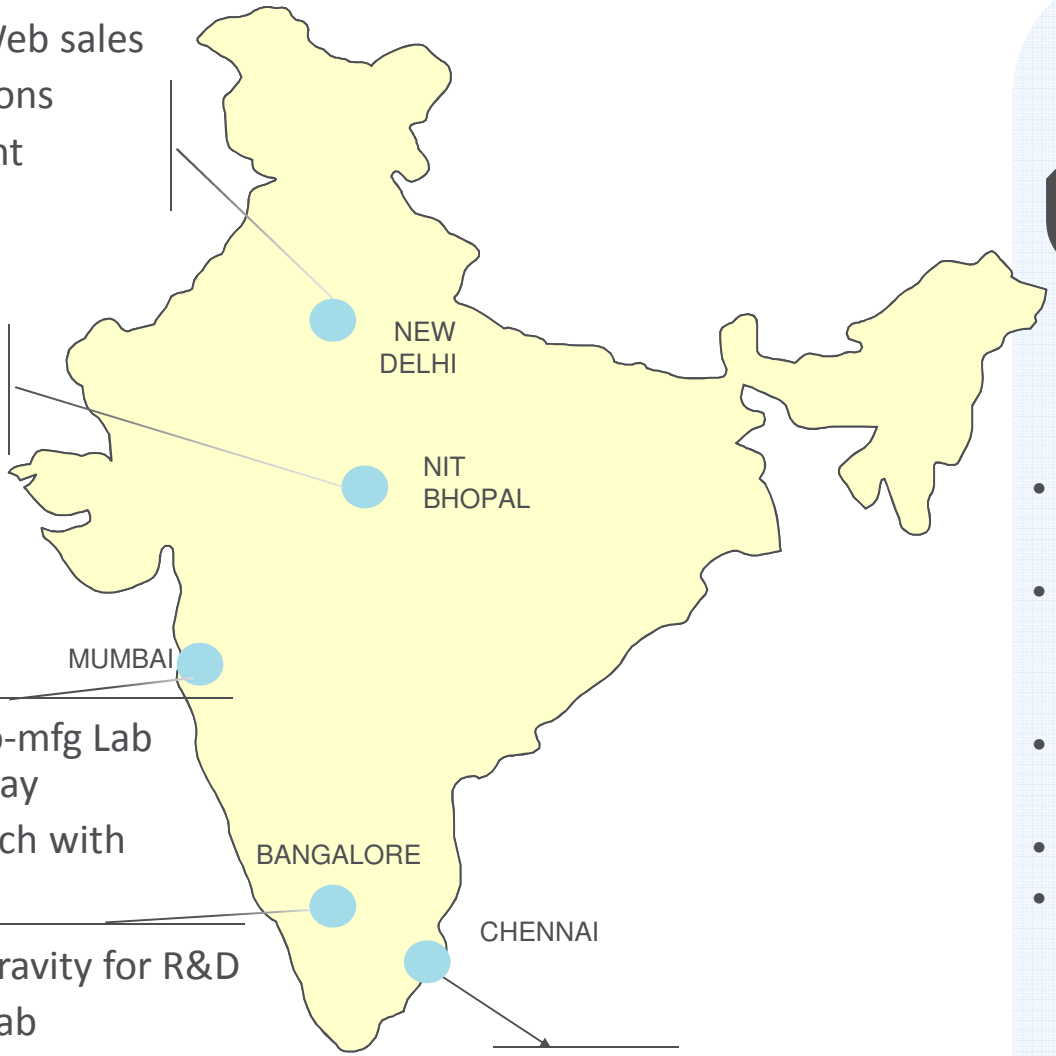
Founded:	June, 2002
Headquarters:	Bangalore,
India Presence:	Bangalore, Chennai, Delhi, Mumbai
Lab Space:	> 25,600 sq. ft.
University Spend:	**> INR 75 CR**
Employees*:	~ *2300

Data as of Oct 7th 2014

*Including RFTs, contractors & associates

- Solar and Web sales
- Collaborations
- Government Interface

- Computational lab



- AMAT Nano-mfg Lab at IIT-Bombay
- Joint research with IIT-B

- Center of Gravity for R&D
- Reliability Lab
- Validation lab
- COE for simulation

Factory Automation Software

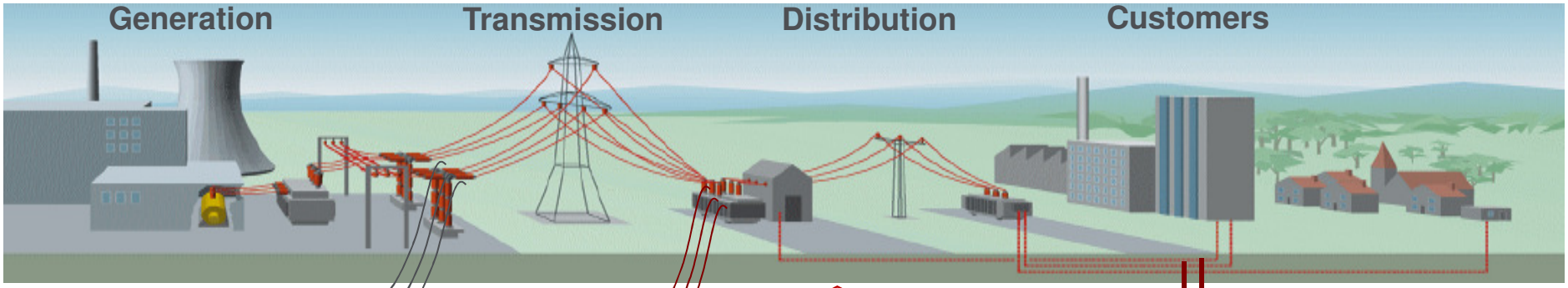
APPLIED MATERIALS®

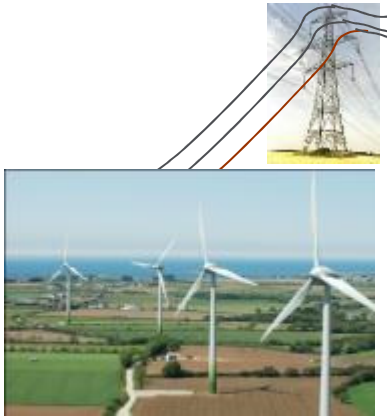
In INDIA

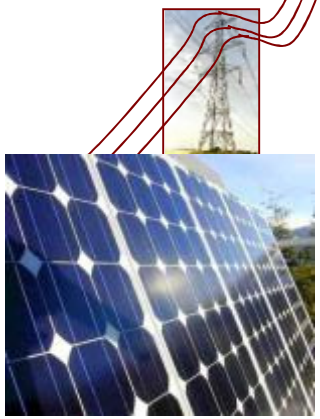
- Grew to 2300 employees from none in 10 years
- Virtually every product has engineering contributions from India
- Collaborations with leading universities and institutes
- Investing in start ups
- Laid the foundation with Indian government for creating semiconductor manufacturing in India
- Funded many social philanthropy projects

A key R&D, engineering, software & IT infrastructure center

Drivers of the Fault problems







Increased Fault Current Level

New Generation

- Renewable energy – wind, solar, hydro
- Increased grid interconnection

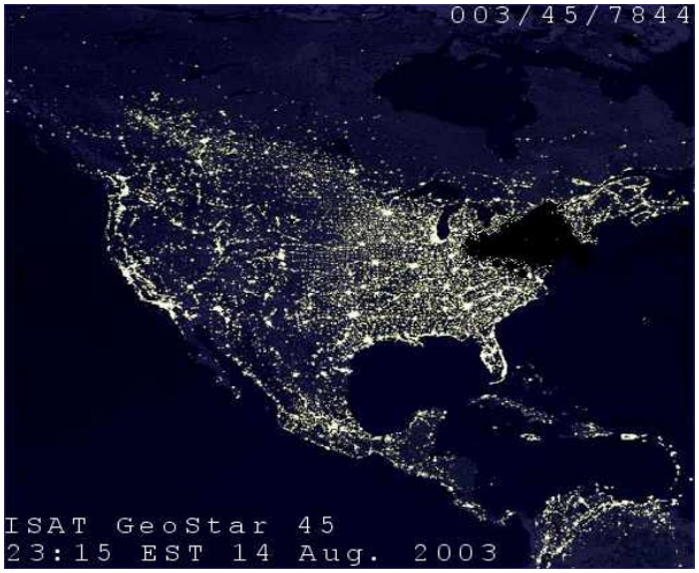
Increased demand

- Urbanization - Population growth
- Transportation - Electric cars, trains

Economic Growth and Large Investments in Distributed Generation are driving new Grid Architectures.
Fault currents are rising

Fault Currents are Destructive

- Large fault currents can cause the grid to fail catastrophically
- Lower fault currents can even damage the grid's capital infrastructure
  - Age equipment
  - Premature failures
  - Performance degradation



Scenarios for use of FCLs

Driver	SCFCL Role	Benefit to customer
Increase Substation Capacity	Limit FC on system and allow more generators to be connected	Defer capital expenditures on new substation or Equipment
Interconnect new generation for IPPs and other Power Producers	Limit FC created by new generators	Increased revenue for IPPs Improve asset utilization Reduce transmission lines by connecting to closest subs-station
Protect Key Assets	Protect transformers or circuit breakers from FC and extend key asset life	Reduce Repair and Maintenance cost and downtime
Interconnect Distributed Generators	Limit FC on transformers Allow more power flow in parallel	Facilitate integration of distributed/ localized generation (solar, wind micro-hydel etc.)
A More Reliable and Resilient Grid	Enable closing of Bus Ties, interconnect Substations Tightly Meshed Grid for increased Power Reliability and resiliency	More reliable and strong grid increasing options to deliver high quality power

Scenarios for use of FCLs for IPPs

Driver	SCFCL Role	Benefit to customer
Increase generation	Reduce fault currents to level mandated by the Transmission Utilities	Higher revenue from generating more power
Reduce Transmission line length	Help reduce fault currents due to proximity to generation	Reduce transmission costs of transmission lines and towers
Enable higher level of Distributed Generation	Reduce impact of fault currents	Reduce costs of interconnecting DG to the gird
Increasing reliability and reducing cost of captive power plants	Reduce impact of fault currents	Reduce downtime Improve life of auxiliary equipment
Quality of Power	Reduce impact of fault current on voltage sag	Reduction in penalties for voltage sag Improve goodwill - No need to upgrade sub-station for FC

Current options to mitigate Fault Currents

- ✓ Utility over-engineer system
- ✓ Introduce mitigations with detrimental impact

Mitigations	Impact	
Bus Splitting ($$)	***Reduces***	flexibility and reliability
High impedance transformers ($$$)	***Increases***	transformer cost and losses
Current Limiting Reactors ($$)	***Increases***	active and reactive power loss, voltage drops causing voltage stability issues
Breaker & Busbar Upgrades ($$)	***High***	sub-station down-time and cost
New Substations ($$$$)	***High***	cost of land & new cable lines

