IEEE Houston Section Continuing Education on Demand

INTERTIE SUBSTATION DESIGN

CenterPoint Energy expectations for intertie substations
and
the required operation / maintenance practices

Brian Clowe
CenterPoint Energy

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INTERTIE SUBSTATION DESIGN

CenterPoint Energy expectations for intertie substations
and
the required operation / maintenance practices

OUTLINE:

1. Basic system overview
2. How transmission service is extended
3. Load request and interconnection study
4. Customer substation configurations and switching
5. Customer Substation specification
6. Outage Clearance and Coordination Procedure
7. System faults and automatic reclosing

COMPANY OVERVIEW

Electric Transmission and Distribution - We maintain the wires, poles and electric infrastructure serving our 5,000-square-mile electric service territory in the Houston metropolitan area. CenterPoint Energy ensures the reliable delivery of power to 2.2 million metered homes and businesses, but does not generate power or sell it to customers.

Natural Gas Distribution - We sell and deliver natural gas to 3.3 million homes and businesses in Arkansas, Louisiana, Minnesota, Mississippi, Oklahoma and Texas. In Minnesota, CenterPoint Energy offers the Home Service Plus, a home appliance repair and maintenance service.

Competitive Natural Gas Sales and Services - Our natural gas sales and services business, CenterPoint Energy Services (CES), provides energy solutions to approximately 100,000 commercial, industrial and wholesale customers in 26 states. TrueCost, which is an electric retail shopping service, and Mobile Energy Solutions, which offers portable natural gas, both reside in this business unit.

COMPANY OVERVIEW

CenterPoint Energy, Inc.

CenterPoint Energy, Inc., headquartered in Houston, Texas, is a domestic energy delivery company that includes electric transmission and distribution, natural gas distribution and competitive natural gas sales and services. The company serves more than 5.9 million metered customers primarily in Arkansas, Louisiana, Minnesota, Mississippi, Oklahoma and Texas.

Total assets	$22.7 billion
Revenue	$9.6 billion
Operating income	$1.072 billion
Number of employees	7,964
Community volunteerism	146,000 hours
Values	Safety, Integrity, Accountability, Initiative, Respect
Vision	Lead the nation in delivering energy, service and value.
Strategy	Operate, Serve, Grow
Brand promise	Always There®
Company mailing address	PO Box 4567 Houston, TX 77210-4567
Company physical address	1111 Louisiana St. Houston, TX 77002

Statistics as of Dec. 31, 2017

Electric transmission and distribution

Our electric transmission and distribution business serves a 5,000-square-mile area that includes Houston, the nation's fourth largest city. We deliver electricity on behalf of retail electric providers.

Metered customers	2,444,299
Residential	2,164,073
Gigawatt hours delivered	88,636
Residential	29,703
Transmission and distribution	
Overhead distribution lines	28,883 miles
Overhead transmission lines	3,688 miles
Underground distribution lines	24,662 miles
Underground transmission lines	26 miles
Substations	235

Natural gas distribution

Our natural gas distribution business operates in Arkansas, Louisiana, Minnesota, Mississippi, Oklahoma and Texas. The major cities we serve are Houston, Texas; Minneapolis, Minn.; Little Rock, Ark.; Biloxi/Gulfport, Miss.; Shreveport, La.; and Lawton, Okla.

Total number of customers	3,469,791
Total natural gas sold/delivered	412 billion cubic feet (Bcf)
Miles of natural gas mains	75,000

Number of customers and natural gas delivered by classification

Residential	3,213,140	151 Bcf
Commercial and industrial	256,651	261 Bcf

CenterPoint Energy Services (CES)

CES provides a wide range of competitive energy services to meet the needs of our more than 100,000 customers in 32 states. In 2017, CES marketed approximately 1,200 Bcf of natural gas.

CES 800-495-9880

Other services

myTrueCost.com electric portal	800-461-3056
CenterPointEnergy.com/HSP	877-HSP-1664

RETAIL DELIVERY SERVICE

Tariff applicable to customer that takes transmission service

http://www.centerpointelectric.com/cehe/about/tariffs/

'Current tariff for retail delivery service'

(Rev. No. 7th, Effective: 1/15/15)

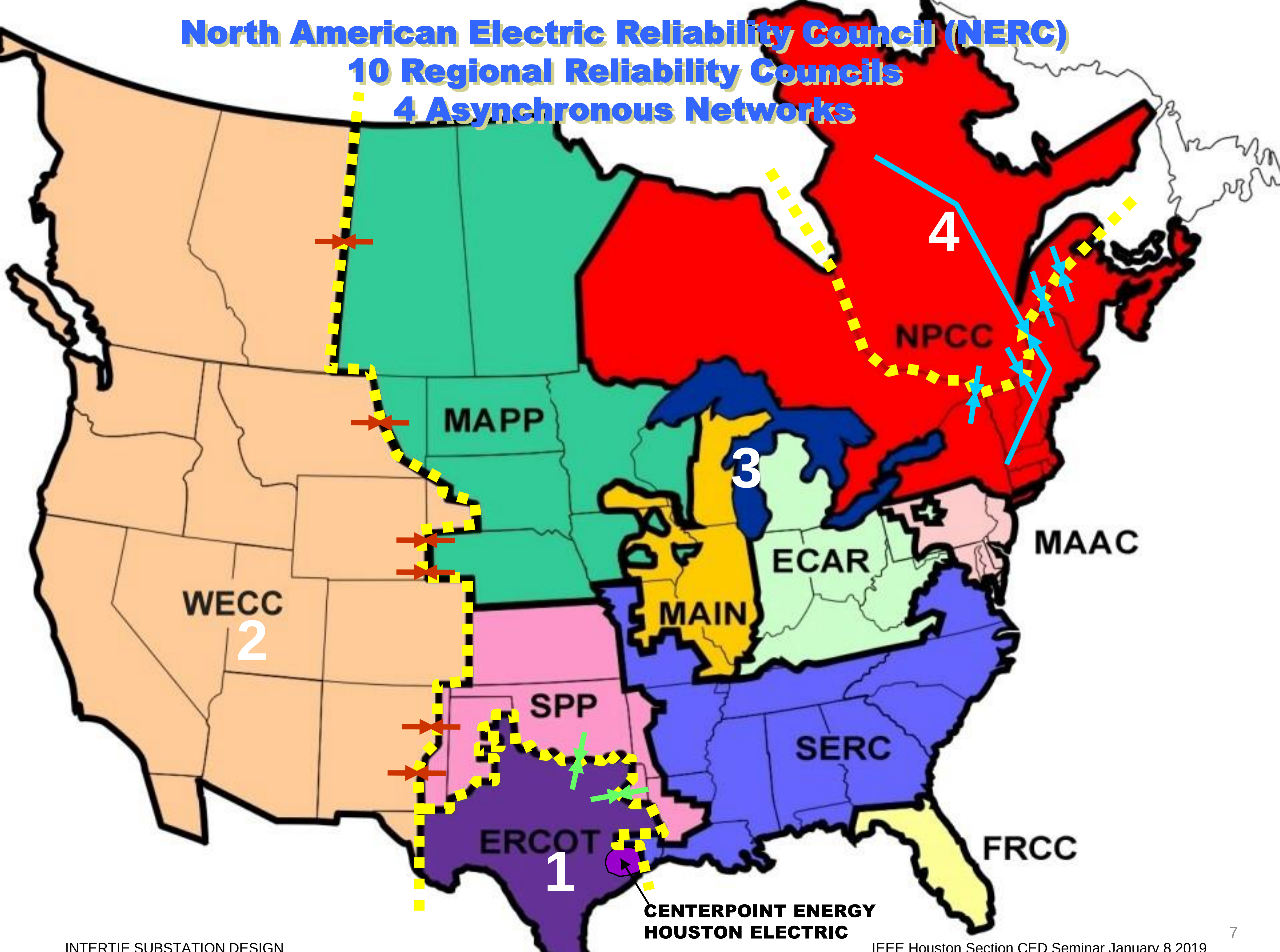
Section 5.5.5 Power Factor

95% lagging

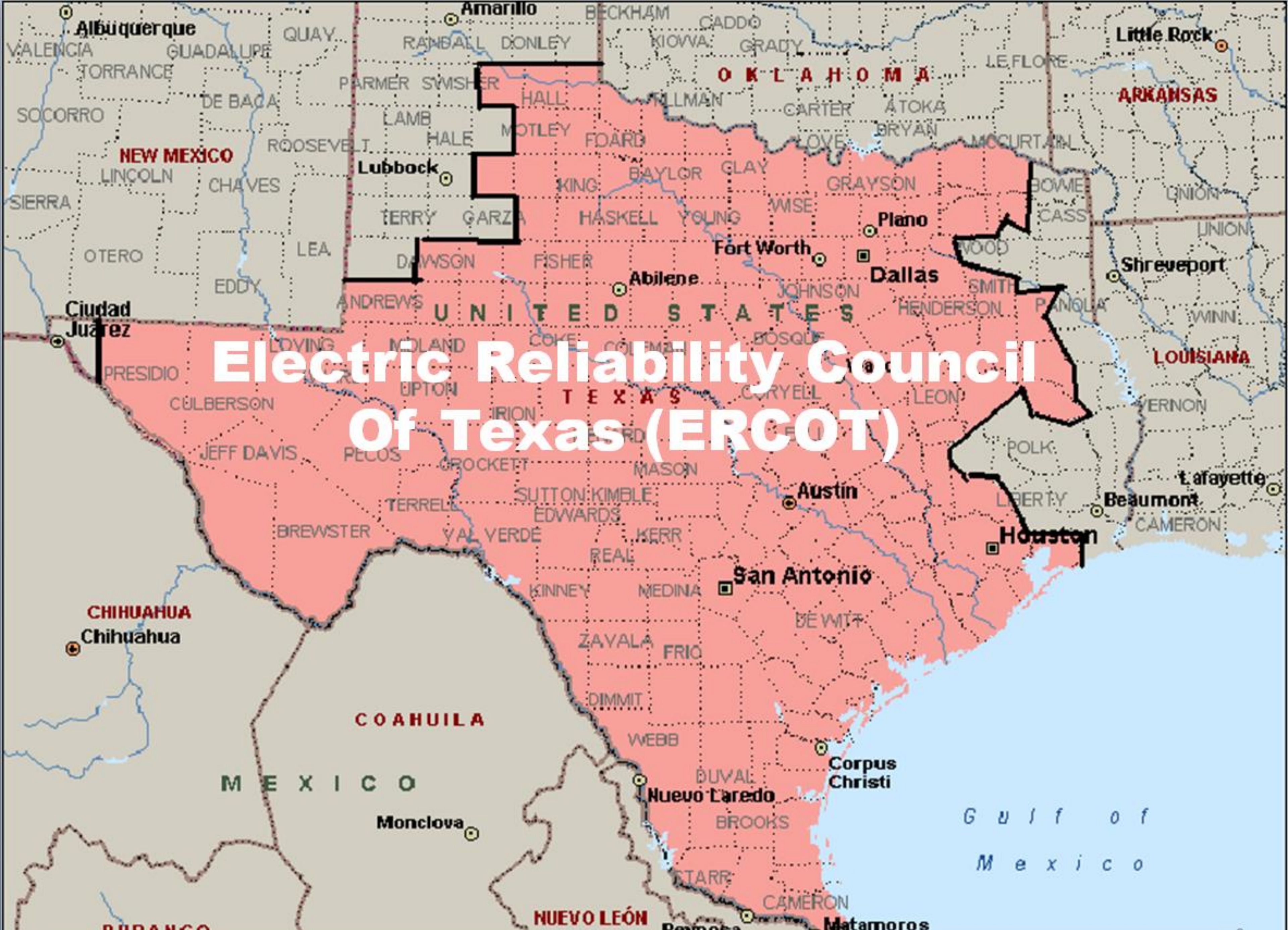
Customer installs corrective equipment
Or demand associated with customer's use of delivery service is increased by formula
Or CenterPoint Energy may installs corrective equipment and charge customer

Basic Power System Overview
And
CenterPoint Energy
Transmission System

North American Electric Reliability Council (NERC)
10 Regional Reliability Councils
4 Asynchronous Networks



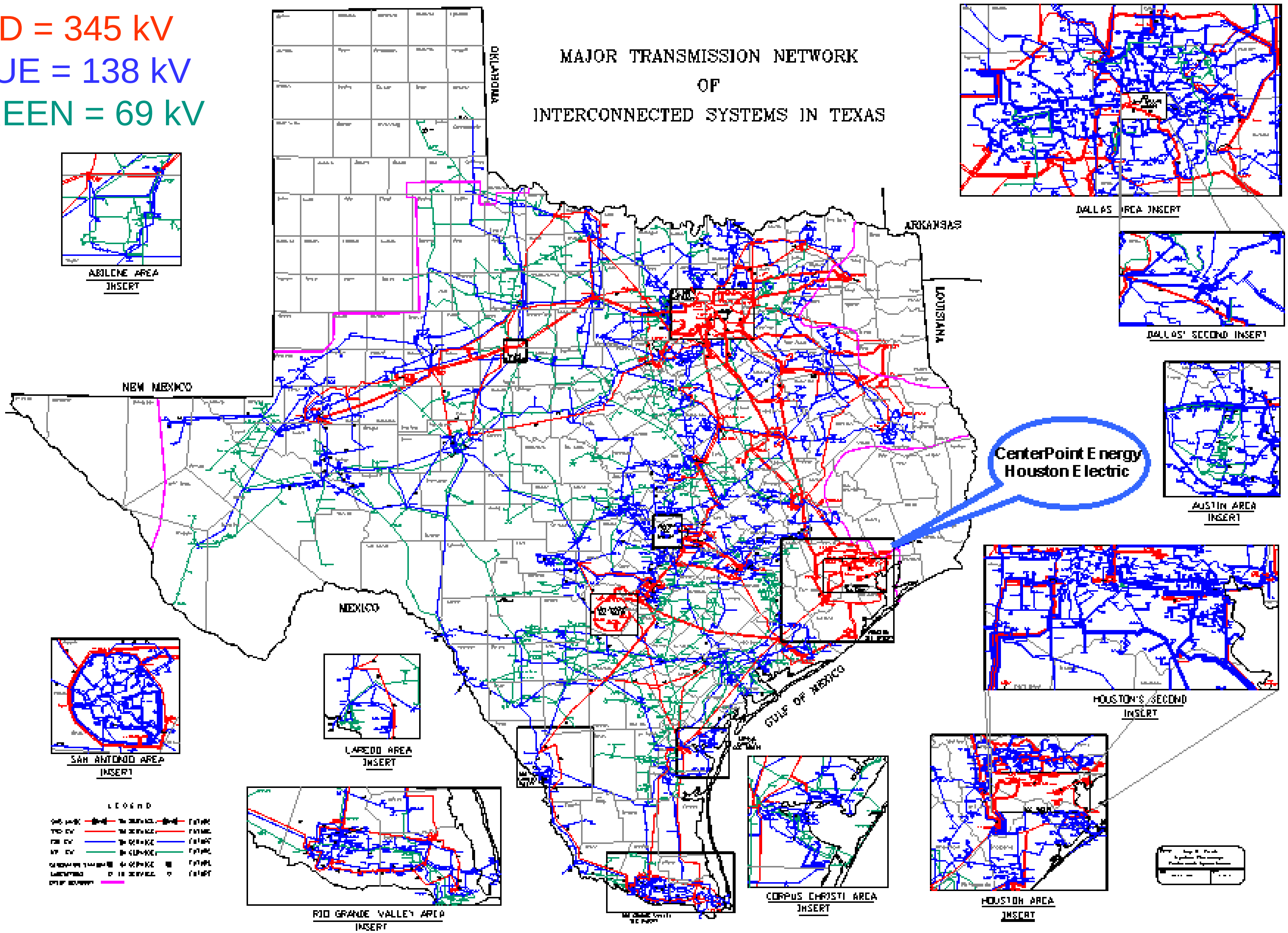
Electric Reliability Council Of Texas (ERCOT)



RED = 345 kV

BLUE = 138 kV

GREEN = 69 kV



CLASSIFICATION OF POWER LINES

DISTRIBUTION (2.4 - 34.5 KV)
Typically radial in configuration and utilized to transmit power to final retail customer.

SUBTRANSMISSION (13.8 - 138 KV)
Radial or network configuration and utilized to transmit power to distribution substations or to transmit power to bulk retail users.

TRANSMISSION (69 - 765 KV and above)
Almost always network in configuration and utilized to transmit power between major substations & interconnecting systems, to wholesale outlets and to large bulk retail users.

TRANSMISSION IS FURTHER DIVIDED INTO:

High Voltage (HV) 115 - 230 kV

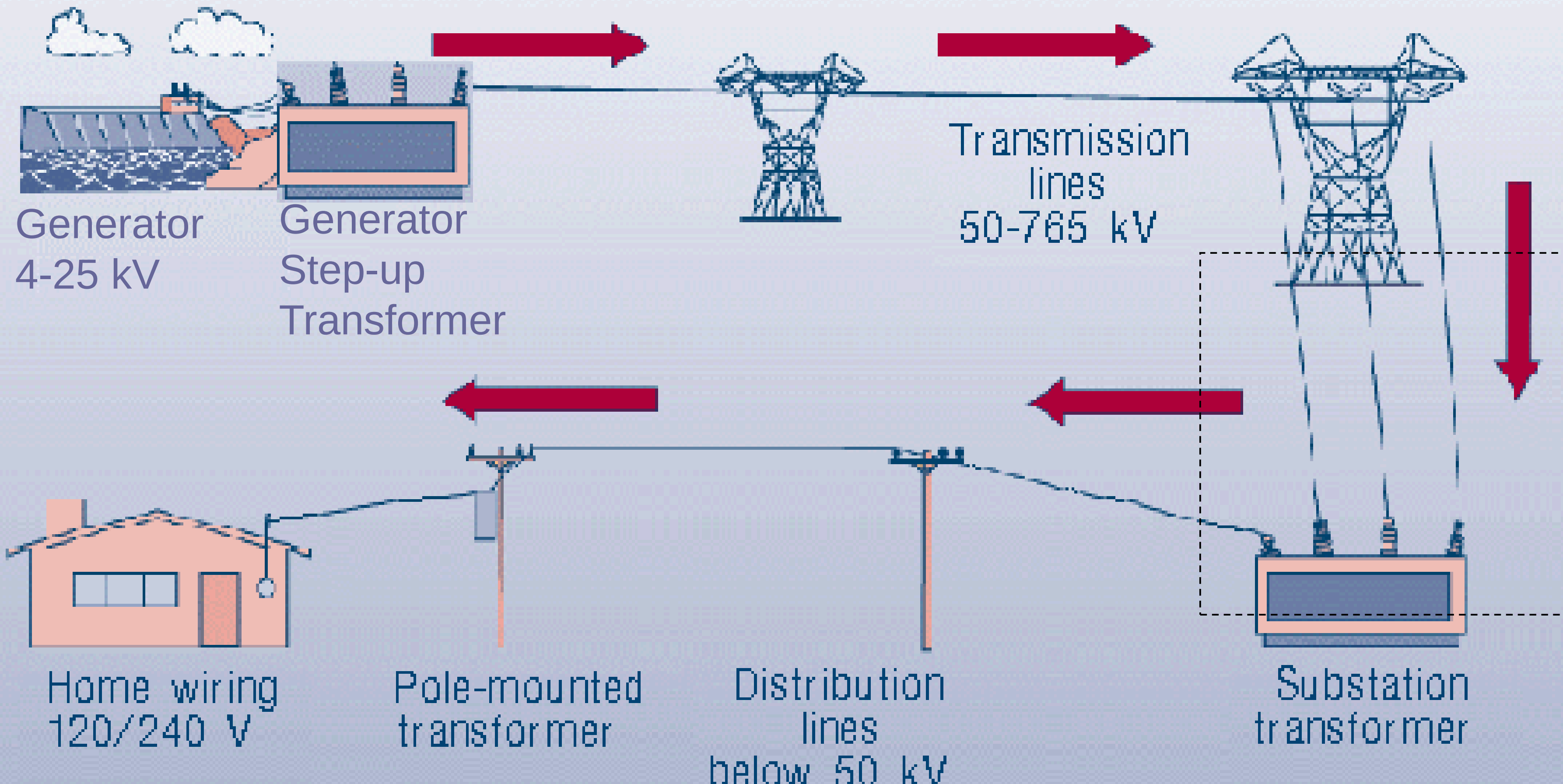
Extra High Voltage (EHV) 345 - 765 kV

Ultra High Voltage (UHV) greater than 765 kV

SOME COMMON TRANSMISSION/DISTRIBUTION SYSTEM VOLTAGES (KV) AND CNP VOLTAGES

765
500
345 ^ EHV
230
138
115 ^ Transmission
69
34.5 ^ Subtransmission
13.8
12.47
7.2
4.16
2.3 ^ Distribution

Basic Electric Power System

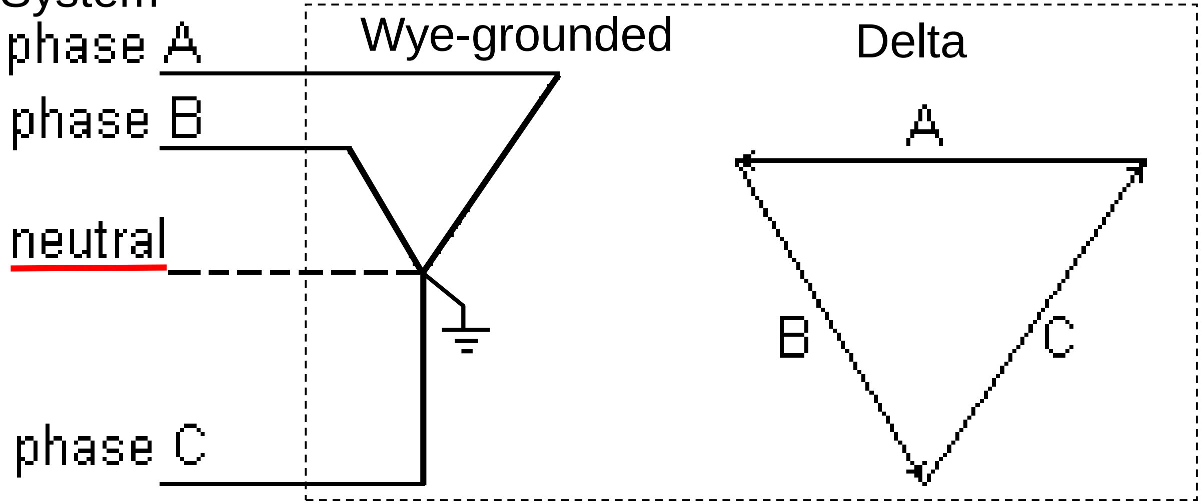


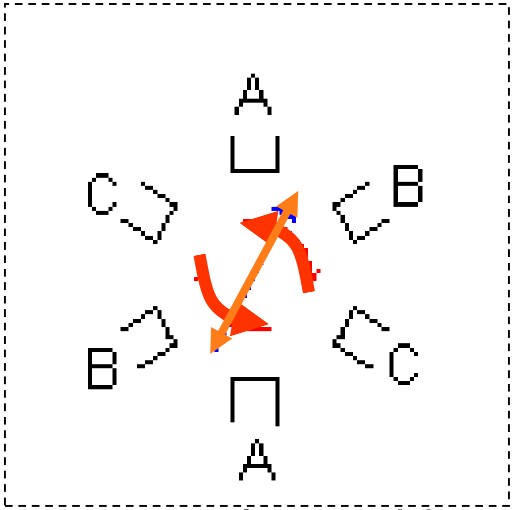
CenterPoint Energy Transmission System

Transmission System

Step-Up (GSU) Transformer

Generator





balanced 3-phase circuit; neutral not required.

three voltages or currents at 120° add up to zero

(one cycle is 360 electrical degrees)

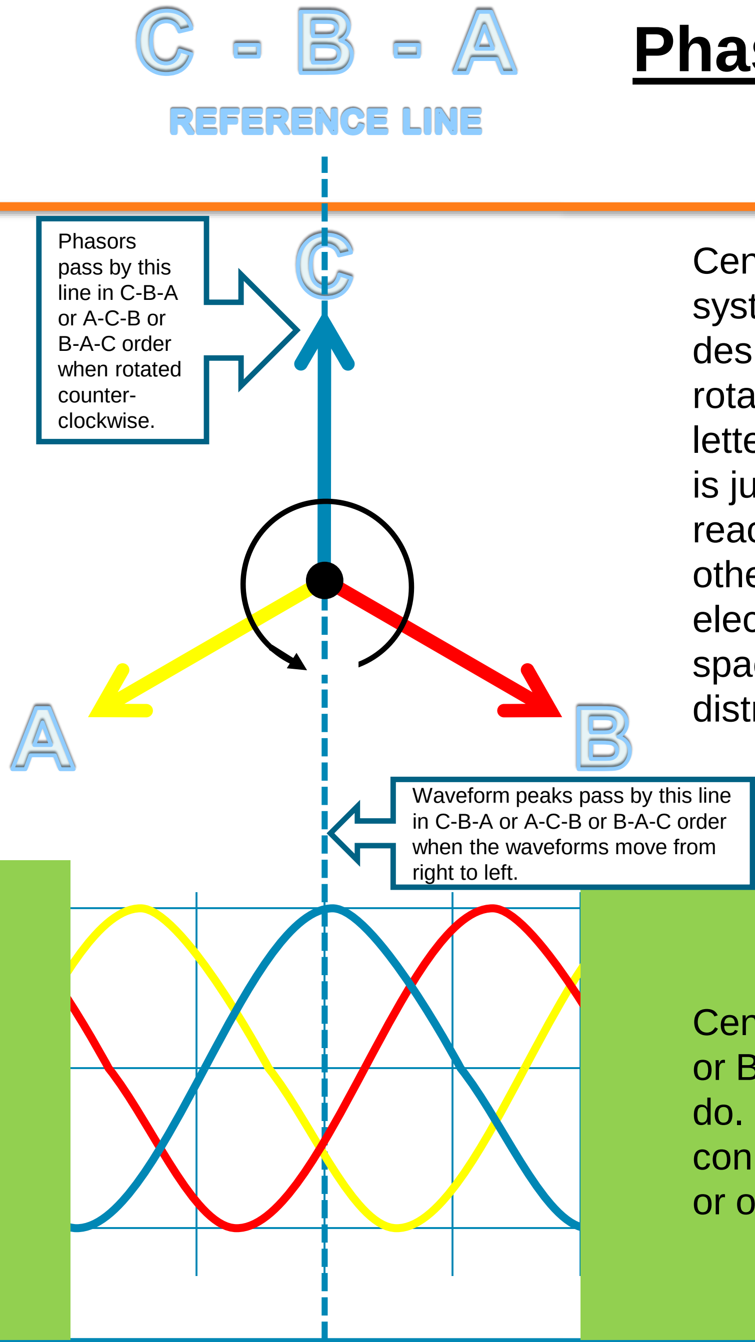
Three-Phase Alternating Current

two-pole machine magnetic field rotates once per cycle

60 times per sec.

3600 rpm

Phase Designations



CenterPoint Energy (CNP) transmission and distribution systems use the C-B-A counter-clockwise phase rotation designation. This can also be called A-C-B, or even B-A-C rotation designation (any of these is correct as long as the letters are in the same sequence). The phasor rotation diagram is just a way to symbolize the sequence in which the phases reach a peak. Each phase vector is 120 degrees apart from the others which corresponds to each phase sinewave which is 120 electrical degrees apart from the others (this is optimum spacing, the peaking at different times allows the even distribution of 3-phase power to supply large loads).

CenterPoint Energy does not use the A-B-C (also called C-A-B, or B-C-A) phase rotation designations, but some other utilities do. So, it is easy to see where problems would arise if connecting CNP C-B-A phases to another utility's C-A-B phases or other designation used by industrial customers

PHASE DESIGNATION AND INTERCONNECTION COMPARISON CHART

US Industry Standard	A	B	C
CNP Transmission/Distribution System	C	B	A
CNP substation drawings 67Vl-n	3	2	1
CNP substation drawings 115Vl-n	6	5	4
CNP High Voltage Metering department (inside the metering cabinet*)	A	B	C
CPS Energy, STP	C	B	A
AEP, LCRA, ONCOR, STEC, TMPA, BEC, LST	B	C	A
TNMP	A	B	C
AE	B	A	C
Typical relay manufacturer connection diagrams	1	2	3
European Standard	R	S	T

* CNP High Voltage Metering refers to this as A-B-C clockwise

Interconnected Phasing Notes (and designations shown on older drawings):

All designation are referred to as counter-clockwise rotation except as noted.

