

Distribution Substation - Network Feeder 'Back Feed' Protection

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67th Annual Conference for Protective Relay Engineers

Texas A&M University

March 31 – April 3, 2014

'Street Network' and 'Spot Network'

CenterPoint Energy offers a range of overhead and underground single phase, two phase and three phase types of services.

At CenterPoint Energy's option, in certain locations, CenterPoint Energy offers service from 208V underground secondary 'Street Network' and 480V & 4160V secondary 'Spot Networks'.

These secondary networks are characterized by a bus fed by multiple network transformers with a given secondary network operating voltage (208 V, 480 V, 4160 V).

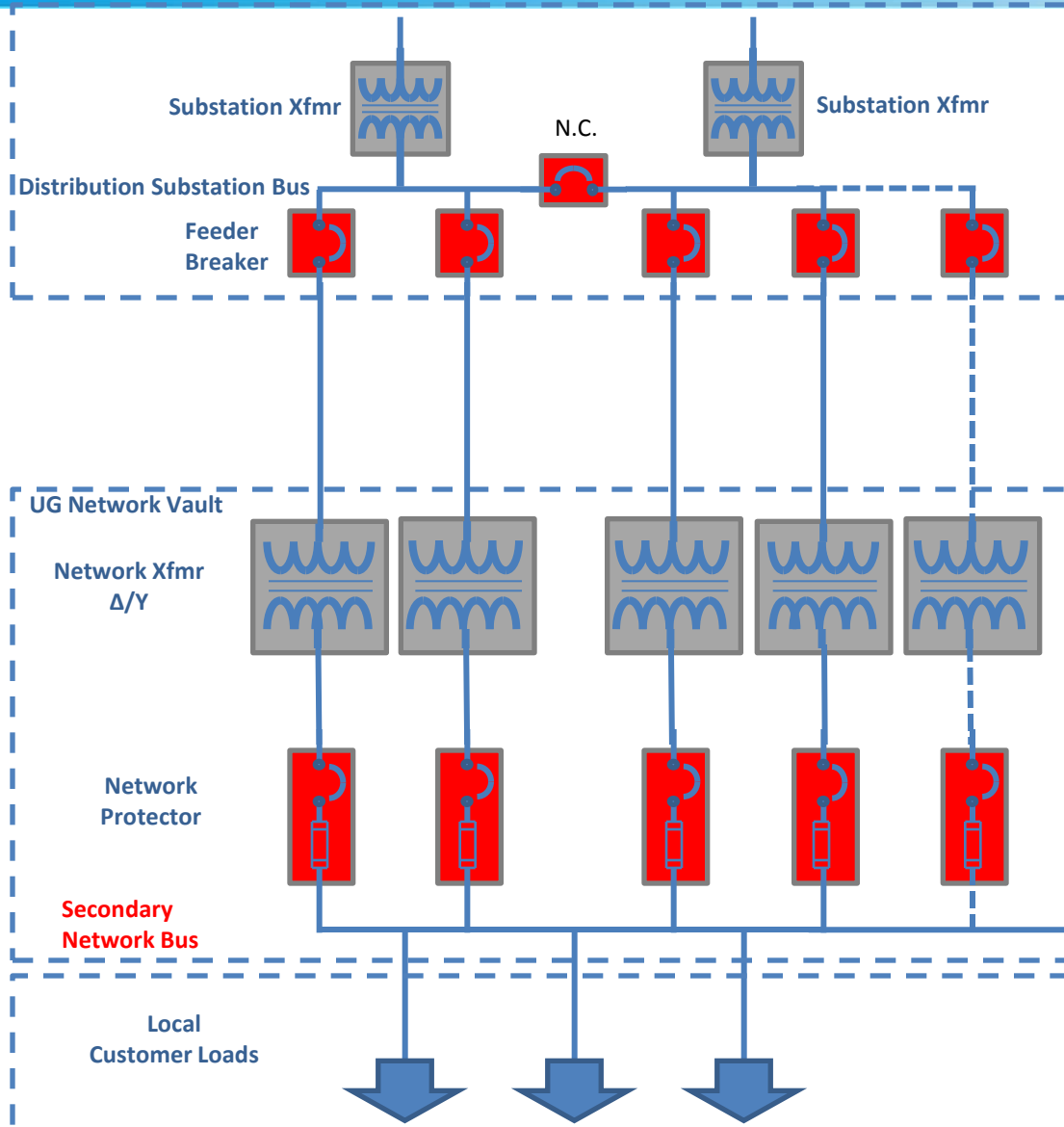
Each network transformer has a 12.47 kV delta connected primary voltage winding. For a given secondary network, each network transformer is connected to a separate 12.47 kV substation feeder.

All of the 12.47 kV feeders that supply a set of network transformers originate from the same substation.

Two substation power transformers supply all of the network feeders that make up a 'network grid'.

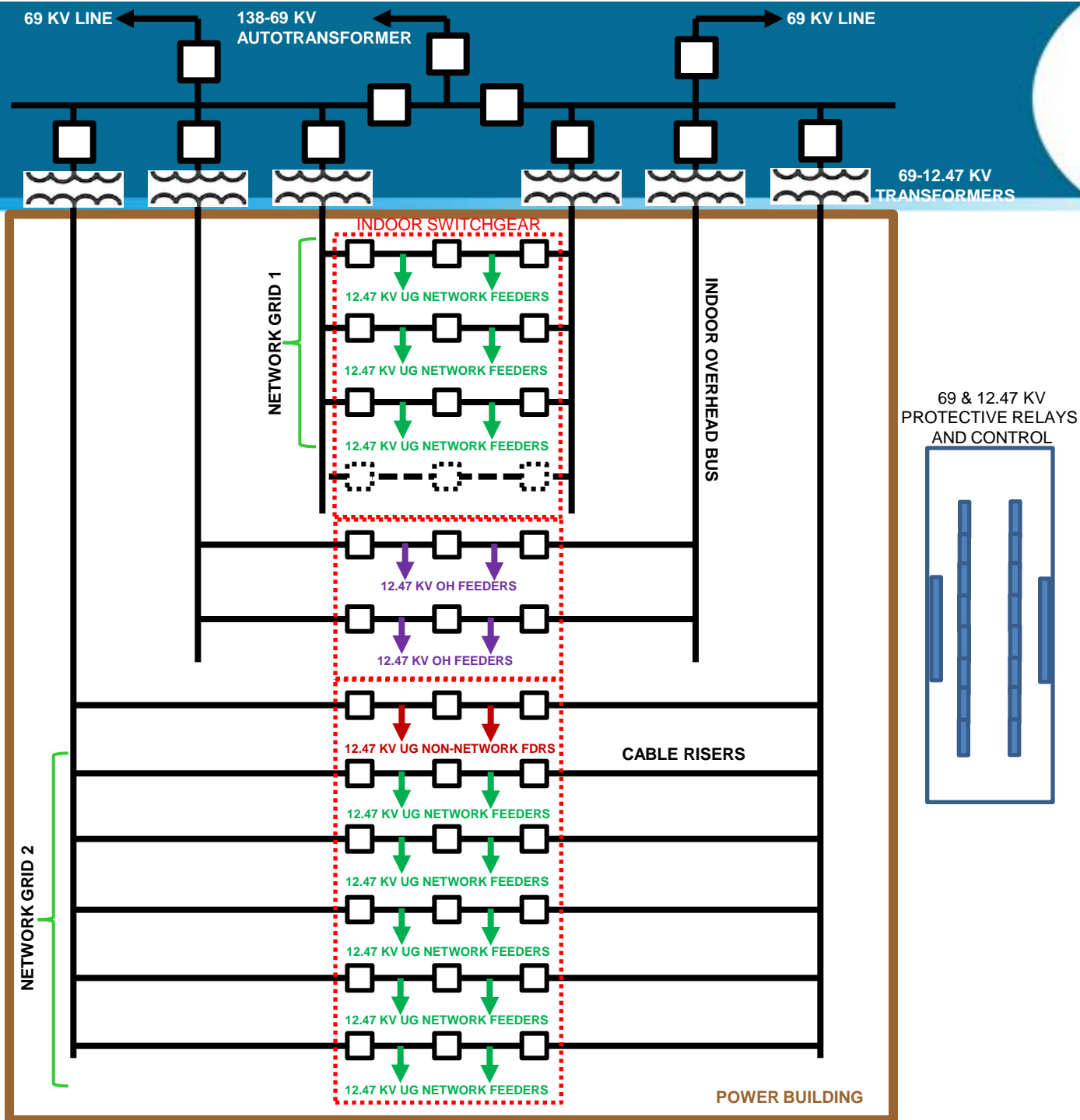
'Street Network' and 'Spot Network'