Current Solutions are non-optimum and may require additional mitigation

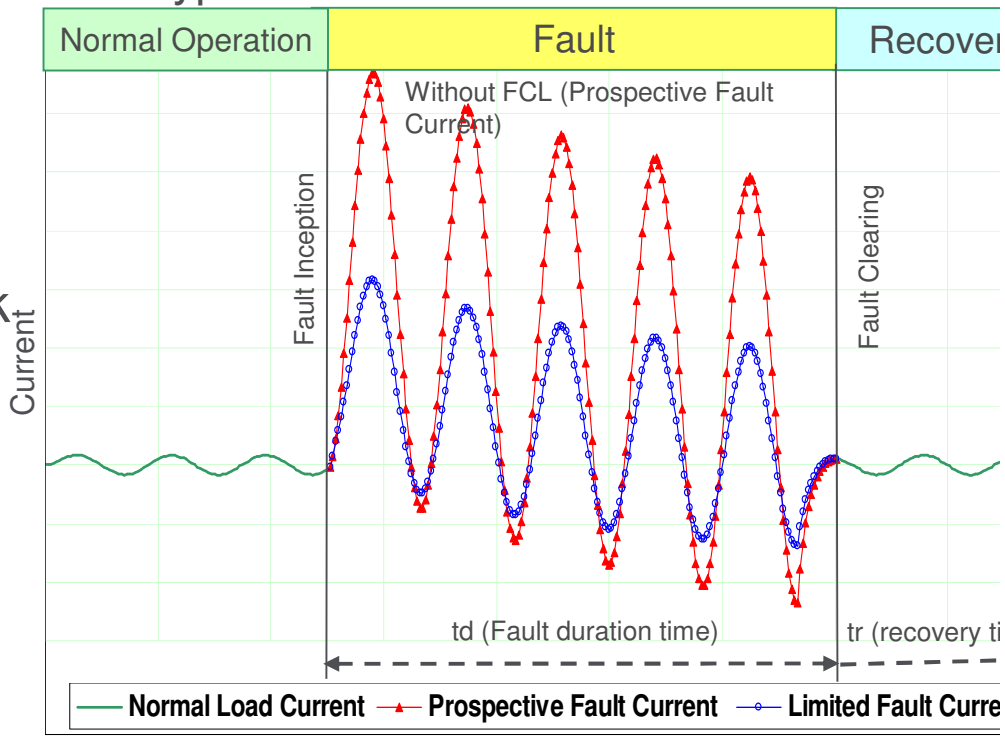
System Benefits of Fault Current Limiters

- FCL neutralizes the effects of fault current on grid architecture
- Reducing fault currents creates greater flexibility in grid design and component selection enabling:
  - Increased substation capacity
  - Easier addition of new generation
  - Protecting key assets
  - Improved Stability, Reduced TRV Problems
  - Safety, Arc Flash Reduction, Brush Fire Suppression
  - Easier interconnection of distributed generation
  - A more reliable and resilient grid

Desired Characteristics of an Ideal FCL

- An Ideal Fault Current Limiter would
  - In normal operation, it is virtually **"transparent**“ (no power or voltage loss) to the network
  - **Increase the impedance** on the line well before the first fault peak (when the most damage occurs)
  - Diminish the fault current by at least a **factor of 2** for its duration
  - Return the source impedance to its **original value**

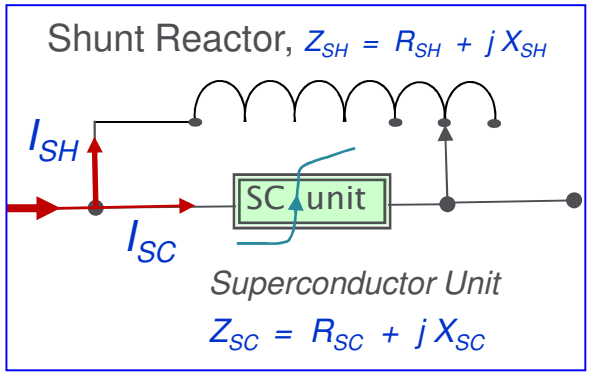
Typical current waveforms due to fault



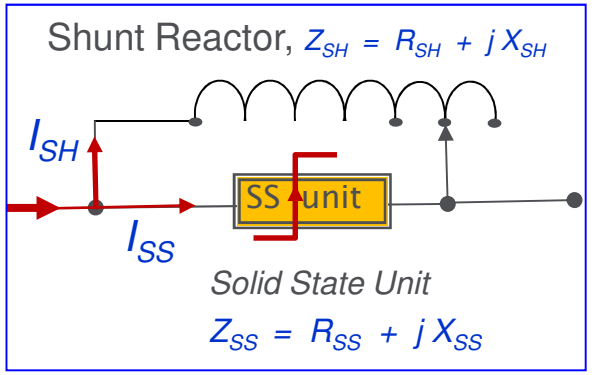
Fault Current Limiters reduce Fault Currents Without the Need for Mitigation

Applied Materials Fault Current Limiter Platforms

- **Transmission System FCL**
  - Superconducting Fault Current Limiter **(SCFCL)**
  - 11 kV to 400 kV transmission voltage levels
  - > 1000 A load current
  - Up to 50 % or higher fault current reduction
- **Distribution System FCL**
  - Solid State Fault Current Limiter **(SSFCL)**
  - Superconducting Fault Current Limiter – If required
  - Up to 45 kV distribution voltage levels
  - > 1000 A load current
  - Up to 50 % or higher fault current reduction

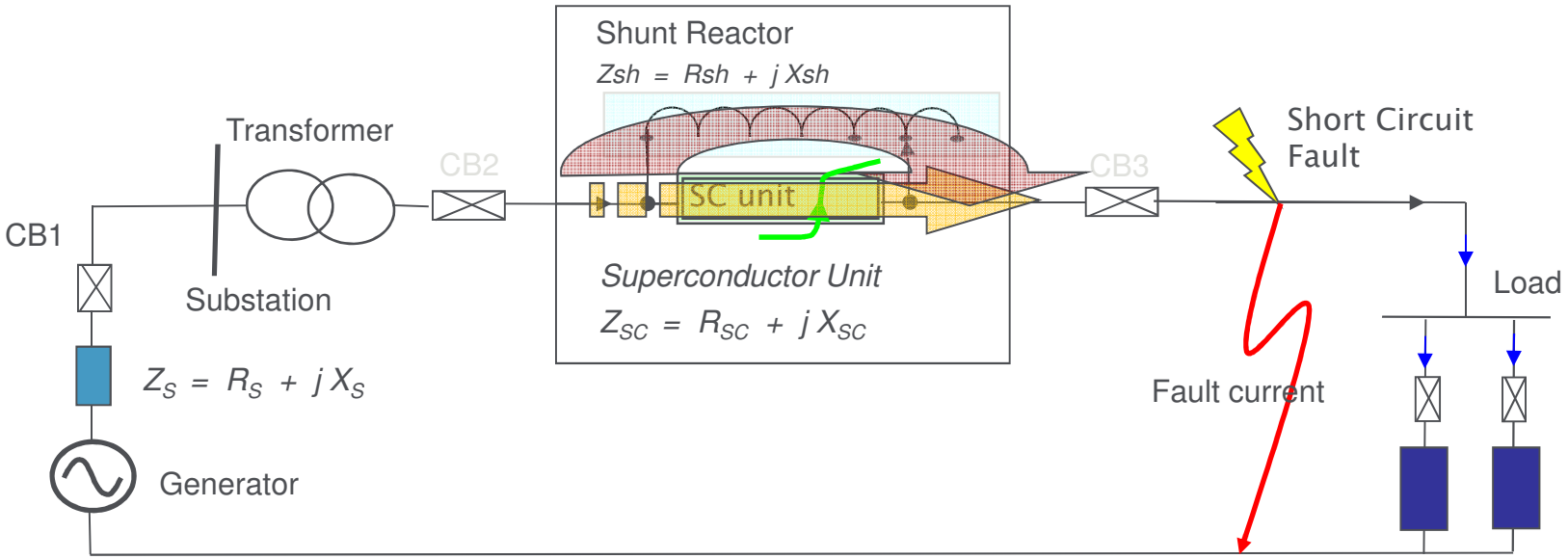


SCFCL



SSFCL

How an SCFCL works



Normal operation

- Load current flows through superconducting unit
- SCFCL introduces nearly zero impedance and zero voltage drop

Fault Condition

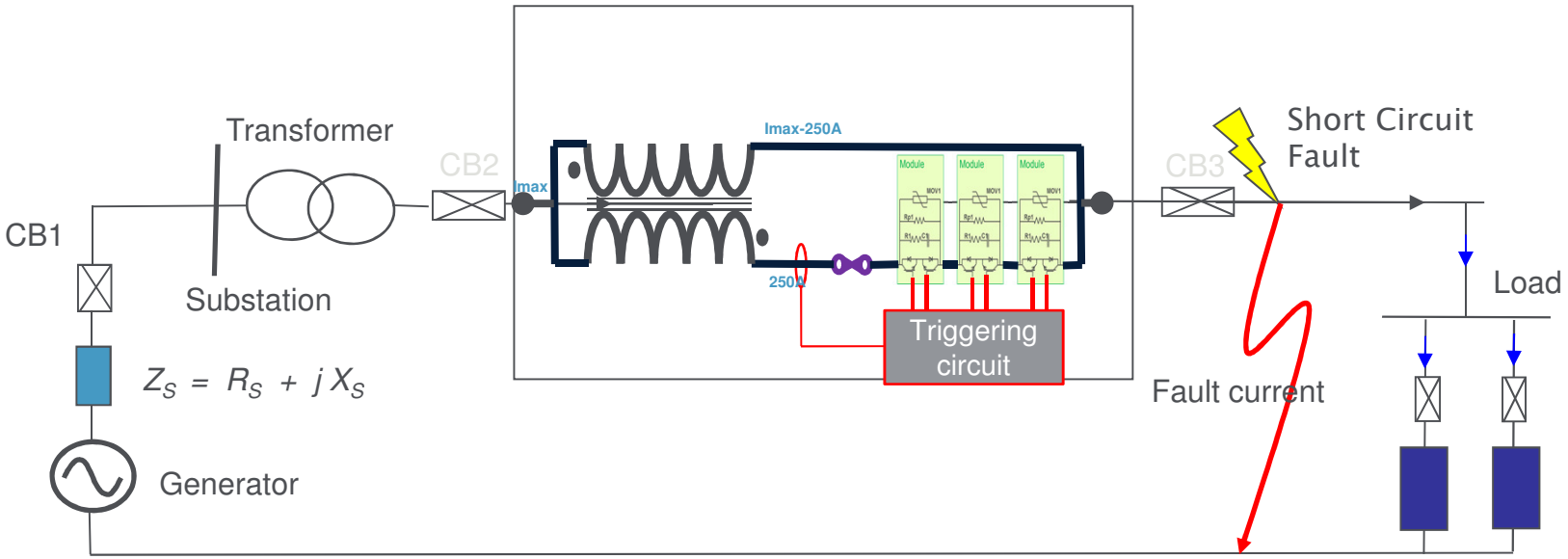
- Superconductor inherently senses fault current, quenches, ***inserts high resistance in ~ 1 ms***
- Current transfers to shunt and limits fault current

Recovery

- Superconducting unit recovers superconducting state quickly (seconds)

Fault detection and current limiting is done with passive inherent superconductor properties – laws of physics rather than electronics

Solid State Fault Current Limiter



Normal operation

- Opposing current flows through interleaved windings of Mutual reactor
- SSFCL introduces nearly zero impedance and zero voltage drop