TNMP = Texas-New Mexico Power (also TNP, formerly Community Public Service, CPS)

TMPA = Texas Municipal Power Agency

AEP = American Electric Power (formerly Central Power & Light, CP&L)

LCRA = Lower Colorado River Authority

BEC = Brazos Electric Cooperative

CNP = CenterPoint Energy (formerly Reliant Energy, HL&P, Houston Lighting & Power)

CPS Energy = City Public Service Energy San Antonio (formerly City Public Service Board, CPSB)

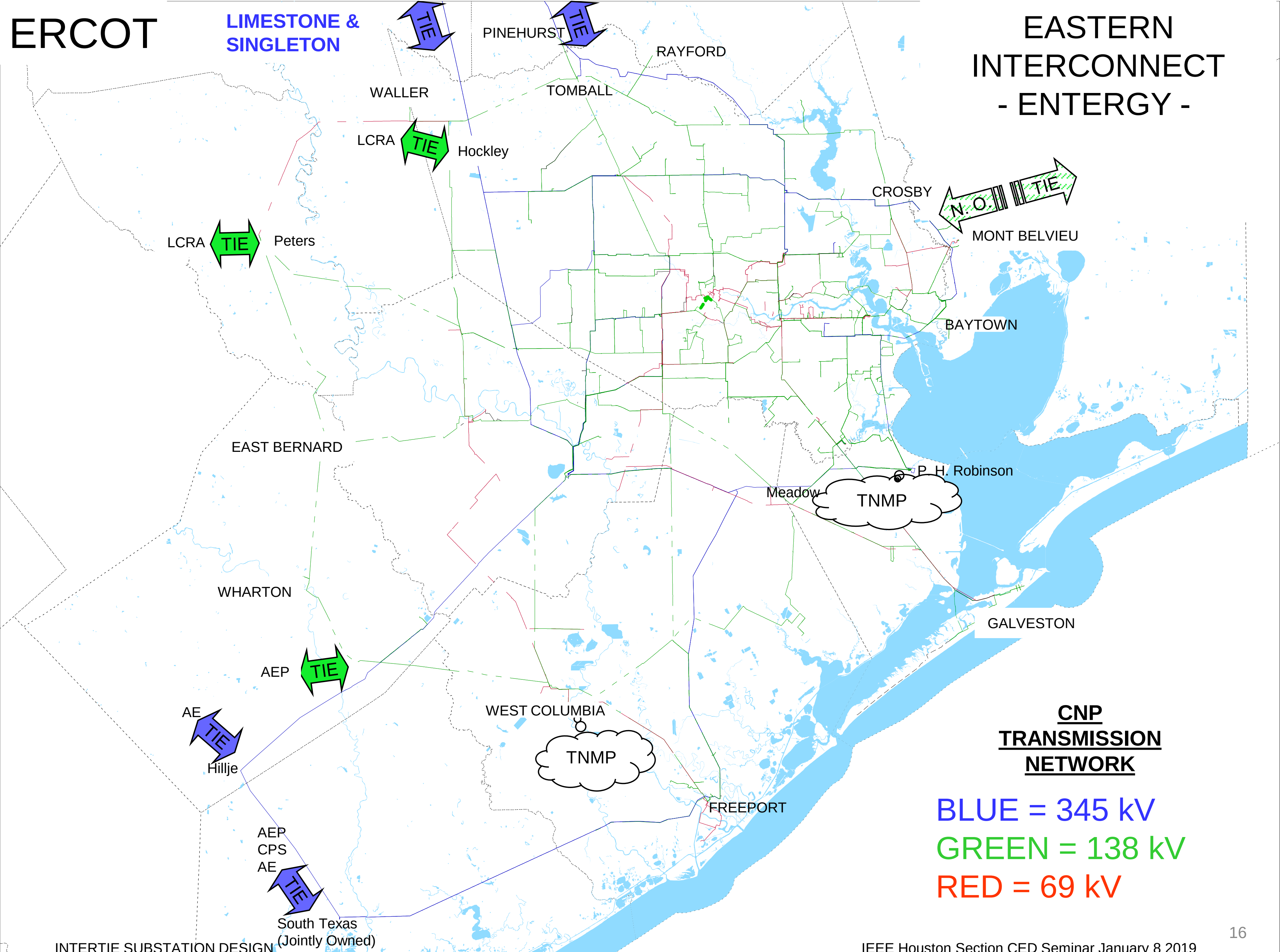
AE = Austin Energy (City of Austin, COA)

STP = South Texas 345 kV Substation

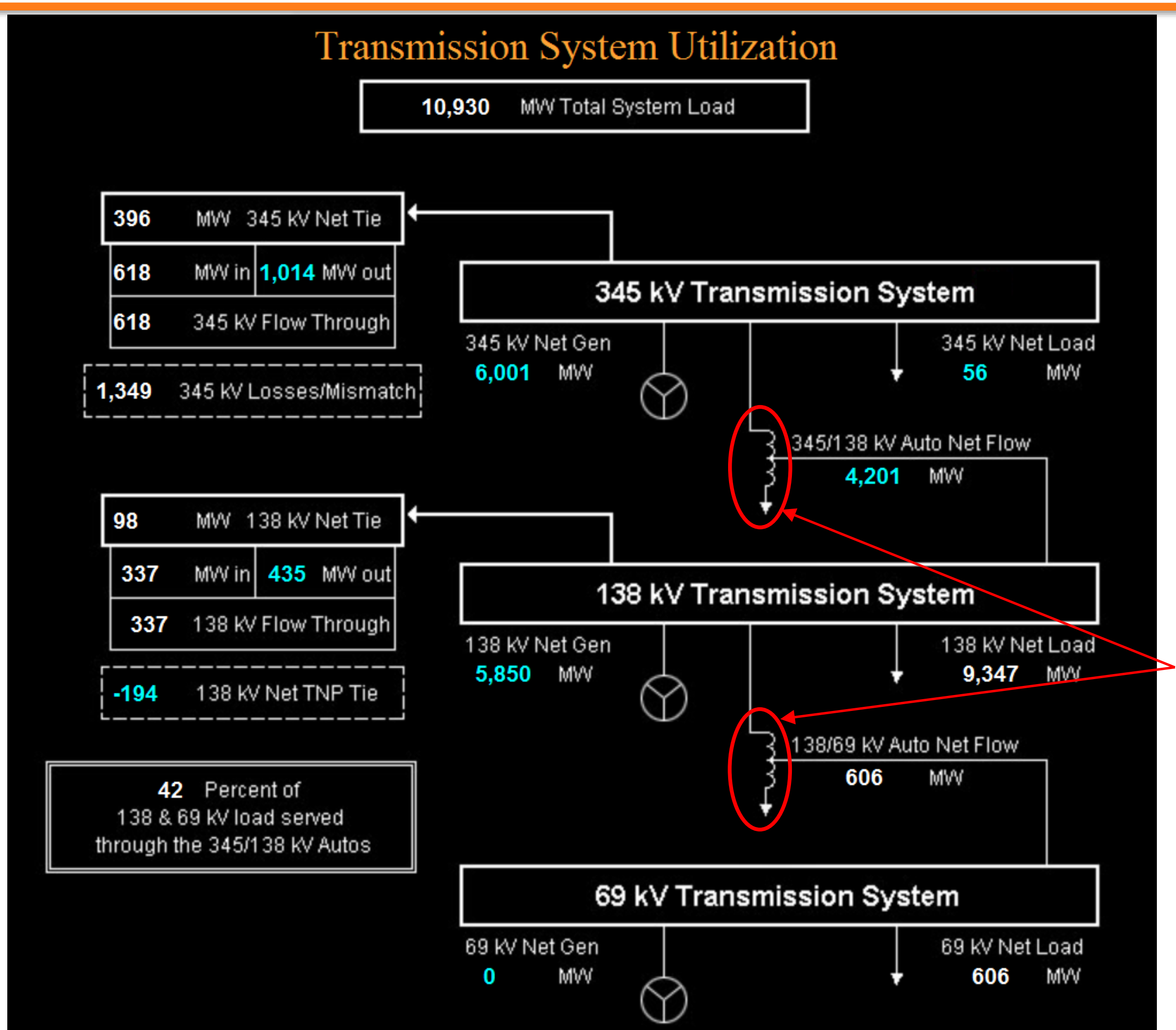
STEC = South Texas Electric Cooperative

ONCOR = Oncor (Texas Utilities, TXU)

LST = Lone Star Transmission


ERCOT
LIMESTONE & SINGLETON
TIE
PINEHURST
TIE
RAYFORD
EASTERN INTERCONNECT - ENTERGY -
WALLER
TOMBALL
LCRA
TIE
Hockley
CROSBY
N. O.
TIE
MONT BELVIEU
LCRA
TIE
Peters
BAYTOWN
EAST BERNARD
P. H. Robinson
Meadow
TNMP
WHARTON
GALVESTON
AEP
TIE
AE
TIE
Hillje
WEST COLUMBIA
TNMP
CNP TRANSMISSION NETWORK
FREEPORT
BLUE = 345 kV
GREEN = 138 kV
RED = 69 kV
AEP
CPS
AE
TIE
South Texas
(Jointly Owned)

RELATIONSHIP BETWEEN TRANSMISSION VOLTAGE LEVELS

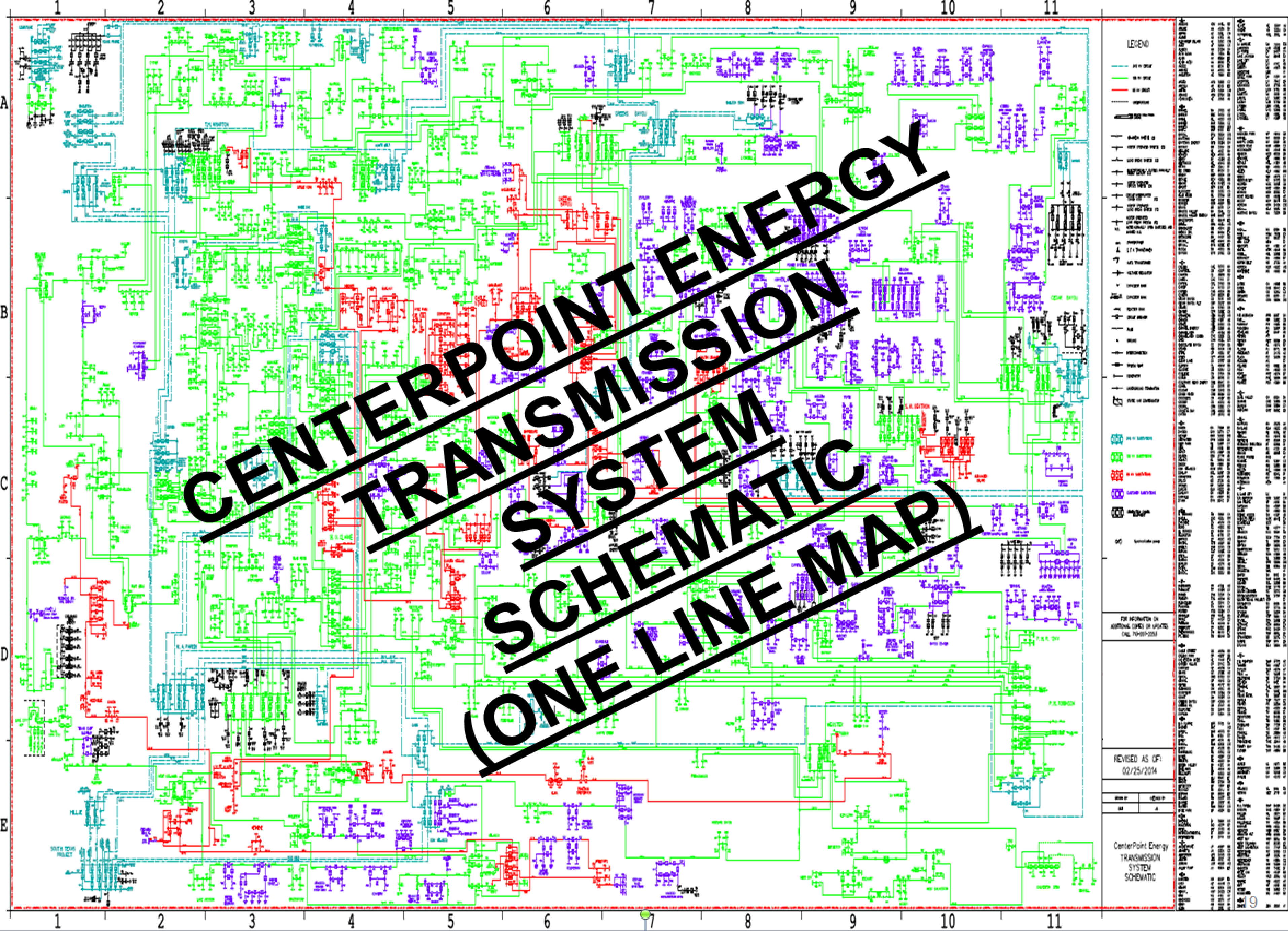


Autotransformers which are effectively wye-grounded/ wye-grounded transformers (i.e. no phase shift and connected in the zero sequence network)

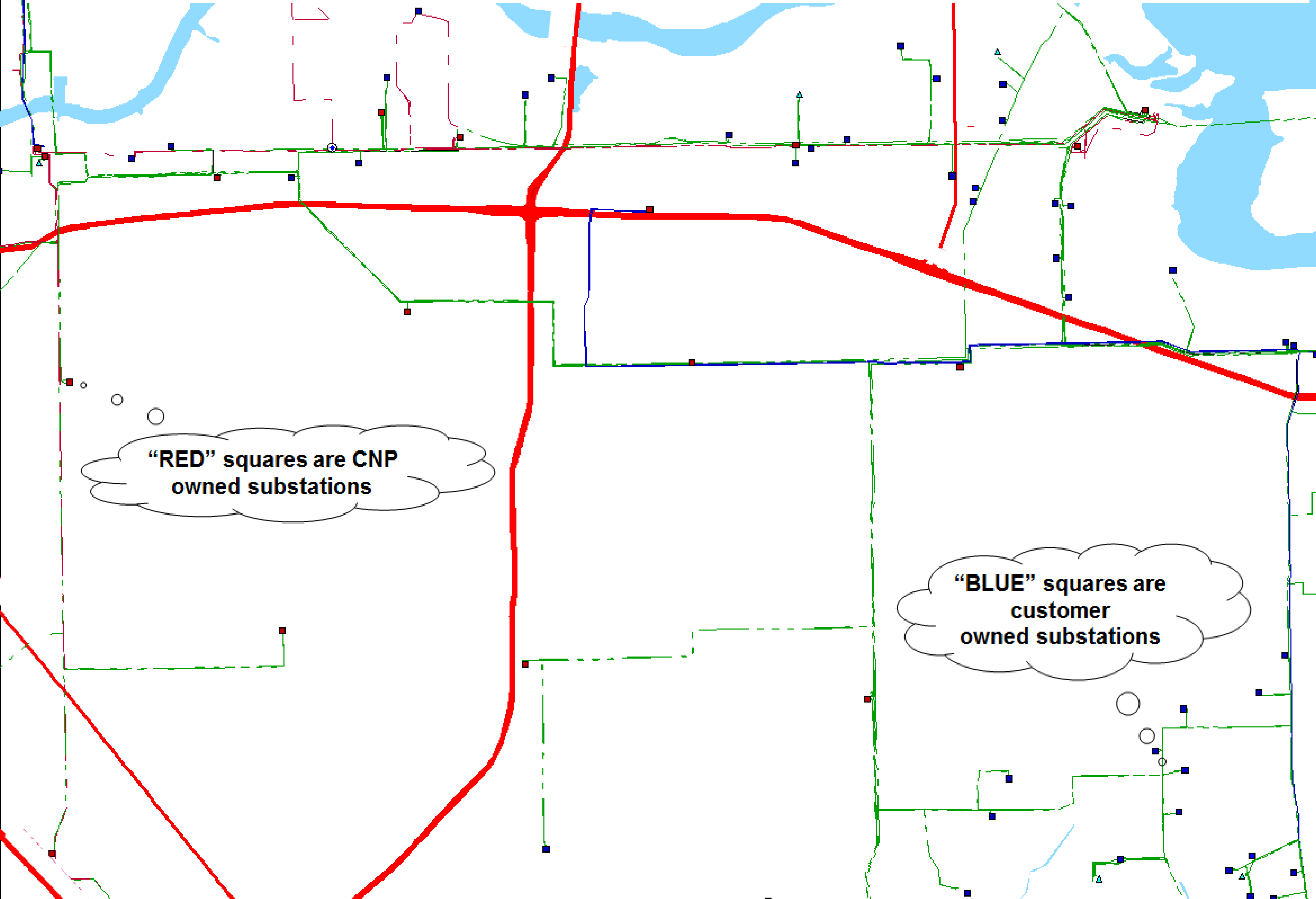
THE ROLE OF SUBSTATIONS

Generating station electric power system - An area or group of equipment containing switches, circuit breakers, buses, and transformers **for switching power circuits** and to transform power from one voltage to another or from one system to another.

Transmission and distribution - An assemblage of equipment for purposes other than generation or utilization, through which electric energy in bulk is passed **for the purpose of switching** or modifying its characteristics. A substation is of such size or complexity that it incorporates one or more buses, a multiplicity of circuit breakers, and usually is either the sole receiving point of commonly more than one supply circuit, or it sectionalizes the transmission circuits passing through it by means of circuit breakers.

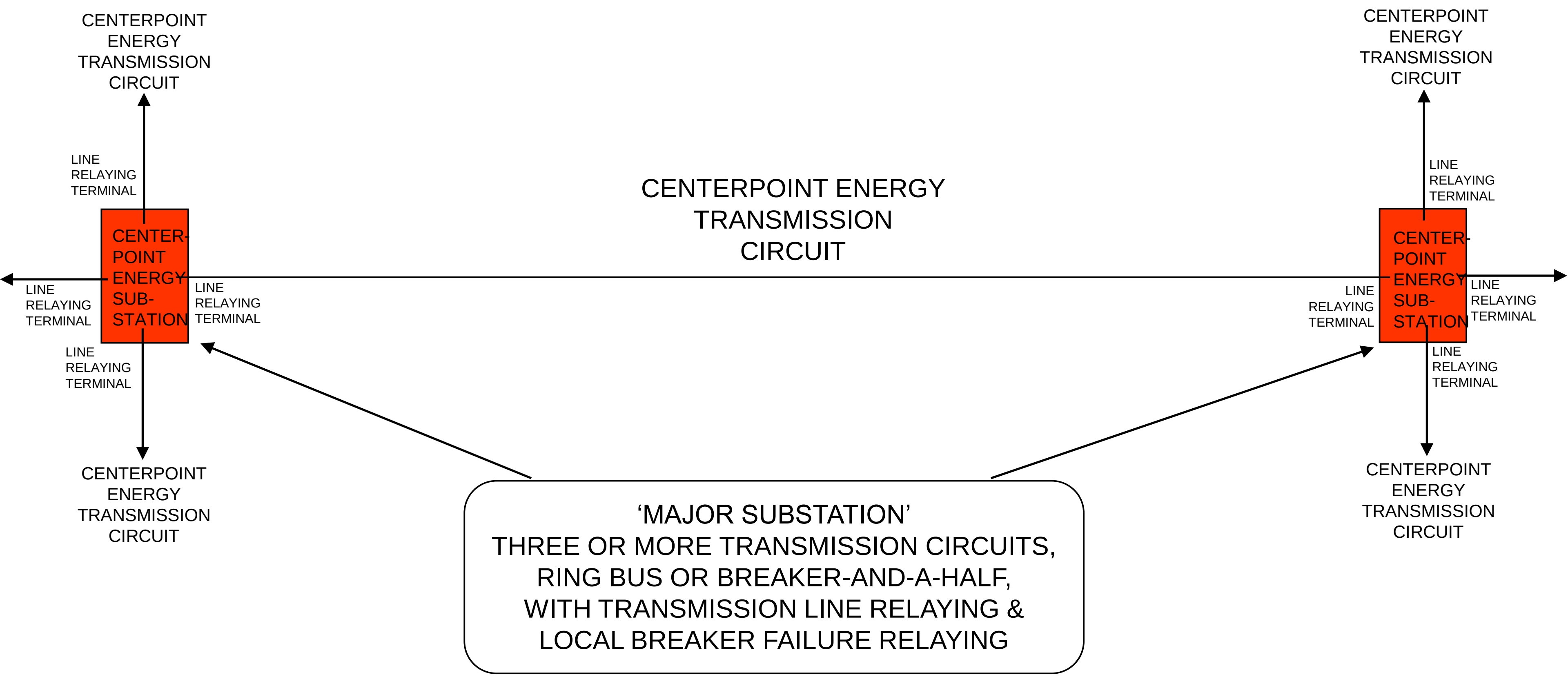

CENTERPOINT ENERGY
TRANSMISSION
SYSTEM
SCHEMATIC
(ONE LINE MAP)
LEGEND
REVISED AS OF:
02/25/2014
CenterPoint Energy
TRANSMISSION
SYSTEM
SCHEMATIC

CENTERPOINT ENERGY VS CUSTOMER OWNED SUBSTATIONS

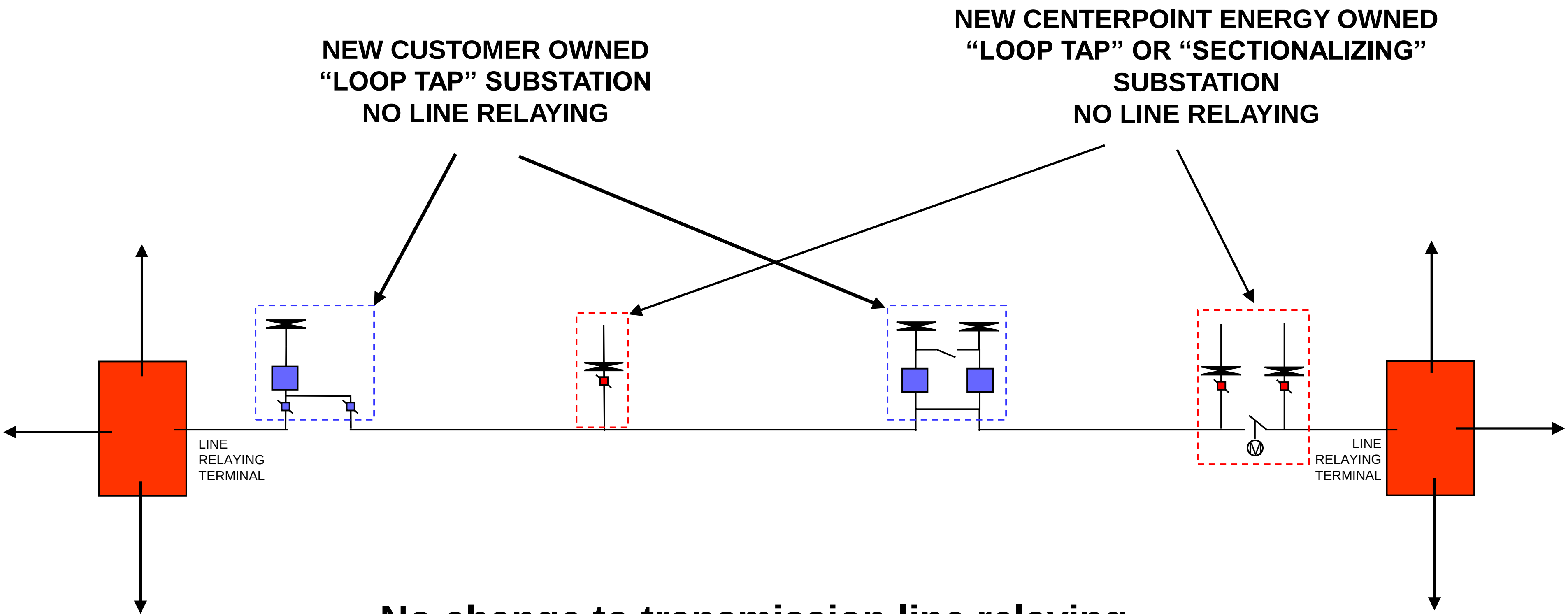


HOW TRANSMISSION SERVICE IS EXTENDED

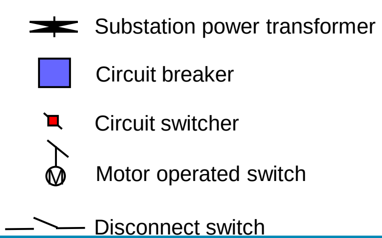
HOW THE TRANSMISSION SYSTEM IS TYPICALLY EXTENDED TO A CUSTOMER OWNED SUBSTATION