Substation

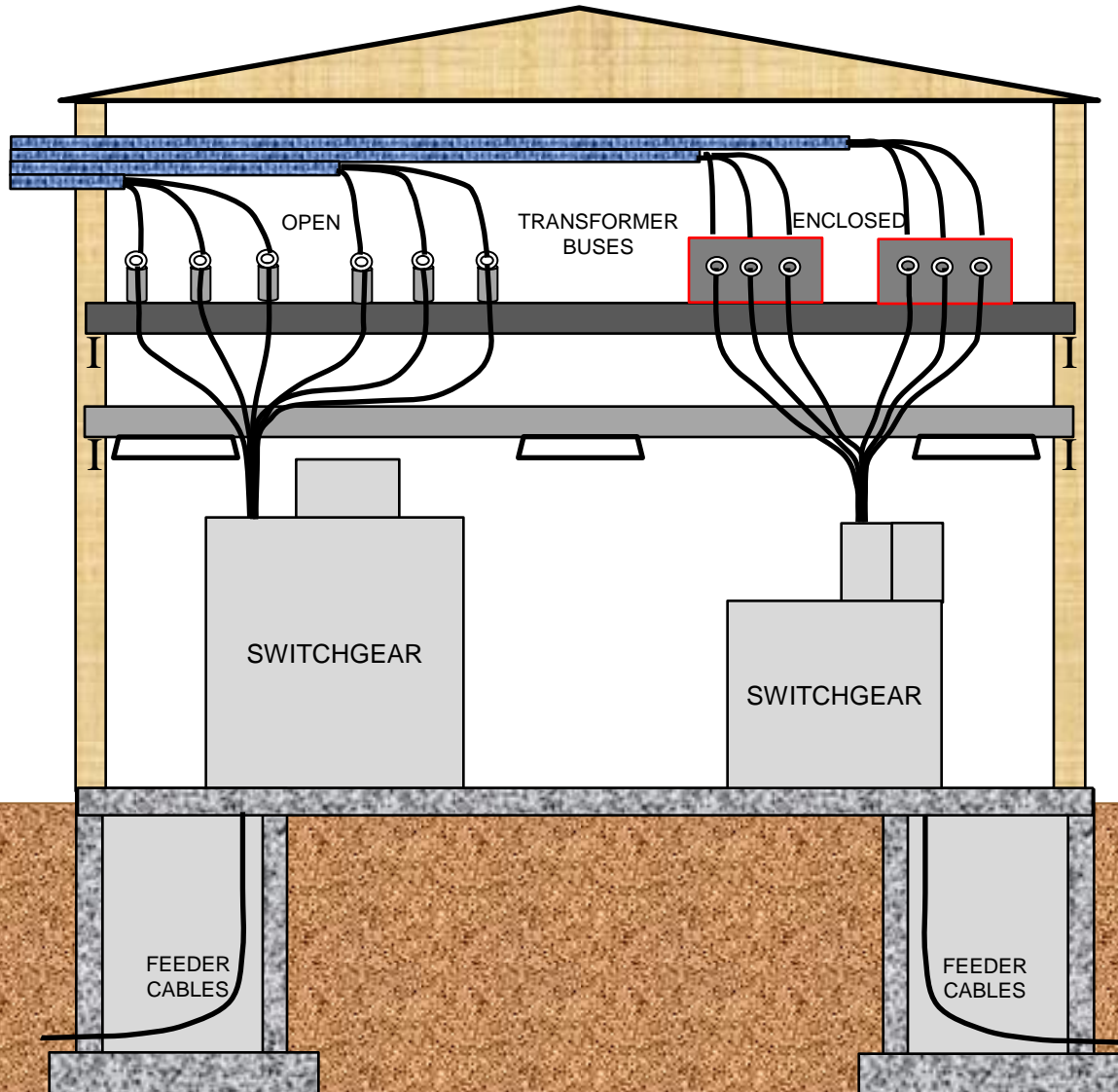


- Two substation transformers are connected to a common bus. (Networked Substation Bus)
- Networked underground feeders leave the sub to serve UG network vaults.
- Each feeder serves a UG network transformer.
- The network transformer secondary is connected, through a network protector, to a common bus.
- The secondary network is a bus fed by multiple transformers, from multiple feeders, at a given operating network voltage (208 V, 480 V, 4160 V).
- CNP has 1-208V secondary network and numerous 480V/4160V spot networks.
- CNP Network Systems are designed to be able to lose a feeder without effecting the customer (N-1).