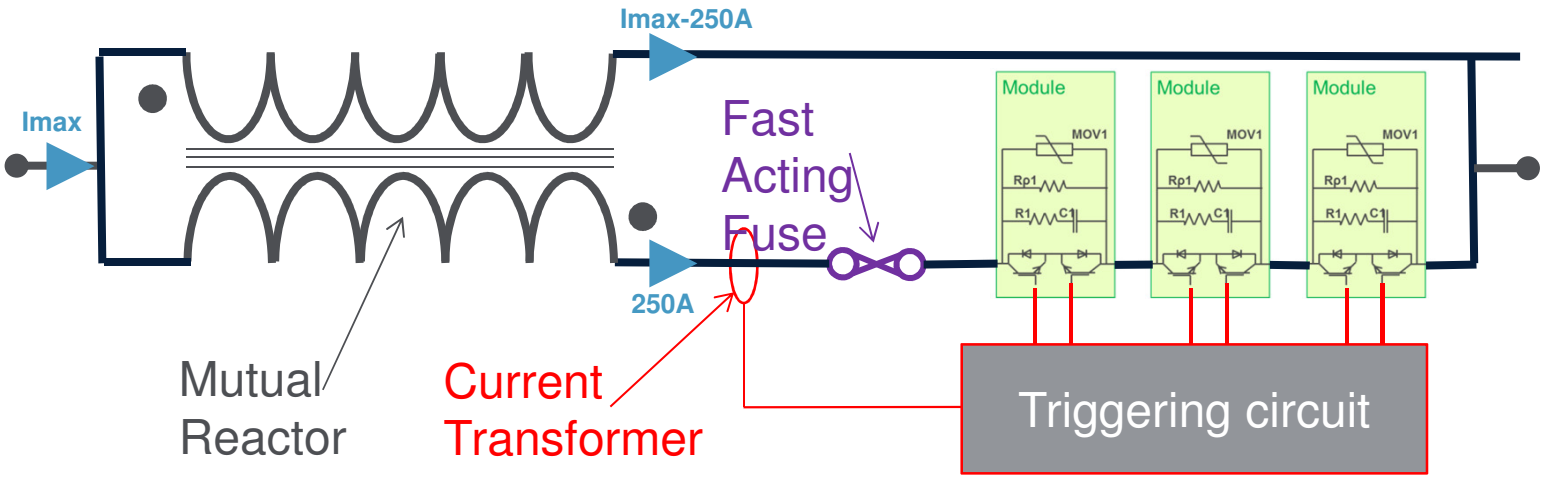
Fault Condition

- IGBTs Switch off
- Mutual reactor offers designed impedance
- ***inserts high resistance in micro seconds***

Recovery

- IGBTs switch on in micro seconds, sensing the current
- Opposing current flows through interleaved windings of Mutual reactor
- Hence, offers zero impedance

SSFCL Architecture

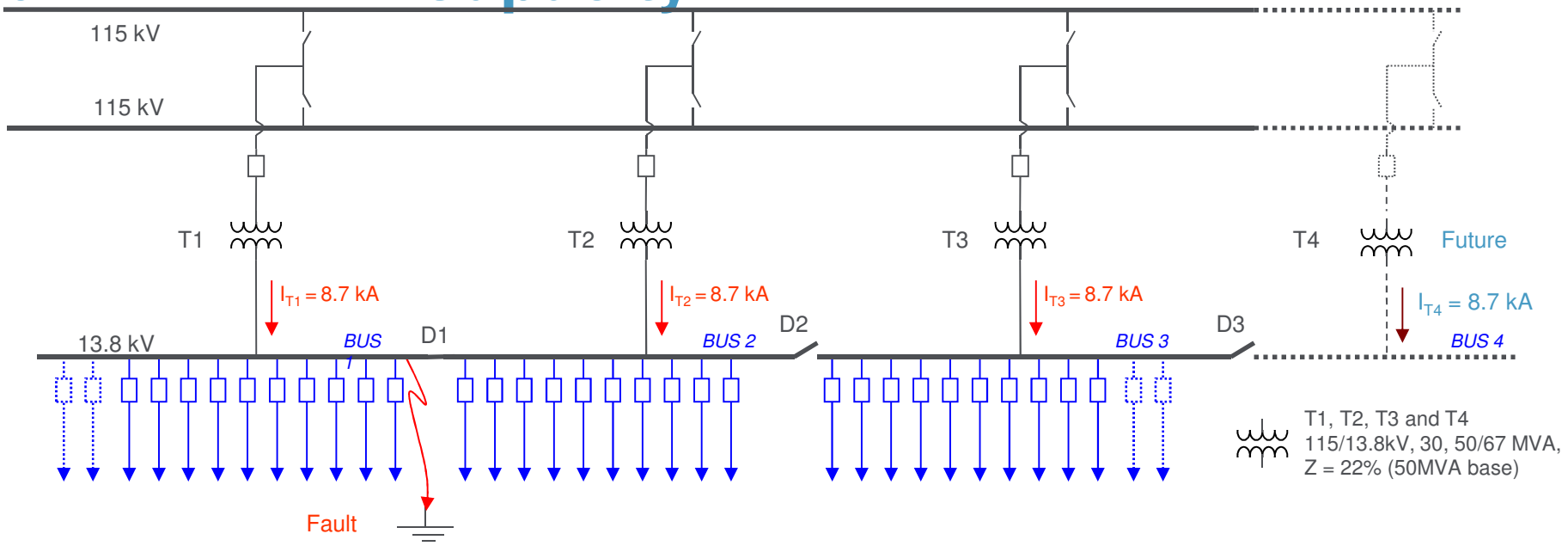


Mutual Reactor

- Winding ratio: I_{max}:250A
- I_{max} winding has sufficient impedance to limit the fault current to the desired value when energised alone.
- Windings wound in opposite direction so magnetic flux cancelled when both windings carrying current, resulting in low losses.

Fault Current Limiter – Application cases

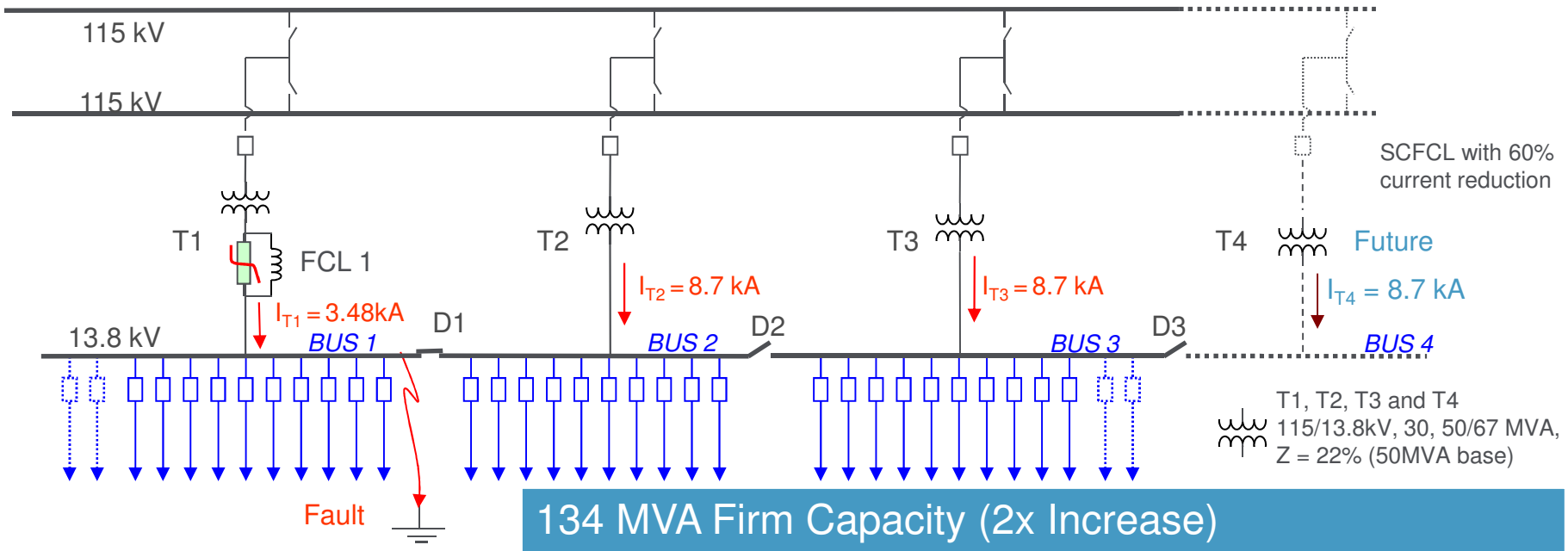
Customer A– Prospective Fault Currents
67 MVA Firm Capacity



Fault Location	*D1 Status*	*D2 status*	*D3 status*	*Prospective fault Current [kA]*
BUS1	***Open***	***Open***	***Open***	***8.7***
BUS1	***Closed***	***Open***	***Open***	***17.4***
BUS1	***Closed***	***Closed***	***Open***	***26.1***
BUS1	***Closed***	***Closed***	***Closed***	***34.8***

- Capacity limited, want 4th transformer
- Fault Level must be below 21 KA
- Can FCL's close the bus and allow the 4th transformer to be installed?

Fault Current Reduction with 1 In-line SCFCL

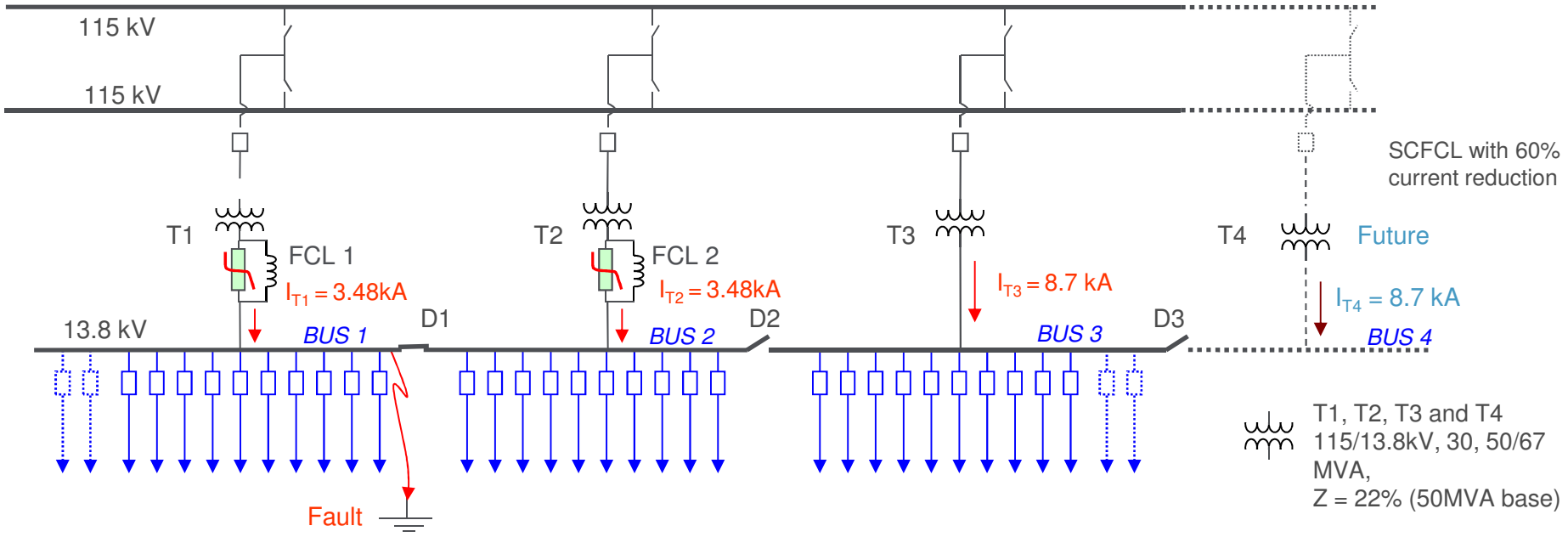


- Limits fault current contribution from feeder transformer by 60%
- It protects 2 bus interconnection system
- Does not allow for the introduction of a 4th transformer
- Firm Capacity = 134 MW (+67 MW)

134 MVA Firm Capacity (2x Increase)

Fault Location	D1 Status	D2 status	D3 status	Prospective fault Current	Limited Fault Current	Current Reduction	Current Limitation requirement
BUS 1	Open	Open	Open	8.7	3.48	60.0%	Satisfied
BUS 1	Closed	Open	Open	17.4	12.18	30.0%	Satisfied
BUS 1	Closed	Closed	Open	26.1	20.88	20.0%	Satisfied
BUS 1	Closed	Closed	Closed	34.8	29.58	15.0%	Over Design Limit