HOW THE TRANSMISSION SYSTEM IS TYPICALLY EXTENDED TO A CUSTOMER OWNED SUBSTATION

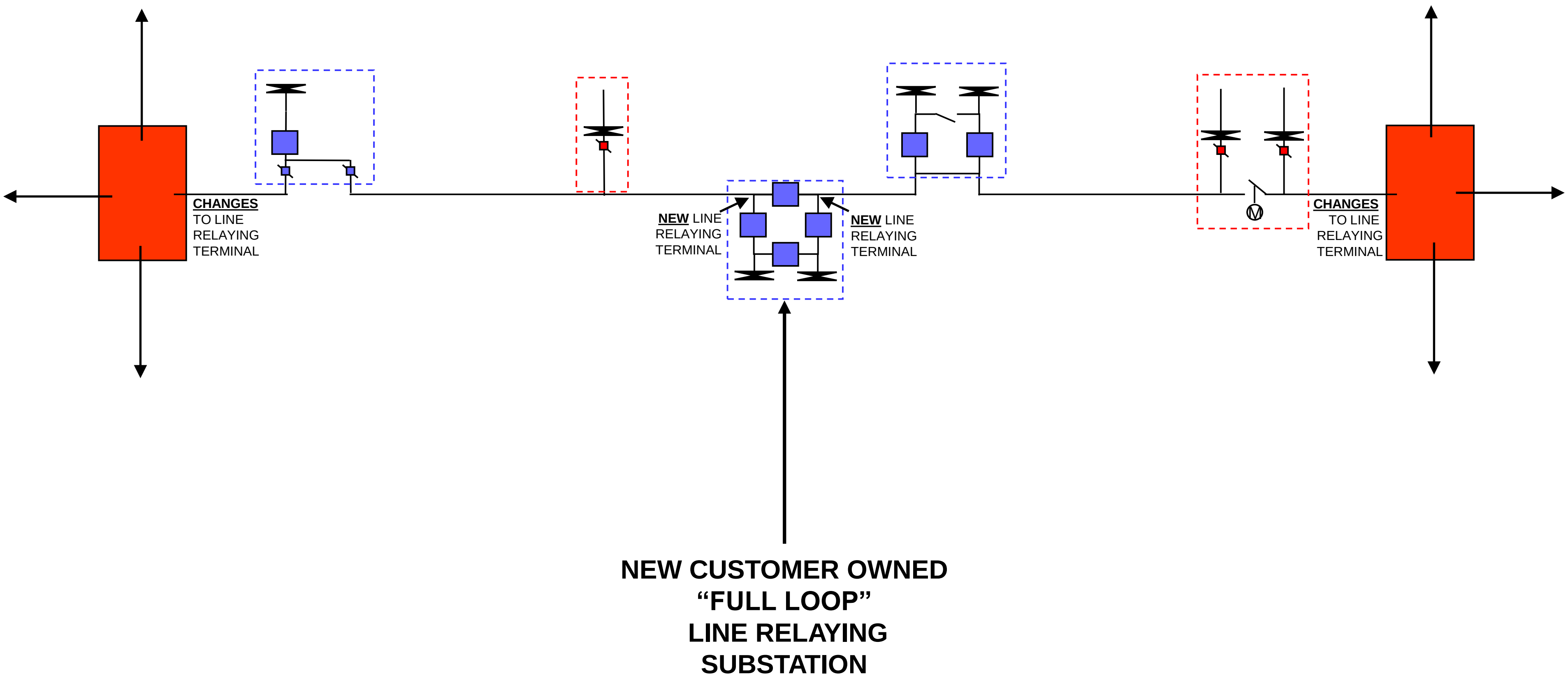


No change to transmission line relaying

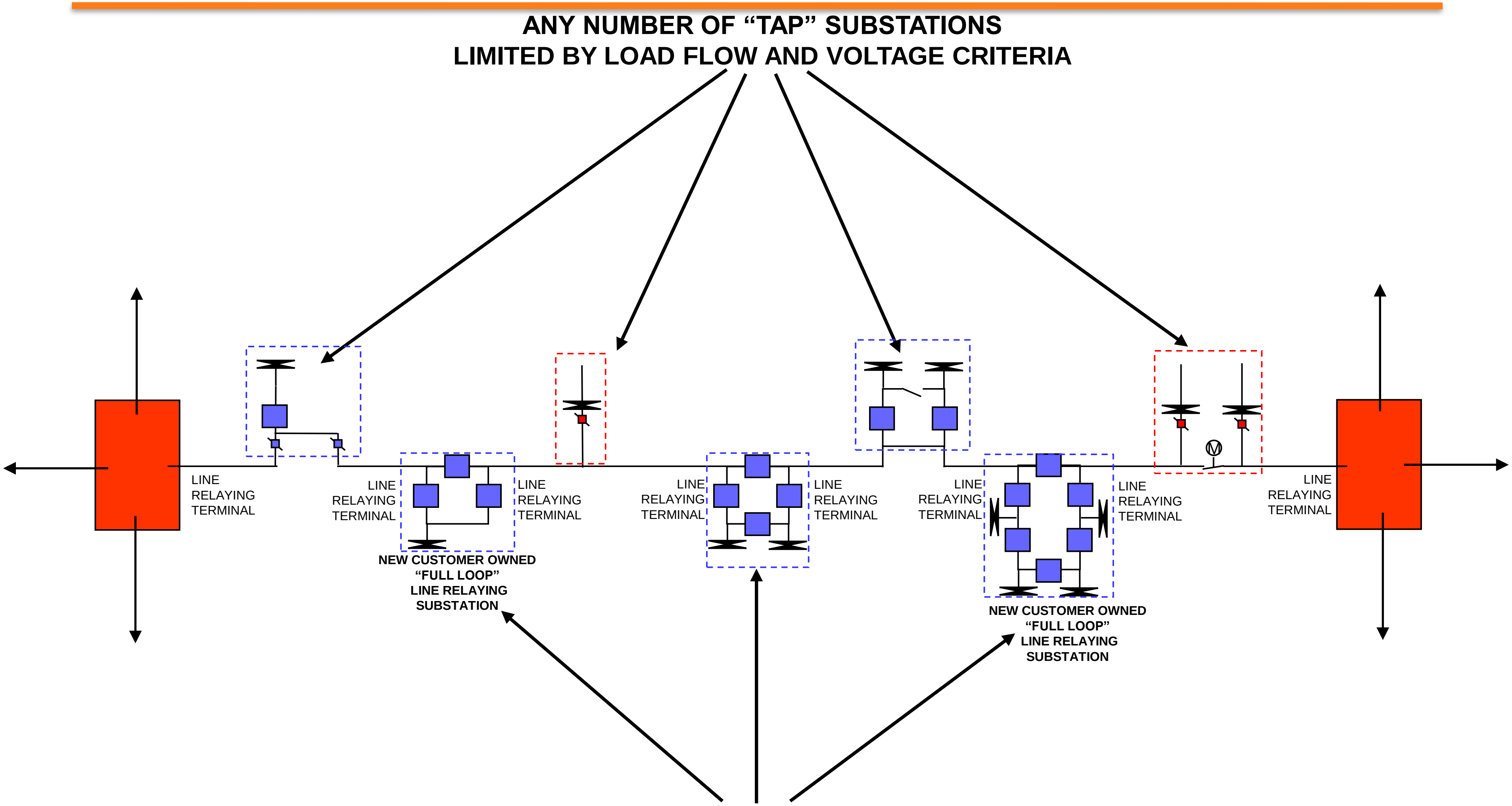


HOW THE TRANSMISSION SYSTEM IS TYPICALLY EXTENDED TO A CUSTOMER OWNED SUBSTATION

Changes to transmission line relaying required

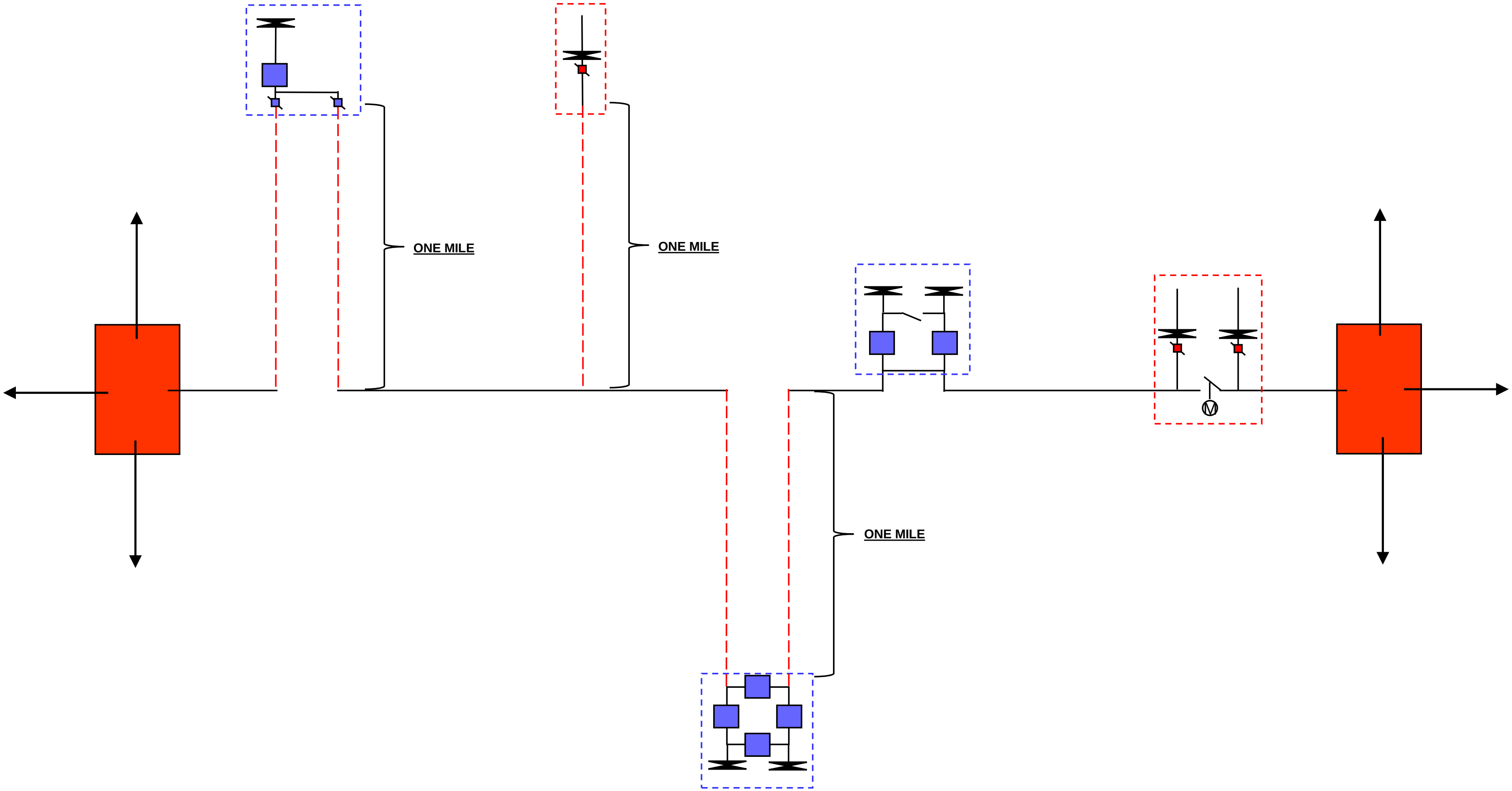


HOW THE TRANSMISSION SYSTEM IS TYPICALLY EXTENDED TO A CUSTOMER OWNED SUBSTATION



To the extent that it is reasonably and economically practical, CenterPoint Energy seeks to limit the number of "full loop" substations on a transmission line segment between major substations (3 or more line terminals) to three or less.

‘LONG FORM’ CERTIFICATE OF CONVENIENCE & NECESSITY (CCN)



LOAD REQUEST AND INTERCONNECTION STUDY

LOAD REQUEST AND INTERCONNECTION STUDY

Type of interconnection study requested: (Choose from the following)

☐ New Load Customer ☐ Existing Customer Adding Load

Study Information:

*Values in blue are calculated

Planned in-service date for new load: ____________________

Amount of load increase or new load: __________ MVA ______ p.f. __________ MW*

Requested study completion date (12 weeks min.): ____________________

a. Select one of the following types of interconnection substation customer intends to build. See attachment B for various substation configurations.

- ☐ Figure 1: "Loop-Tap" Alternative 'a' Diagram
- ☐ Figure 2: "Loop-Tap" Alternative 'b' Diagram
- ☐ Figure 3: "Full-Loop" Alternative 'a' Diagram
- ☐ Figure 4: "Full-Loop" Alternative 'b' Diagram
- ☐ Figure 5: "Full-Loop" Alternative 'c' Diagram
- ☐ Figure 6: "Plant Internal "Loop" Lines Diagram

LOAD REQUEST AND INTERCONNECTION STUDY

CenterPoint Energy

b. Amount of transmission or distribution load transferred from existing substation ______________ to new location, if any, ________ MVA ______ p.f. ________ MW*

c. Peak load at the existing ______________________ sub, if any,

________ MVA ______ p.f. ________ MW* Note: Existing and transferred load is included in the TOTAL load below

d. Amount of self-serve generation at existing ______________ sub, if any ________ MW and amount of self-serve load ________ MVA ______ p.f. ________ MW*

e. Amount of self-serve generation at new substation, if any, ________ MW, and amount of self-serve load ________ MVA ______ p.f. ________ MW*

f. Provide the new/additional expected substation load growth per year (MVA, p.f.) Provide p.f. as measured at the transmission voltage (high side) delivery point (>= 0.95 p.f. is required)

*Values in blue are calculated

Year	Month	Load (MVA)	P.F.	**TOTAL** Load at Substation			
				MVA*	MW*	MVAr*	P.F.
				0.00	0.00	0.00	0.0000
				0.00	0.00	0.00	0.0000
				0.00	0.00	0.00	0.0000
				0.00	0.00	0.00	0.0000

TRANSMISSION SYSTEM DESIGN CONSIDERATIONS

CenterPoint Energy utilizes standard electric transmission system simulations (power flow, short circuit, stability, etc.) and, when applicable, develops project cost estimates to compare system improvement options. The following technical parameters are also considered in the design of the CenterPoint Energy transmission system:

1. To the extent that it is reasonably and economically practical, CenterPoint Energy seeks to limit the number of two-line, loop breakered substations on a transmission line segment between major (three or more line terminals) substations to three or less. This is to limit the exposure of multiple two-line, loop breakered substations to separation from the CenterPoint Energy transmission system.

2. To the extent that it is reasonably and economically practical, CenterPoint Energy strives to limit the amount of generation that would be tripped to, at most, 1250 MW with the loss of a double circuit transmission line in the design of generator interconnections.

3. CenterPoint Energy considers protective relay system dependability, security, and simplicity when determining transmission circuit configurations (e.g., a long radial tap connected to a transmission line section).

TRANSMISSION SYSTEM DESIGN CONSIDERATIONS

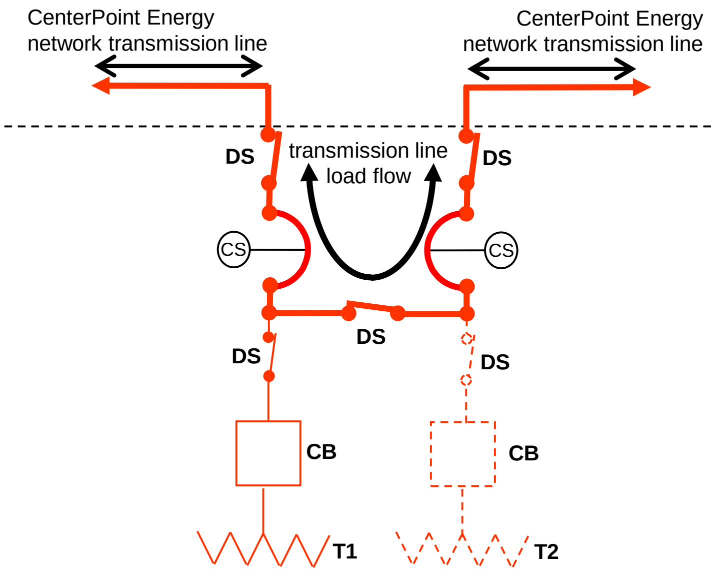
4. CenterPoint Energy designs its transmission system such that switching of its transmission capacitor banks or inductive reactors (static reactive devices) limits the momentary voltage change at a transmission bus to less than 2% with the strongest source out of service for major buses (with three or more network transmission elements). For other buses (with only two network transmission elements), CenterPoint Energy designs its transmission system such that switching of its static reactive devices limits the momentary change at a transmission bus to less than 2% with both network transmission elements in-service.

5. CenterPoint Energy also requires that the starting of customer equipment (motors, arc furnaces, etc.) does not result in a momentary voltage change greater than 2% at the customer's high-side bus with the strongest transmission line segment out of service.

6. CenterPoint Energy seeks to limit the number of in-series sectionalizing devices (motor operated disconnect switches, circuit switchers, etc.) on a transmission line segment between breakered substations to three or fewer. This is necessary to limit the number of automatic circuit breaker reclose attempts required to isolate the faulted line section and the increased complexity of fault sectionalizing schemes.

CUSTOMER SUBSTATION CONFIGURATIONS AND SWITCHING

“LOOP-TAP” ALTERNATIVE ‘a’



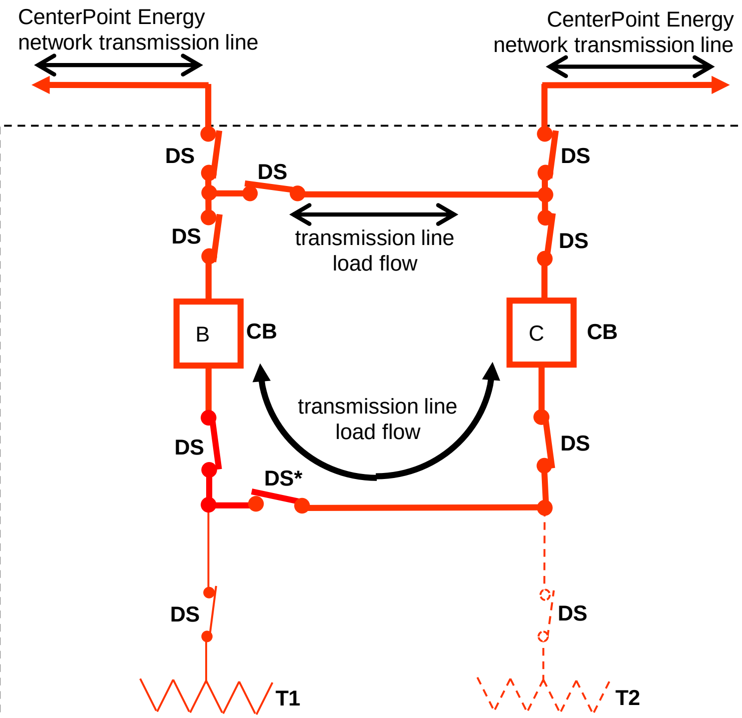
“Loop-Tap” alternative ‘a’ Customer 138 kV Substation
2 Circuit Switchers with 1 or 2 Transformers/Circuit Breakers

CS = circuit switcher
CB = circuit breaker
DS = disconnect switch

Must have a continuous current rating of 4000 A minimum
Can be less than 4000 A

All disconnect switches only have ‘arcing horns’. ‘Circuit Switchers’ are required to be installed in this configuration. The ‘Circuit Switchers’ are used for manual switching of the transmission line sections.

“LOOP-TAP” ALTERNATIVE ‘b’



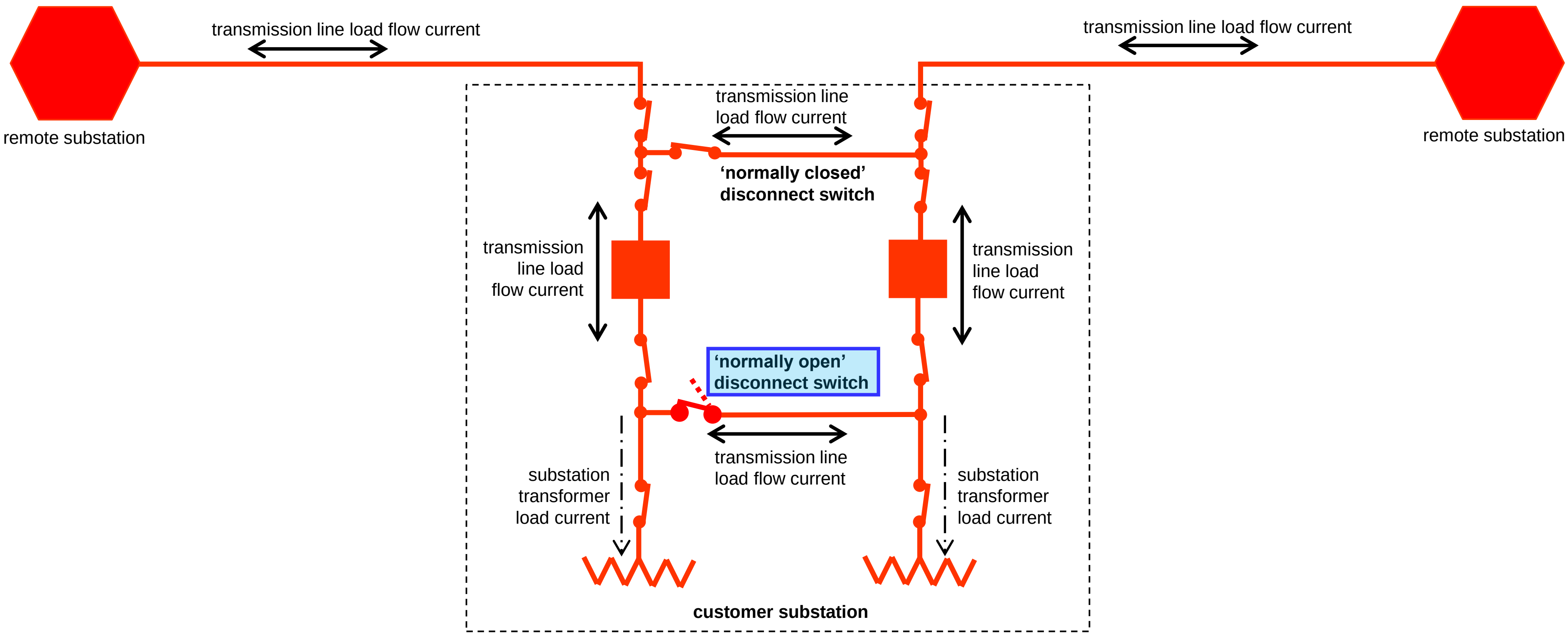
“Loop-Tap” alternative ‘b’ Customer 138 kV Substation
2 Circuit Breakers with 1 or 2 Transformers

CB = circuit breaker
DS = disconnect switch

Must have a continuous current rating of 4000 A minimum
Can be less than 4000 A

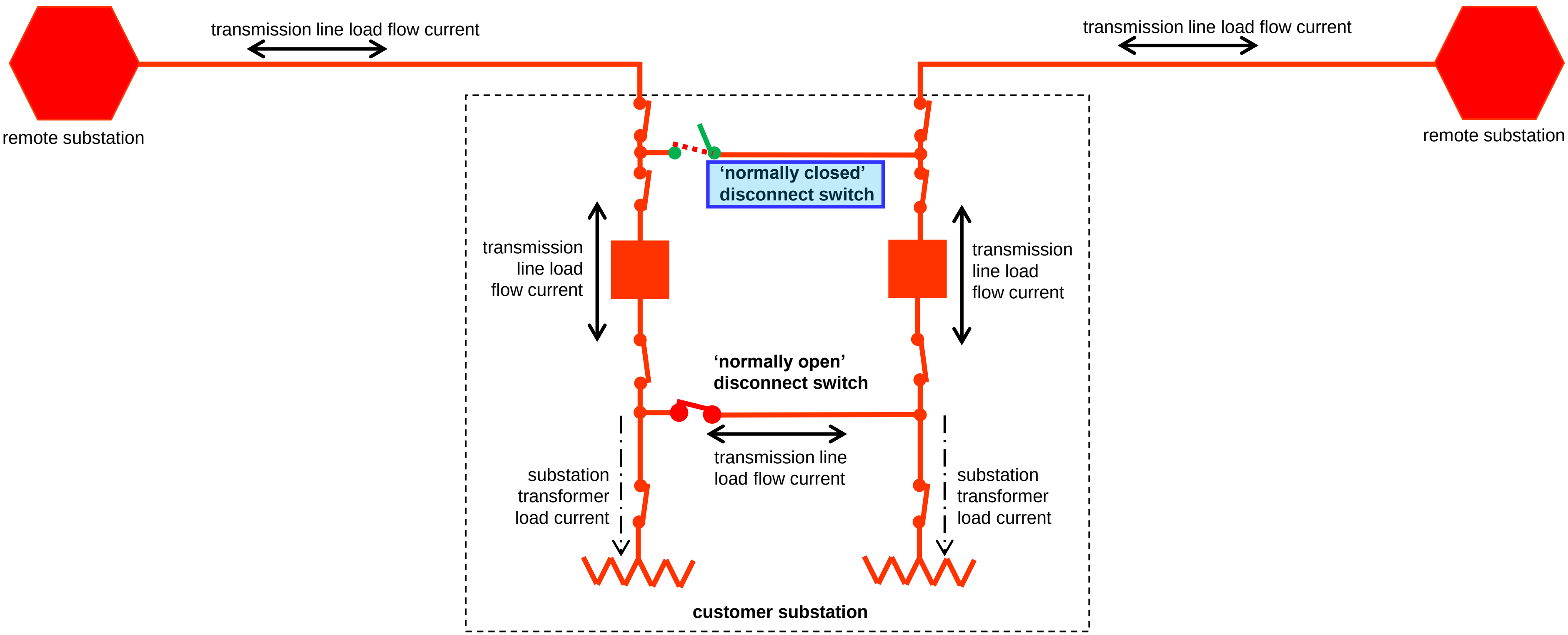
All disconnect switches only have ‘arcing horns’. ‘Circuit Switchers’ are not used in this configuration. The circuit breakers are used for manual switching of the transmission line sections.
* If two transformers are installed then this ‘DS’ is installed and is ‘normally open’.

“LOOP-TAP” ALTERNATIVE ‘b’ SWITCHING – STEP 1



STEP 1 – Close the ‘normally open’ disconnect switch

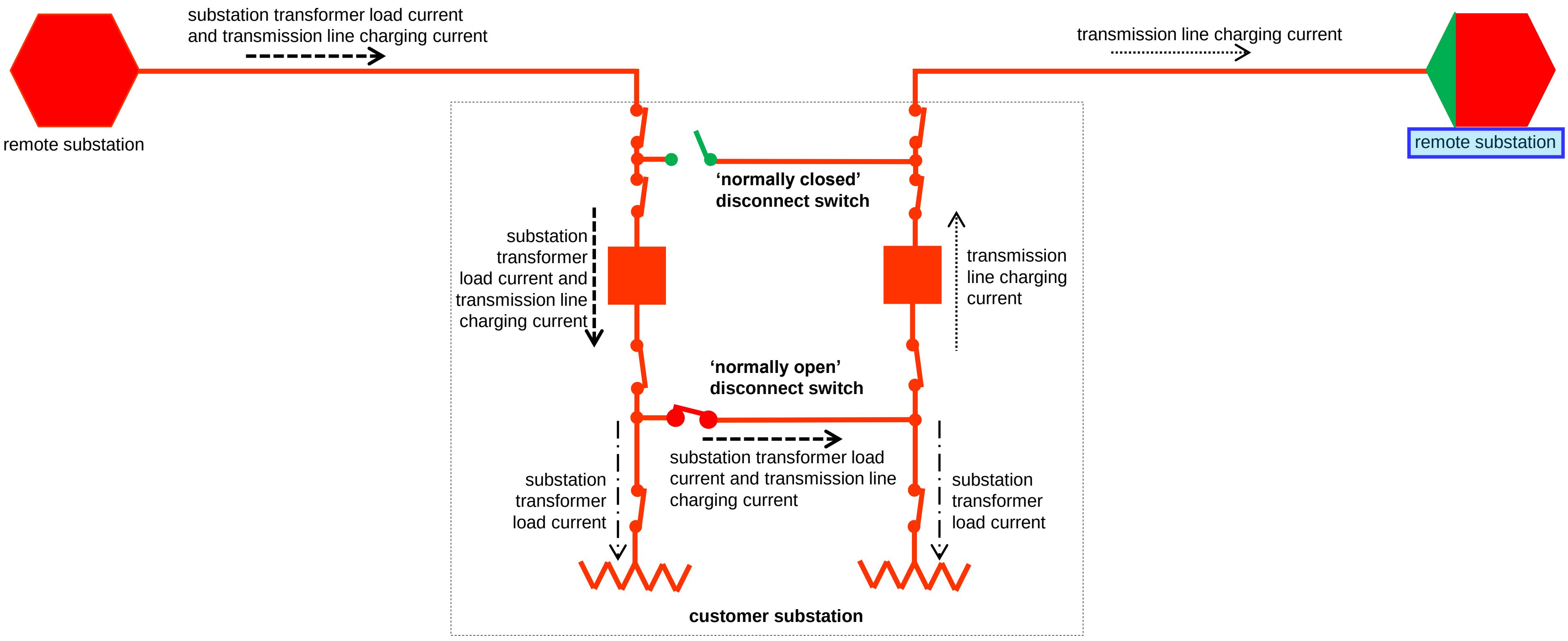
"LOOP-TAP" ALTERNATIVE 'b' SWITCHING – STEP 2



STEP 2 – Open the 'normally closed' disconnect switch.

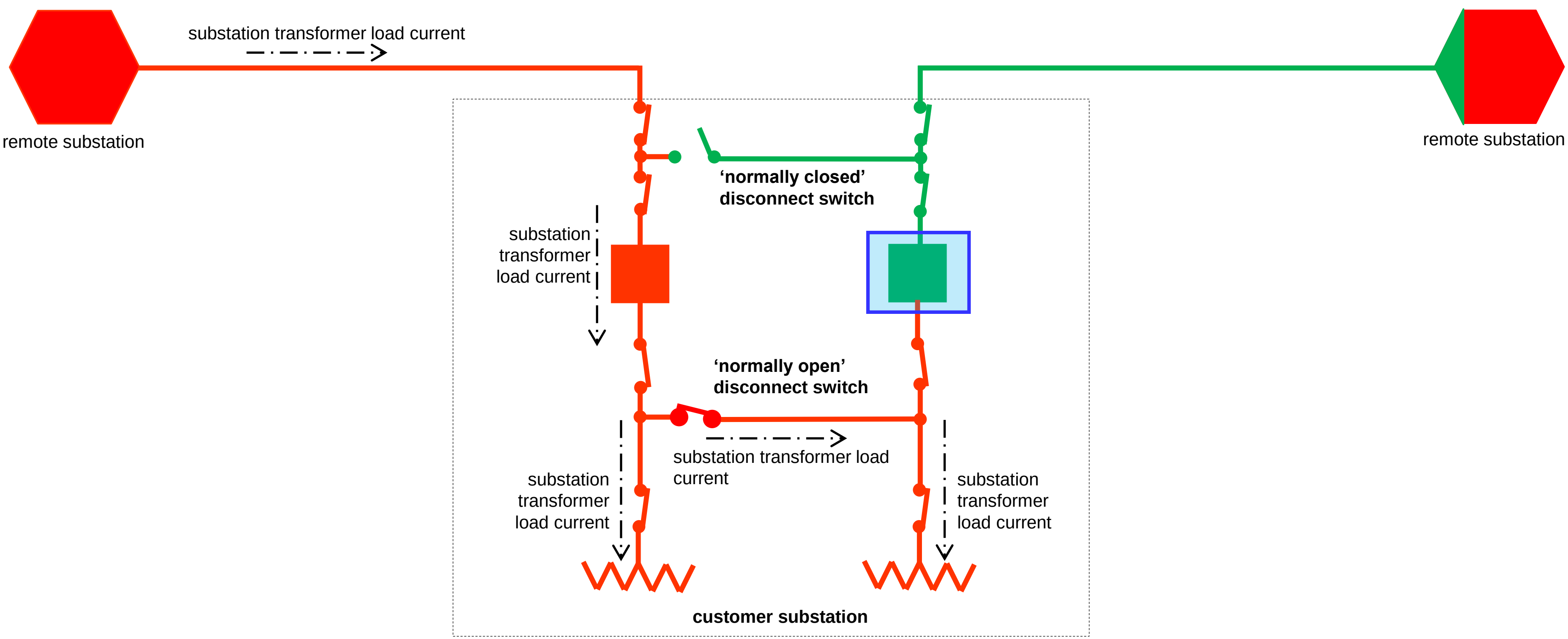
This is referred to as 'closed-loop switching' within a substation. No current is interrupted. The current is diverted to the other path within the substation. A disconnect switch with arcing horns is capable of performing this type of switching.