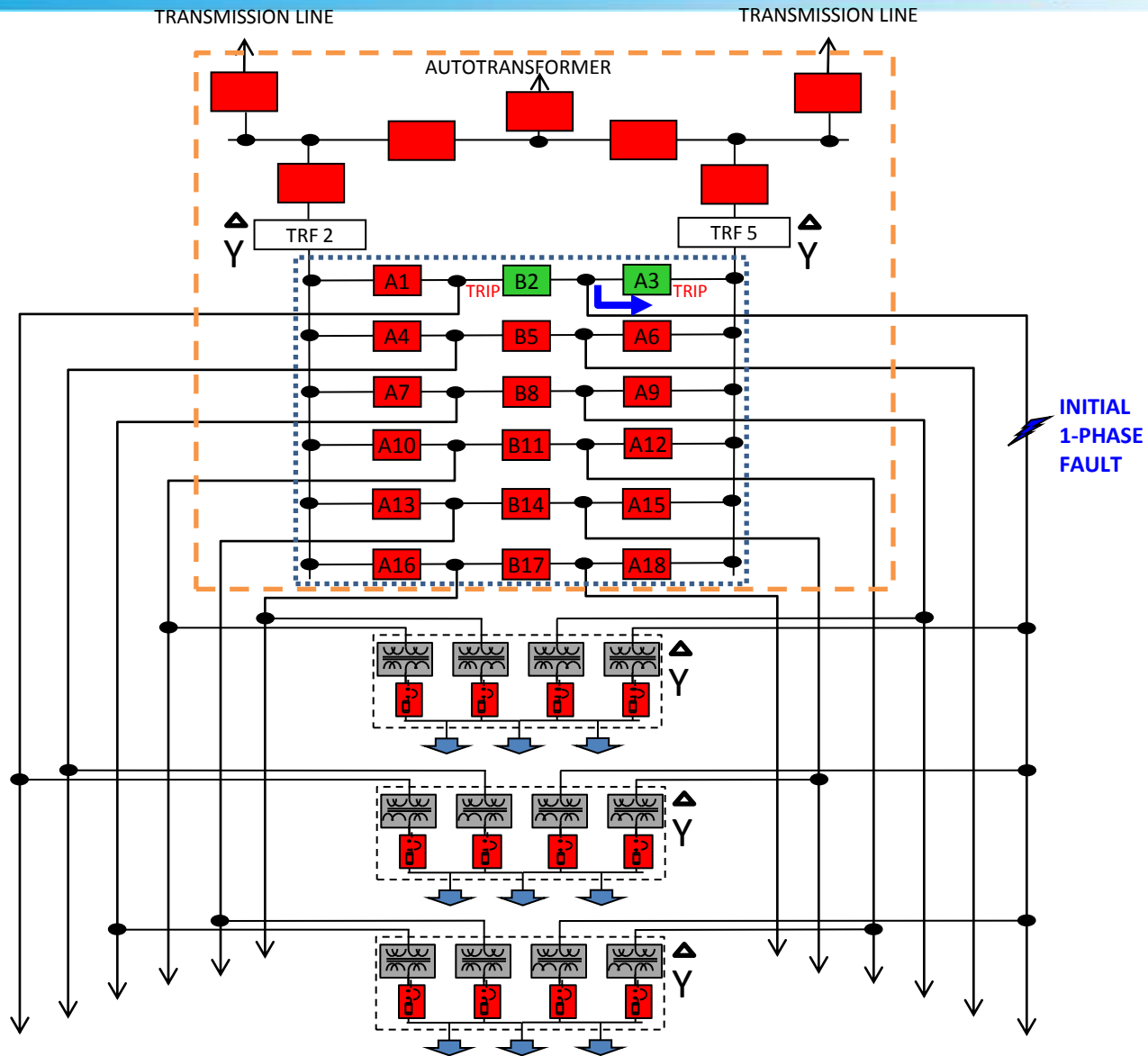
SUBSTATION CONFIGURATION



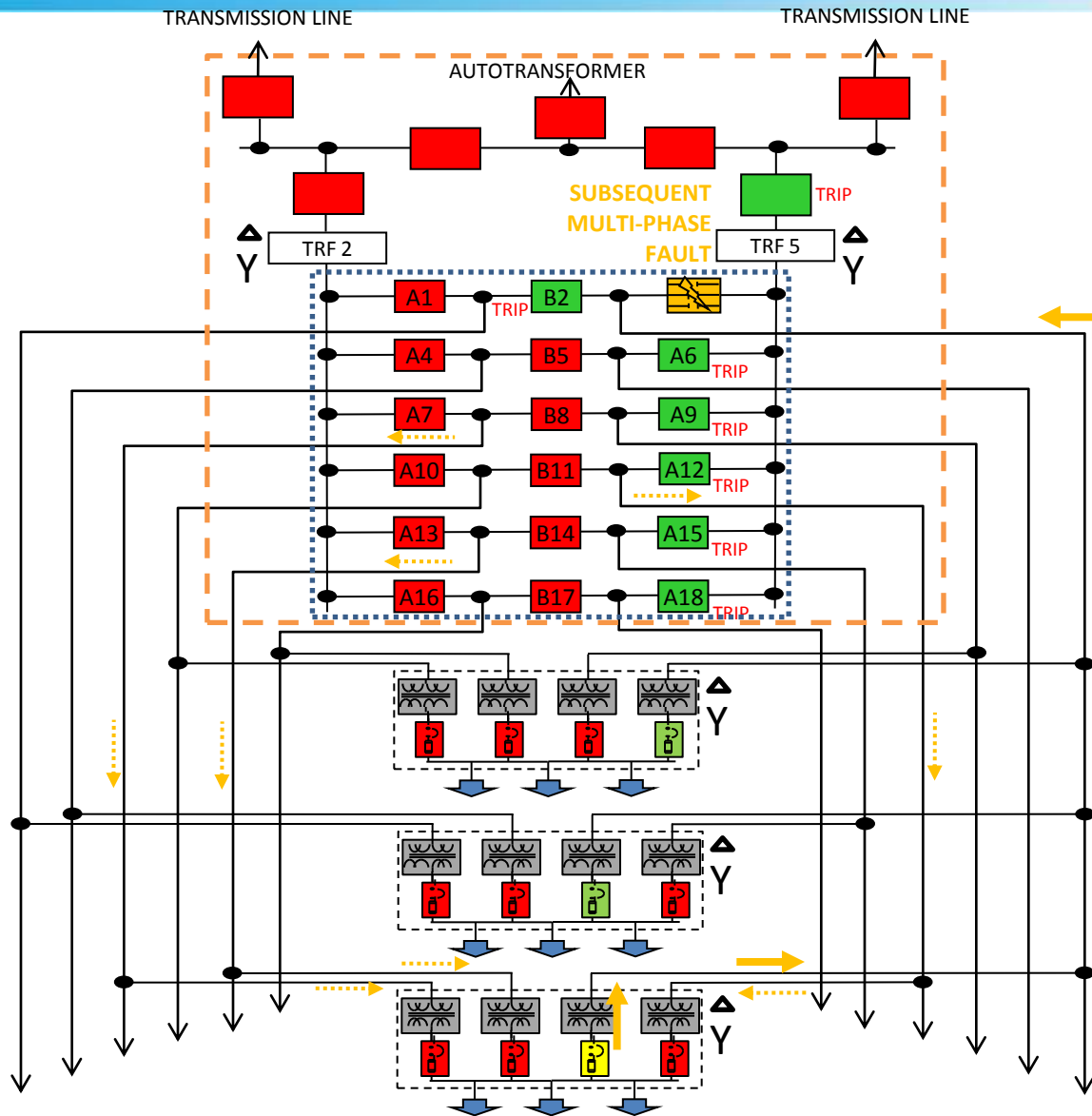
POWER BUILDING



October 5, 2006



October 5, 2006

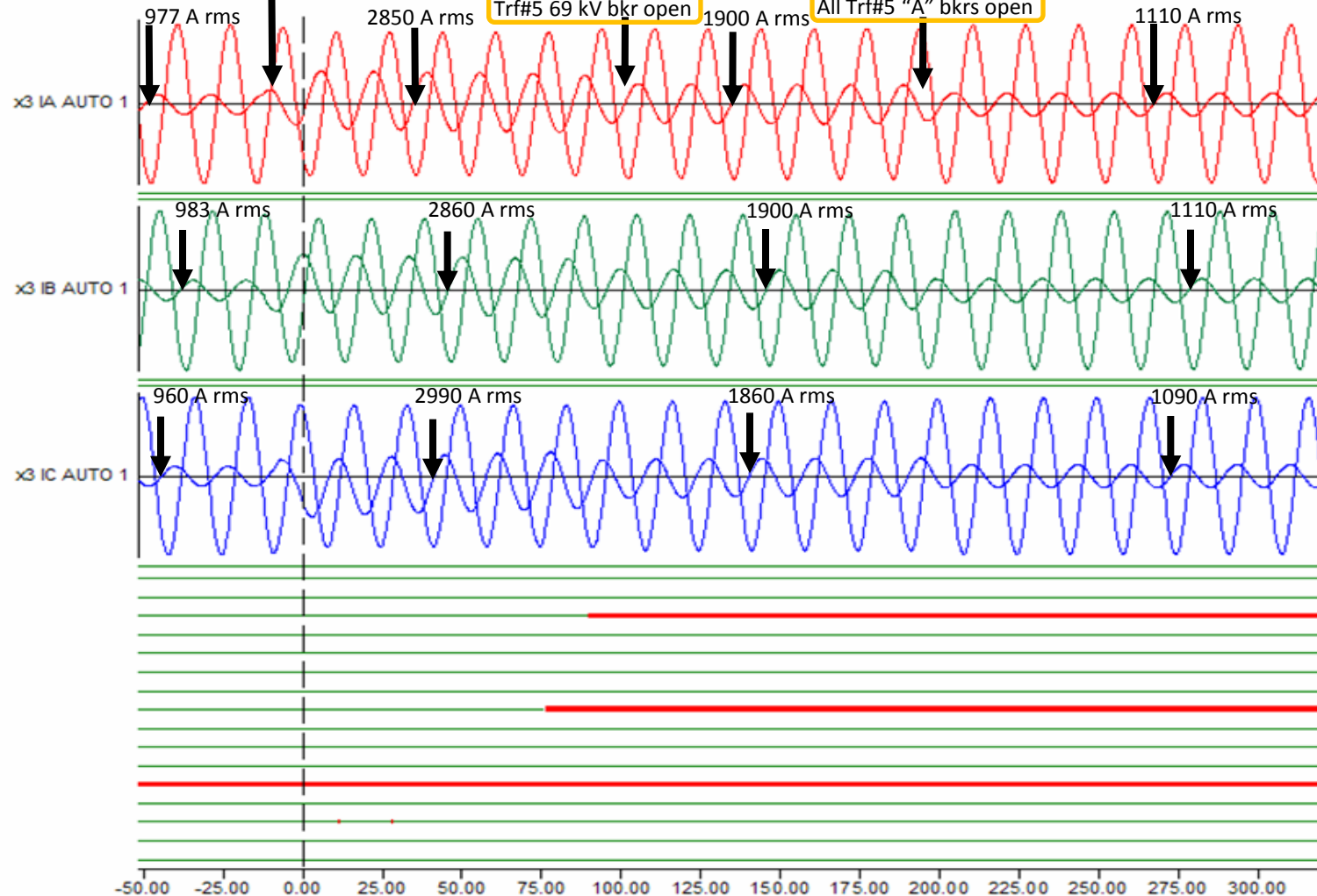


October 5, 2006

SUBSTATION 69 KV
DIGITAL FAULT
RECORDER
T = 0

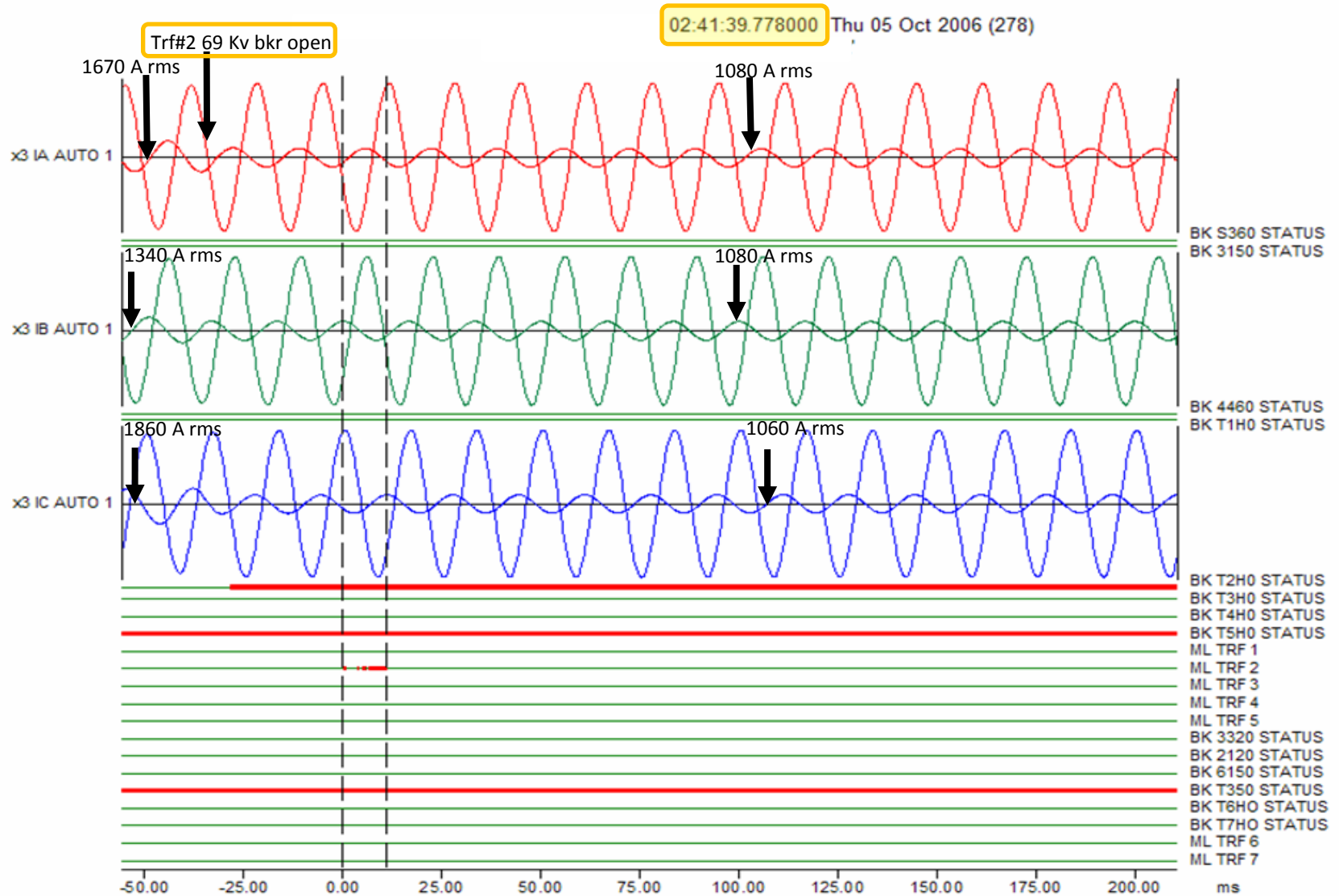
B2 opens but A3 interrupter fails
Results in multi-phase fault