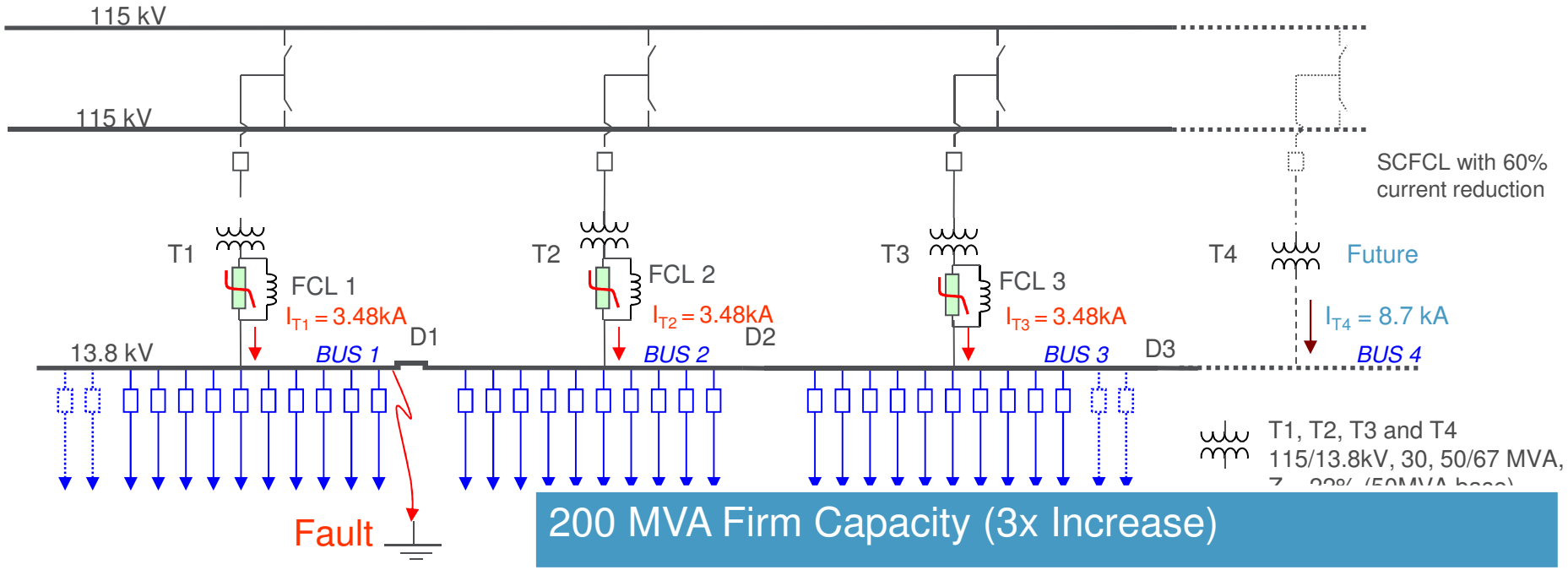
Fault Current Reduction with 2 In-line SCFCLs 134 MVA Firm Capacity (2x Increase)



- Limits fault current contribution from feeder transformer by 60%
- It protects 2 bus interconnection system with greater margin
- Does not allow for the introduction of a 4th transformer
- Firm Capacity = 134 MW

Fault Location	D1 Status	D2 status	D3 status	Prospective fault Current	Limited Fault Current	Current Reduction	Current Limitation requirement
BUS 1	Open	Open	Open	8.7	3.48	60.0%	Satisfied
BUS 1	Closed	Open	Open	17.4	6.96	60.0%	Satisfied
BUS 1	Closed	Closed	Open	26.1	15.66	40.0%	Satisfied
BUS 1	Closed	Closed	Closed	34.8	24.36	30.0%	Over Design Limit

Fault Current Reduction with 3 In-line SCFCLs



200 MVA Firm Capacity (3x Increase)

- Limits fault current contribution from feeder transformers by 60%
- It protects 4 bus interconnection system
- Allows for the 4th transformer to be added
- Firm Capacity = 200 MW (+67 MW)

Fault Location	D1 Status	D2 status	D3 status	Prospective fault Current	Limited Fault Current	Current Reduction	Current Limitation requirement
BUS 1	Open	Open	Open	8.7	3.48	60.0%	Satisfied
BUS 1	Closed	Open	Open	17.4	6.96	60.0%	Satisfied
BUS 1	Closed	Closed	Open	26.1	10.44	60.0%	Satisfied
BUS 1	Closed	Closed	Closed	34.8	19.14	45.0%	Satisfied

Asset Utilization and Firm Capacity

- Current configuration allows T1 and T2 to Run at 50 % (N-1)
- With 1 FCL D2 closes and T1, T2 and T3 can run at 66 % (N-1)
- With 3 FCL's D1, D2 and D3 are closed and T1, T2, T3, and T4 run at 75 % (N-1)
- The Introduction of 3 FCL's increases asset utilization from 50 % to 75 % and fully reliable power from 67MW to 200 MW

Fault Location	D1 Status	D2 status	D3 status	Prospective fault Current	1 SCFCL-Limited Fault Current	2 SCFCLs-Limited Fault Current	3 SCFCLs-Limited Fault Current	Firm Capacity
BUS 1	Closed	Open	Open	17.4	12.2	7.0	7.0	67 MVA
BUS 1	Closed	Closed	Open	26.1	20.9	15.7	10.4	134 MVA
BUS 1	Closed	Closed	Closed	34.8	29.6	24.4	19.1	200 MVA

Customer B Requirement

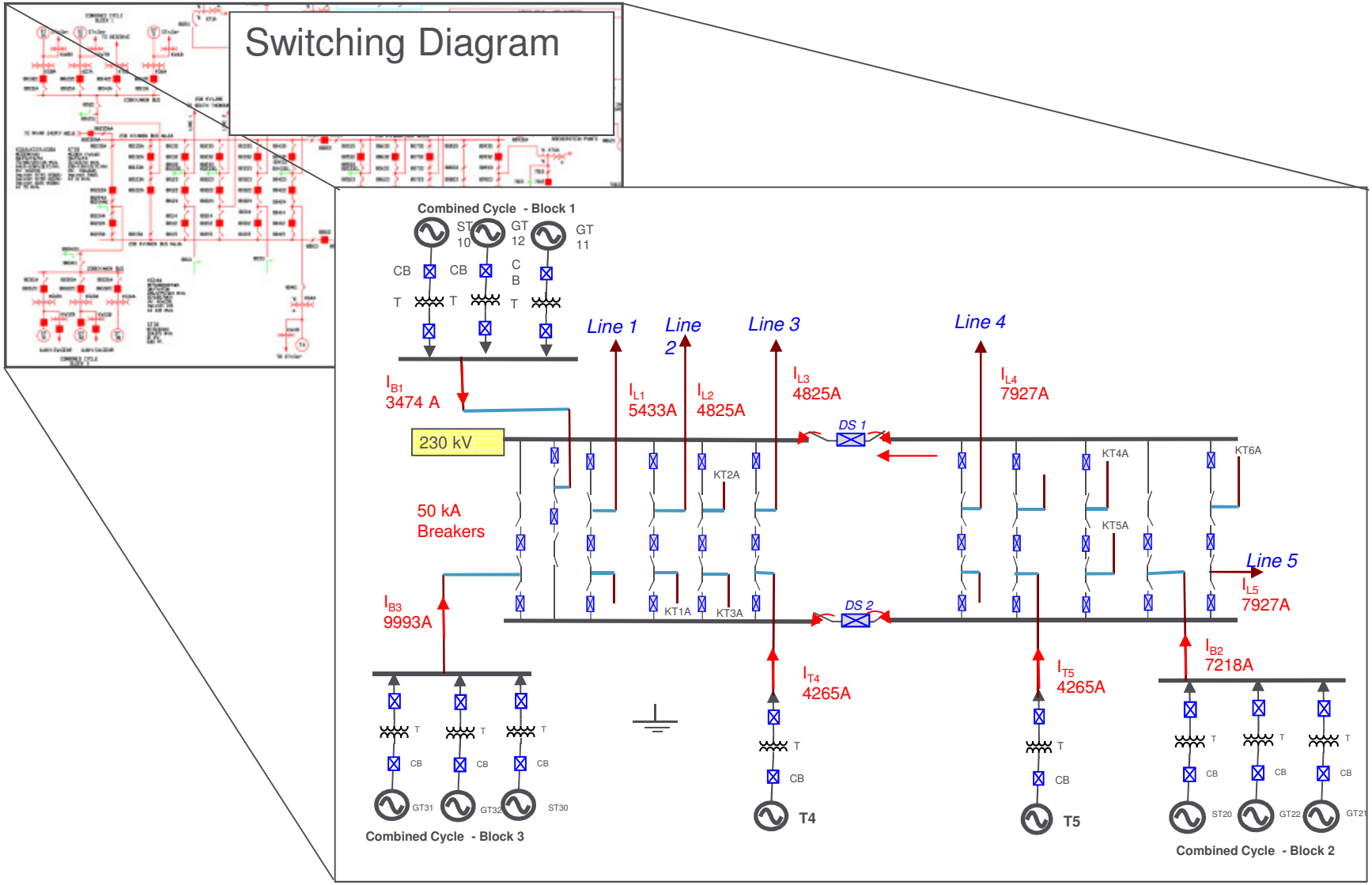
Current Status

- Total Single Phase-to-ground fault
  - Section 1 = 33,564 A
  - Section 2 = 28,133 A
  - → Substation total = **61,697 A**

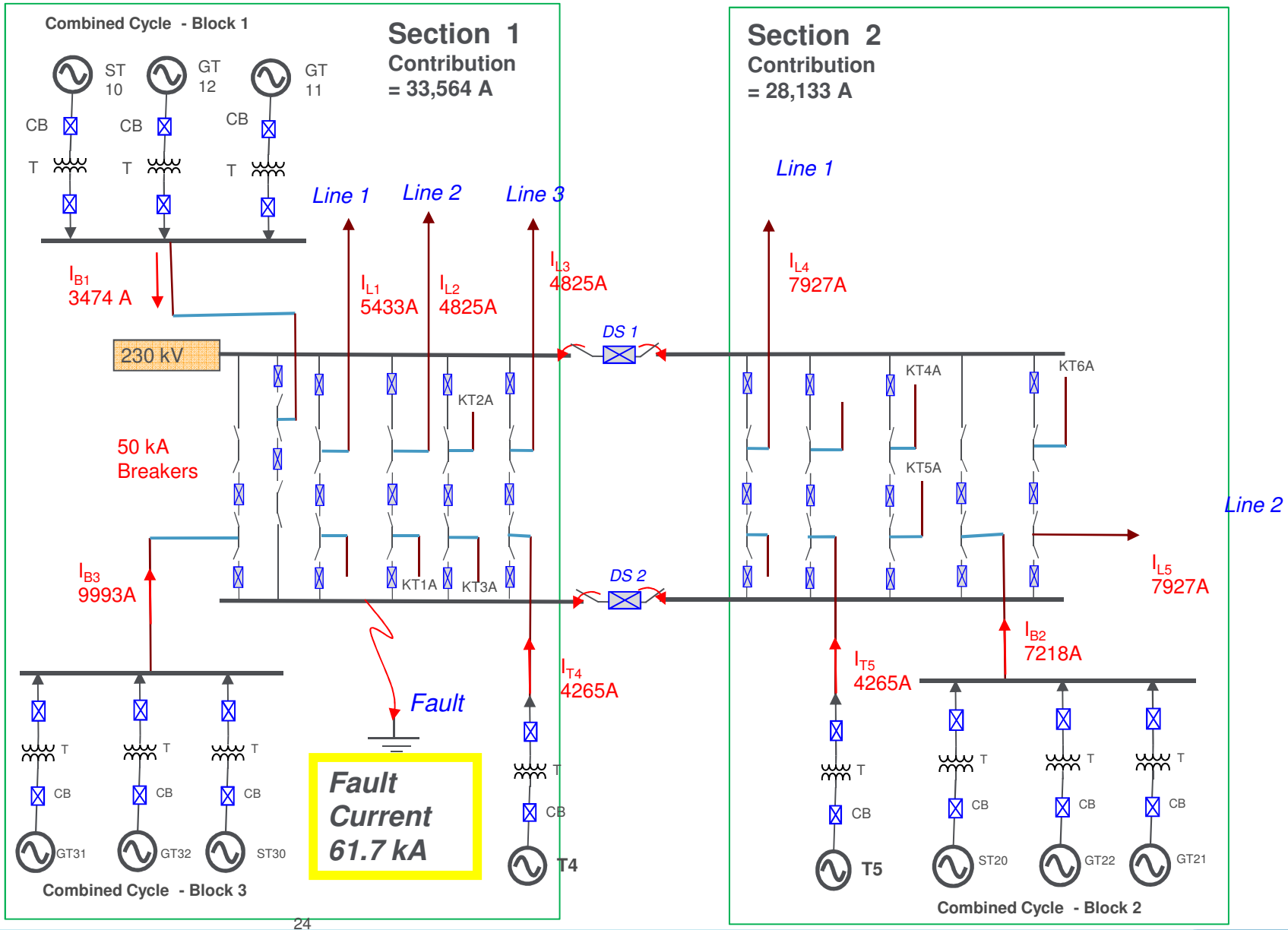
Requirement

- Reliably keep bus ties closed
  - Reduce total fault current to < 50 kA
  - Equals a ~20 % fault current reduction (minimum)