"LOOP-TAP" ALTERNATIVE 'b' SWITCHING – STEP 3



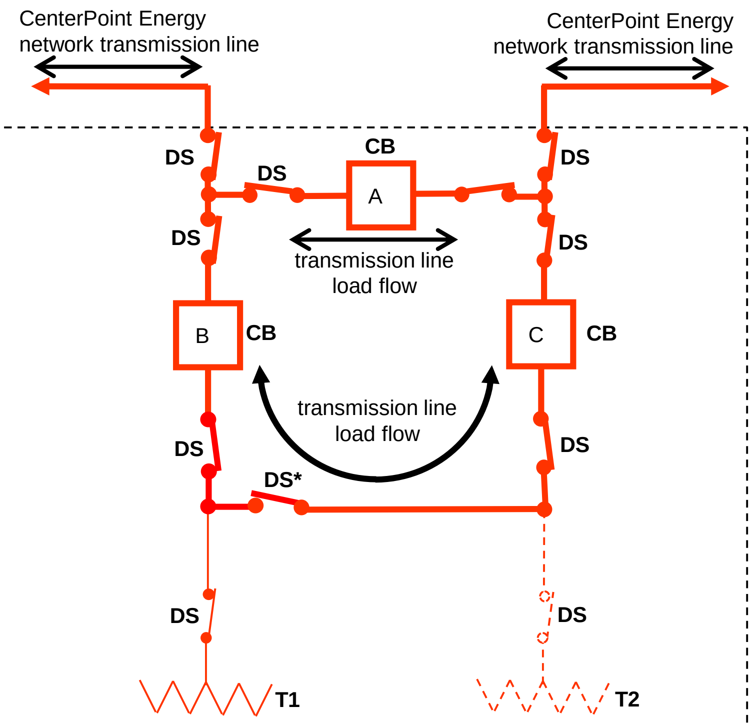
STEP 3 – Open the remote substation circuit breaker(s) or remote substation transmission line switching device.

“LOOP-TAP” ALTERNATIVE ‘b’ SWITCHING – STEP 4



STEP 4 – Open the customer substation circuit breaker

“FULL-LOOP” ALTERNATIVE ‘a’



“Full-Loop” alternative ‘a’ Customer 138 kV Substation
3 Circuit Breakers with 1 or 2 Transformers

CB = circuit breaker
DS = disconnect switch

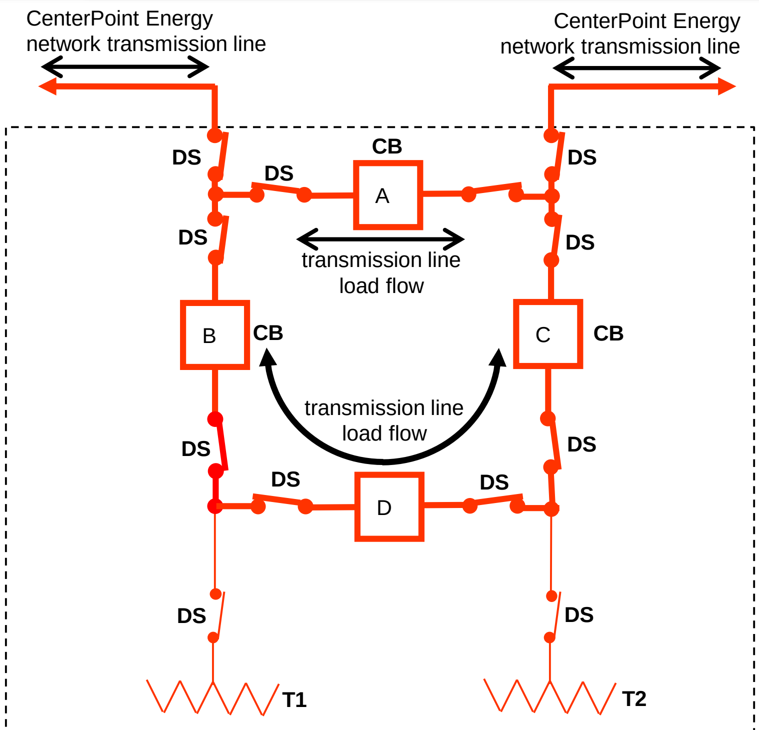
Must have a continuous current rating of 4000 A minimum
Can be less than 4000 A

All disconnect switches only have ‘arcing horns’. ‘Circuit Switcher’ are not used in this configuration. The circuit breakers are used for manual switching of the transmission line sections.

* If two transformers are installed then this DS is ‘normally open’ or ‘normally closed’ depending on customer operating preference.

“FULL-LOOP” ALTERNATIVE ‘b’

CenterPoint Energy



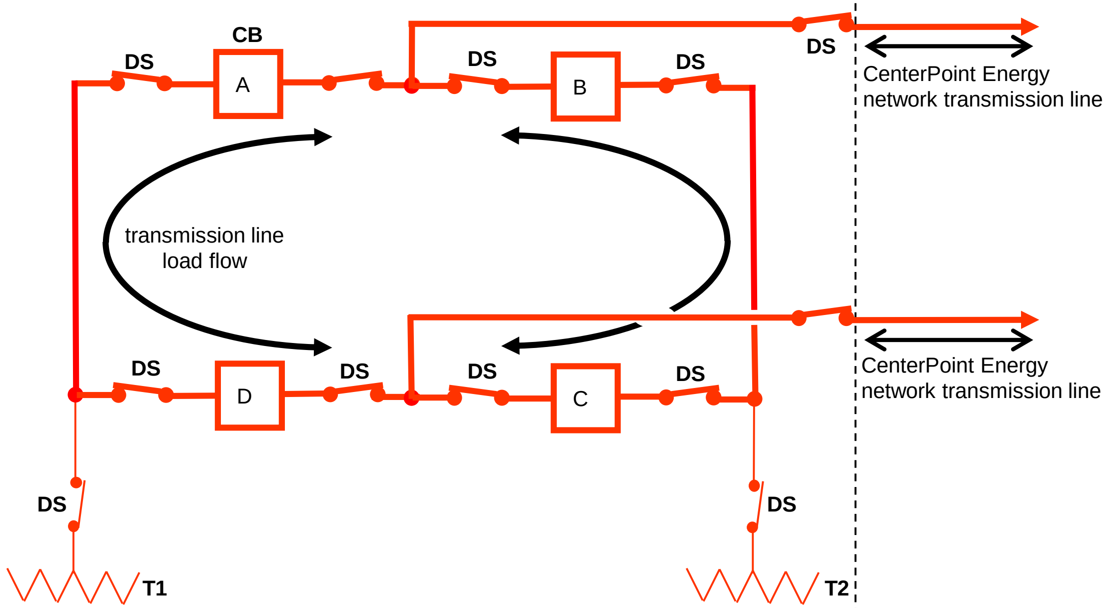
“Full-Loop” alternative ‘b’ Customer 138 kV Substation
4 Circuit Breakers with 2 Transformers

CB = circuit breaker
DS = disconnect switch

Must have a continuous current rating of 4000 A minimum
Can be less than 4000 A

All disconnect switches only have ‘arcing horns’. ‘Circuit Switchers’ are not used in this configuration. The circuit breakers are used for manual switching of the transmission line sections.

“FULL-LOOP” ALTERNATIVE ‘c’



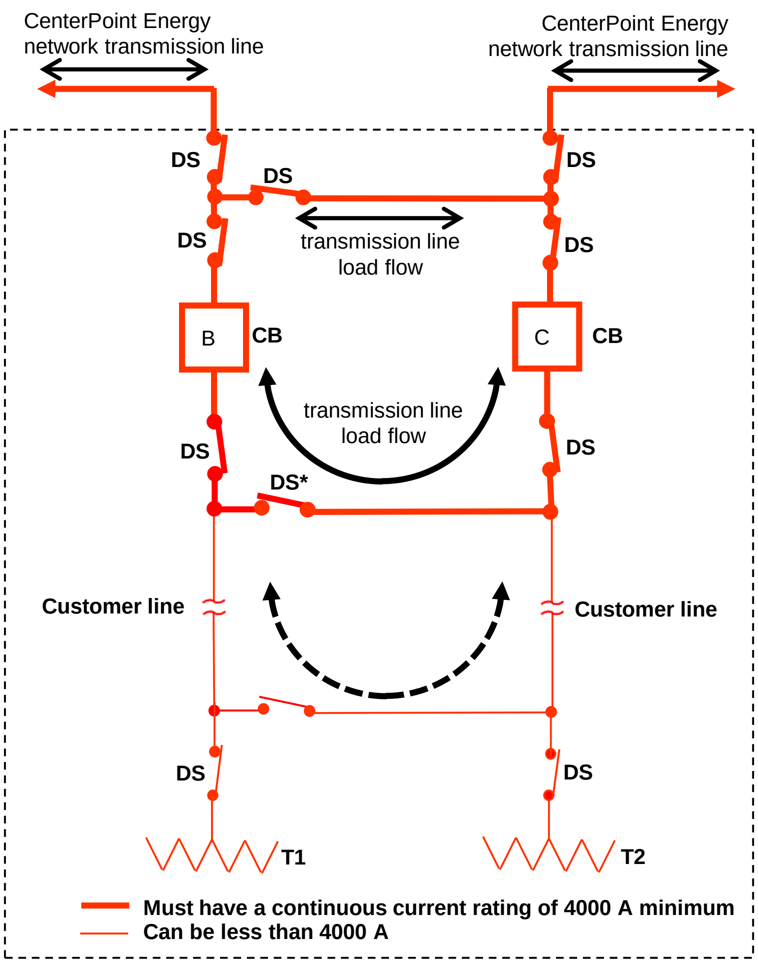
“Full-Loop” alternative ‘c’ Customer 138 kV Substation
4 Circuit Breakers with 2 Transformers

CB = circuit breaker
DS = disconnect switch

Must have a continuous current rating of 4000 A minimum
Can be less than 4000 A

All disconnect switches only have ‘arcing horns’. ‘Circuit Switchers’ are not used in this configuration. The circuit breakers are used for manual switching of the transmission line sections.

PLANT INTERNAL "LOOP" LINES



Any customer connection from the "Full-Loop" substation or "Loop-Tap" substation to the customer's transformers, customer buses, or customer lines (i.e. customer plant internal "loop lines", etc.) are not required to be 4000 A minimum. However, operational scenarios may exist after scheduled outages for which the transmission line load flow may circulate beyond the "Full-Loop" or "Loop-Tap" portion of the substation and potentially overload the customer's equipment if rated less than the 4000 A minimum. Therefore, CenterPoint Energy suggests that any customer "loop line" and customer bus/bay equipment (except customer 'radial' line or customer transformer bus connection) be 4000 A minimum.

CENTERPOINT ENERGY
SPECIFICATION FOR CUSTOMER 138 kV SUBSTATION DESIGN

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GENERAL

Because the customer’s substation becomes an integral part of the CenterPoint Energy transmission system network, CenterPoint Energy requires access to the substation and CenterPoint Energy right-of-ways 7 days-a-week, 24 hours-a-day, 365 days-a-year. Plant site access and access to plant roads to the substation by CenterPoint Energy personnel should be considered when determining the substation location and plant operating procedures

CENTERPOINT ENERGY SYSTEM CHARACTERISTICS

CenterPoint Energy's phase rotation is designated C-B-A counterclockwise and the customer shall phase equipment accordingly. Connection of the customer's H1-H2-H3 power transformer leads to CenterPoint Energy's C-B-A, B-A-C or A-C-B, respectively, is recommended.

The CenterPoint Energy 138 kV transmission system is wye, effectively grounded. The nominal system voltage is 138L-L/79.7L-G kV +/- 5%. Actual steady-state operational voltage varies around the power system but facilities with a means to regulate the 138 kV transmission system are typically used to control the voltage to be no more than approximately 142 kV to provide a margin from the maximum + 5% (145 kV). Transient conditions exceeding this range may be encountered. See Sub-Articles 3.4, 3.5, 4.7 and 7.1.4 of this specification for additional relevant information. Only instrument transformers, surge arresters, station service voltage transformers, generator step up transformers and auto transformers are allowed to be connected phase-to-ground.

Frequency, which the Electric Reliability Council of Texas Independent System Operator ("ERCOT ISO") is responsible for maintaining, is nominally 60 Hz. Refer to ERCOT (www.ercot.com) Nodal Operating Guides and Protocols for information regarding frequency regulation.

ELECTRICAL DESIGN CRITERIA

The minimum acceptable electrical design characteristics are listed below:

Transformer Winding Impulse Level	550 kV BIL
Bus and Switch Insulator, Apparatus Bushing Impulse Level (circuit breaker bushings, transformer bushings, CVT, CT, PT, surge arresters etc.)	650 kV BIL
Bus and Switch Insulator Leakage Distance	132 in. creep (equivalent to extra creep 650 kV BIL or 750 kV BIL. May require coating in extra heavy contamination areas)
Apparatus Bushing Leakage Distance (circuit breaker bushings, transformer bushings, CVT, CT, PT, surge arresters etc.)	92 in. creep (equivalent to 650 kV BIL – light contamination levels. May require coating in some areas)
Phase to Ground Clearance	52 in. (Metal to Metal)
Phase to Phase Bus Spacing (including vertical spacing at crossover point of high and low bus)	63 in. (Metal to Metal)
Phase to Phase Horizontal Spacing Center Line to Center Line, at Incoming Line Dead-End Structure	144 in. (regardless of the line angle)

ELECTRICAL DESIGN CRITERIA

The 138 kV substation shall be designed for a short circuit current of 63 kA rms symmetrical, with X/R ratio of 15, unless otherwise specified by CenterPoint Energy.

The application of key interlock systems are not permitted on customer substation 138 kV equipment.

The customer's connected load and equipment shall be designed and operated to adhere to the recommended harmonic limits of IEEE Std. 519 and limits of voltage fluctuations and associated light flicker of IEEE Std. 1453.

The operation of customer's equipment (starting of motors, operating furnaces, energizing capacitor bank, etc.) shall not produce a step voltage change greater than 2.0% at the customer's high side bus with any one transmission line segment directly associated with the electrical supply to the customer substation out-of-service.

The substation ground mat shall be designed for a short circuit current of 63 kA rms symmetrical with X/R ratio of 15 and duration of 0.25 seconds and comply with IEEE Std. 80 and IEEE C2 (NESC). Ground mat connections shall comply with IEEE Std. 837, unless otherwise specified by CenterPoint Energy.

The substation direct lightning stroke shielding design shall comply with IEEE Std. 998

ELECTRICAL DESIGN CRITERIA

Requirement for 2-hr emergency current rating:

The 2-hr emergency current rating of all equipment in the transmission line loop or ring portion of the substation shall be 4,400A minimum (110% of 4000A continuous rating). This includes line disconnect switches, conductors, circuit breakers, line traps, etc. which are in the transmission line loop or ring portion of the substation.

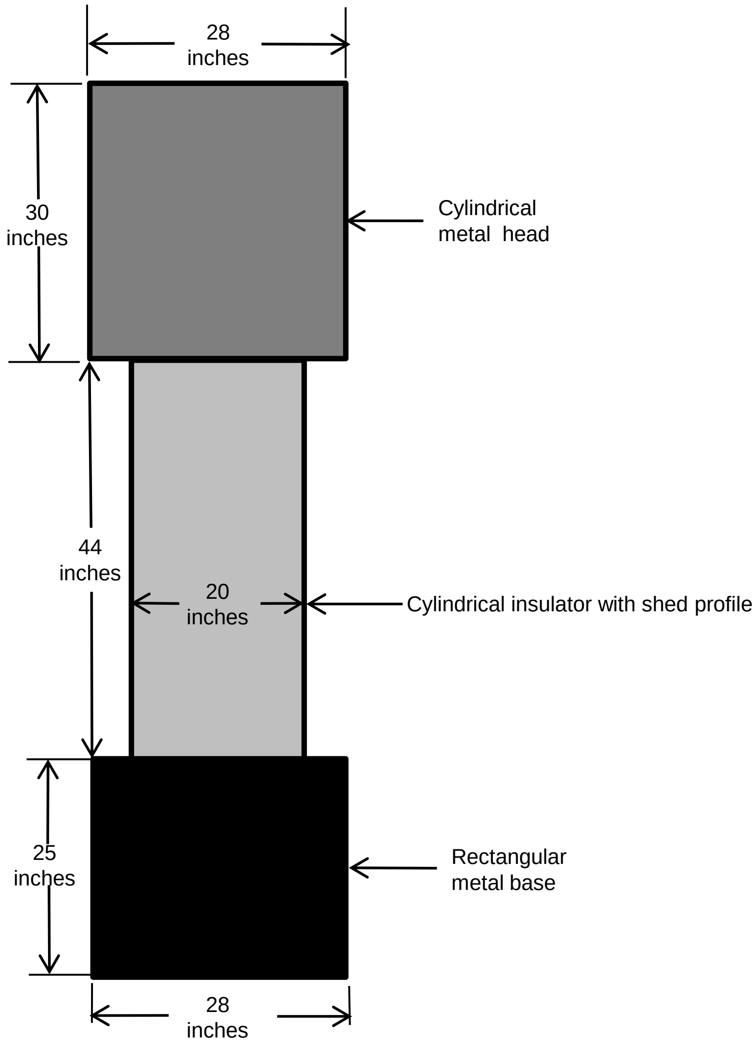
STRUCTURAL AND MECHANICAL DESIGN CRITERIA
138 kV METERING INSTRUMENT TRANSFORMER STANDS

CenterPoint Energy

Removed diagrams showing design parameters and inserted text with design parameters:

The customer will design a mounting stand and foundation for the hurricane wind speeds and overloads from section 5.4.2. If the AISC ASD design method is used, the 1/3 increase in allowable stress will not be permitted. If the AISC LRFD method is used, the structure must have a second order elastic analysis (also called a Geometric Nonlinear Analysis). The Customer shall limit the horizontal deflection of the PT/CT at the instrument mounting height to the mounting height divided by 100. The wind load used for the deflection limit shall be the 5 year mean recurrence interval wind. A conversion factor of 0.78 applied to the hurricane wind pressure will yield the 5 year MRI.

INSTRUMENT TRANSFORMER MAXIMUM DIMENSIONS AND WEIGHT



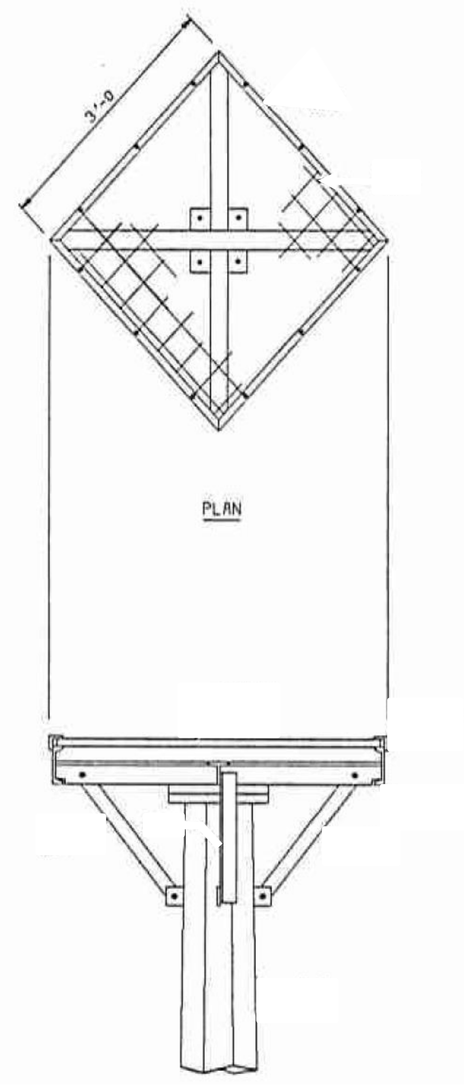
This diagram represents the maximum dimensions, and maximum weight of possible 138 kV CT's or PT's that CenterPoint Energy will provide for the 138 kV billing metering.

This diagram provides the necessary structural and mechanical design parameters to be used for the instrument transformer foundations and stands that will support 138 kV CT's or PT's that CenterPoint Energy will provide.

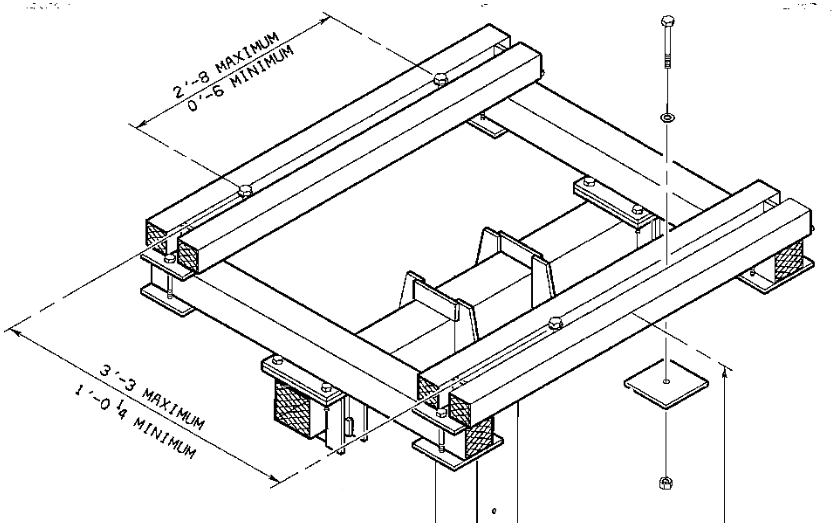
This diagram must also be used, in conjunction with substation bus profile dimensions, to determine the height of the stands that will support the instrument transformers that CNP would provide for the 138 kV billing metering.

After the instrument transformer stand height has been determined based on the above information, the manufacturer's outline drawing for the actual 138 kV CT's and PT's that CenterPoint Energy will provide must be used to determine the details of the primary connection(s) and secondary terminal box conduit connection.

INSTRUMENT TRANSFORMER STAND MOUNTING SURFACE



The instrument transformer stand mounting surface for the 138 kV CT & PT that CenterPoint Energy will provide for the 138 kV billing metering must be adjustable or use grating to accommodate diverse instrument transformer mounting bolt patterns.



STRUCTURAL AND MECHANICAL DESIGN CRITERIA

Additional design documentation:

The customer shall provide a complete structural and foundation design package for the dead-end structures (supporting the CenterPoint Energy transmission lines connected to the customer's 138 kV substation) and the instrument transformer stands in accordance with Article 15.0. The design package shall be signed and sealed by a professional engineer registered in Texas (including the firm name and firm registration number) and shall include design references/codes, computer analysis, member design, connection design, foundation design, soil report, structural and foundation drawings, and all other information that documents the design of the structure(s).

CIRCUIT BREAKERS

Accommodation to interface with any existing circuit breakers with 2000:5 multi-ratio CT's in an existing substation while maintaining the design capability for 4000 ampere operation in the future and in a new substation:

Each 138 kV circuit breaker shall be equipped with two 3,000:5 A multi-ratio CT's per 138 kV bushing. Each CT shall have an accuracy of C800 on the 2,000:5 A tap in accordance with IEEE C57.13. The secondary resistance of circuit breaker bushing CT's shall not exceed 0.0025 ohms per turn. CT secondary rated continuous current shall be 10 A minimum. Rating Factor (R.F.) shall equal 2.0.

CIRCUIT BREAKERS

Additional information required:

The customer shall indicate on the relay and metering one-line diagram whether the low SF6 gas pressure wiring to set to 'BLOCK TRIP' or to 'AUTOMATICALLY TRIP' the circuit breaker.

138 kV METERING INSTRUMENT TRANSFORMERS

CenterPoint Energy

Requirement for three secondary windings required by transmission line protective relaying schemes:

The 138 kV Metering PT's will have three secondary windings (i.e. "X", "Y", and "Z"). The "X" and "Z" windings will be used for relaying, SCADA and the customer's equipment. The "Y" winding will be used exclusively for CenterPoint Energy metering.

PROTECTIVE RELAYING

CNP calculates and implements all settings for the Customer’s relays installed for the protection and automatic reclosing of CNP transmission lines and for the Customer’s relays installed to prevent back-energizing CNP’s system from generation installed on the low side of the Customer’s power transformers. On a case-by-case basis, CNP may issue settings for other relays owned by the Customer. The relay settings implemented by CNP for the Customer’s relays will be provided to the Customer upon request.

PROTECTIVE RELAYING

Requirement regarding communication ports to electronic device that can directly or indirectly trip a circuit breaker connected to a CenterPoint Energy transmission circuit:

11.10. An electronic device that can directly or indirectly trip a circuit breaker connected to a CenterPoint Energy transmission circuit (i.e. transmission line protective relay, transformer bus protective that includes breaker failure relaying, etc.) is not allowed to be monitored via routable protocol communication (i.e. Ethernet), serial or dial-up communication. Data can be provided from the CenterPoint Energy RTU (refer to CenterPoint Energy specification 007-400-02 for details) or customer may install separate monitoring devices.

PROTECTIVE RELAYING

Additional information regarding line tuner installation:

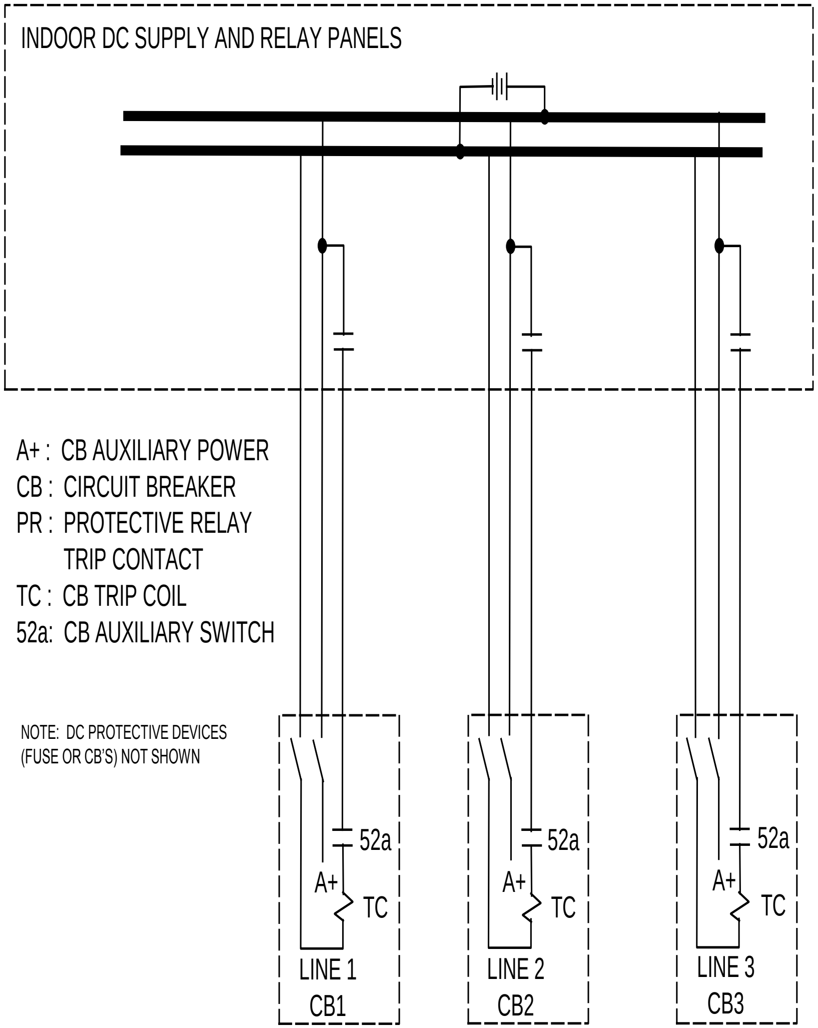
The line turner requires separate mounting at the base of the coupling capacitor stand. A single conductor must be run as directly as possible between this line turner and the coupling capacitor base housing. The single conductor must be 4 AWG stranded, 5 kV, non-shielded, XLP insulation. The single conductor must be mounted on insulators and fed through bushings at each end. The single conductor insulation should be unbroken between its ends to maintain low leakage. The single conductor must not be directly up against or touching the coupling capacitor support column or other metal components.