02:36:00.166000 Thu 05 Oct 2006 (278)



October 5, 2006

SUBSTATION 69 KV
DIGITAL FAULT
RECORDER
T = 5 min.



SWITCHGEAR CIRCUIT BREAKER COMPARTMENT



REMAINS OF SWITCHGEAR CIRCUIT BREAKER



SWITCHGEAR 'A-B-A' CIRCUIT BREAKER COMPARTMENTS AND CABLE RISERS TO INDOOR OVERHEAD BUS



INDOOR OVERHEAD 12.47 KV BUS



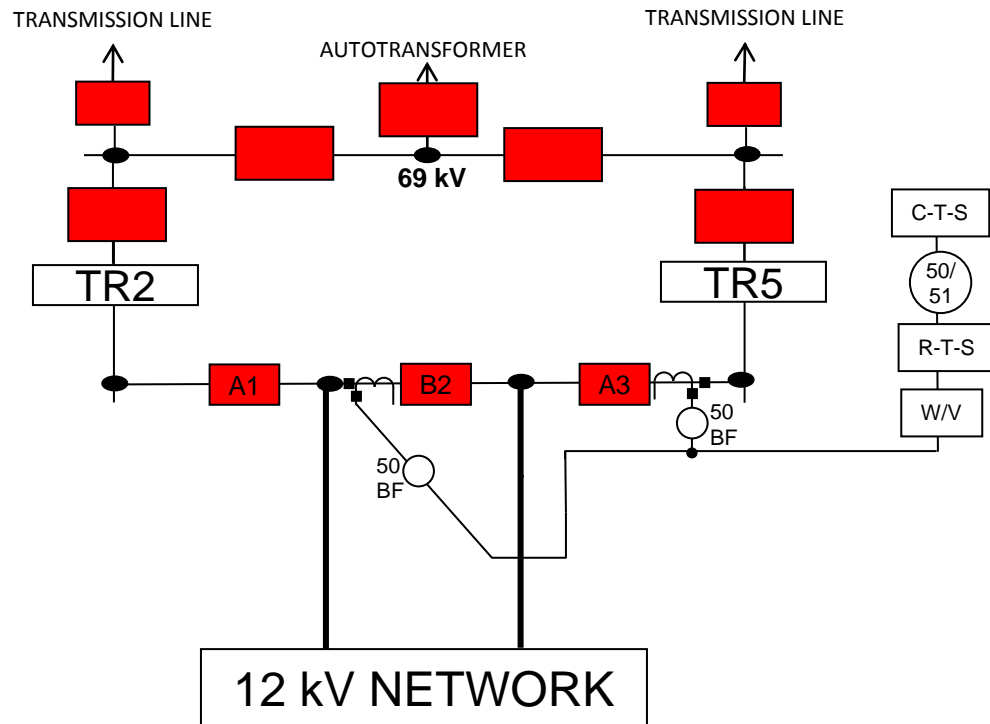
RESTORATION

- OTHER TRANSFORMERS WERE MANUALLY TRIPPED TO ALLOW FIRE DEPARTMENT TO PUT OUT THE FIRE IN THE CUBICLE.
- TOOK 8 HOURS TO ISOLATE DAMAGED EQUIPMENT, CLEAN, TEST AND RE-ENERGIZE FEEDERS THAT WERE NOT DAMAGED.
- REMAINING CLEANUP EFFORTS TOOK 7-10 DAYS TO COMPLETE.
- DAMAGED SWITCHGEAR AND CIRCUIT BREAKERS WOULD HAVE TO BE REPLACED LATER.

NEAR TERM FIXES

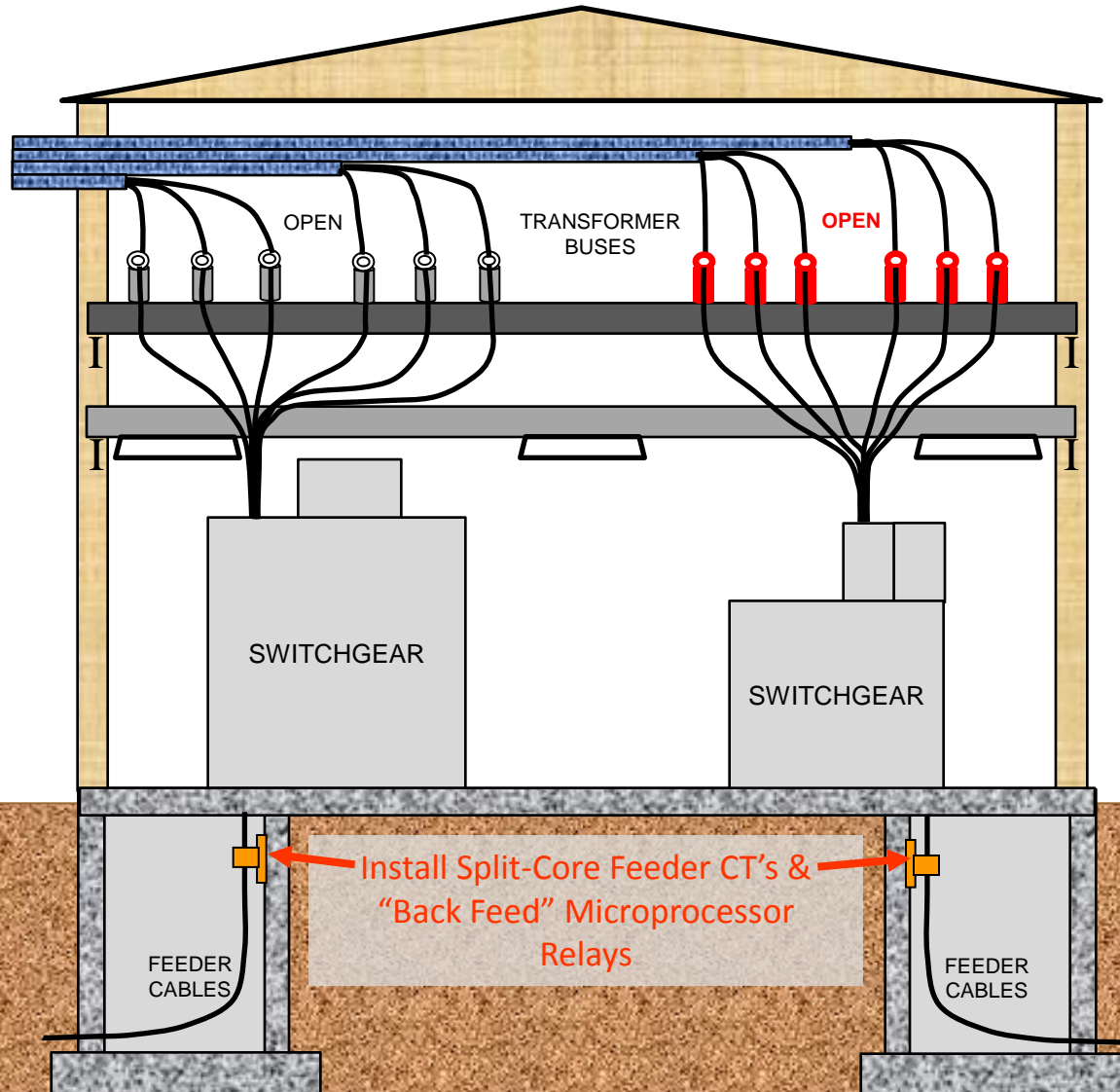
- SEND SIMILAR SWITCHGEAR CIRCUIT BREAKERS FROM FOUR SUBSTATIONS TO MANUFACTURER FOR REHAB - ADD STRUT UPGRADE KIT, REPLACE PUSH RODS, REPLACE PRIMARY TRIP PROP ASSEMBLY, REPLACE TRIP SPRINGS, REPLACE CONTACT SPRINGS, ROUTINE MAINTAINCE LUBRICATION, TESTS AND CHECKS.
- REPLACE INDOOR ENCLOSED TRANSFORMER BUS WITH OPEN AIR BUS.
- ADD FIRE-PROOF BARRIER TO INDOOR CONTROL CABLE TRAY.
- DEVELOP AND IMPLEMENT A NEW SUBSTATION BASED 'BACK FEED' PROTECTIVE RELAYING SCHEME.