System Layout / Simplification



Short Circuit Fault Current Analysis - NO FCL's

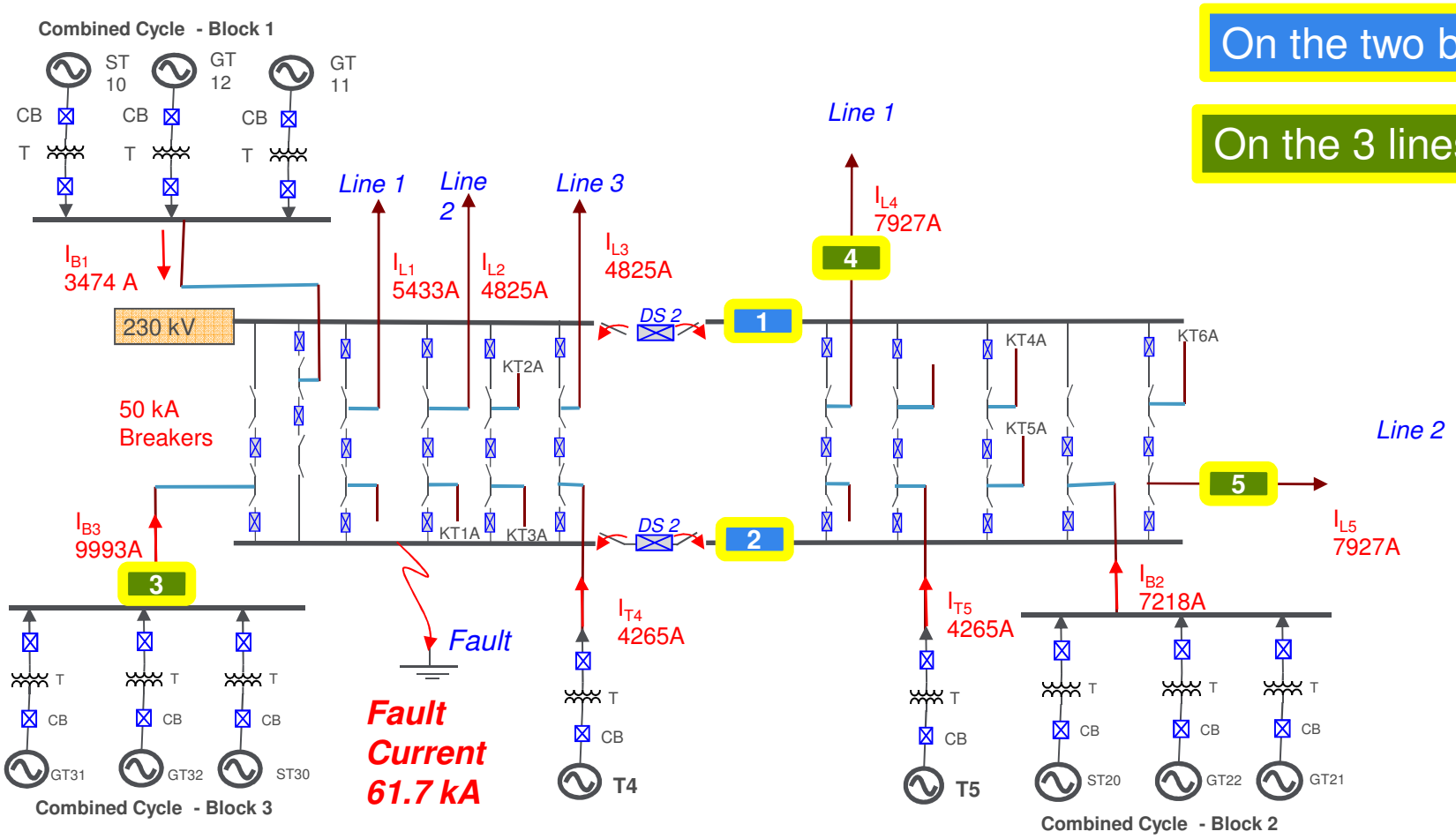


Alternatives to run the substation reliably with the bus ties closed without FCL

- Disconnect ~20% of power - Need to add a new substation to make up the difference
- Upgrade breakers, busbars – Expensive, intrusive and time consuming
- Split bus (reduce reliability) – May need to add infrastructure to ensure reliable power elsewhere in the system
- High impedance – Transformer, Reactors etc. Burn real and reactive power, can lead to voltage instability

Standard Mitigation is costly, time consuming and/or system degrading

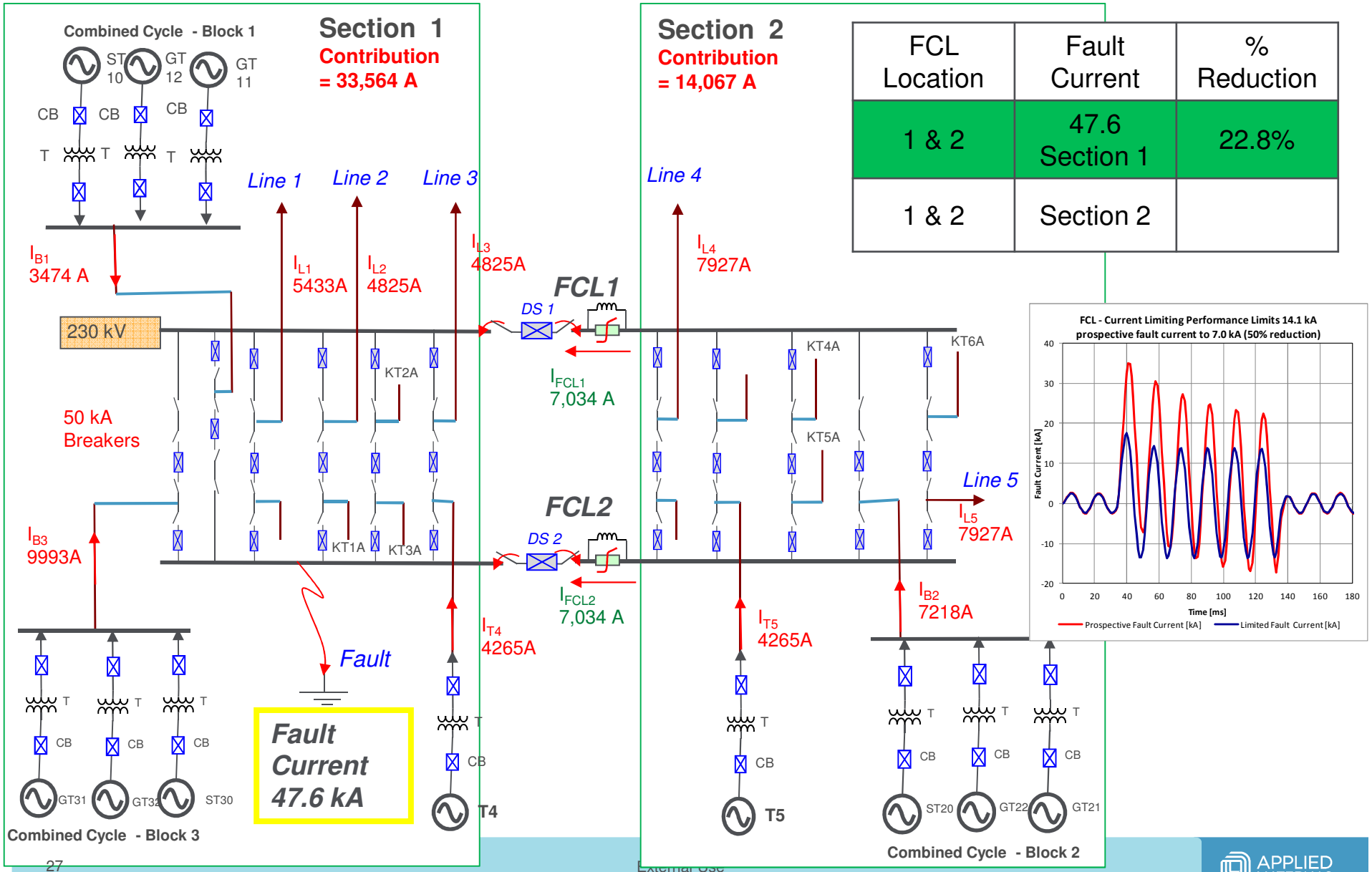
Potential Locations for FCL Placements



Location	Application	Function
1, 2	Bus Tie	Bi-directional limiting across sections of grid
3	In-line	Limit the >9kA contribution from Block 3
4	In-line	Limit the ~8kA contribution from Line No.1
5	In-line	Limit the ~8kA contribution from Line No.2