PROTECTIVE RELAYING

Method to help identify underground fiber optic cable:

CenterPoint Energy will also pull a single conductor #10 stranded copper wire (supplied by CenterPoint Energy) along with the fiber optic cable in below grade PVC conduit to make fiber optic cable route identifiable in the future when locating underground objects.

PROTECTION & CONTROL WIRING ROUTING METHOD



With outdoor circuit breakers and indoor relay panels a routing method herein called "radial", shall be used since the dc circuitry to the circuit breakers radiates outward from the control cubicle. Routing of the conductors is from the dc supply to the relay panels or switchboards and then on to the circuit breakers. Positive and negative conductors are carefully routed together so that sudden changes in current, such as those from tripping a circuit breaker, do not result in large magnetic coupling to other control and measuring conductors. (The effects of external magnetic fields tend to cancel when the "go" and "return" conductors are in close proximity.) All wires of a circuit should be contained in the same cable so that all are affected similarly by any inductive coupling

GENERAL

Suggested practice:

When terminal blocks and other connections permit, ring tongue lugs should be used instead of spade or stab-on lugs which can become loose and fall off.

DRAWING COMPLIANCE REVIEW

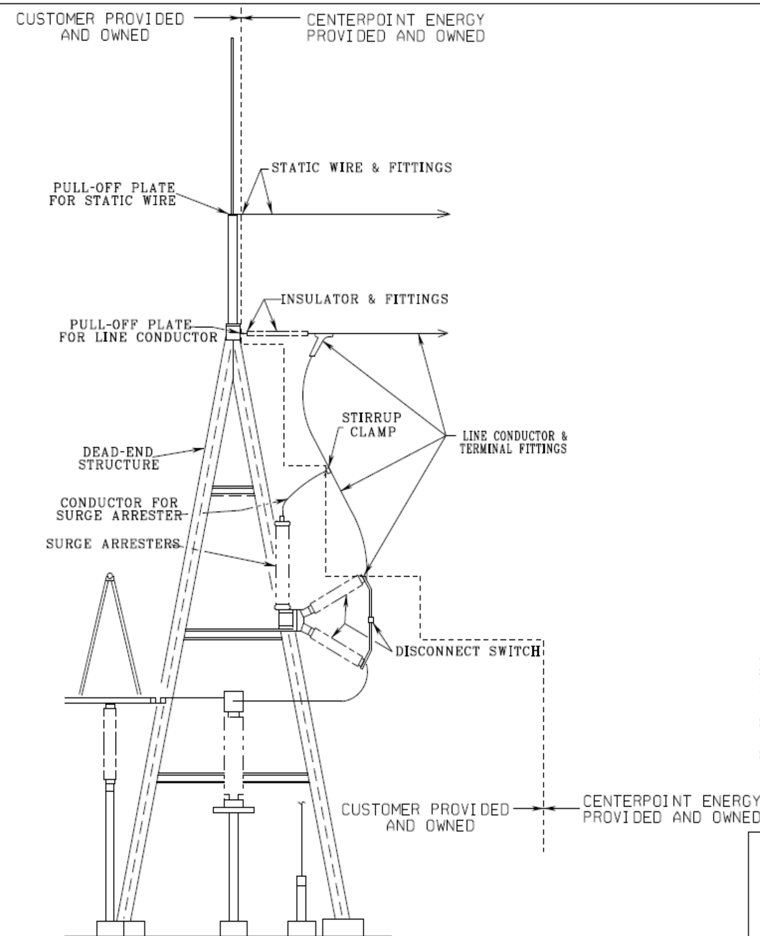
This specification is not intended to be totally comprehensive. To ensure the efficient coordination between CenterPoint Energy and the customer during the design and construction of the customer's substation, CenterPoint Energy requires that engineering documents be submitted to CenterPoint Energy for review before certain equipment is ordered or construction begins. All items requiring CenterPoint Energy review are listed in Article 14.0 of this specification and shall be submitted in writing to the designated CenterPoint Energy representative.

DRAWING COMPLIANCE REVIEW

Details of needed information on 'site plot' including substation site elevation:

Site plot plan drawings shall be submitted to CenterPoint Energy for comment. Facilities that must be shown on this drawing include dimensions of the substation site, dead-end structure location, access roadways to substation, space around the outside of the substation (roadways, railroad tracks, walks, pipe racks, culverts, ditches etc.). Additionally, the elevation of the substation site should be indicated on the drawing.

DIVISION OF OWNERSHIP AT LINE TERMINATION



ELEVATION

NOTES:

1. DRAWING INDICATES TERMINATION OF CENTERPOINT ENERGY LINE & SERVICE TO CUSTOMER SUBSTATION.
2. THIS DRAWING NOT INTENDED TO SHOW THE LOCATION OR TYPE OF CUSTOMER EQUIPMENT.
3. NUMBER & TYPE OF INSULATORS TO BE DETERMINED BY STATION VOLTAGE.

CUSTOMER OWNED SUBSTATION
LINE TERMINATION STANDARD

CENTERPOINT ENERGY, INC.
HOUSTON, TEXAS

DRAWN 4-18-2012	B. CHATMAN	SCALE	NTS
CHECKED		SHEET 1 OF 2 SHEETS	
CORRECT		DRAWING NUMBER	
APPROVED 4-18-2012	D. SEVCIK	004241 04	

NO.	DATE	JOB NO.	REVISION	BY	CH	COR	APP
2	4-18-2012	---	REDRAWN & CONVERTED TO CAD	BC	BC	---	BC
1	4-24-63	---	ADDED 3RD LINE NOTE & SHEET 2	LHE	---	---	RES
---	3-6-63	---	REVISED DRAWING NUMBER FROM HD-24574	LHE	---	---	---

OUTAGE CLEARANCE AND COORDINATION PROCEDURES

CONTENTS

APPLICABILITY AND PURPOSE

This procedure applies to entities (“the Customers”) who own high voltage transmission and/or generation facilities interconnected to CenterPoint Energy Houston Electric, LLC’s (“CNP”) 69 kV, 138 kV, or 345 kV transmission system. Customer, as used in this document, includes the Customer’s authorized contractors or agents. The Customer shall ensure that the provisions in this document are applied to facilities that may be owned by others and that are interconnected to the Customer’s facility at the same voltage at which the Customer’s facility is interconnected to CNP’s transmission system.

The purpose of this document is to facilitate the coordinated operation, outage coordination, maintenance, design, and modification of the Customer’s high voltage transmission or generation facilities with CNP facilities.

REAL TIME OPERATIONS (RTO) DEPARTMENT

RTO operates CNP's transmission system and coordinates the operation of interconnected high voltage facilities. RTO provides routine and emergency switching instructions, issues clearances, and dispatches CNP personnel in response to electrical outages and problems. The Customer shall schedule planned outages with RTO and obtain from RTO switching instructions for any equipment at the Customer's substation that is directly interconnected with CNP's transmission system. Switching in the Customer's facilities that are remote to the Customer's substation directly interconnected with CNP's transmission system does not need to be scheduled. CNP will notify the Customer one or more days in advance if switching is required in the Customer's substation for planned transmission line outages or if the Customer's substation will be placed in a single-ended condition.

PLANNED OUTAGE SCHEDULING

Equipment Being Requested	Minimum Advance Notice	Contact
69 kV and 138 kV lines, single load transformers, individual breakers and bus outages of no more than one day in duration.	No later than 1200 hours Wednesday two weeks before the Planned Outage is to take place.	Outage Scheduler @ 713-207-2196 or 713-207-2714
All transmission line outages and equipment outages, including busses, of up to four contiguous days duration (daily or continuous outages).	35 Calendar Days	Outage Scheduler @ 713-207-2196 or 713-207-2714
Any transmission line outages and/or equipment outages, including busses, of 5 days or longer duration (daily or continuous)	90 Calendar Days	Outage Scheduler @ 713-207-2196 or 713-207-2714

CUSTOMER SUBSTATION EQUIPMENT ADDITIONS, RELOCATIONS, UPGRADES AND/OR REMOVALS

When installing, relocating, or upgrading transmission system equipment, Customers must contact their appropriate CNP Transmission Accounts representative with sufficient notice to meet the timelines and data requirements shown below. ERCOT Nodal Protocols Section 3.10.1 requires that all changes to transmission equipment energized at 60 kV and above be communicated by CNP to ERCOT using the Network Operations Model Change Request ("NOMCR") process as summarized below:

Table 2

Target Physical Equipment In-Service Month	Deadline to Submit to RTO	Timeline to Submit initial information to Transmission Accounts Rep
Month of January	**Sept. 1**	June 1 (prior year)
Month of February	**Oct. 1**	July 1 (prior year)
Month of March	**Nov. 1**	August 1 (prior year)
Month of April	**Dec. 1**	September 1 (prior year)
Month of May	**Jan. 1**	October 1 (prior year)
Month of June	**Feb. 1**	November 1 (prior year)
Month of July	**Mar. 1**	December 1 (prior year)
Month of August	**Apr. 1**	January 1
Month of September	**May 1**	February 1
Month of October	**June 1**	March 1
Month of November	**July 1**	April 1
Month of December	**Aug. 1**	May 1

PLANT DESIGN CONSIDERATIONS

11.1 Emergency Systems

11.1.1 Continuous electric service from utility power systems cannot be guaranteed even for facilities that are connected to a large number of transmission lines. The possibility exists that a total power outage or separation from the utility system may occur. It is important to consider this when plant emergency systems are designed.

11.2 Automatic Reclosing

11.2.1 CNP utilizes automatic reclosing of high voltage circuit breakers following unplanned tripping of CNP transmission lines. CNP endeavors to intentionally delay the initial reclose attempt by at least one second. The Customer is responsible for the separation of necessary motors or other equipment within one second of the tripping.

11.3 System Voltage

11.3.1 Electric service from a utility power system cannot be guaranteed against fluctuations. Voltage sag is a common fluctuation that occurs during the time of a fault. The large majority of faults on a utility transmission system are single line-to-ground faults. With automatic reclosing of circuit breakers, several voltage sags can occur within a one-minute period. Most voltage sags from faults on transmission systems have a very short duration of less than ten cycles with high-speed fault clearing. Another common fluctuation is a transient voltage oscillation that occurs each time a capacitor bank is energized. Equipment, such as motor contractors, adjustable speed drives, programmable logic controllers, and high intensity discharge lamps, can be sensitive to these short duration voltage sag and transient voltage oscillation.

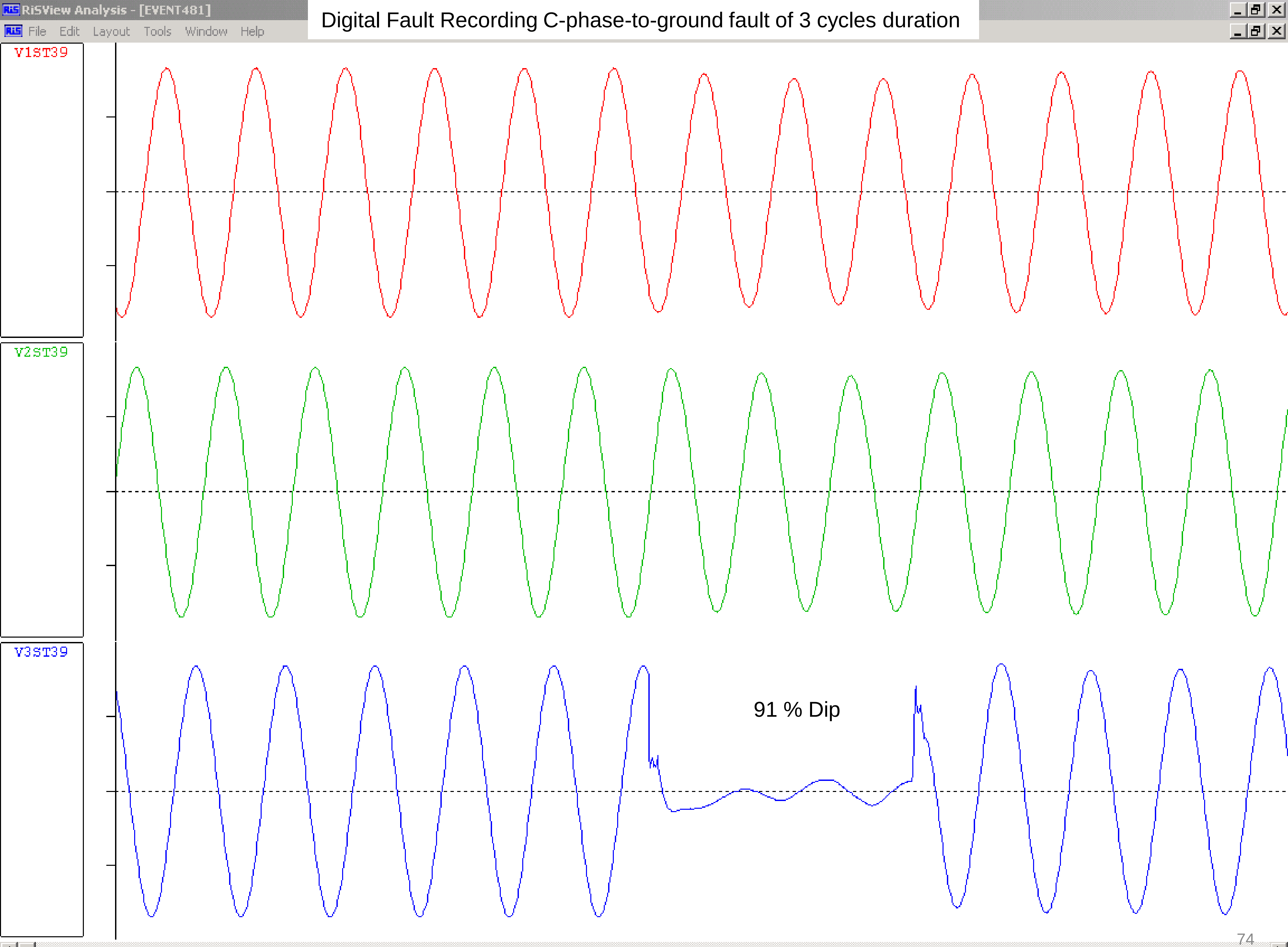
11.3.2 It is important to consider voltage sag “ride-through” for equipment applied to critical processes where nuisance tripping can cause a whole process to shut down. Plant power systems and equipment control systems can be designed or modified to ride-through the most common voltage sags and transient voltage oscillations on utility power systems. CNP will provide additional information upon request.

11.4 Electrical Protection Coordination Studies

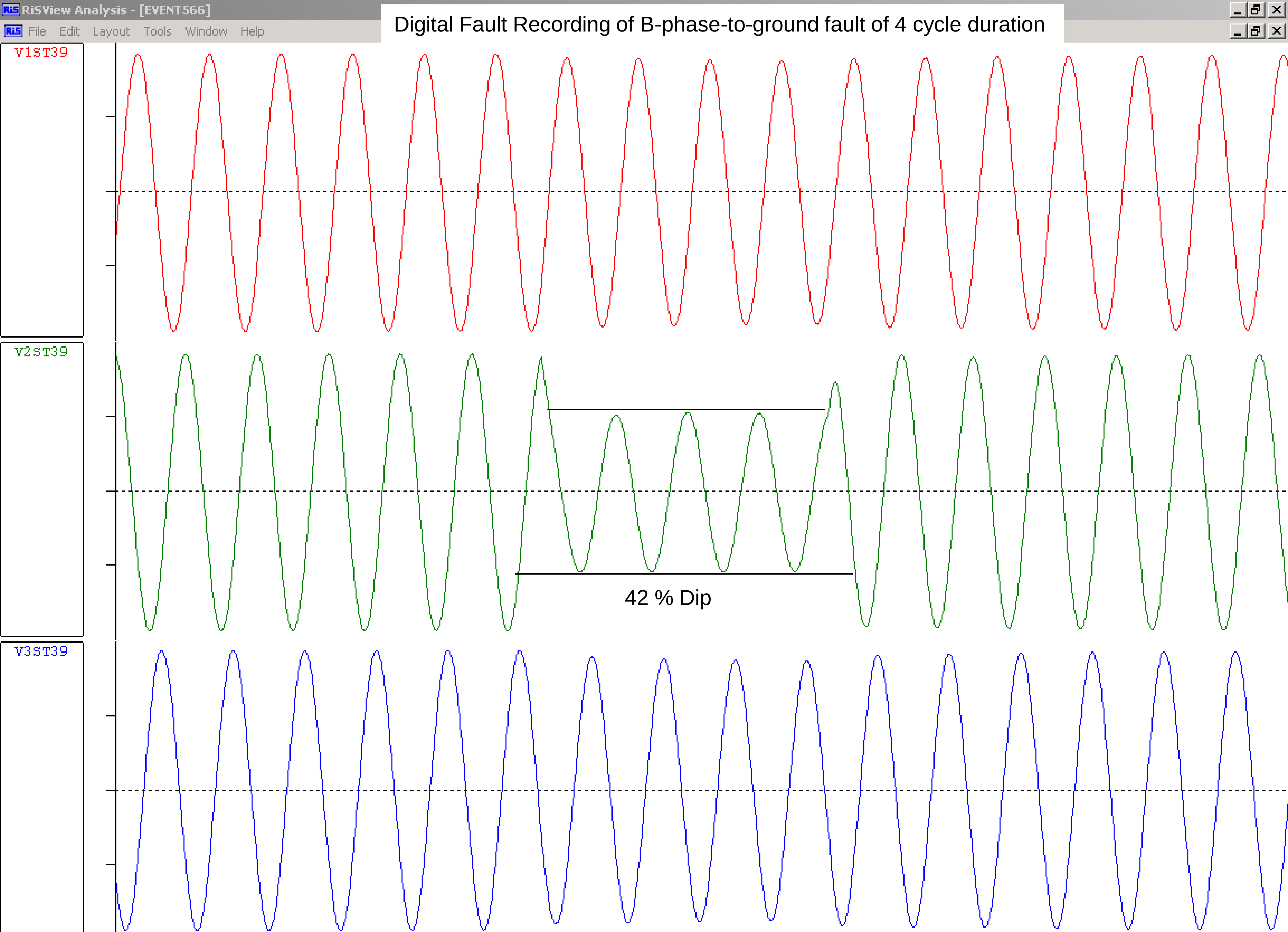
11.4.1 If the Customer performs plant electrical protection coordination studies, the Customer may contact a Transmission Accounts representative to request the available CNP system fault current and system impedance at the Customer’s facility.

SYSTEM FAULTS AND AUTOMATIC RECLOSING

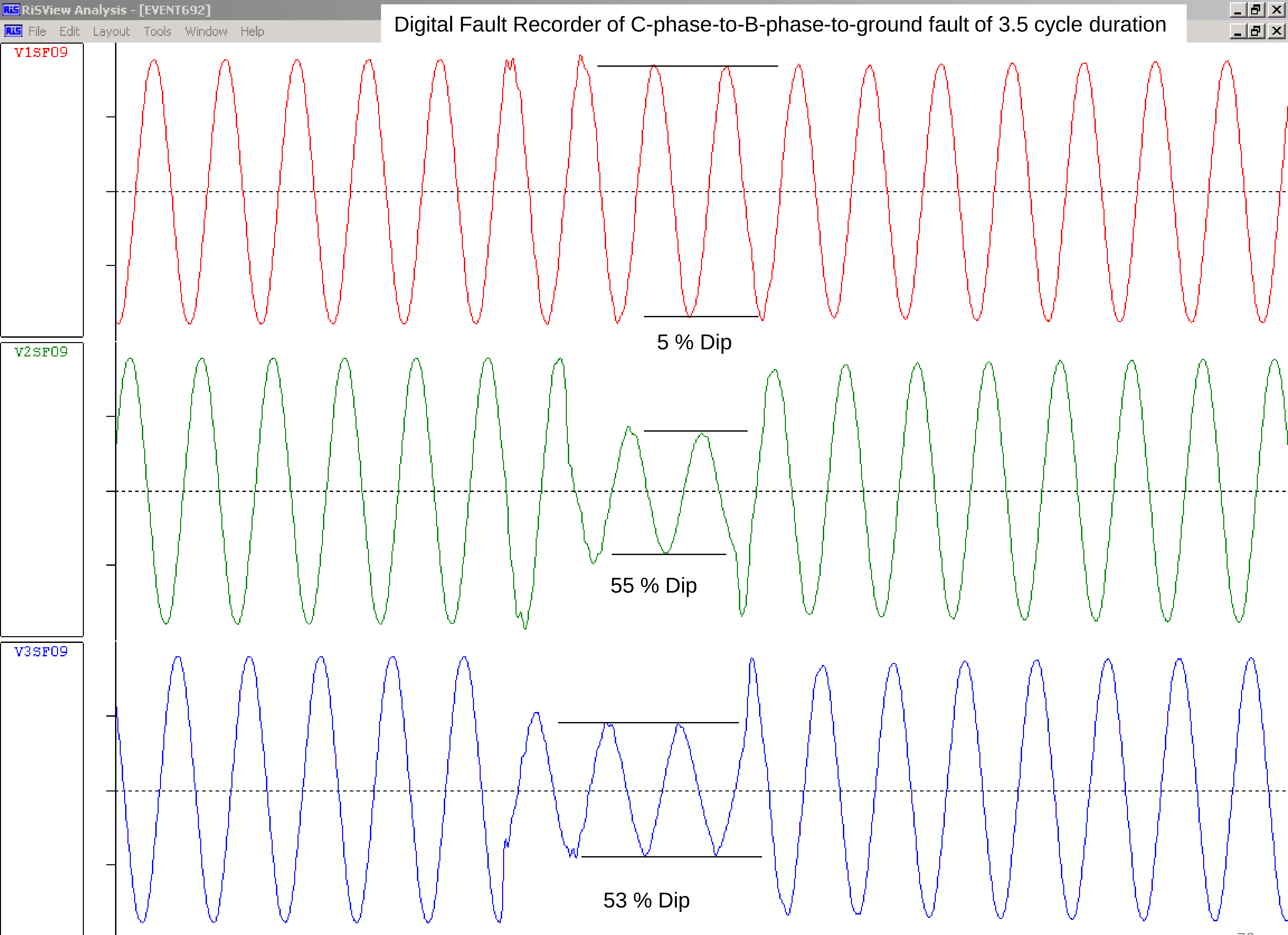
Digital Fault Recording C-phase-to-ground fault of 3 cycles duration



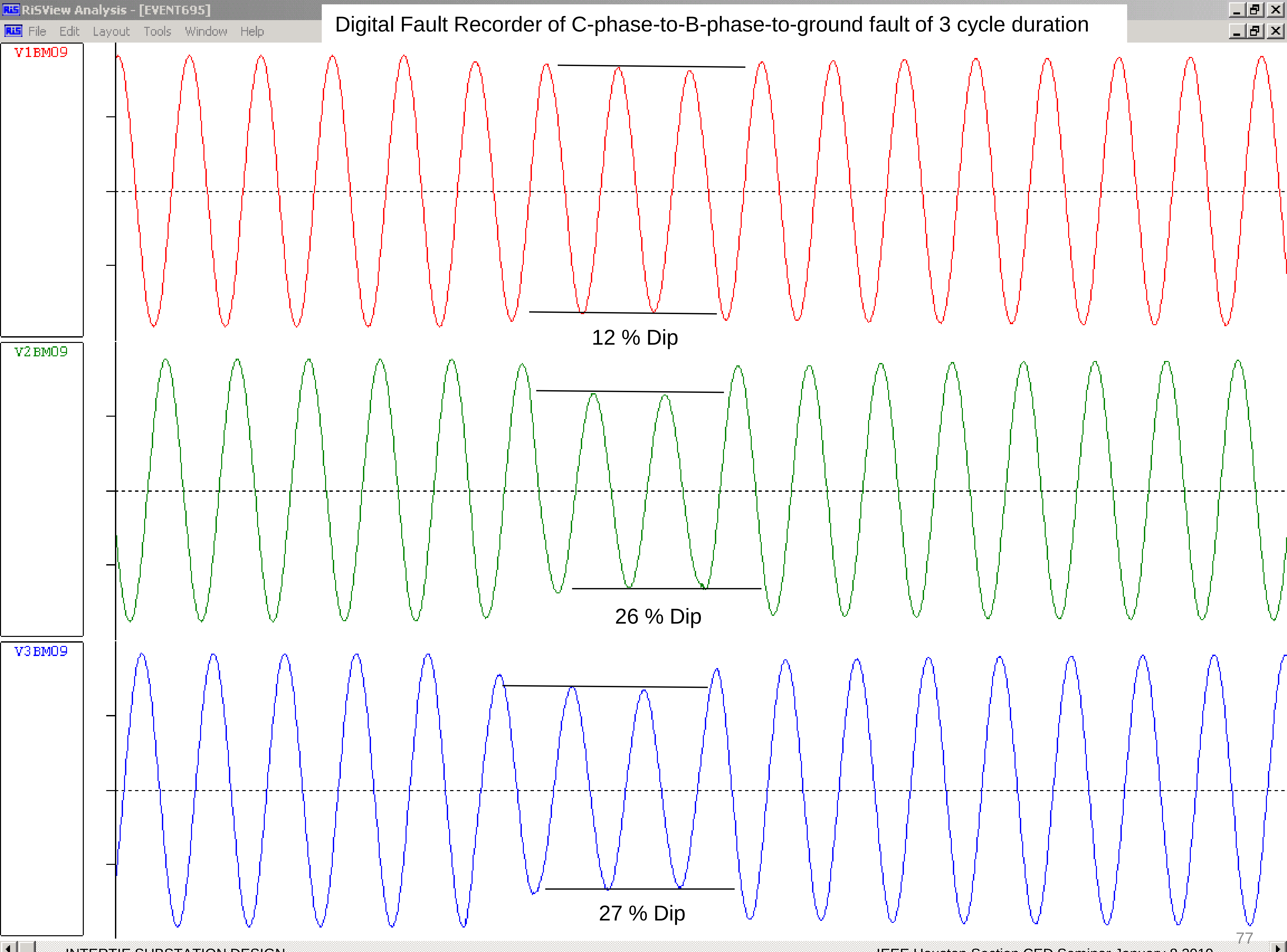
Digital Fault Recording of B-phase-to-ground fault of 4 cycle duration



Digital Fault Recorder of C-phase-to-B-phase-to-ground fault of 3.5 cycle duration