TYPICAL PROTECTION SCHEME

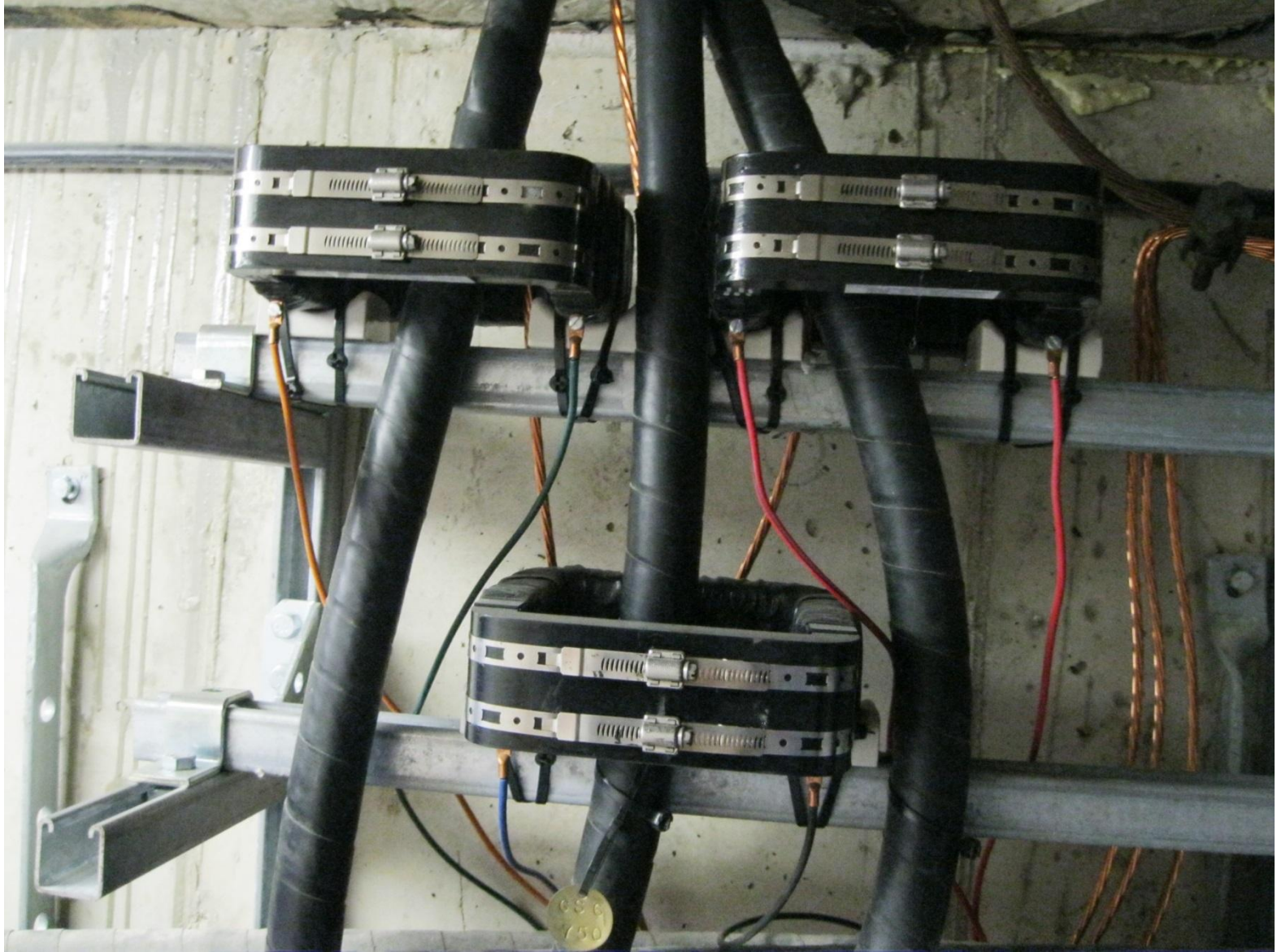




POWER BUILDING

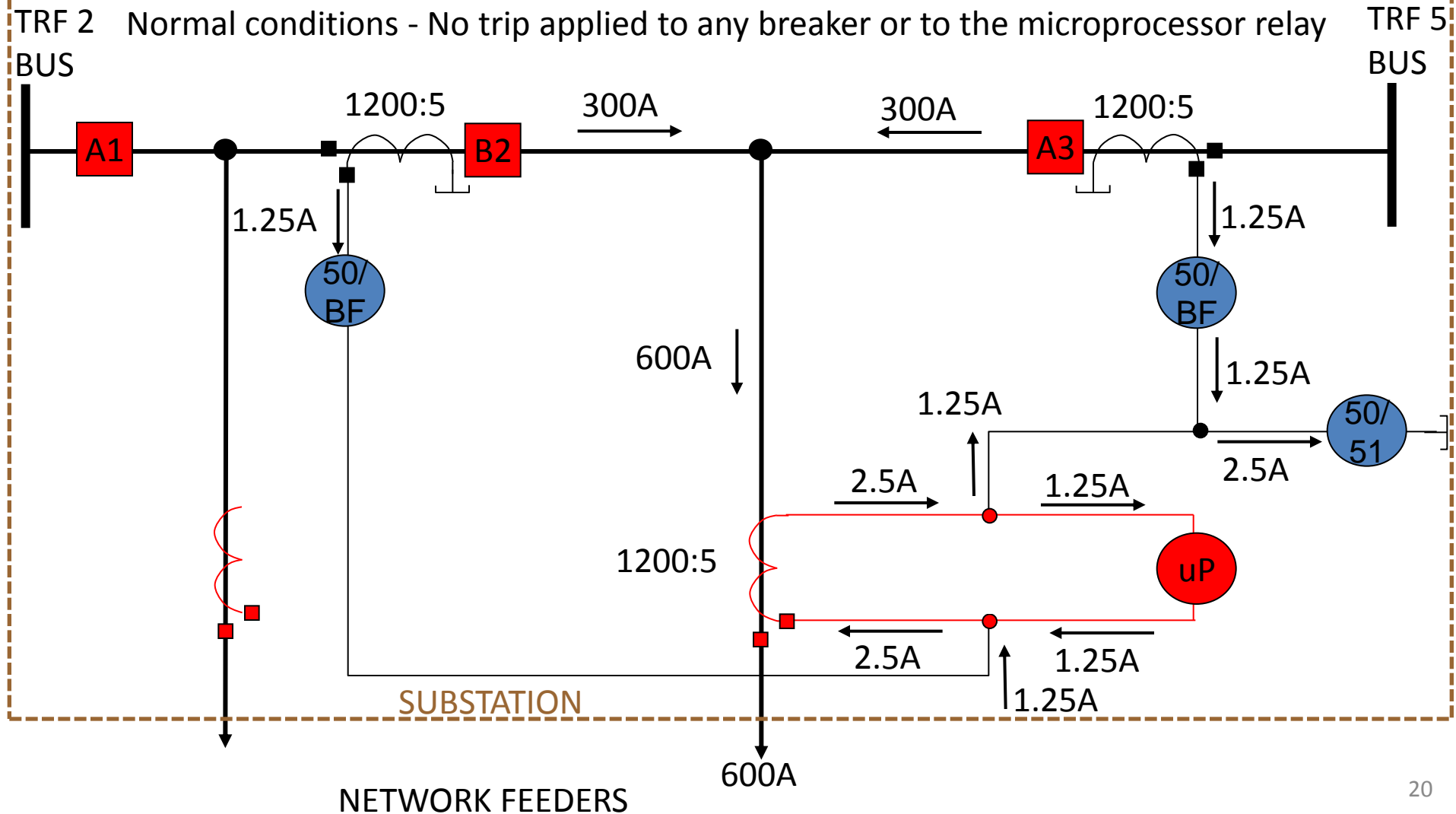


'BACK FEED' PROTECTION – SPLIT-CORE FEEDER CT'S



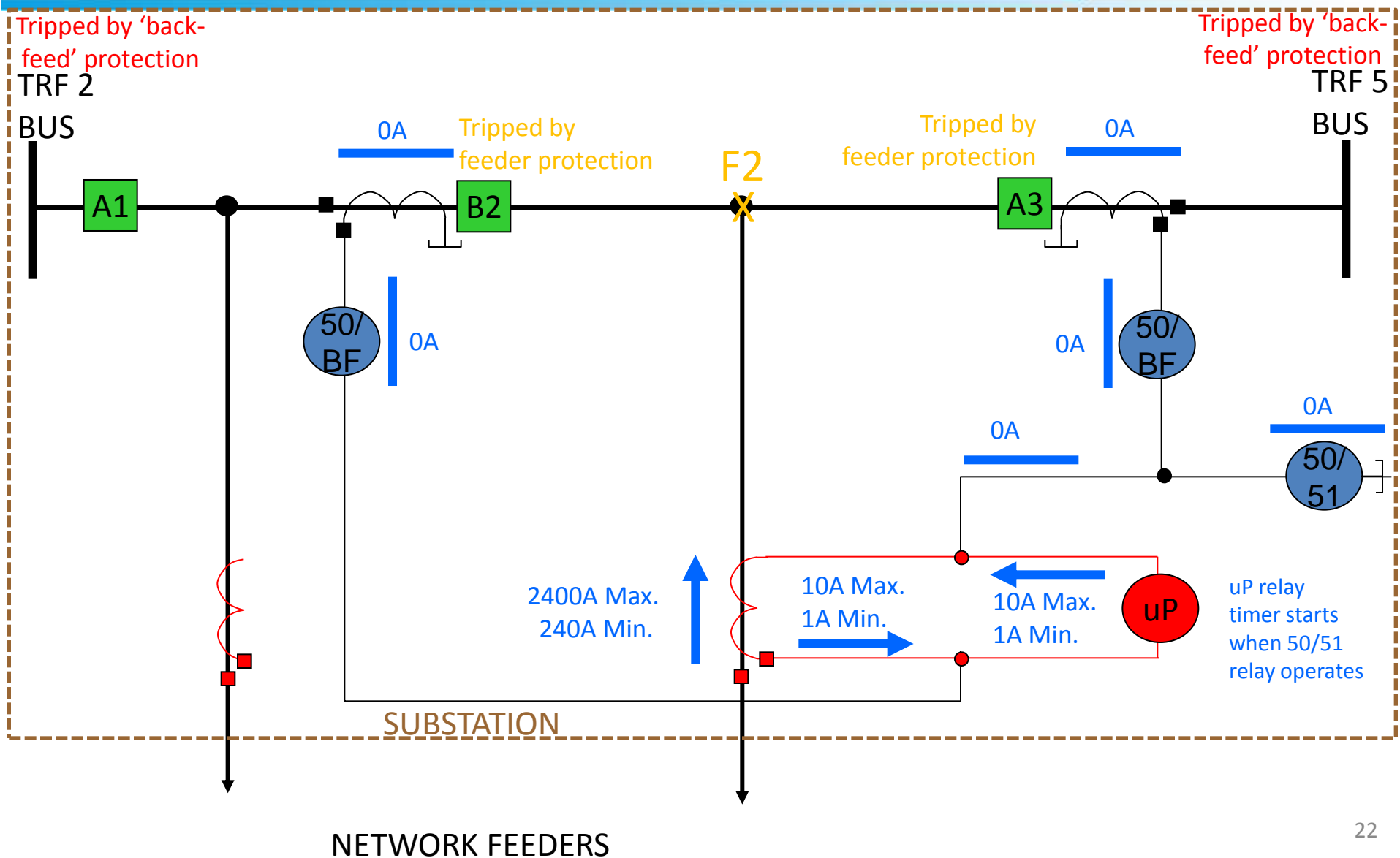