Using 2 Bus-tie FCLs

- Fault at section 1 bus – 22.8 % Fault Current reduction

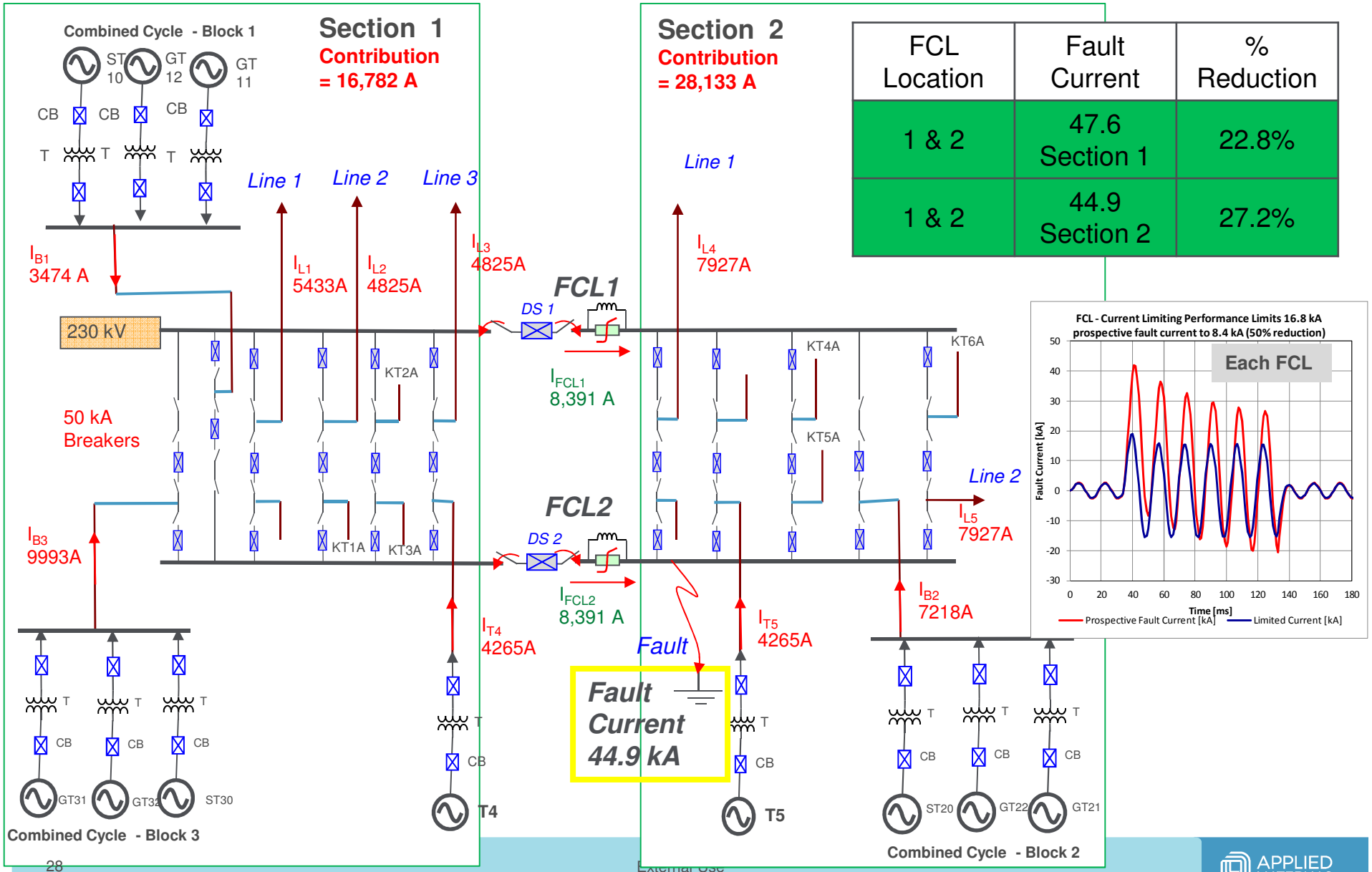


FCL Location	Fault Current	% Reduction
1 & 2	47.6 Section 1	22.8%
1 & 2	Section 2	

APPLIED MATERIALS

Using 2 Bus-tie FCLs

- Fault at section 2 bus – 27.2 % Fault Current reduction

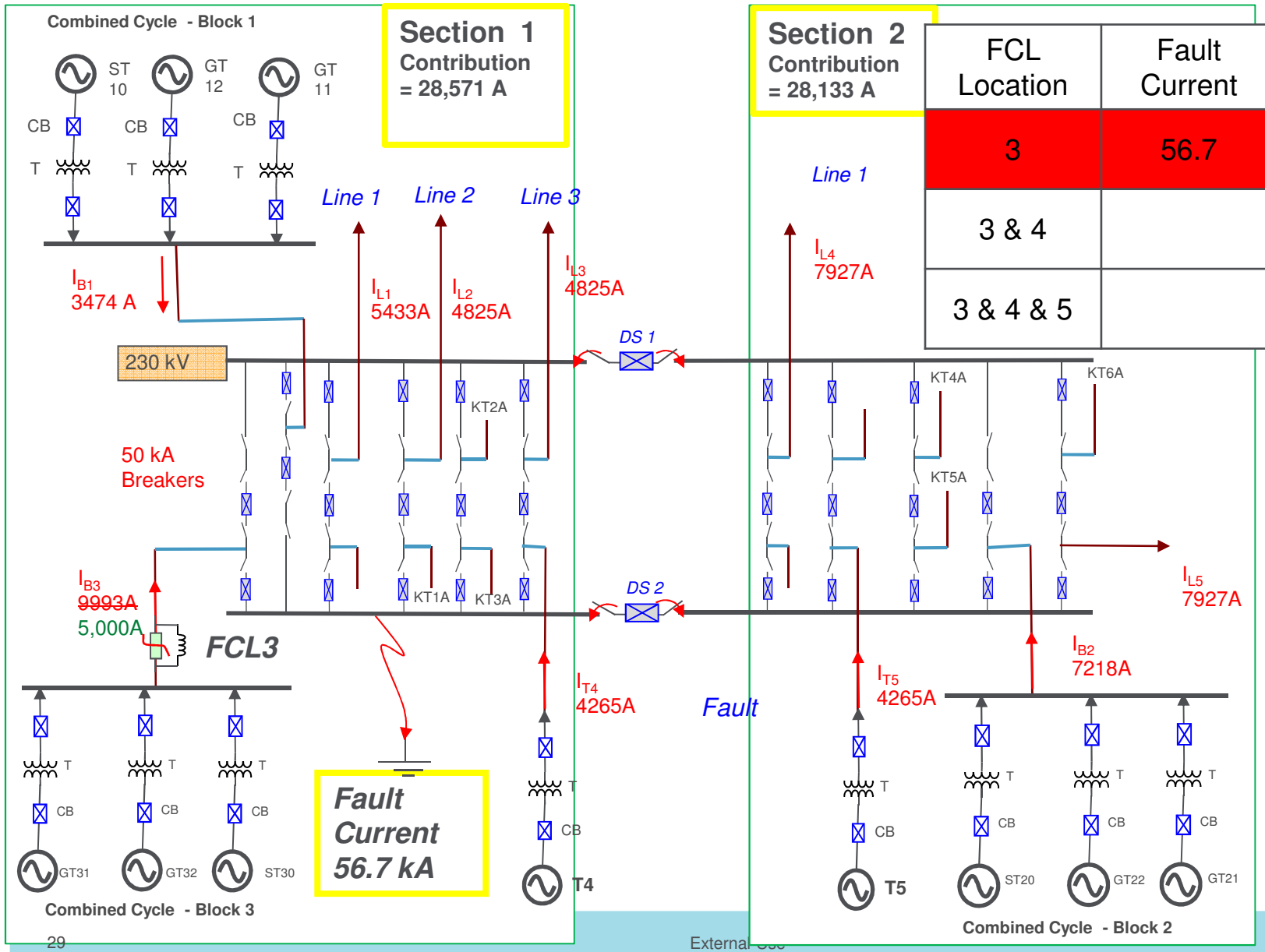


FCL Location	Fault Current	% Reduction
1 & 2	47.6 Section 1	22.8%
1 & 2	44.9 Section 2	27.2%

APPLIED MATERIALS

Using *1 in-line* FCLs

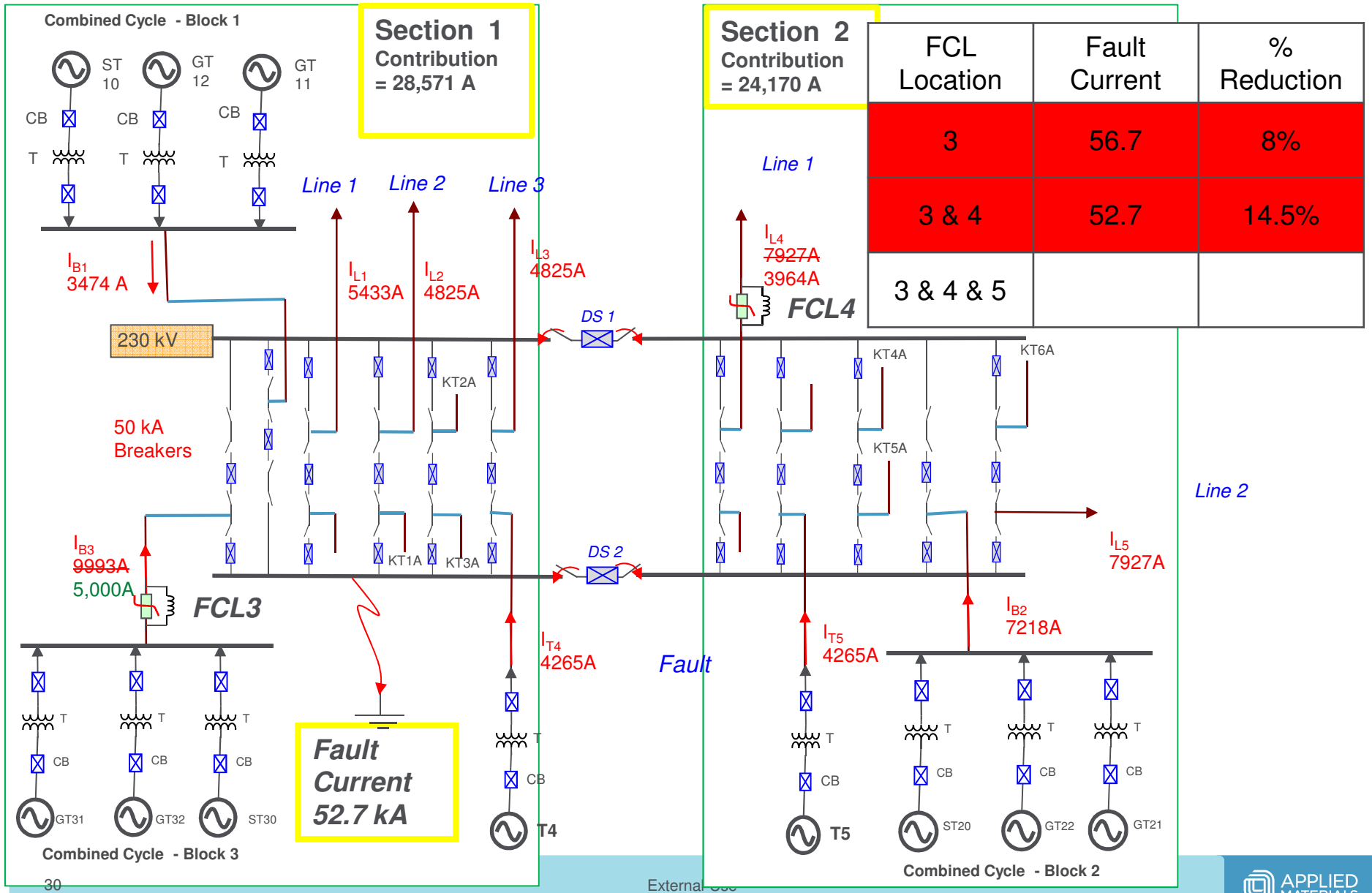
- Substation fault current reduced from 61.7 kA to 56.7 kA