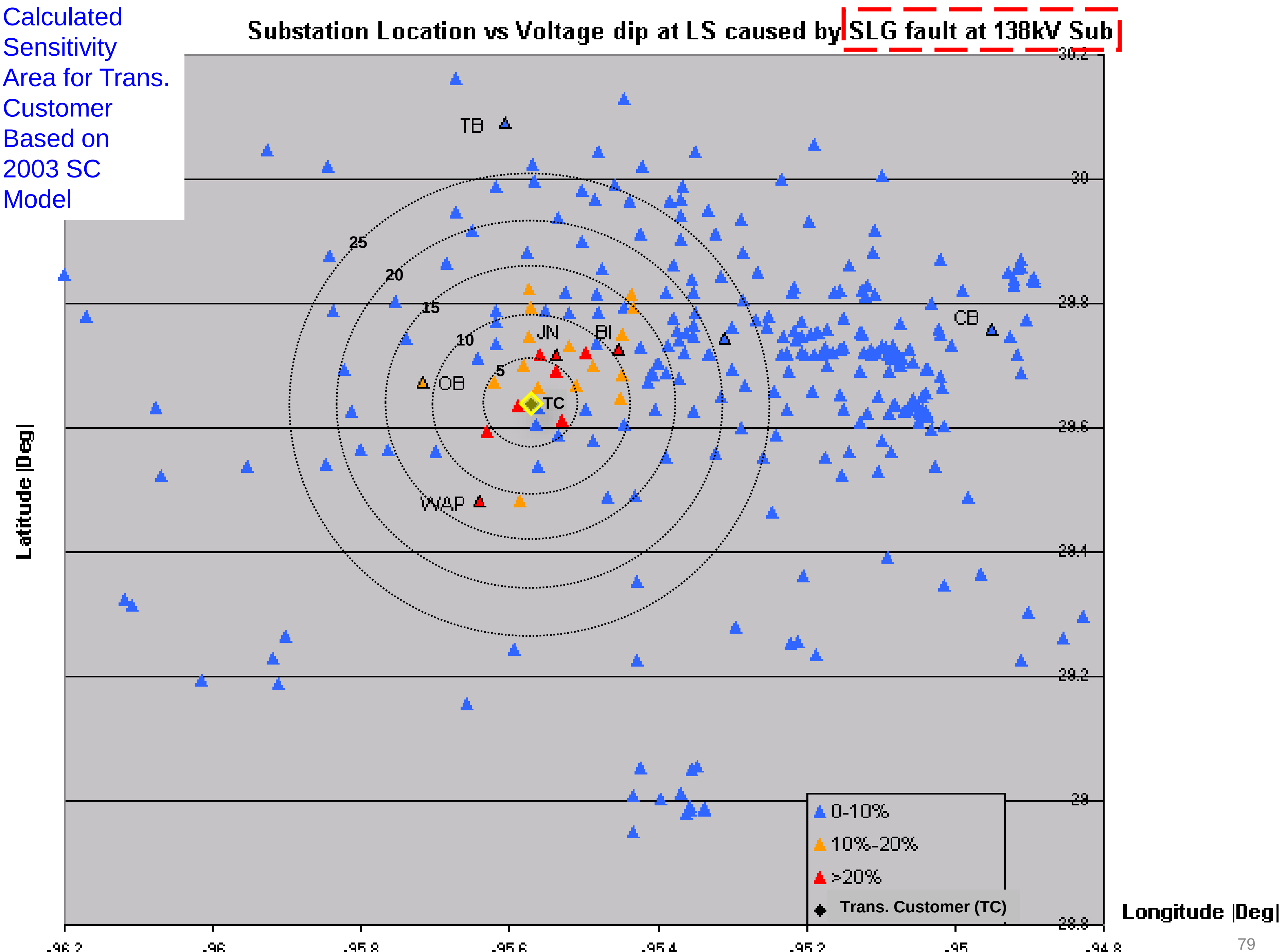
Digital Fault Recorder of C-phase-to-B-phase-to-ground fault of 3 cycle duration



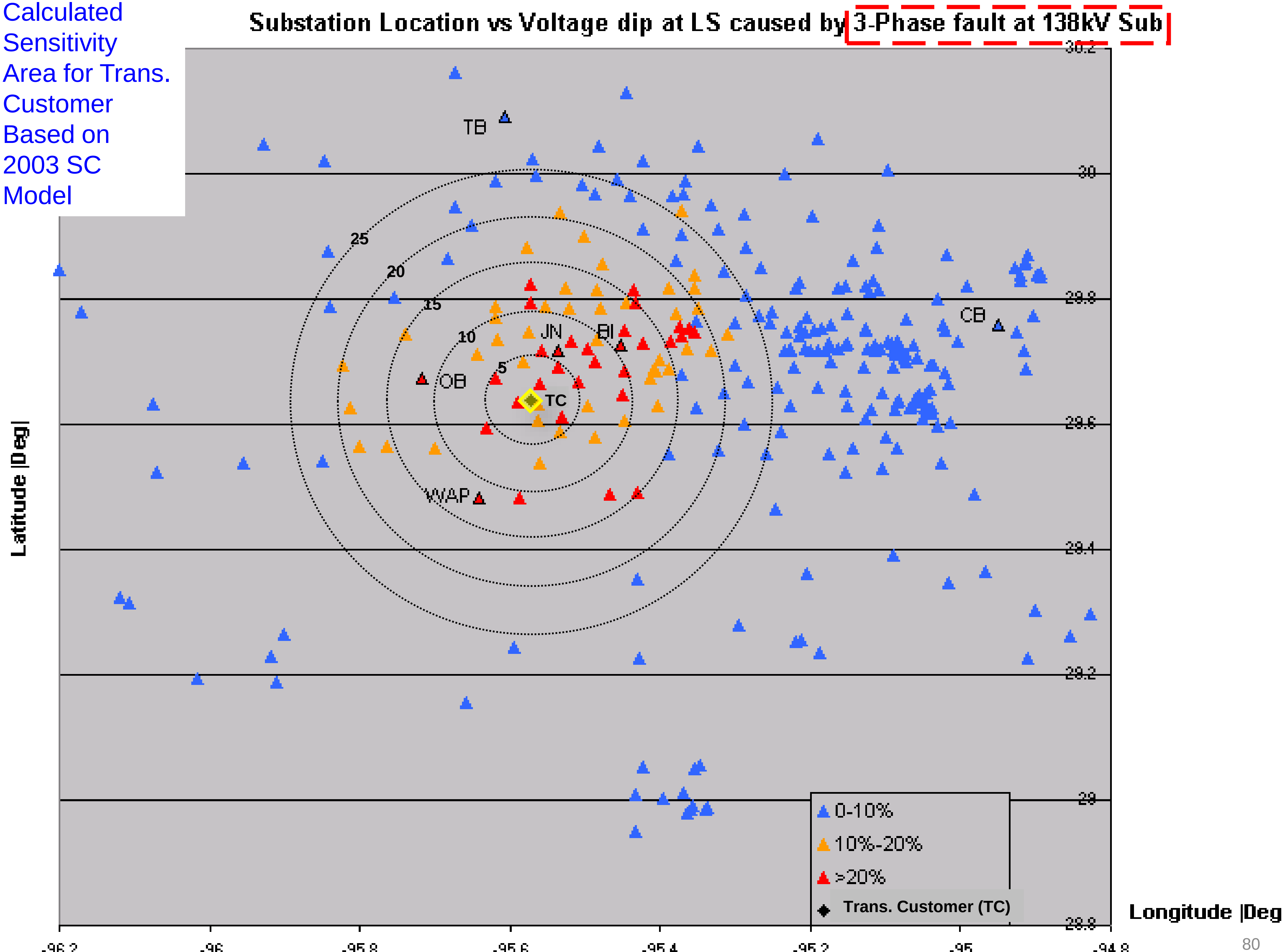
EQUIPMENT FAILURE IMPACT ON POWER QUALITY

Because the transmission system is connected in a network, a fault at a substation or along a transmission circuit will result in a voltage sag at numerous substations remote from the location of the fault.

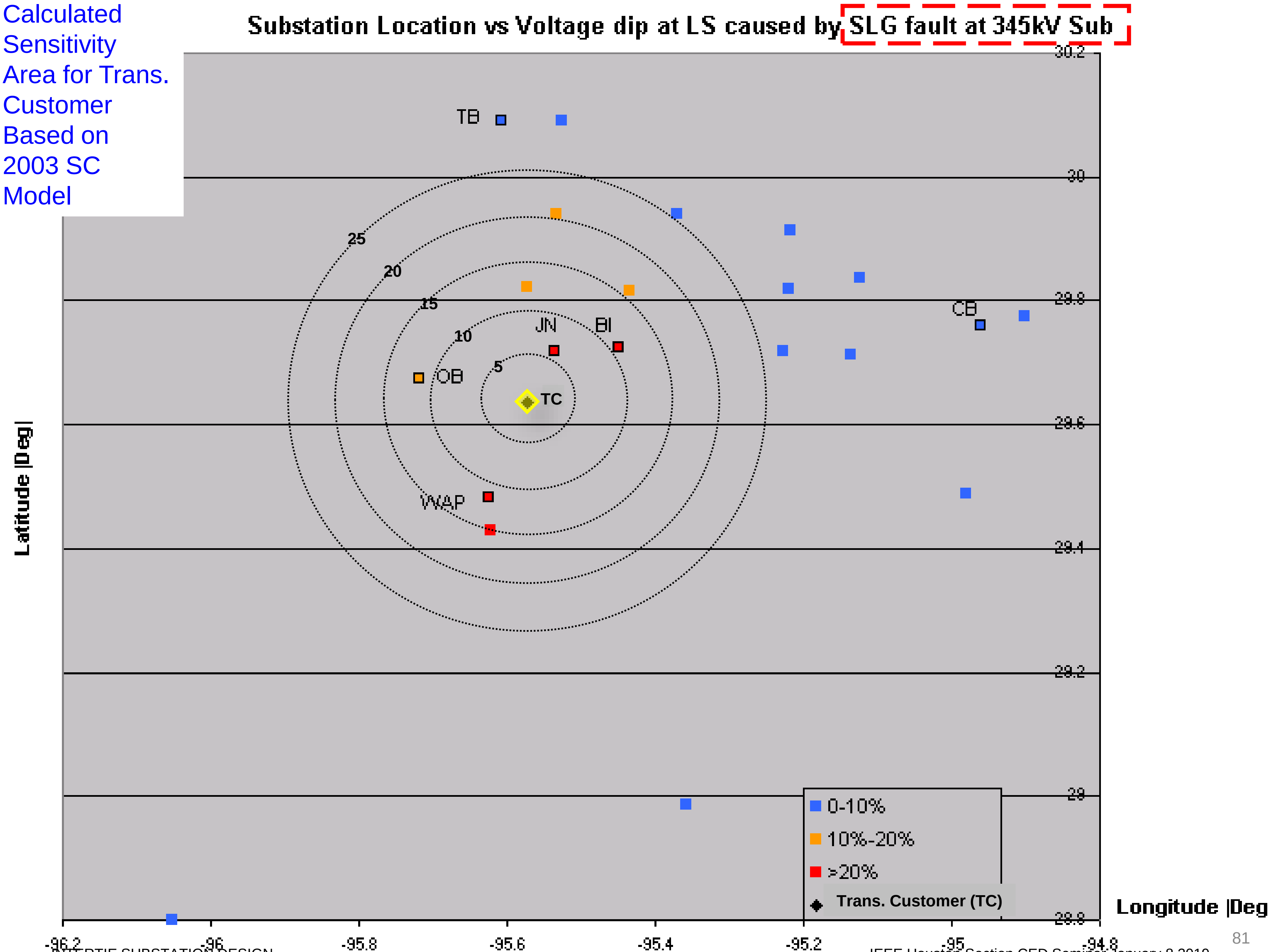
Calculated Sensitivity Area for Trans. Customer Based on 2003 SC Model



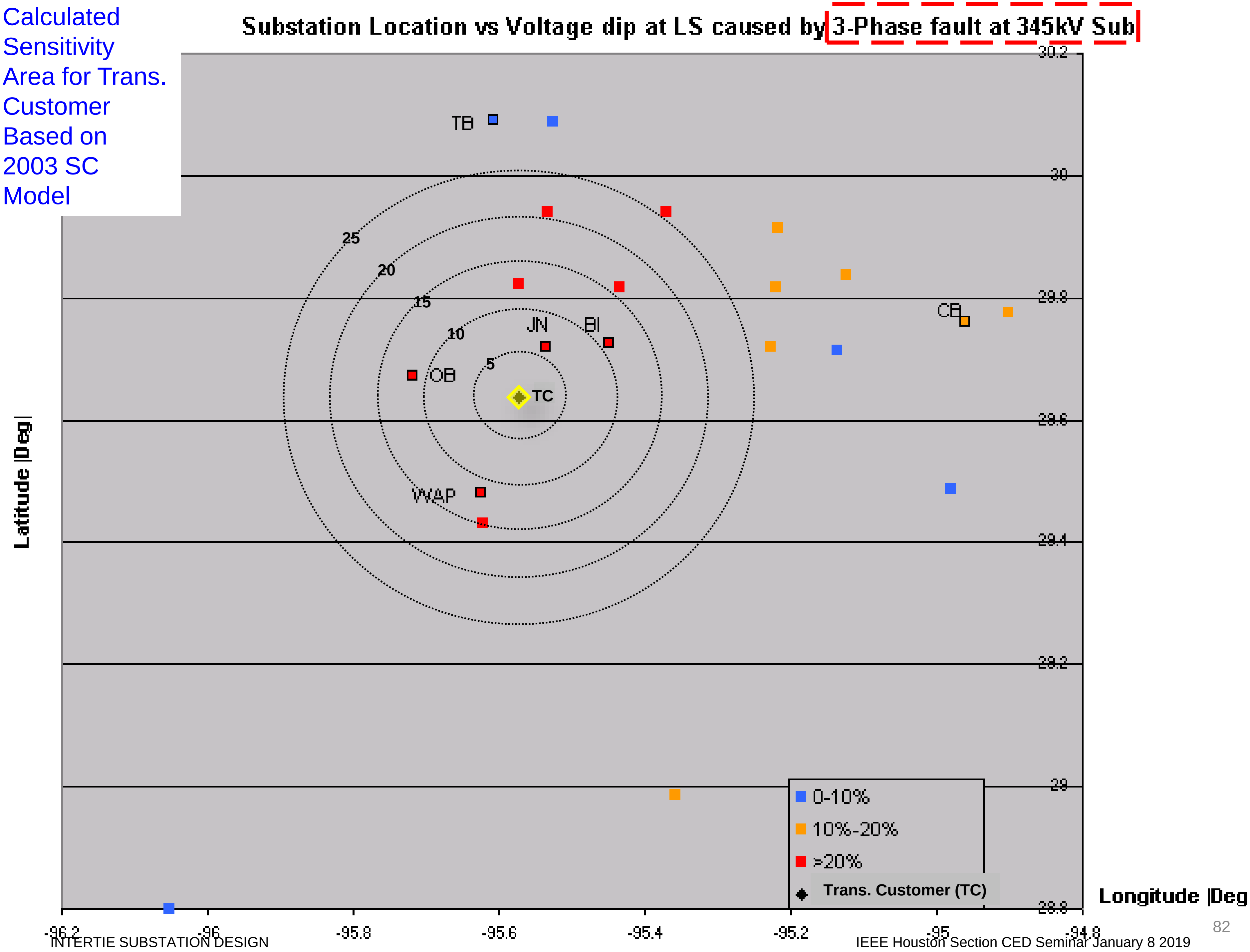
Calculated Sensitivity Area for Trans. Customer Based on 2003 SC Model



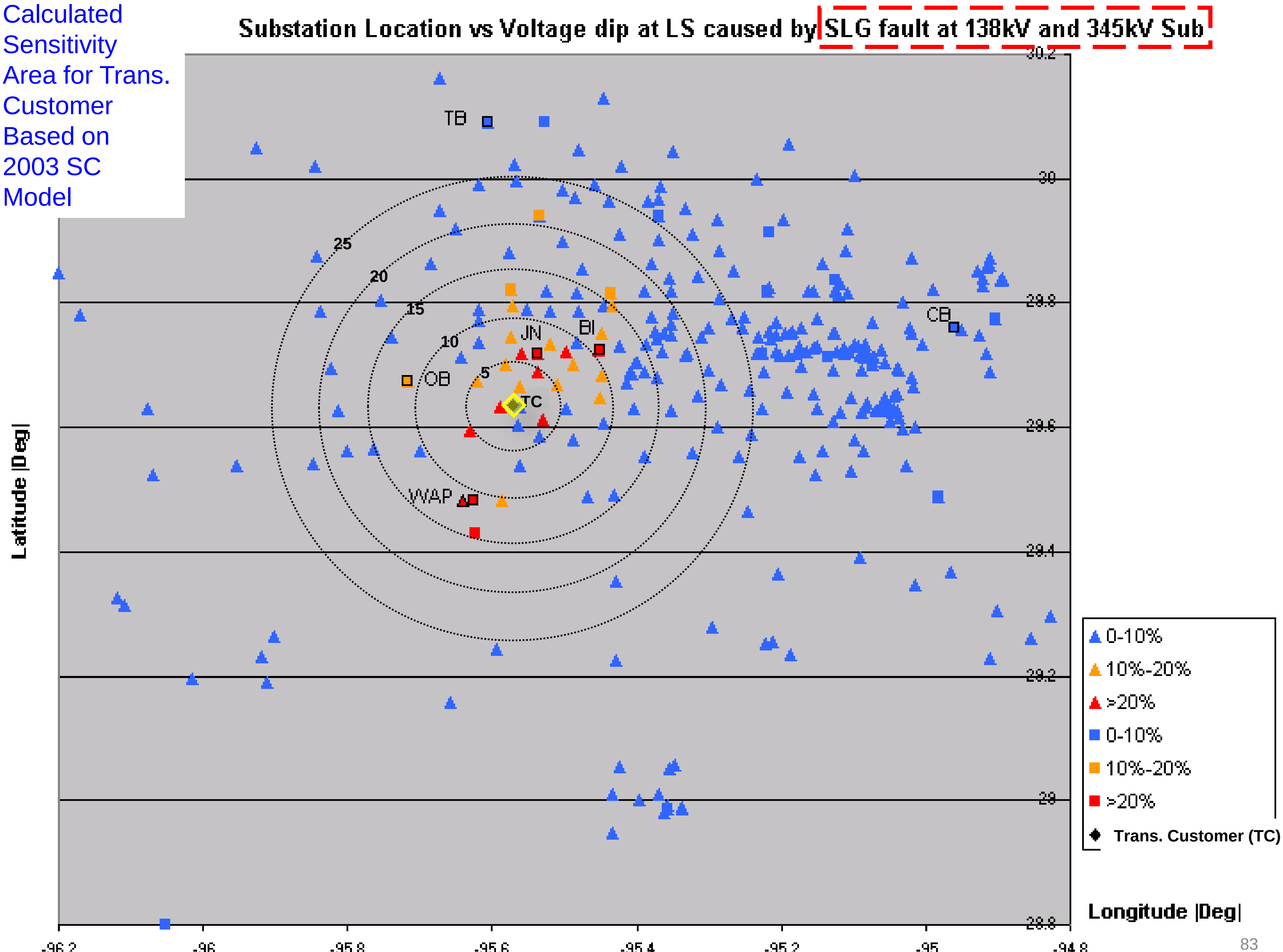
Calculated Sensitivity Area for Trans. Customer Based on 2003 SC Model



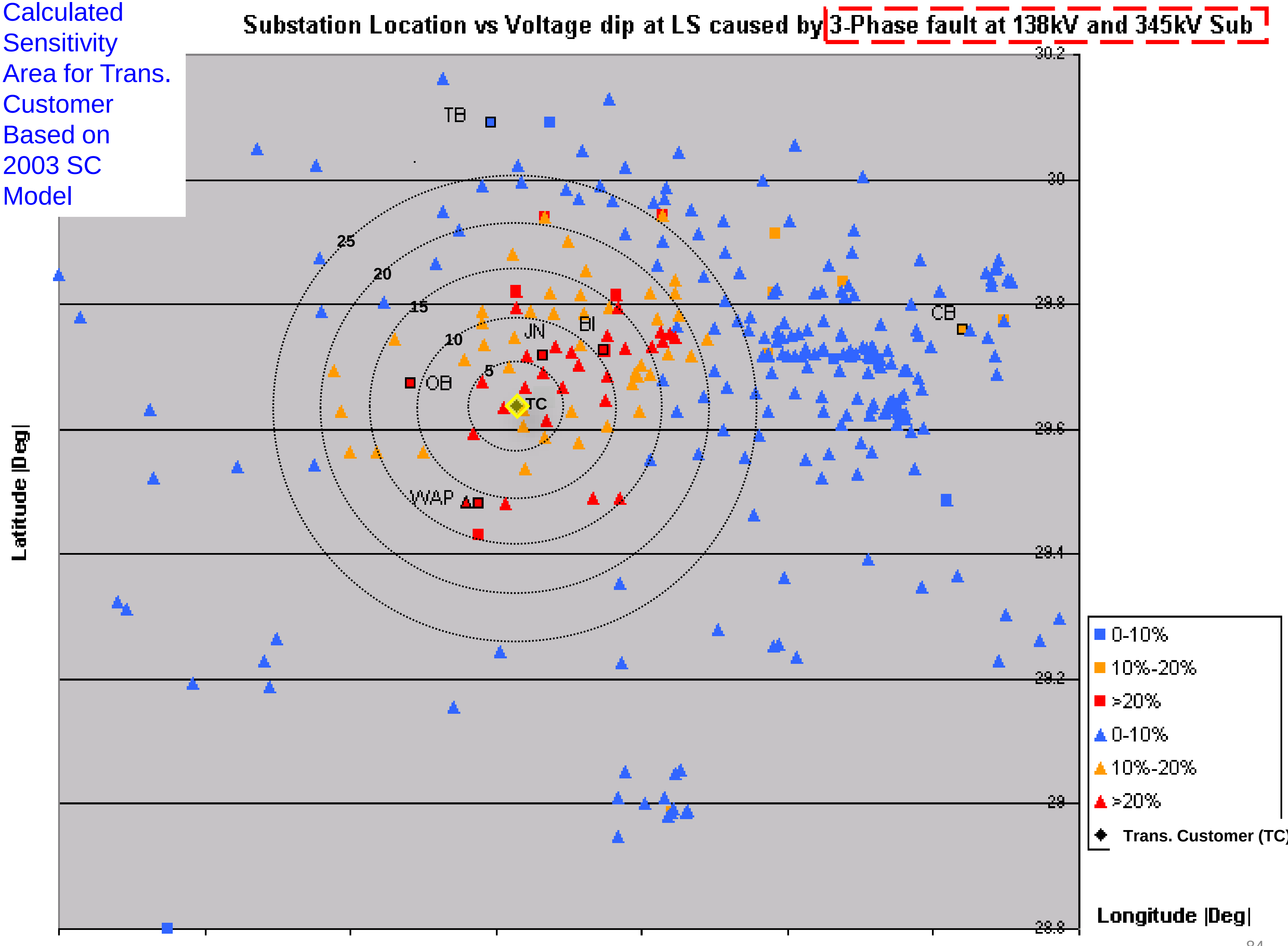
Calculated Sensitivity Area for Trans. Customer Based on 2003 SC Model



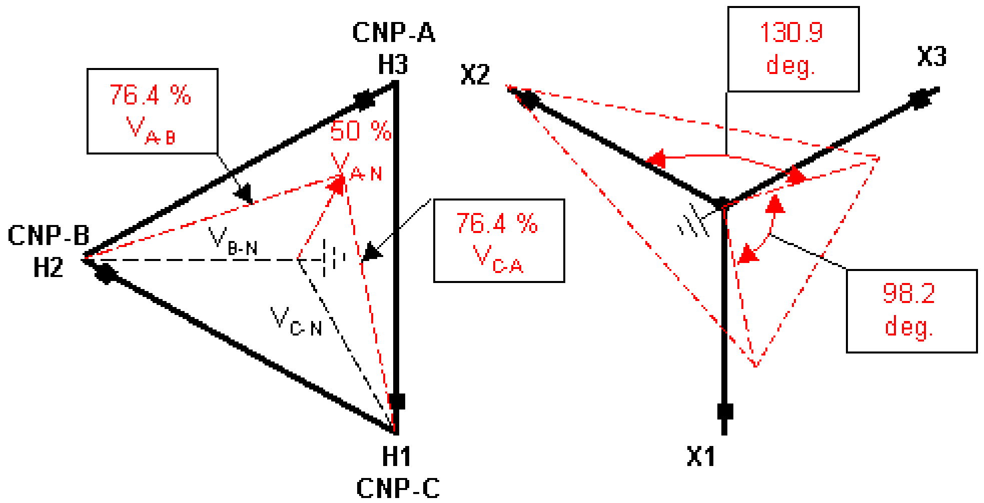
Calculated Sensitivity Area for Trans. Customer Based on 2003 SC Model



Calculated Sensitivity Area for Trans. Customer Based on 2003 SC Model



Translation of Phase-to-Neutral Voltage on Highside To Phase-to-Neutral and Phase-to-Phase Voltage on Lowside



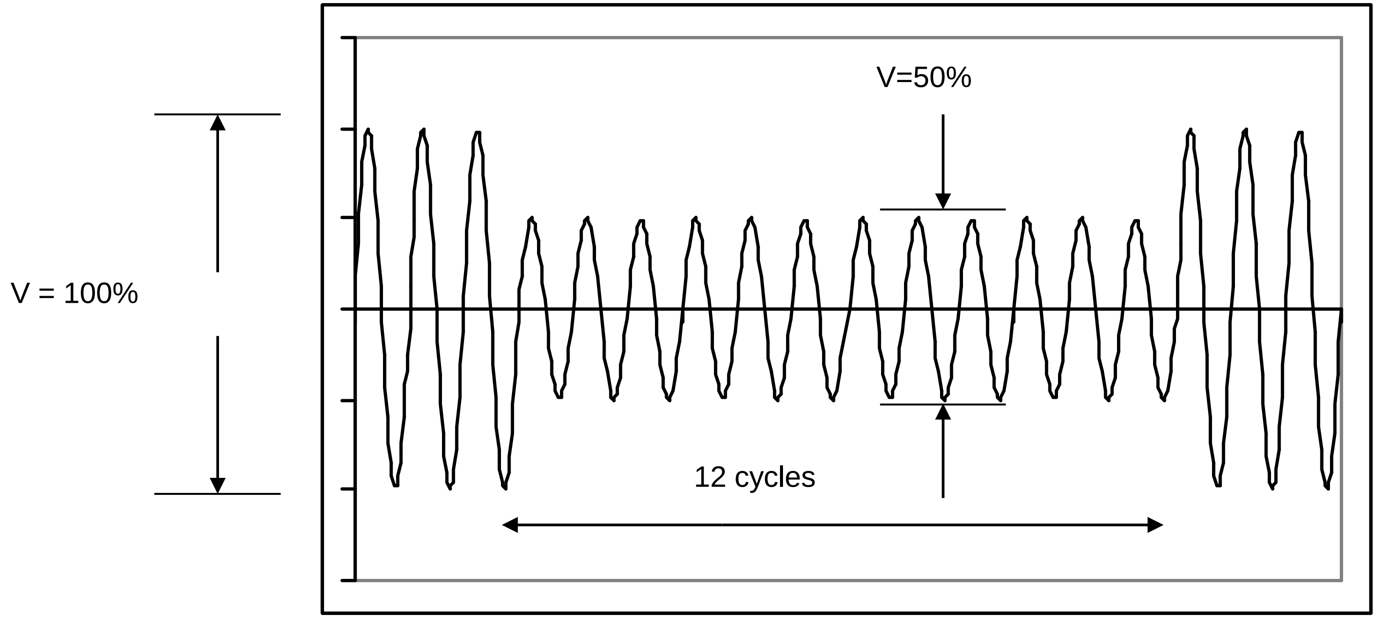
Standard transformer
highside leads the lowside by 30 degrees

50% A-N on highside translates to:

76.4% X3-N, 100% X2-N, 76.4% X1-N
and
66.7% X1-X3, 92.8% X2-X1, 92.8% X3-X2

VOLTAGE DIP RIDE THROUGH

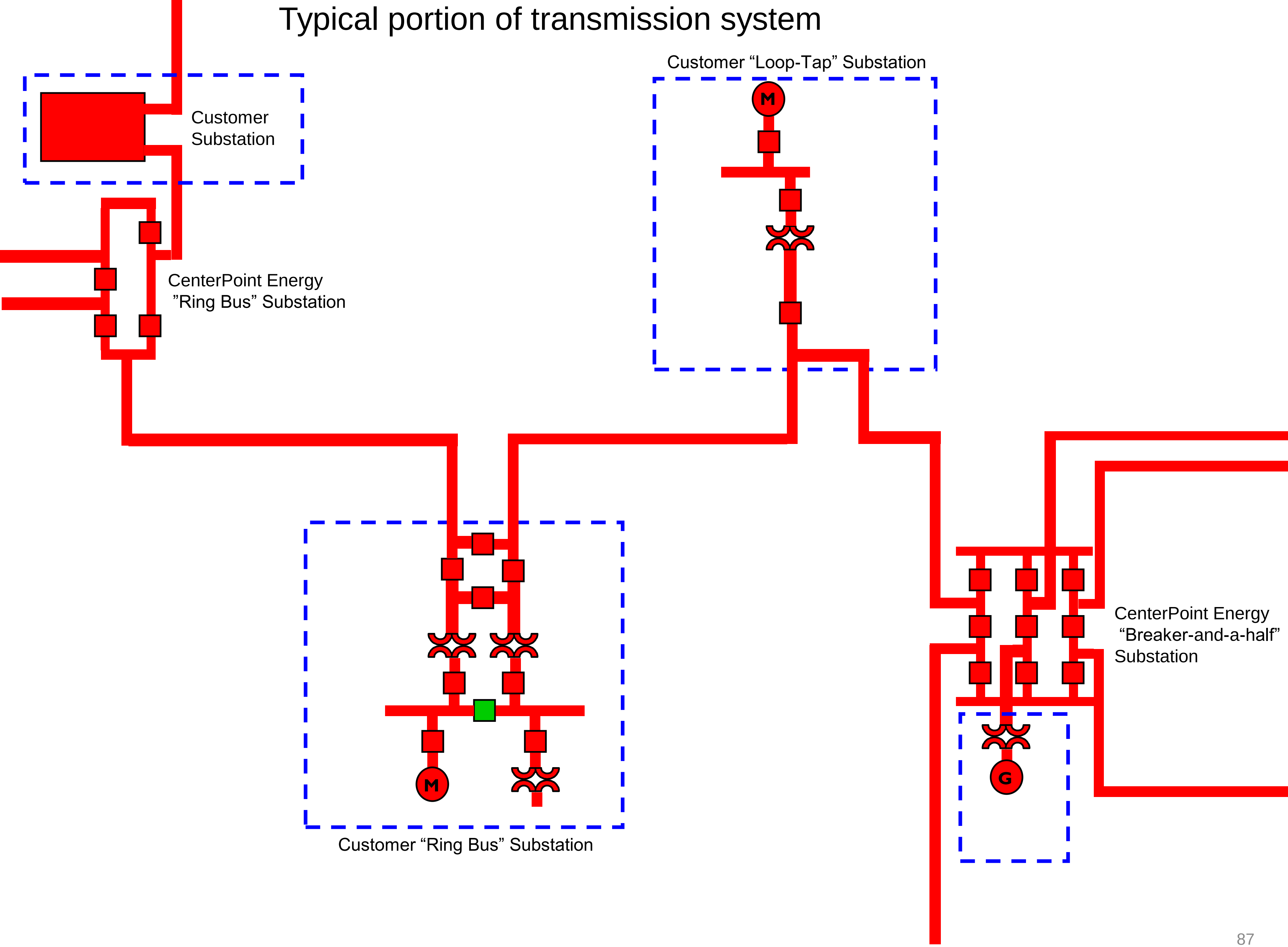
The customer's equipment "voltage dip ride through" design criteria, that CenterPoint Energy suggests the customer utilize when designing and selecting plant equipment is illustrated in figure 3.1.