'BACK-FEED' PROTECTION – NORMAL CONDITIONS

"Back-Feed trip" scheme

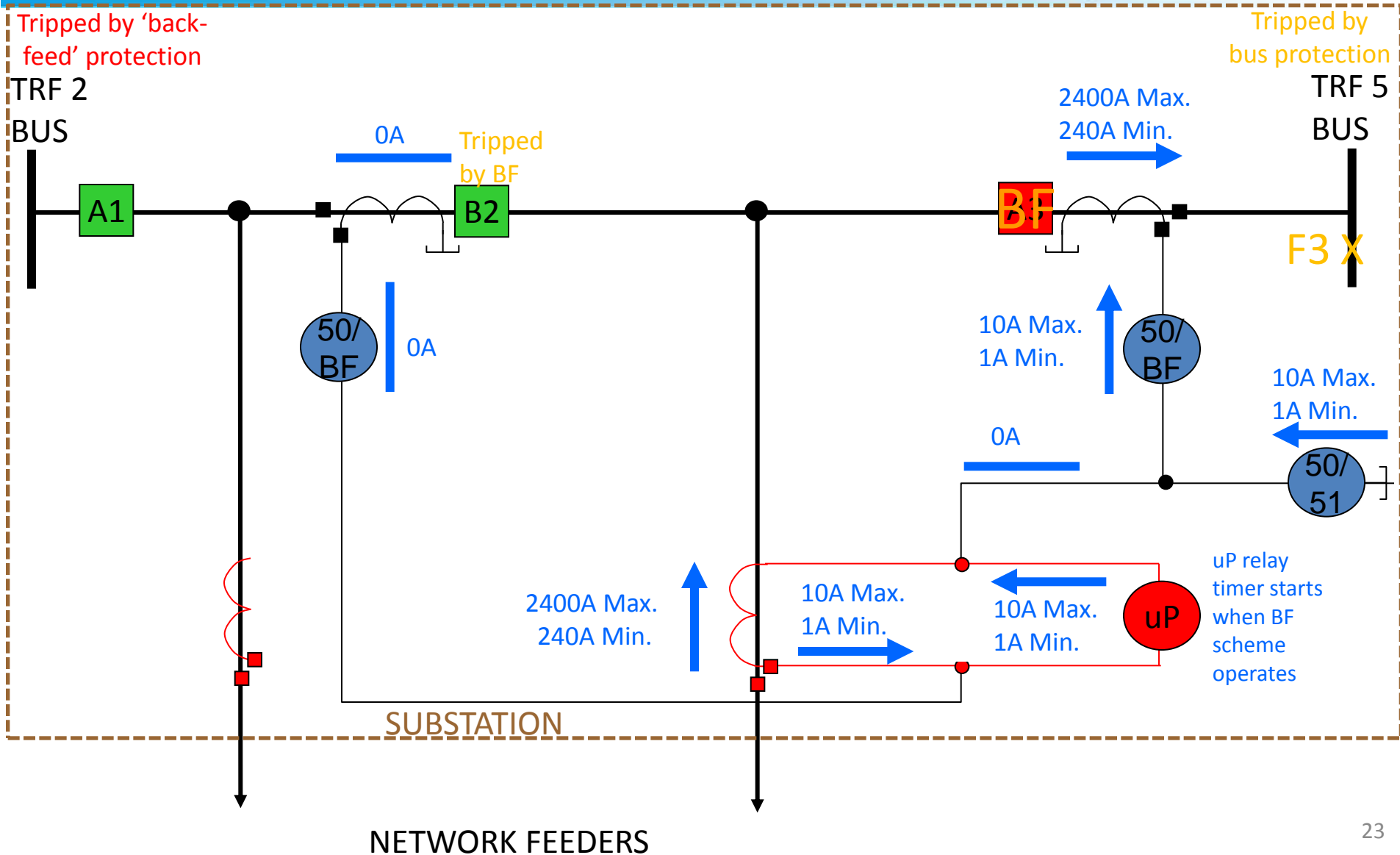




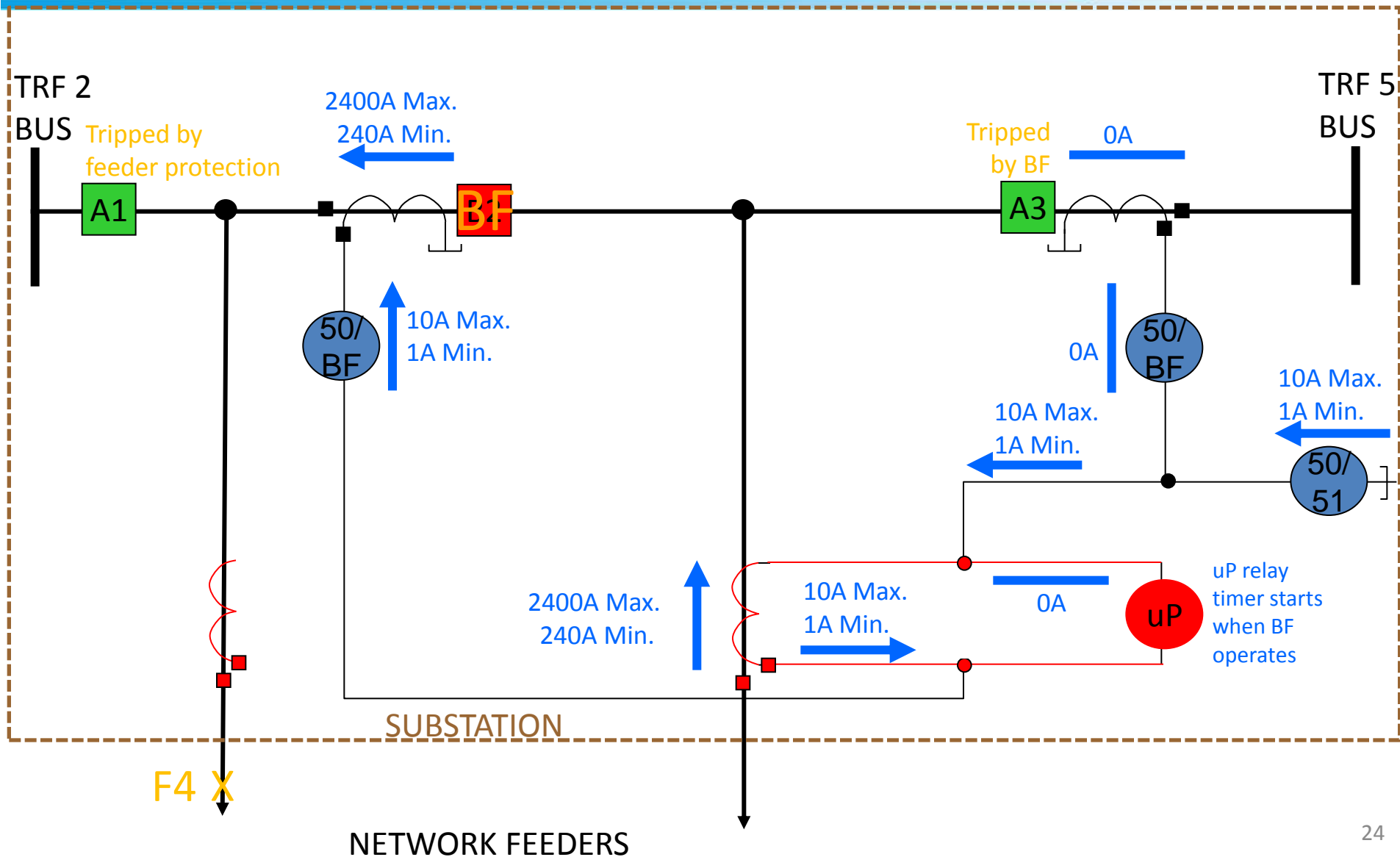
"F2" FAULT - TRIP FROM 'BACKFEED' MICROPROCESSOR RELAY REQUIRED AFTER SET TIME DELAY