FCL Location	Fault Current	% Reduction
3	56.7	8%
3 & 4		
3 & 4 & 5		

Using *2 in-line* FCLs

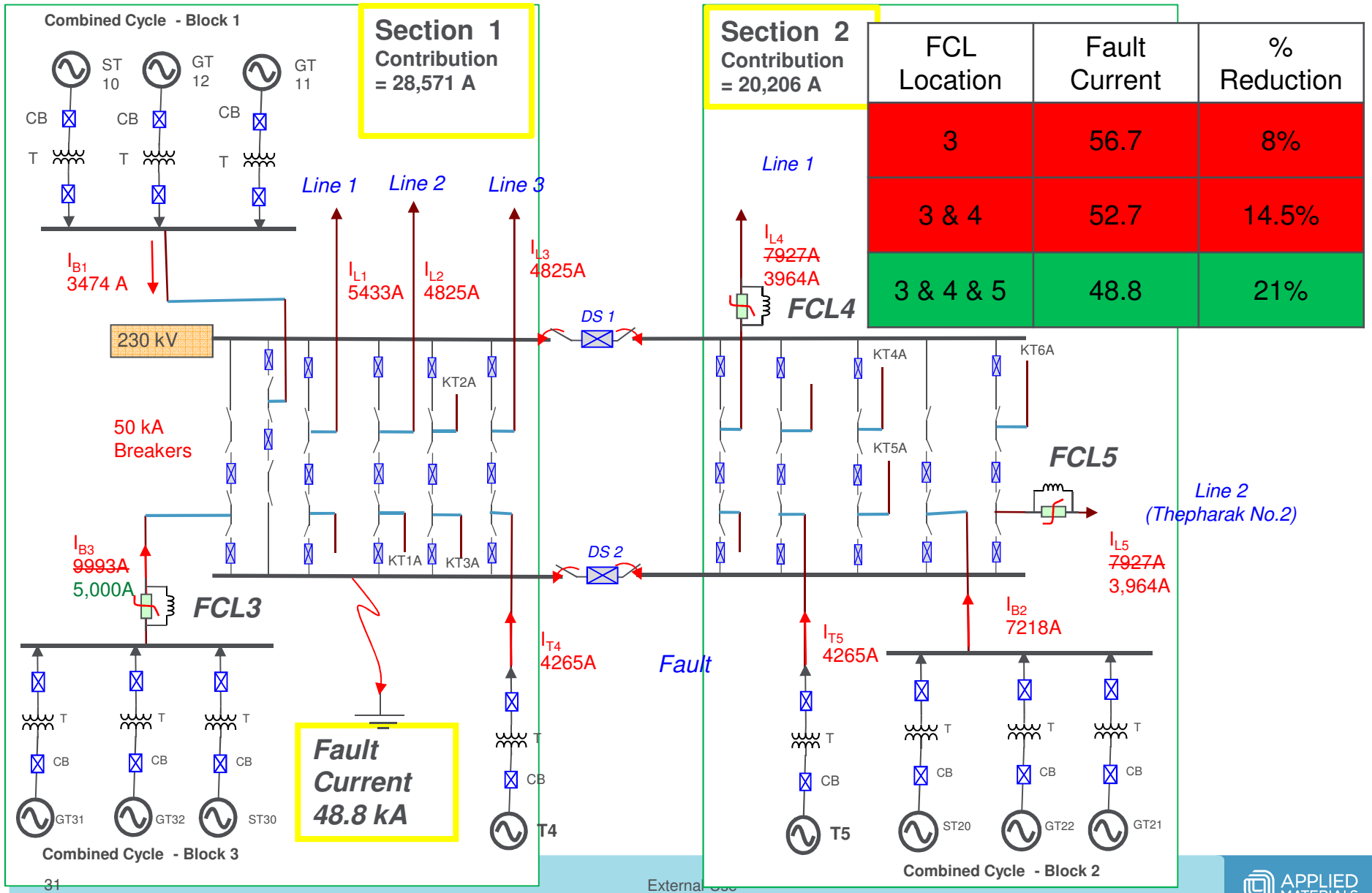
- Substation fault current reduced from 61.7 kA to 52.7 kA



FCL Location	Fault Current	% Reduction
3	56.7	8%
3 & 4	52.7	14.5%
3 & 4 & 5		

Using *3 in-line* FCLs

- Substation fault current reduced from 61.7 kA to 48.8 kA



FCL Location	Fault Current	% Reduction
3	56.7	8%
3 & 4	52.7	14.5%
3 & 4 & 5	48.8	21%

Customer A Substation – Impact of FCL Application Summary

Fault Location	Prospective Fault Current [kA]	Fault Current Limiter Location(s)	Limited Fault Current [kA]	Current Reduction [%]	Current Limitation Requirement [<50kA]
Section 1 or 2 Bus	*61.7*	*No FCL – Current status*	*61.7*	*0.0%*	*23.4% Over Design Limit*
Section 1 or 2 Bus	*61.7*	*1 in-line FCL at Block3*	*56.7*	*8.1%*	*11.3% Over Design Limit*
Section 1 or 2 Bus	*61.7*	*2 in-line FCLs at Block3, Line 4*	*52.7*	*14.5%*	*5.4 % Over Design Limit*
Section 1 or 2 Bus	*61.7*	*3 in-line FCLs at Block3, Line 4 and Line 5*	*48.8*	*20.9%*	*Satisfied*
Section 1 Bus	*61.7*	*2 Bus-tie FCLs*	*47.6*	*22.8%*	*Satisfied*
Section 2 Bus	*61.7*	*2 Bus-tie FCLs*	*44.9*	*27.2%*	*Satisfied*

FCL – More reliable, powerful, stiffer system

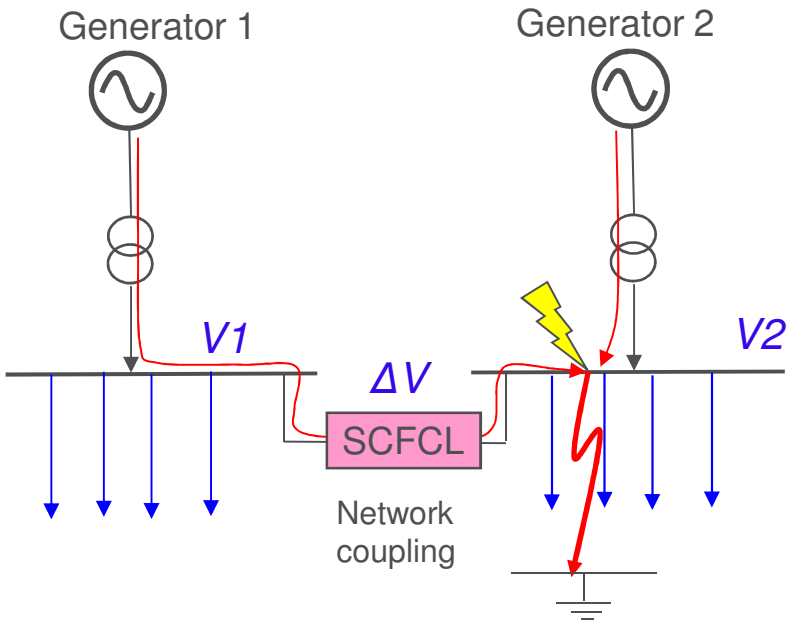
Alternatives to run the substation reliably with the bus ties closed using FCL

- ~~Disconnect ~20% of power~~ - Increase power by 5% (additional Revenue $**Million/Yr**)
- ~~Upgrade breakers, busbars~~ – No Upgrades needed, Capital avoidance (Avoid a New Station, Avoid **Millions**)
- ~~Split bus (reduce reliability)~~ – Bus Closed – Increased Reliability
- ~~High impedance~~ – Not Needed, Can use low impedance Transformers, Stiff Bus Better Voltage Stability

FCL creates a more reliable, stable, stiffer, increased capacity Substation

FCL – Voltage Stability

- SCFCL used to enhance grid interconnection
- Reduces fault current from both sides of the network
- Enables networks to be interconnected



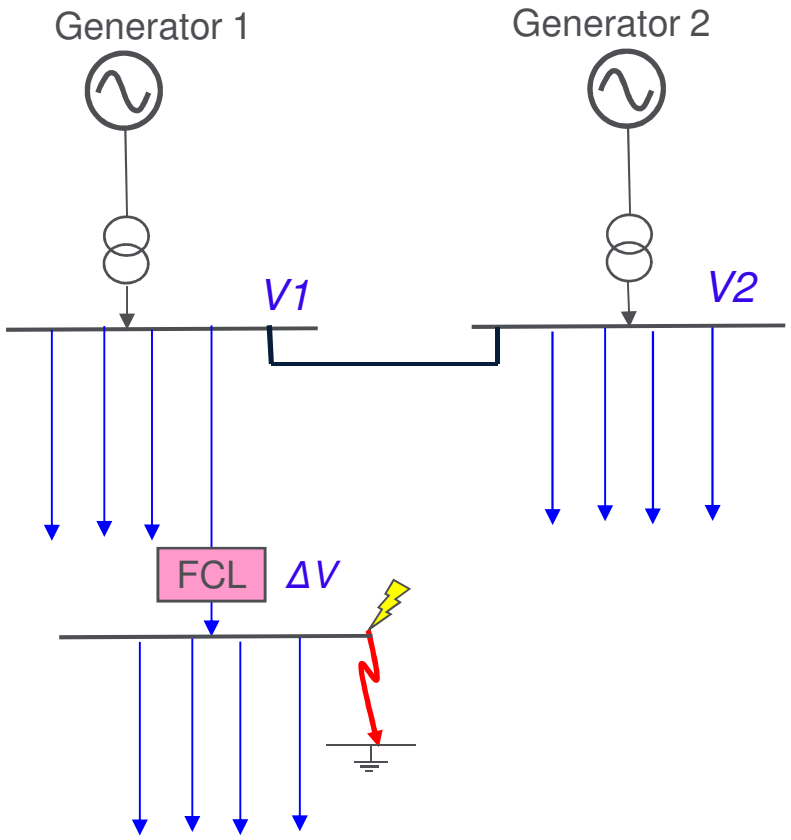
SCFCL limits Fault Current from generator 1

SCFCL Current Reduction	Voltage across SCFCL - ΔV [pu]	V1 – Bus 1 Voltage [pu]	V2 – Bus 2 Voltage [pu]	Voltage dip at Bus 1 [%]
No FCL	0.0	0.0	0.0	~100%
30%	0.3	0.3	0.0	70%
40%	0.4	0.4	0.0	60%
50%	0.5	0.5	0.0	50%
60%	0.6	0.6	0.0	40%
70%	0.7	0.7	0.0	30%
80%	0.8	0.8	0.0	20%
90%	0.9	0.9	0.0	10%

FCL isolates faulty sections and reduces voltage dip - improved voltage stability

FCL – Voltage Stability

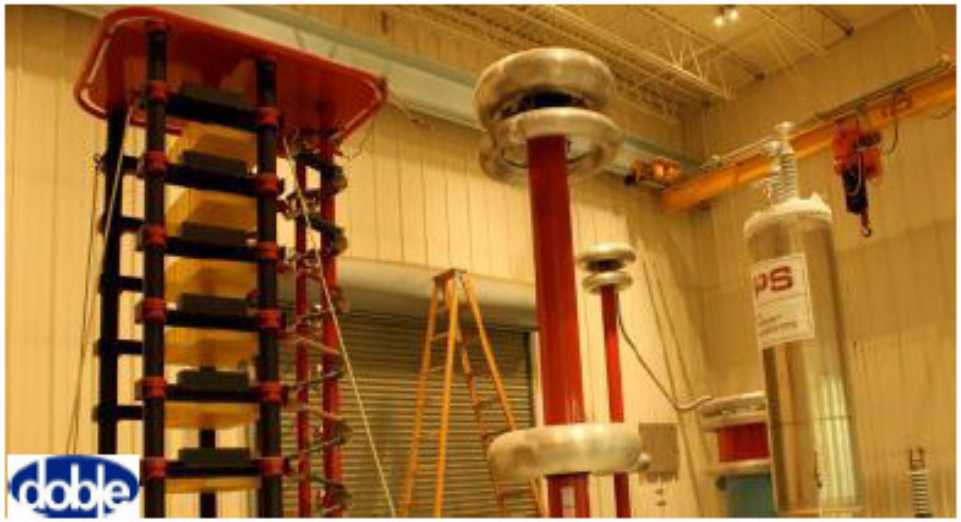
- SCFCL used to enhance grid interconnection
- Reduces fault current from both sides of the network
- Enables networks to be interconnected