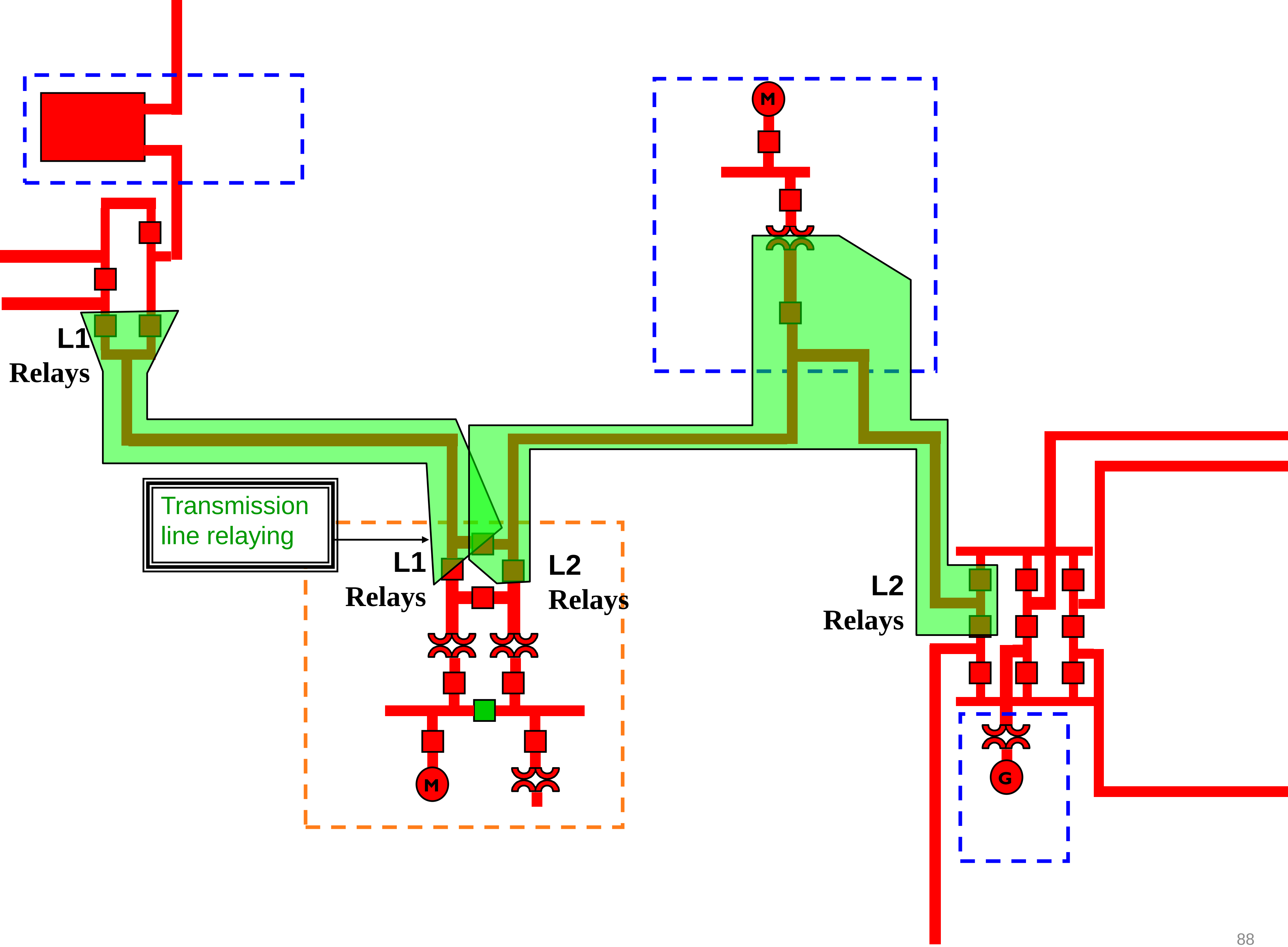


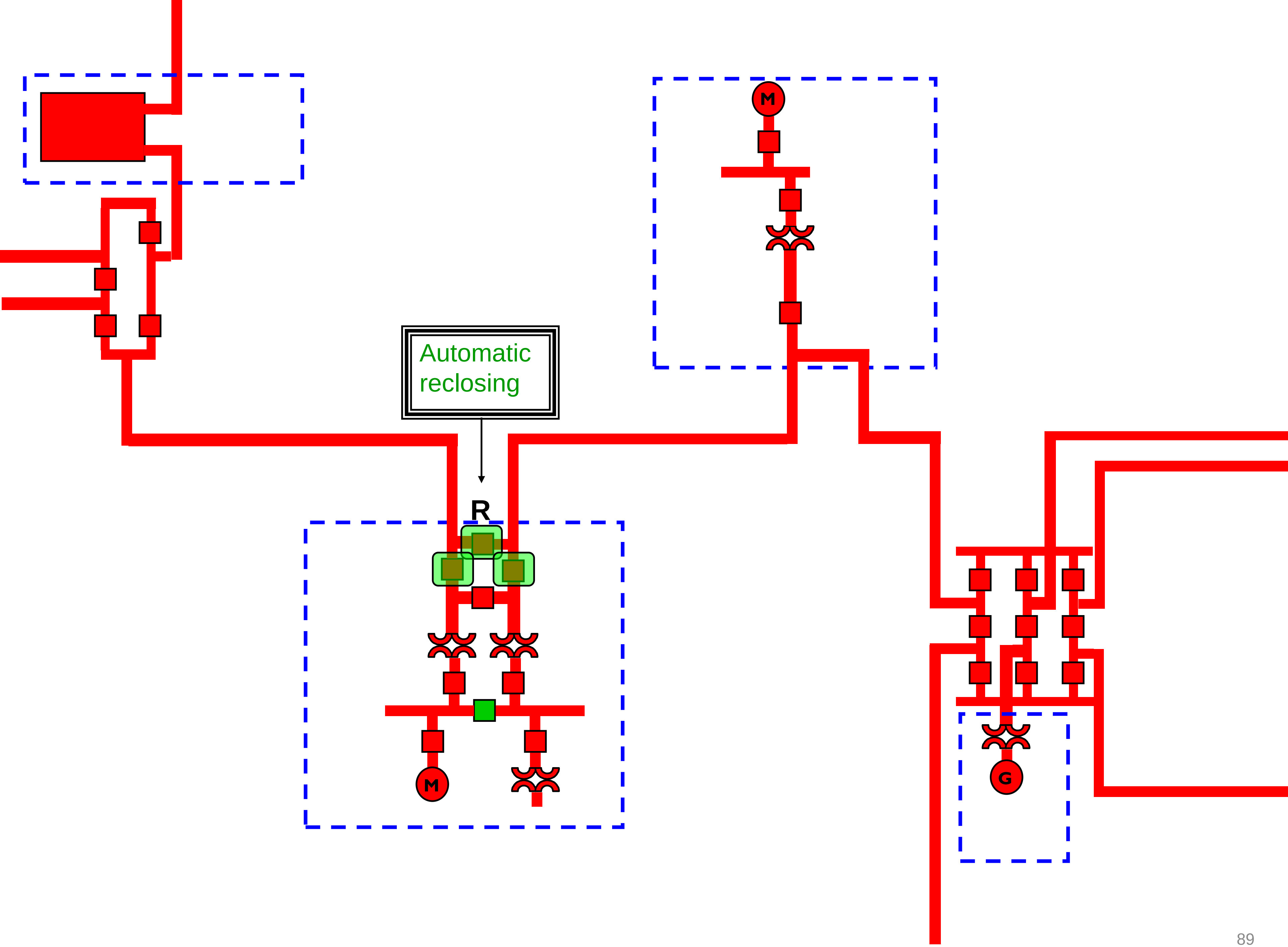
"V" represents the phase-to-neutral voltage at the customer's "load side" of a delta-wye transformer for a phase-to-ground fault at the "high side" of the transformer.

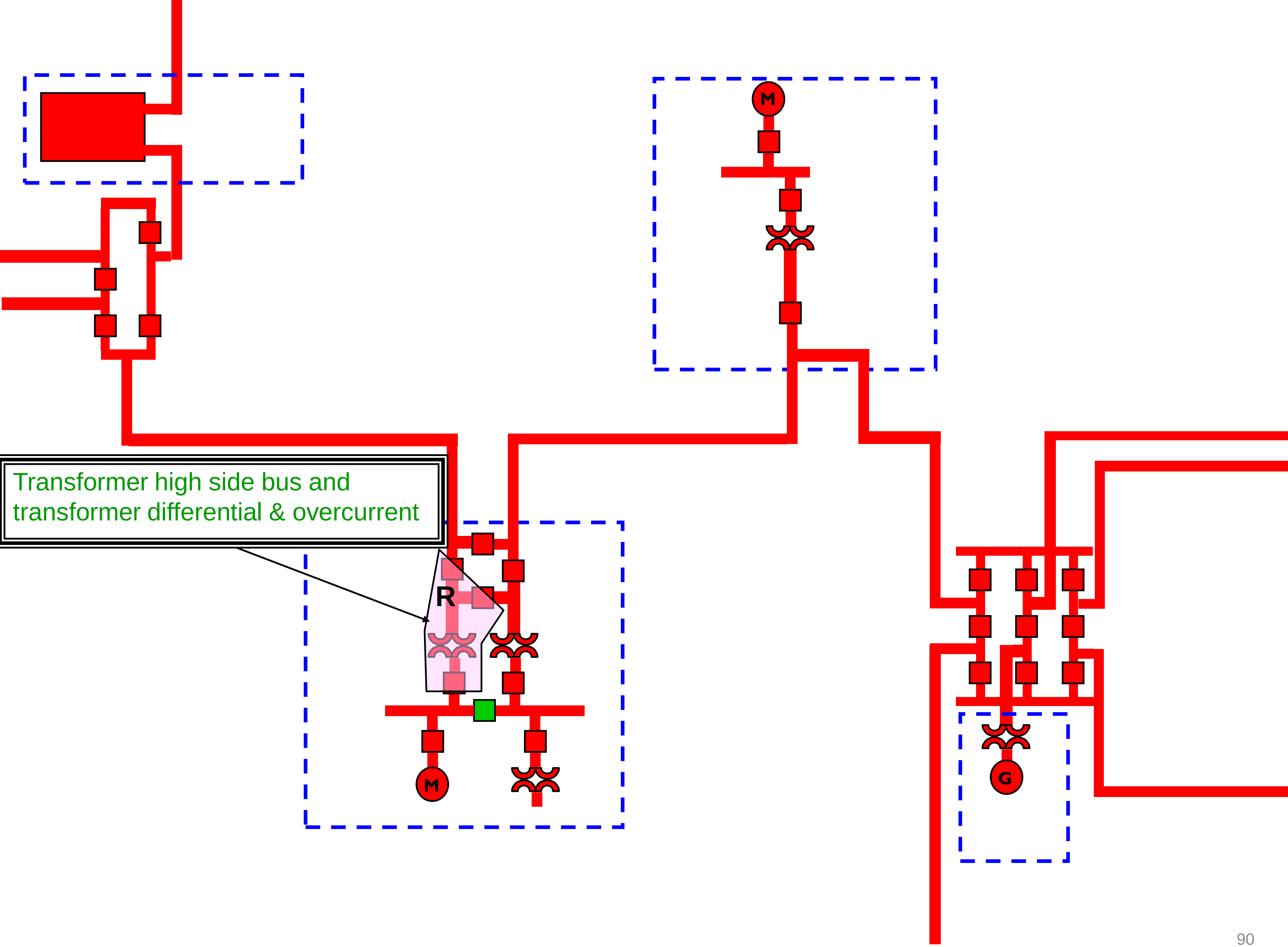
Figure 3.1

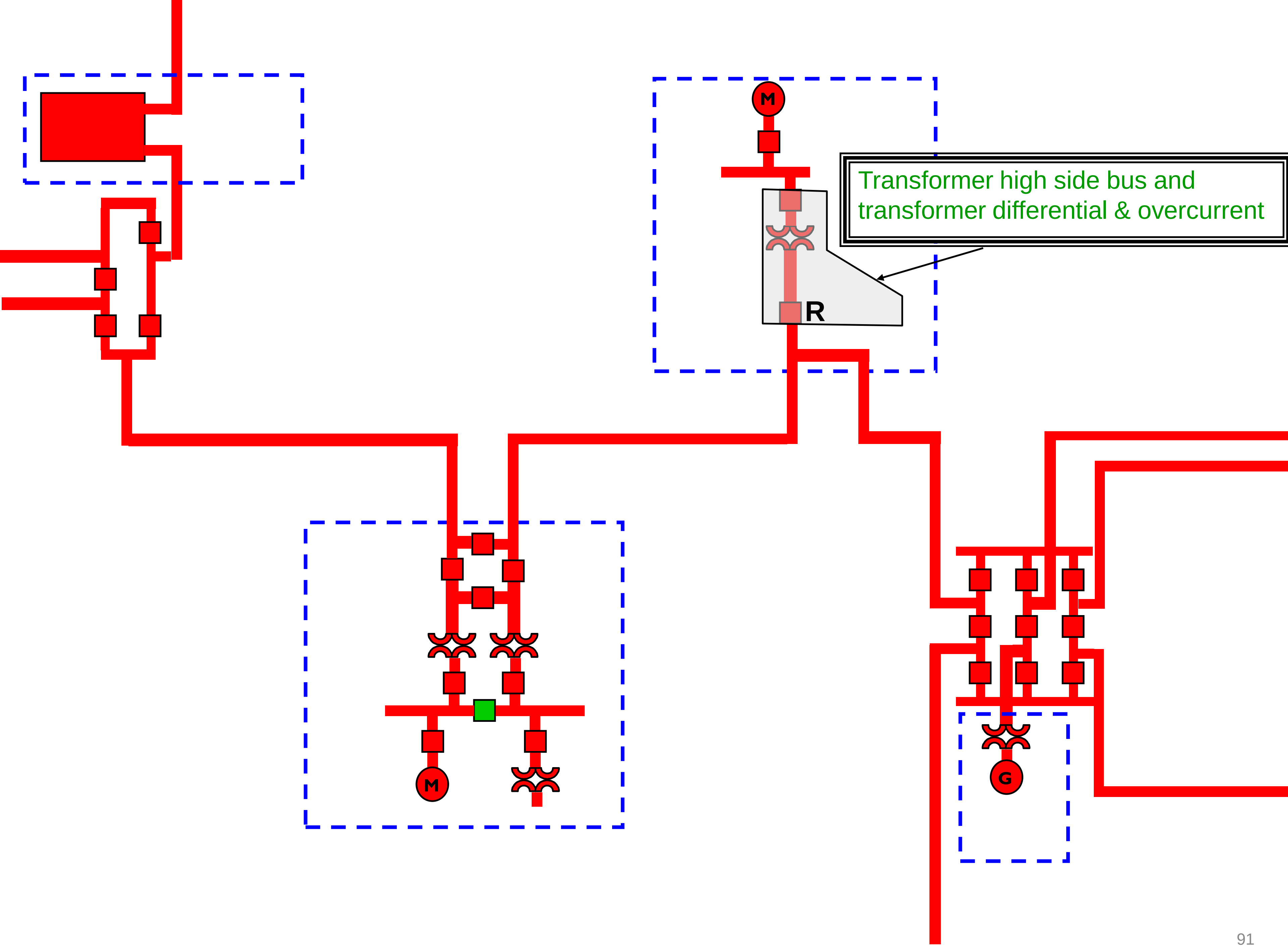
Typical portion of transmission system

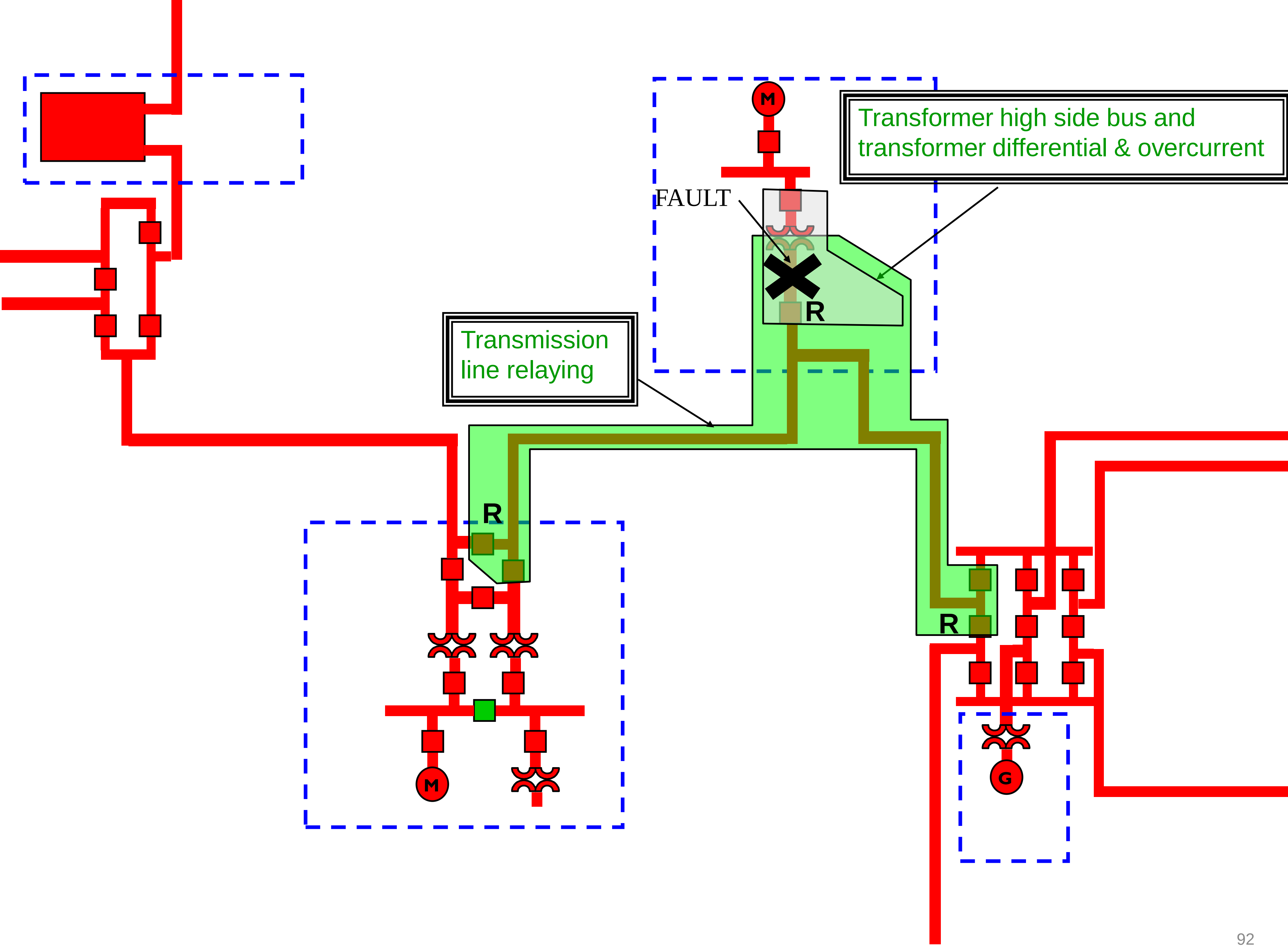



M
L1
Relays
Transmission
line relaying
L1
Relays
L2
Relays
L2
Relays
M
G


Automatic
reclosing
M
R
M
G

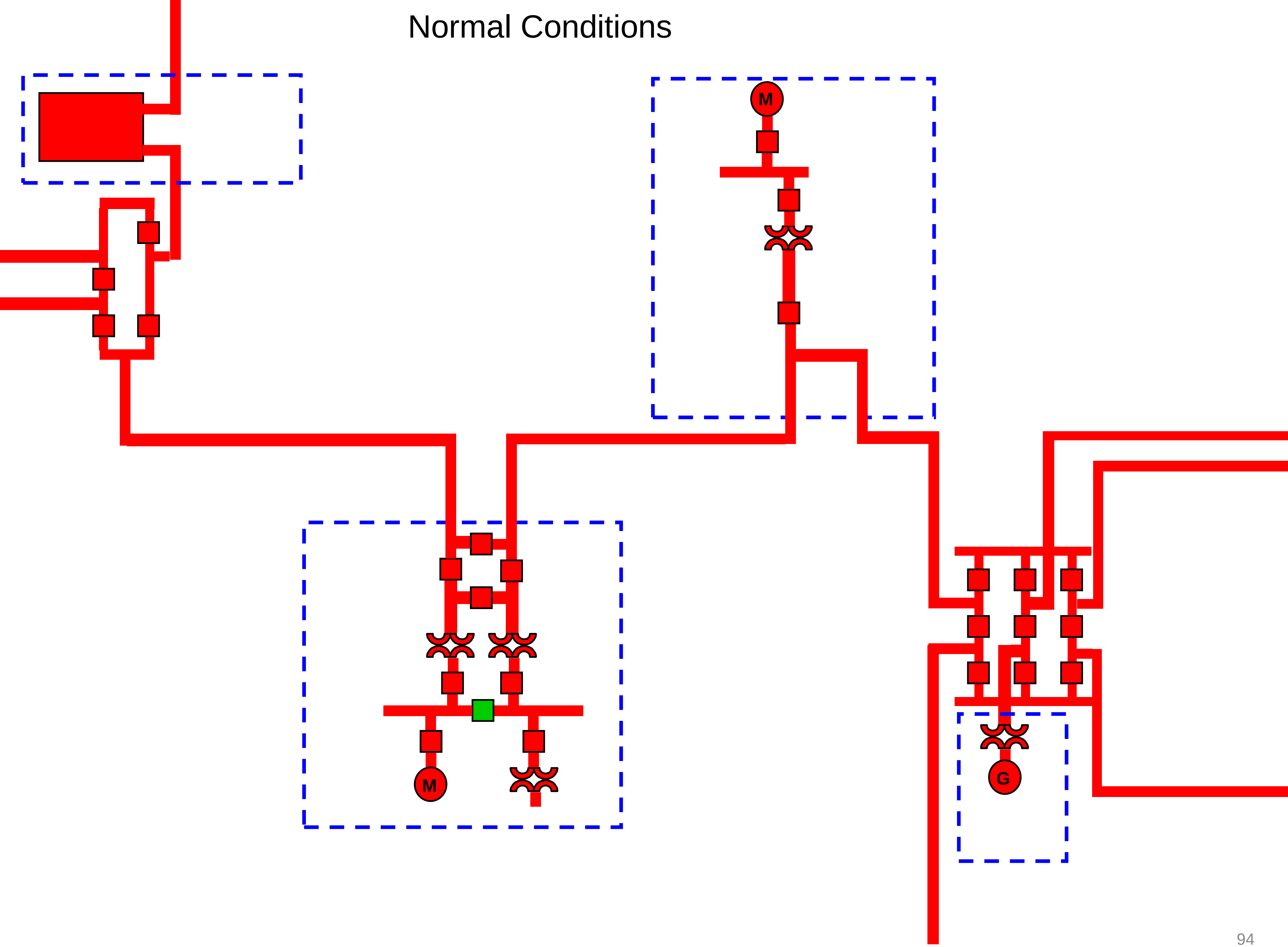

Transformer high side bus and
transformer differential & overcurrent
R
M
M
G


M
Transformer high side bus and transformer differential & overcurrent
R
M
G

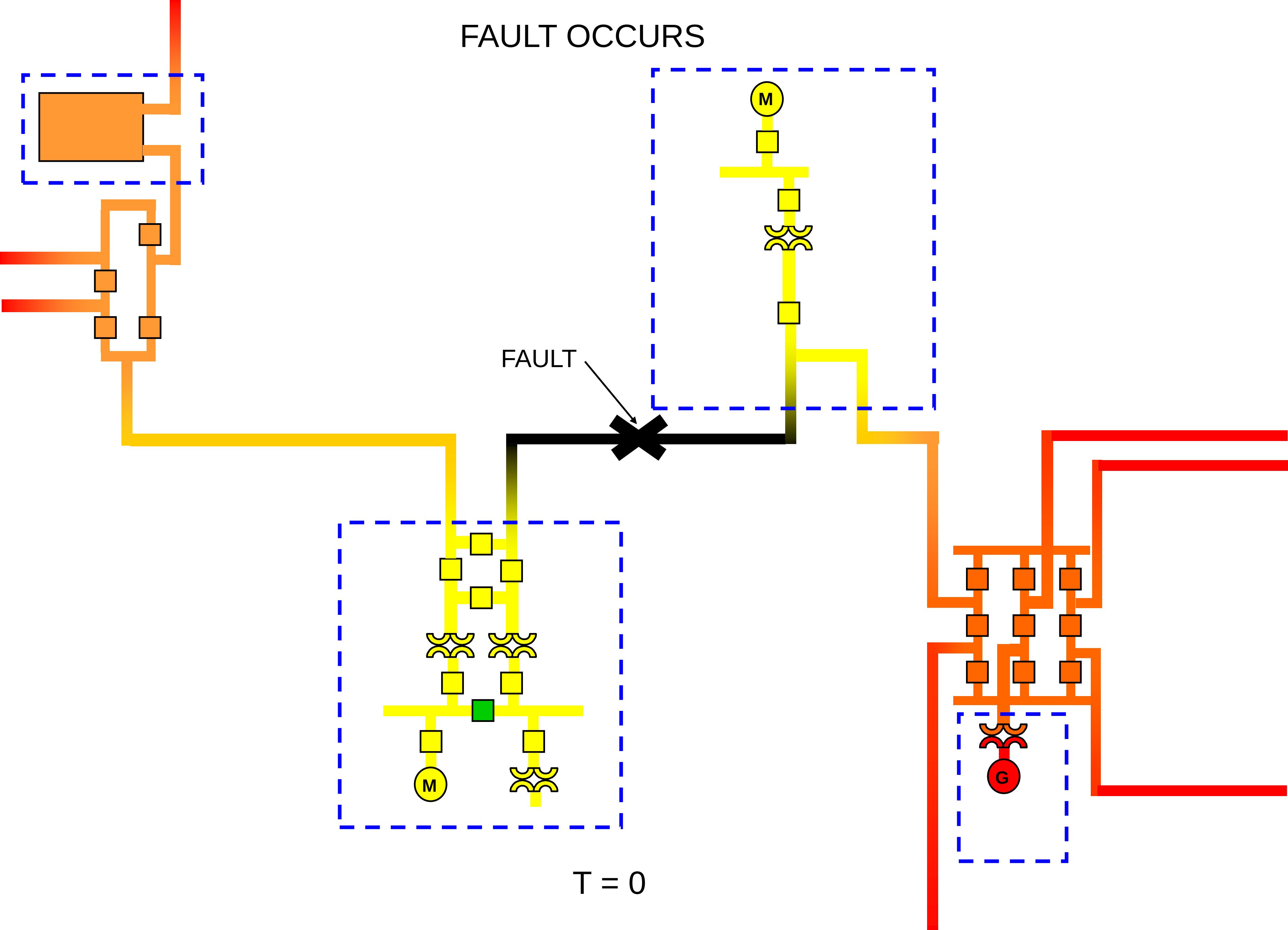

M
Transformer high side bus and transformer differential & overcurrent
FAULT
R
Transmission line relaying
R
M
R
G