“F3” FAULT AND A3 BREAKER FAILURE – TRIP FROM ‘BACKFEED’ MICROPROCESSOR RELAY REQUIRED AFTER SET TIME DELAY



“F4” FAULT AND B2 BREAKER FAILURE – NO TRIP FROM ‘BACK FEED’ MICROPROCESSOR RELAY



December 27, 2012

A FAULT OCCURRED IN THE 12 KV CIRCUIT BREAKER A3 COMPARTMENT.

THE NORMAL FEEDER AND TRANSFORMER PROTECTIVE RELAYS TRIPPED TRANSFORMER #5 AND 12 KV CIRCUIT BREAKER B2 IN SIX CYCLES BUT THE FAULT IN A3 CONTINUED TO BE BACK FEED FROM THE FEEDER VIA TRANSFORMER #2 AND THE DISTRIBUTION NETWORK.

THE SPECIAL 'BACK FEED' PROTECTIVE RELAYING OPERATED AND TRIPPED TRANSFORMER #2 IN APPROXIMATELY ONE SECOND AFTER THE TRANSFORMER #5 TRIP.

SUBSEQUENTLY IT WAS DETERMINED THAT A RAT HAD CAUSED THE FAULT.

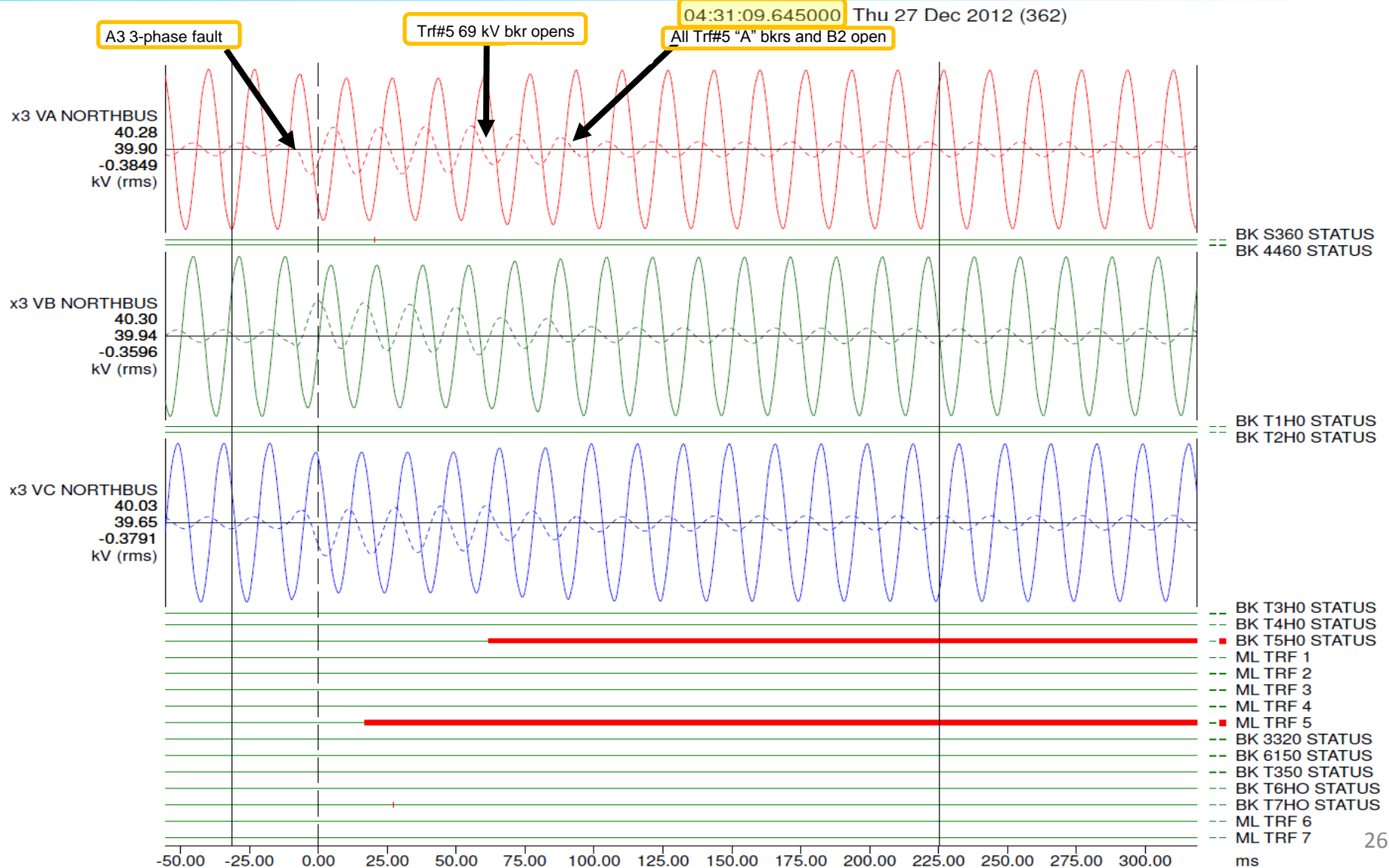
THE B 'BACK FEED' OPERATED AS DESIGNED AND INITIATED ALARMS THROUGH SCADA.

ABLE TO ISOLATE THE CIRCUIT IN THE BUILDING AS WELL AS ISOLATE THE FEEDER IN THE FIELD.

SWITCHING AND RESTORATION WAS COMPLETE IN 90 MINUTES.