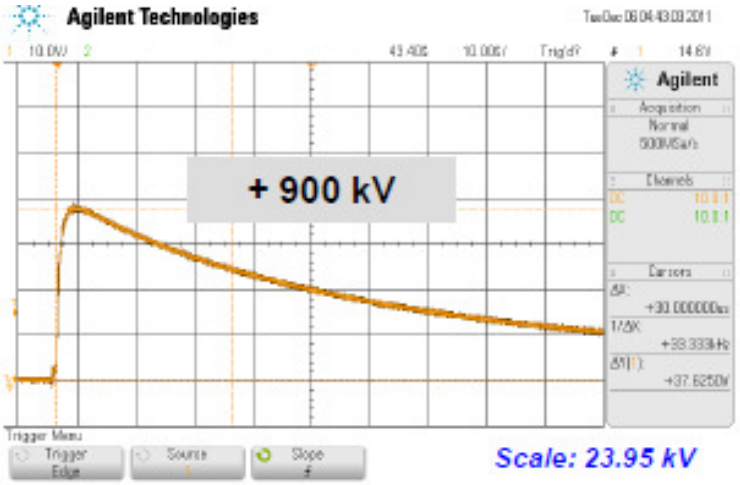


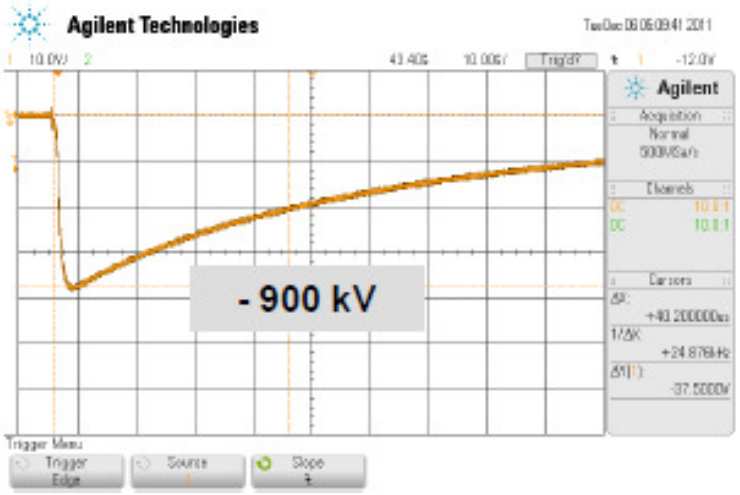
SCFCL Current Reduction	Voltage across FCL - ΔV [pu]	V1 [pu]	V2 [pu]	Voltage dip at Bus 1 and 2 [%]
NO FCL	0.0	0.0	0.0	~100%
30%	0.3	0.3	0.3	70%
40%	0.4	0.4	0.4	60%
50%	0.5	0.5	0.5	50%
60%	0.6	0.6	0.6	40%
70%	0.7	0.7	0.7	30%
80%	0.8	0.8	0.8	20%
90%	0.9	0.9	0.9	10%

FCL isolates faulty sections and reduces voltage dip - improved voltage stability

Transmission Impulse test results



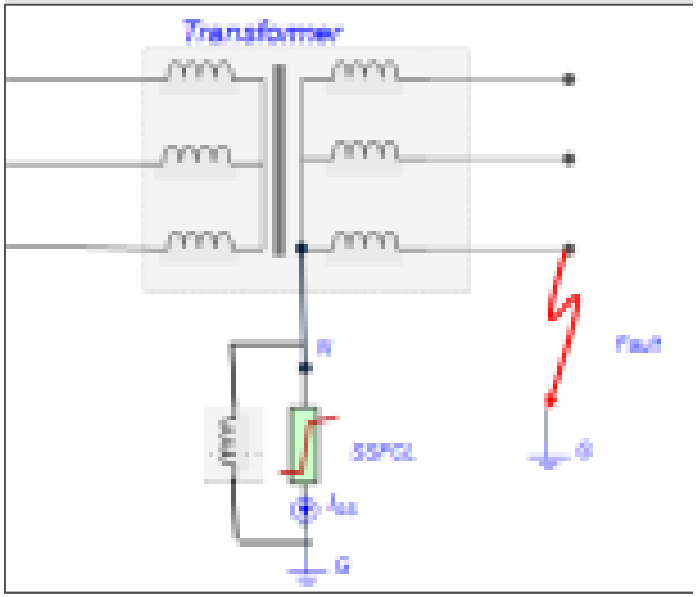




- Impulse test at 900 kV BIL
  - 15 Impulses at +900 kV – **Pass**
  - 15 Impulses at -900 kV – **Pass**
- AC withstand Voltage
  - 266 kV Single Phase (460 kV 3-phase)
  - 1 minute test at 266 kV – **Pass**

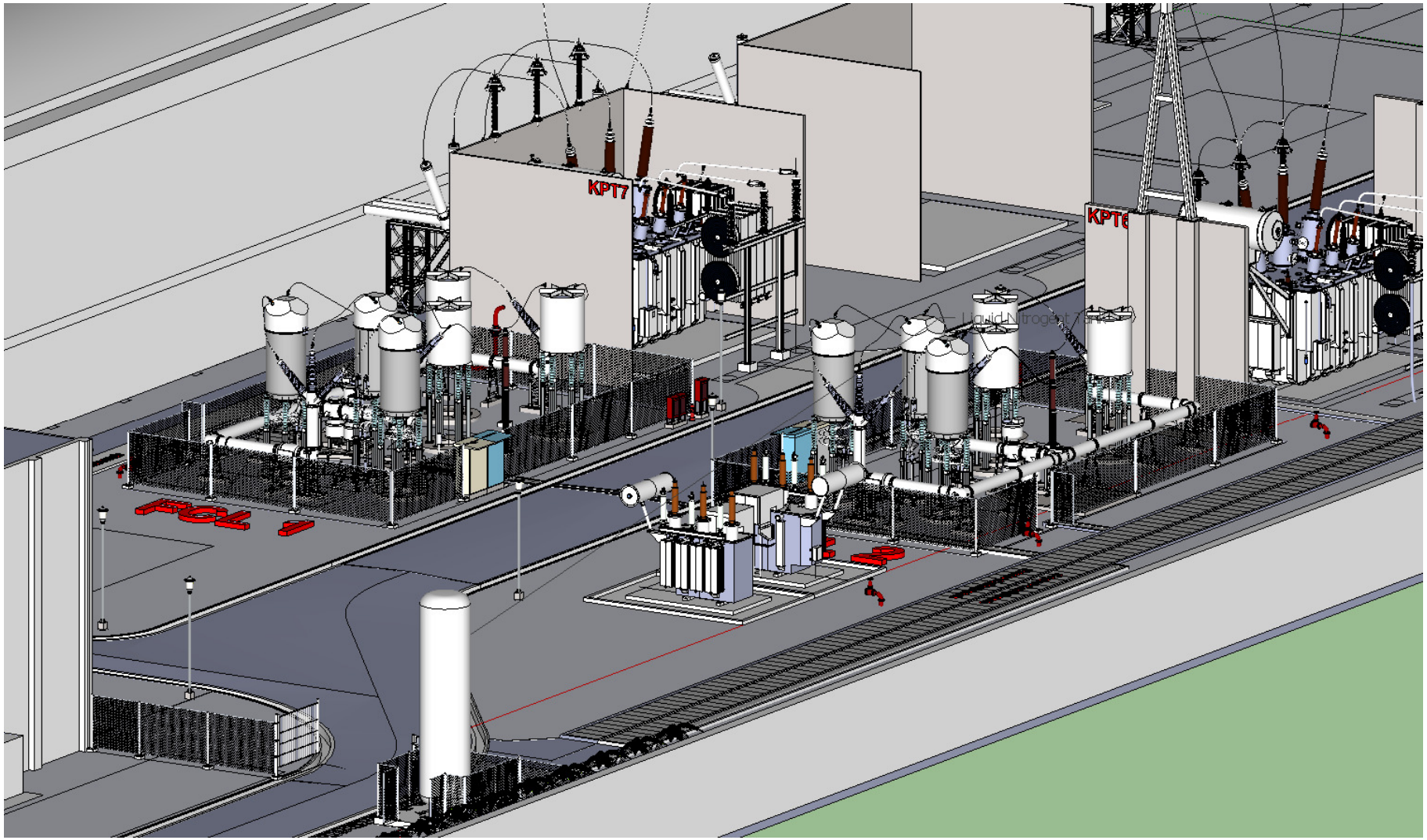
SCFCL on-grid demonstration

Applied Materials’ Superconducting FCL installed on Central Hudson Gas and Electric Company in New York State



- ✓ ***System successfully installed, and online in June 2014.***
- ✓ ***System has demonstrated fault current capture and mitigation 22 times over past 1.5 years***

Isometric View

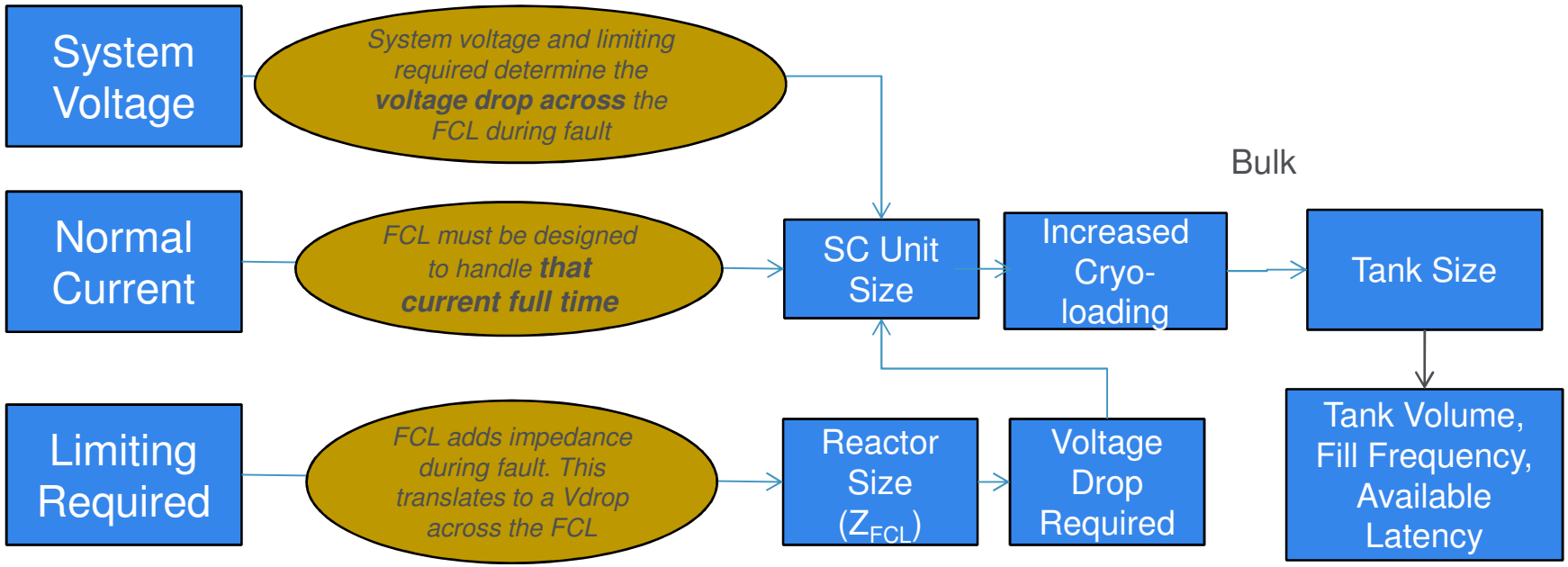


FCL Design Tradeoffs / Sensitivities

Major Items Influencing System Design are:

1. System Voltage
2. System Normal Current
3. Current Limiting Required

Each system requirement has system impacts:



Thank you.

Contacts:
Vikas Dabeer +919686199484
Shankar Kodle +919900164234

http://www.appliedmaterials.com/technologies/fault-current-limiters