December 27, 2012

SUBSTATION 69 KV
DIGITAL FAULT
RECORDER
T = 0



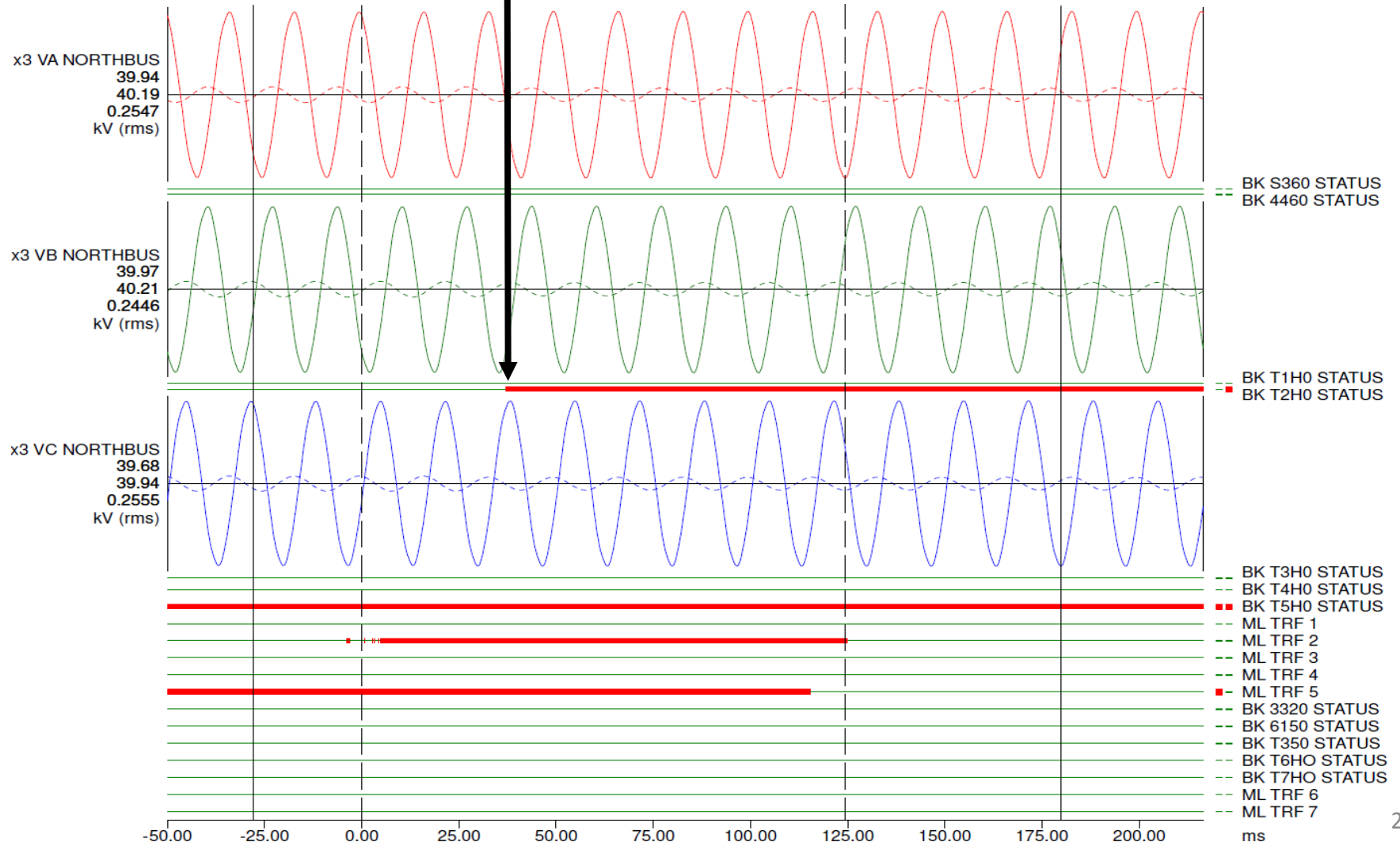
December 27, 2012

SUBSTATION 69 KV
DIGITAL FAULT
RECORDER
T = 1 second

Trf#2 69 kV bkr opens

04:31:10.706000

Thu 27 Dec 2012 (362)



SWITCHGEAR CIRCUIT BREAKER COMPARTMENT



LONG TERM OPTIONS TO ADDRESS A POSSIBLE FUTURE MAJOR EVENT INSIDE OF POWER BUILDING

SHORTLY AFTER THIS EVENT SEVERAL LONG TERM OPTIONS WERE PROPOSED FOR EVALUATION TO PREVENT OR LESSEN DAMAGE IF A SIMILAR OF MORE DESTRUCTIVE EVENT WERE TO OCCUR:

- FIRE DETECTION/SUPPRESSION/POWER-DOWN SYSTEM
- CHANGE TO AN OPEN AIR SUBSTATION DESIGN
- ADD SECOND POWER BUILDING SEPARATED WITH FIREWALLS
- MOBILE BREAKER “SIX PACK” TRAILER RESTORATION SCHEME
- REAL TIME CAMERA MONITORING INSIDE OF POWER BUILDING

LATER IT WAS DETERMINED THAT GAS INSULATED SWITCHGEAR (GIS) HAD SEVERAL ADVANTAGES FOR THIS PARTICULAR APPLICATION.

LONG TERM PLAN

12.47 KV GAS INSULATED SWITCHGEAR (GIS)

GIS SYSTEM INCORPORATES VACUUM BOTTLES INSIDE CAST ALUMINUM TANKS UNDER SF6 GAS PRESSURE AND IS A SINGLE PHASE DESIGN. THEREFORE, PHASE-TO-PHASE FAULT IS NOT POSSIBLE.

ALL THE LIVE PARTS ARE LOCATED INSIDE THE TANK AND THE GEAR IS SAFE TO TOUCH.

NO RACKING AND UNRACKING OF CIRCUIT BREAKERS WOULD BE INVOLVED WITH THE GIS AS OPPOSED TO AIR INSULATED GEAR. THIS WOULD ELIMINATE RACKING/UNRACKING OF THE CIRCUIT BREAKERS. IF A GIS CIRCUIT BREAKER WERE TO FAIL IT WOULD BE COMPLETELY CONTAINED INSIDE THE TANK AND NO DAMAGE WILL BE DONE TO THE BUILDING OR THE OTHER CIRCUIT BREAKERS.

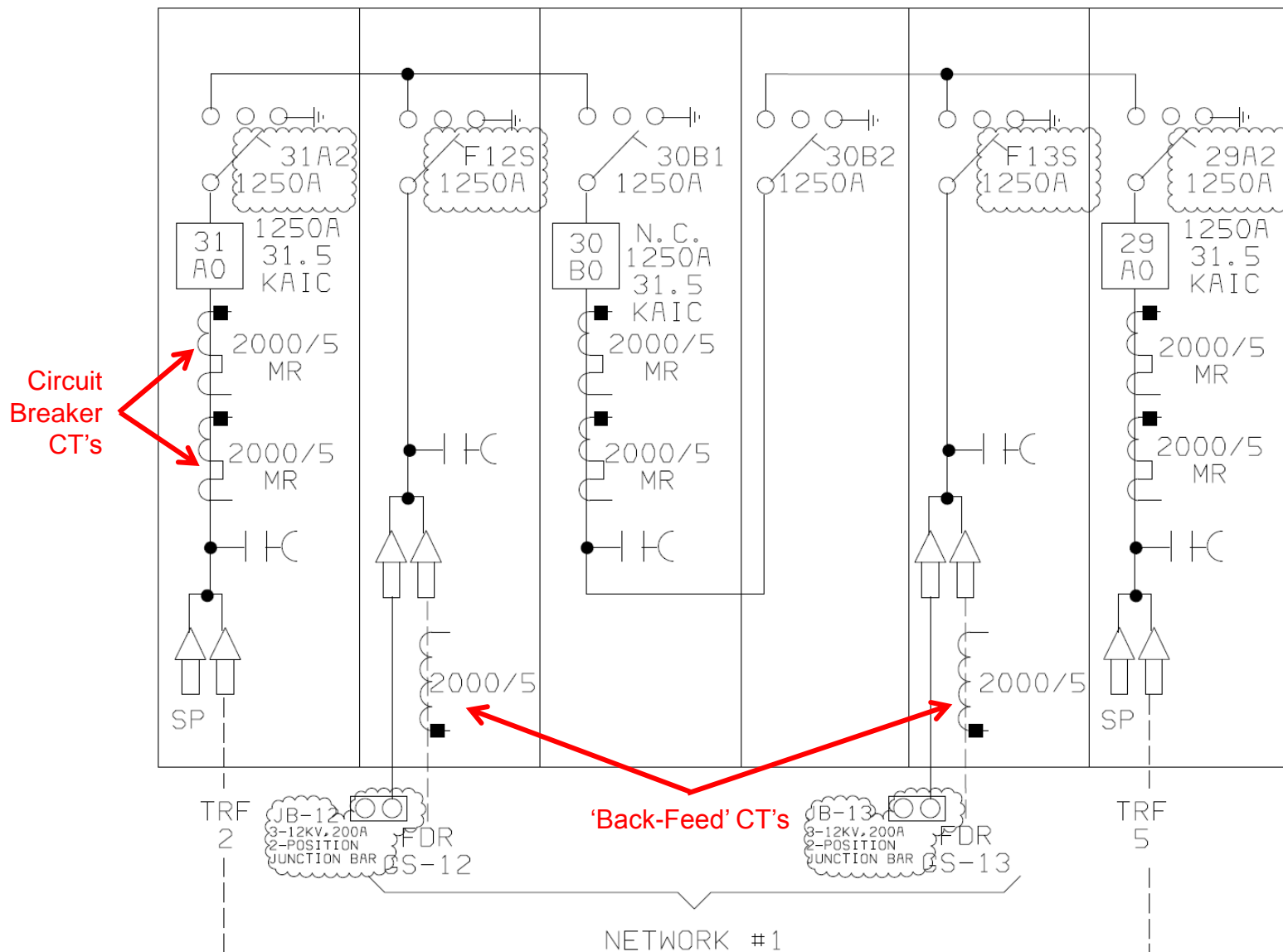
GIS USES CABLE 'PLUGS' FOR ALL TRANSFORMER AND FEEDER CONNECTIONS WHICH ELIMINATES ANIMAL CAUSED FAULT.

SINCE THE HIGH VOLTAGE PARTS ARE INSIDE A PRESSURIZED TANK (SEALED ENVIRONMENT), NO MAINTENANCE WOULD BE REQUIRED FOR THE LIFE OF THE CIRCUIT BREAKER. THE MECHANISM IN A CONVENTIONAL MECHANISM AND CAN BE MAINTAINED LIKE OTHER CIRCUIT BREAKERS.

BACK FEED PROTECTIVE RELAYING SCHEME WILL CONTINUE TO BE USED AS A PRECAUTION.

LONG TERM PLAN

12.47 KV GAS INSULATED SWITCHGEAR



LONG TERM SOLUTION

12.47 KV GAS INSULATED SWITCHGEAR

'Circuit Breaker CT's



'Back-Feed' CT's



Distribution Substation - Network Feeder 'Back Feed' Protection

Questions/Comments?