Example of Typical Protective Relaying Operation Sequence

Normal Conditions

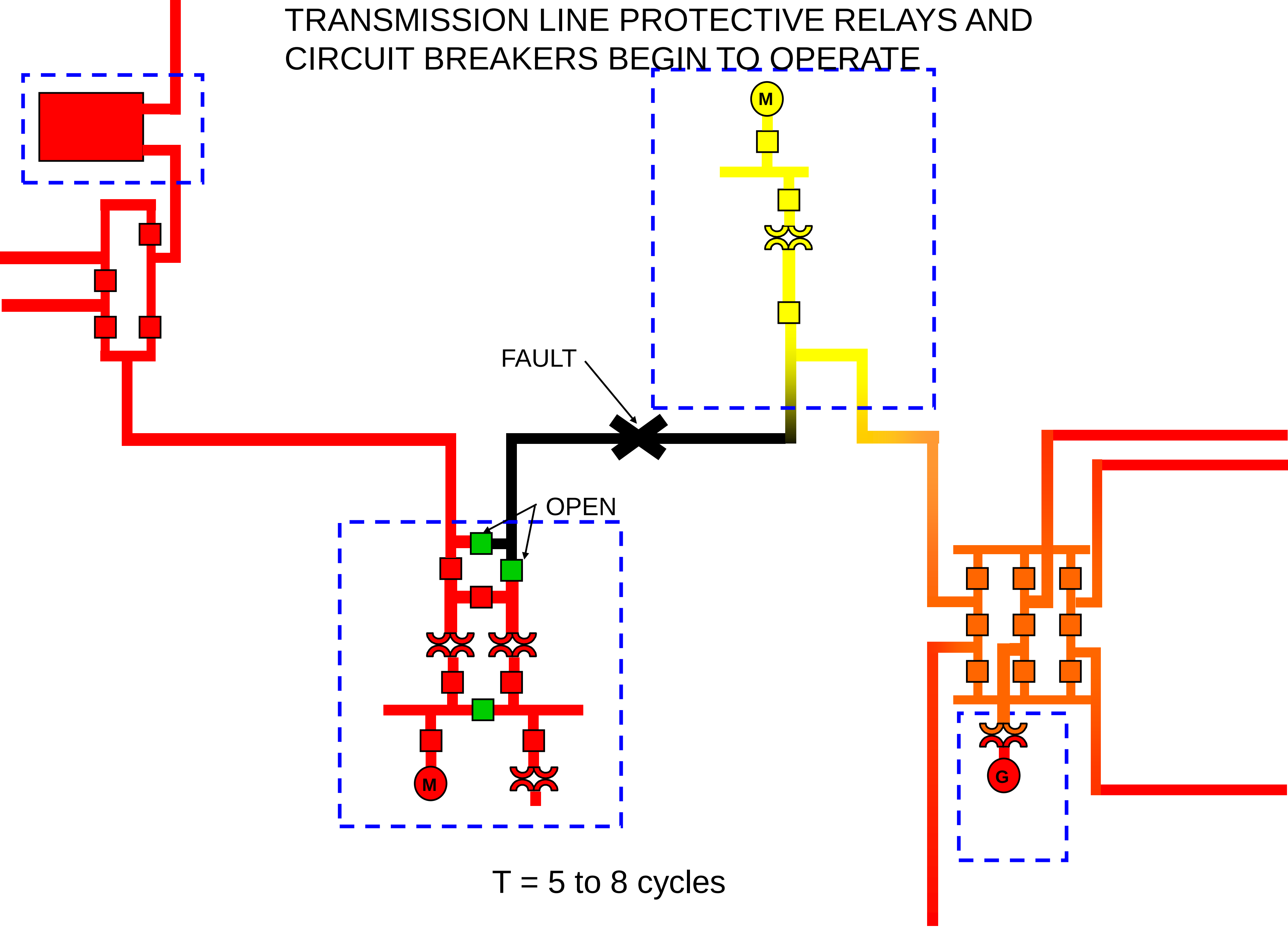


FAULT OCCURS



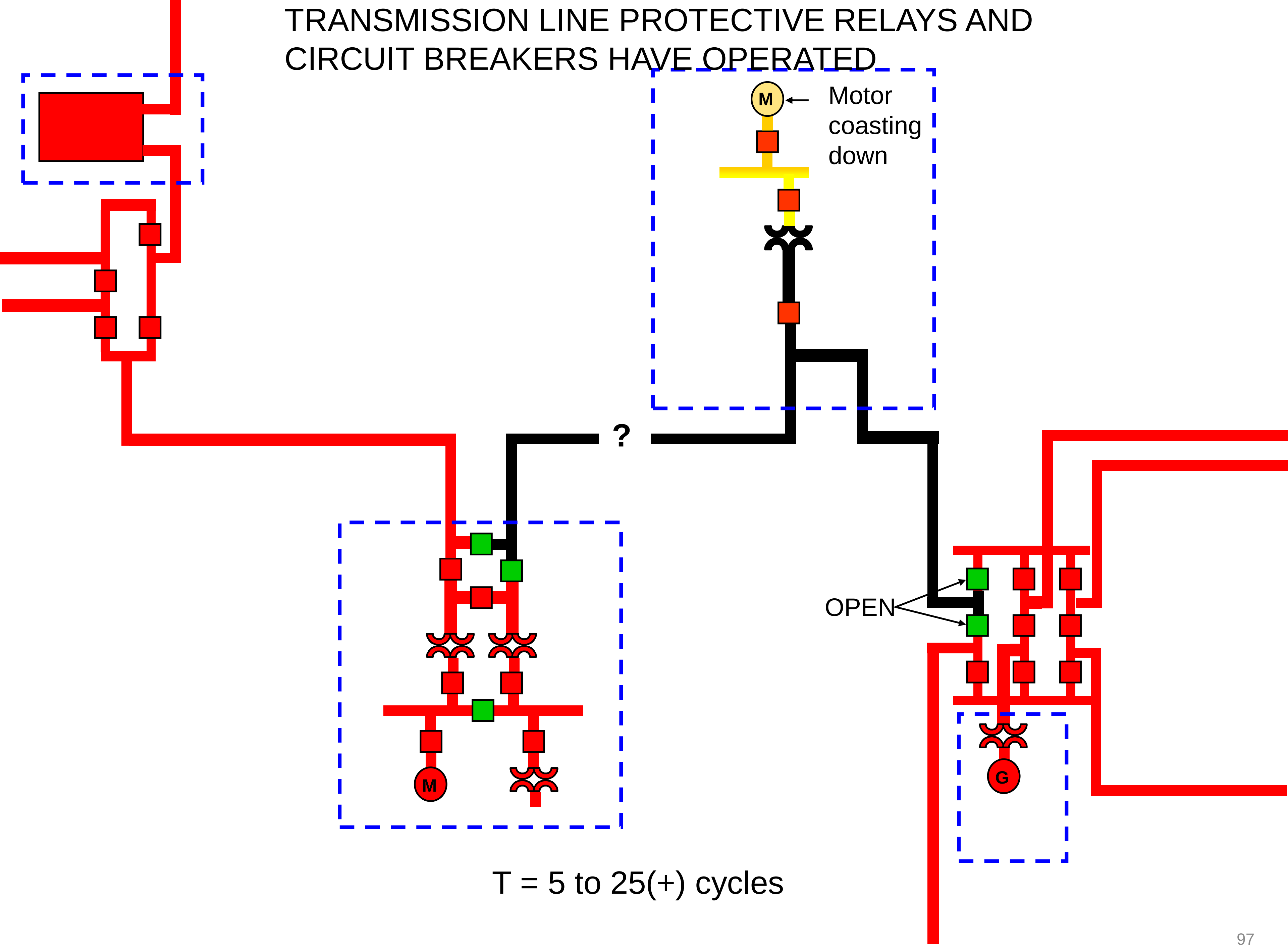
T = 0

TRANSMISSION LINE PROTECTIVE RELAYS AND CIRCUIT BREAKERS BEGIN TO OPERATE



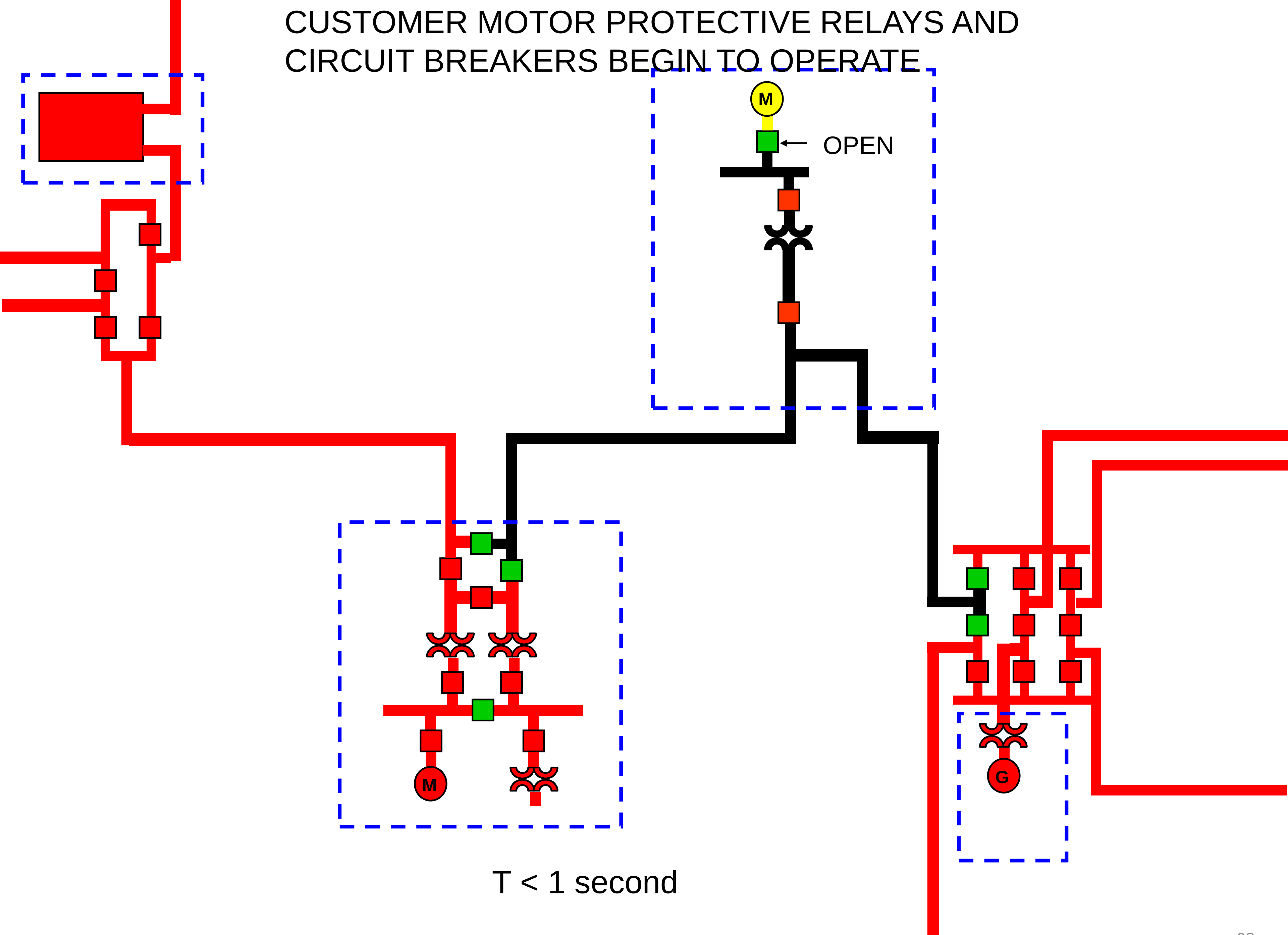
T = 5 to 8 cycles

TRANSMISSION LINE PROTECTIVE RELAYS AND CIRCUIT BREAKERS HAVE OPERATED



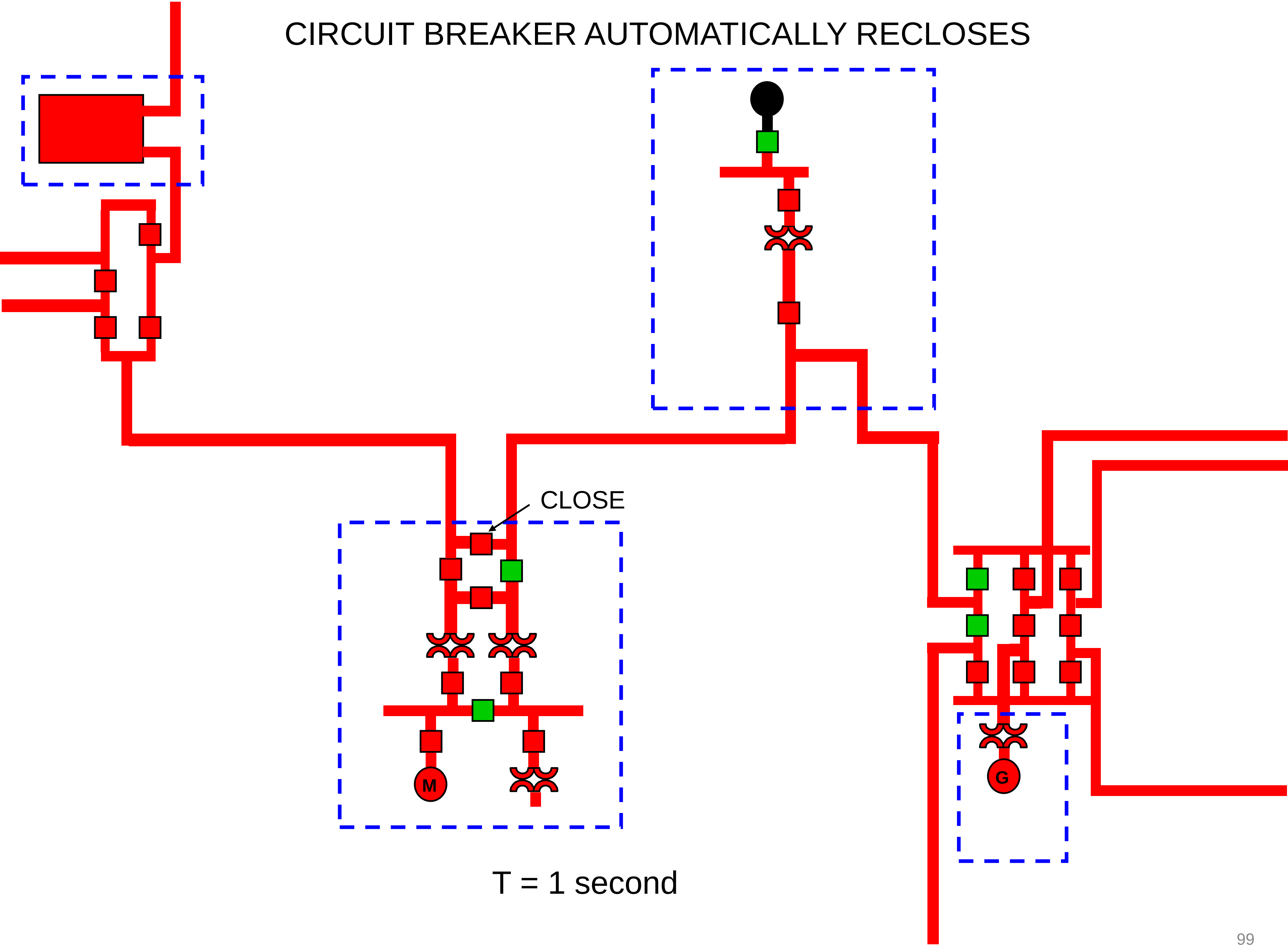
T = 5 to 25(+) cycles

CUSTOMER MOTOR PROTECTIVE RELAYS AND CIRCUIT BREAKERS BEGIN TO OPERATE



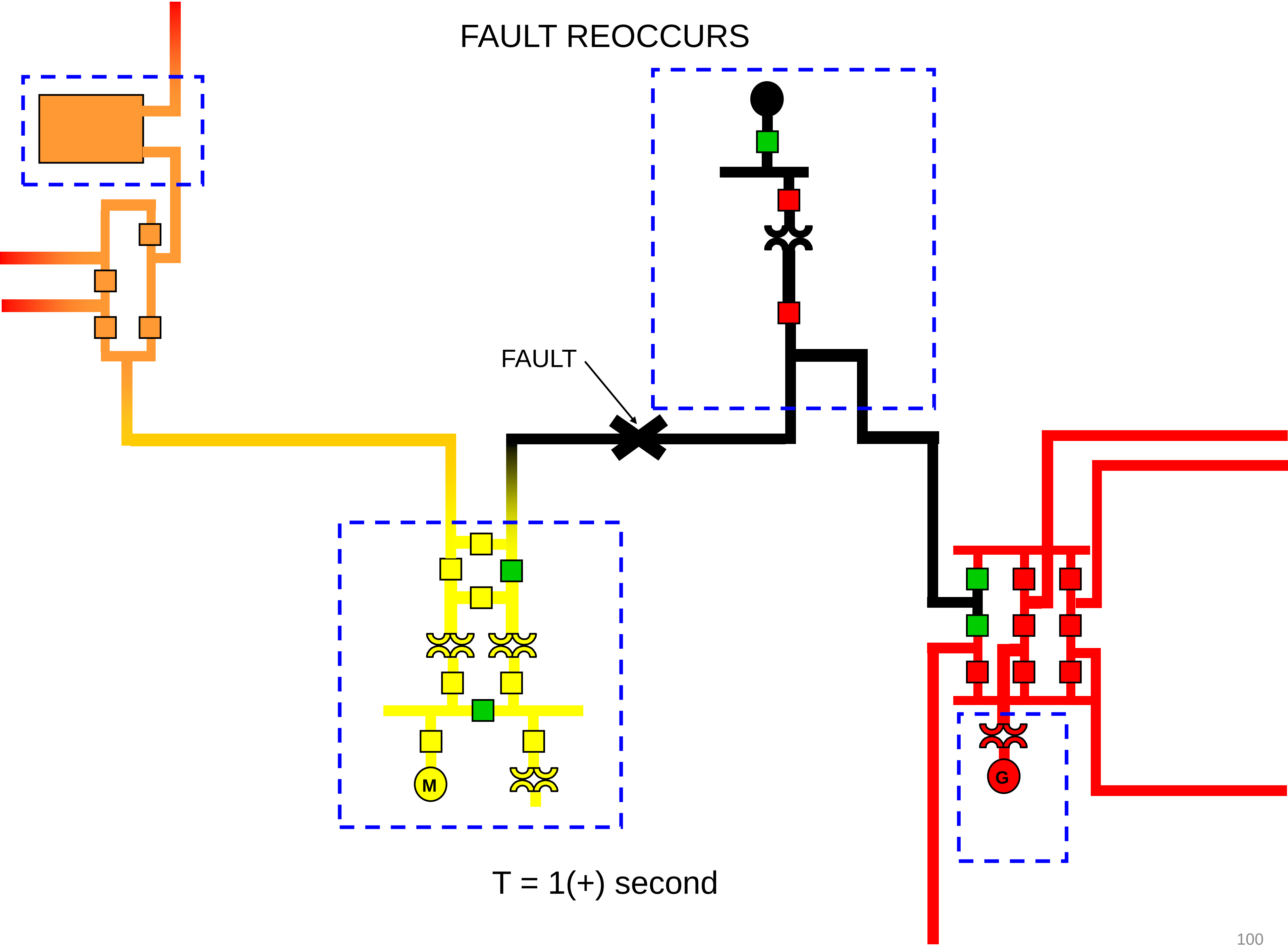
T < 1 second

CIRCUIT BREAKER AUTOMATICALLY RECLOSES



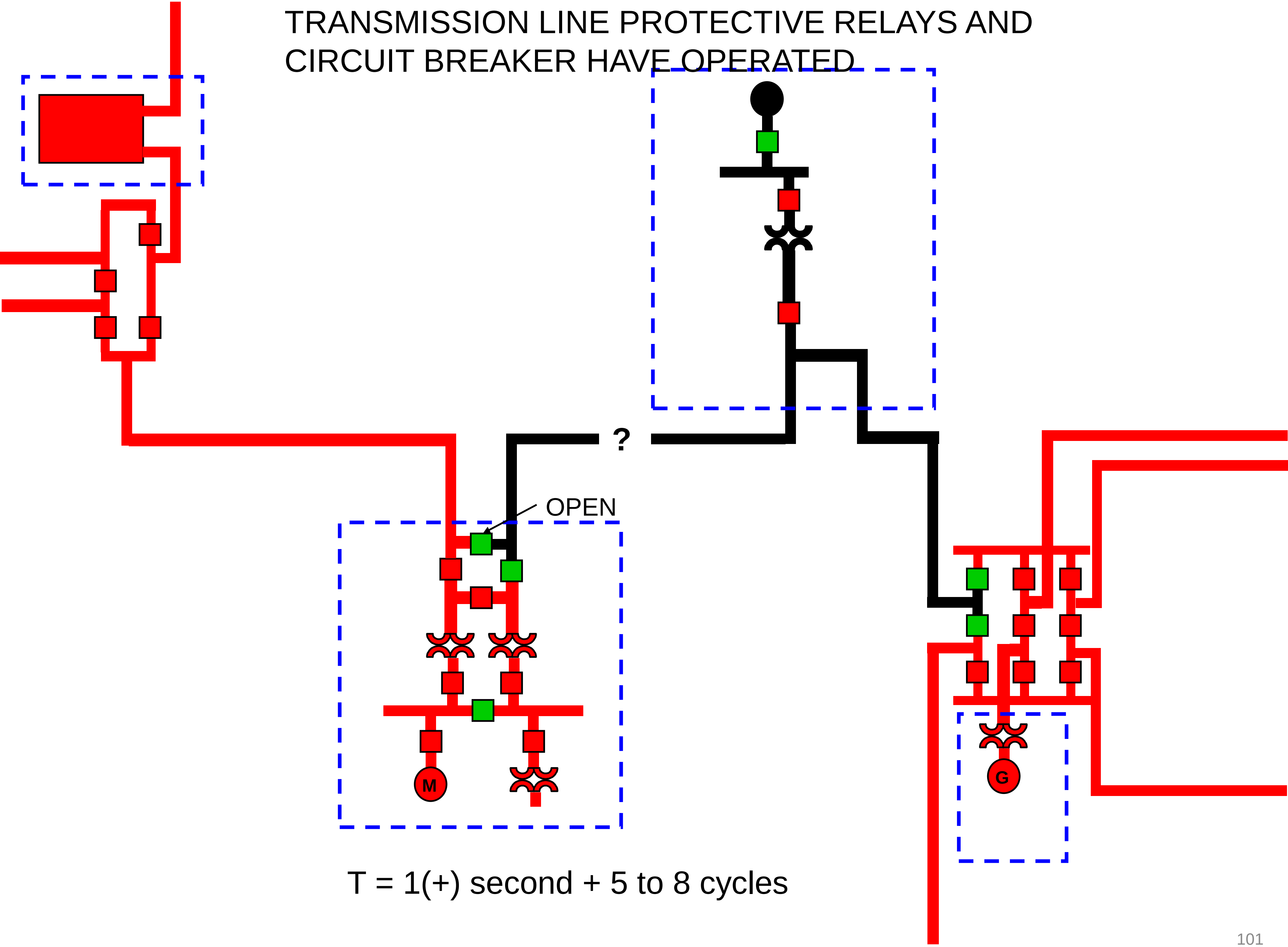
T = 1 second

FAULT REOCCURS



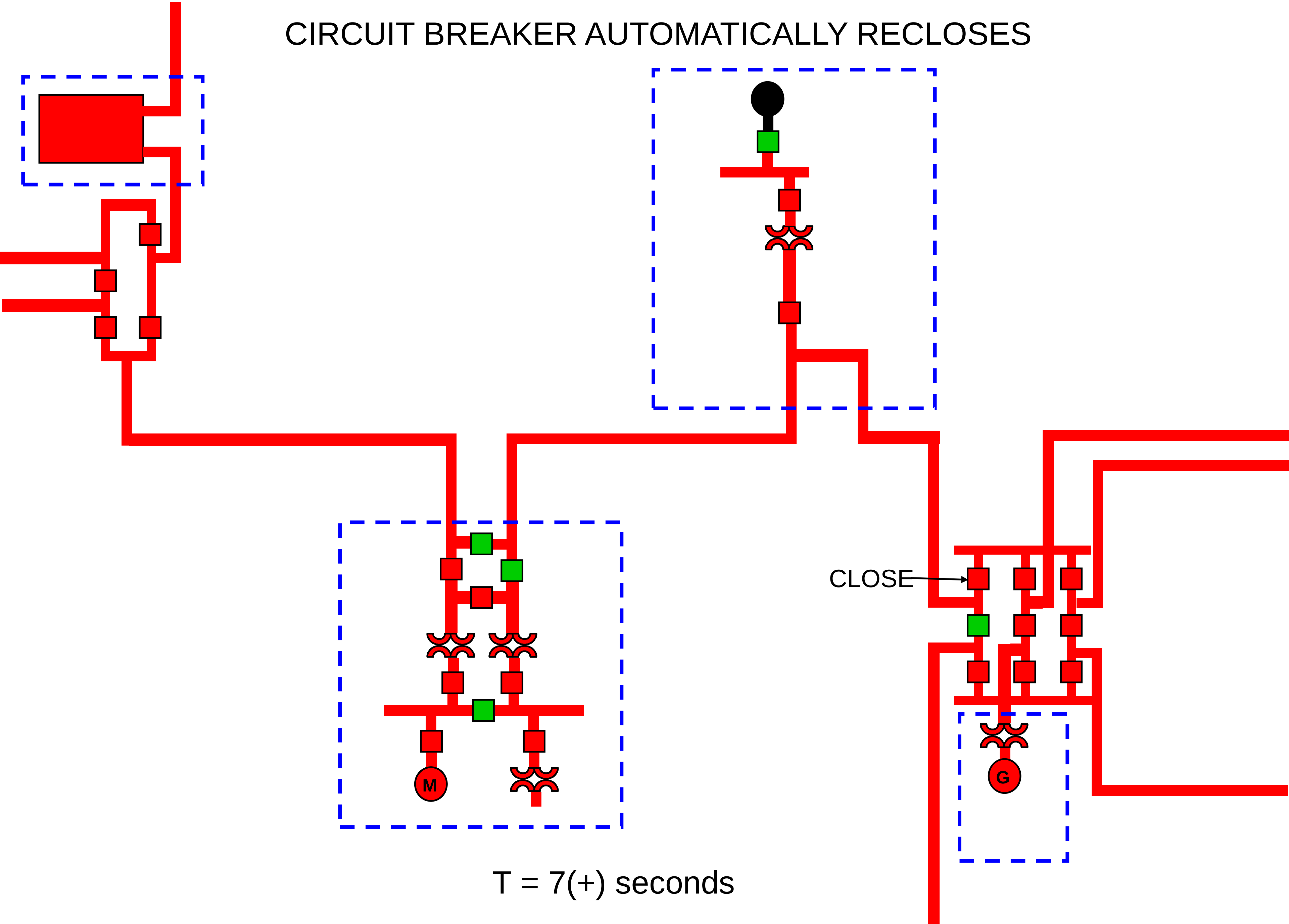
T = 1(+) second

TRANSMISSION LINE PROTECTIVE RELAYS AND CIRCUIT BREAKER HAVE OPERATED



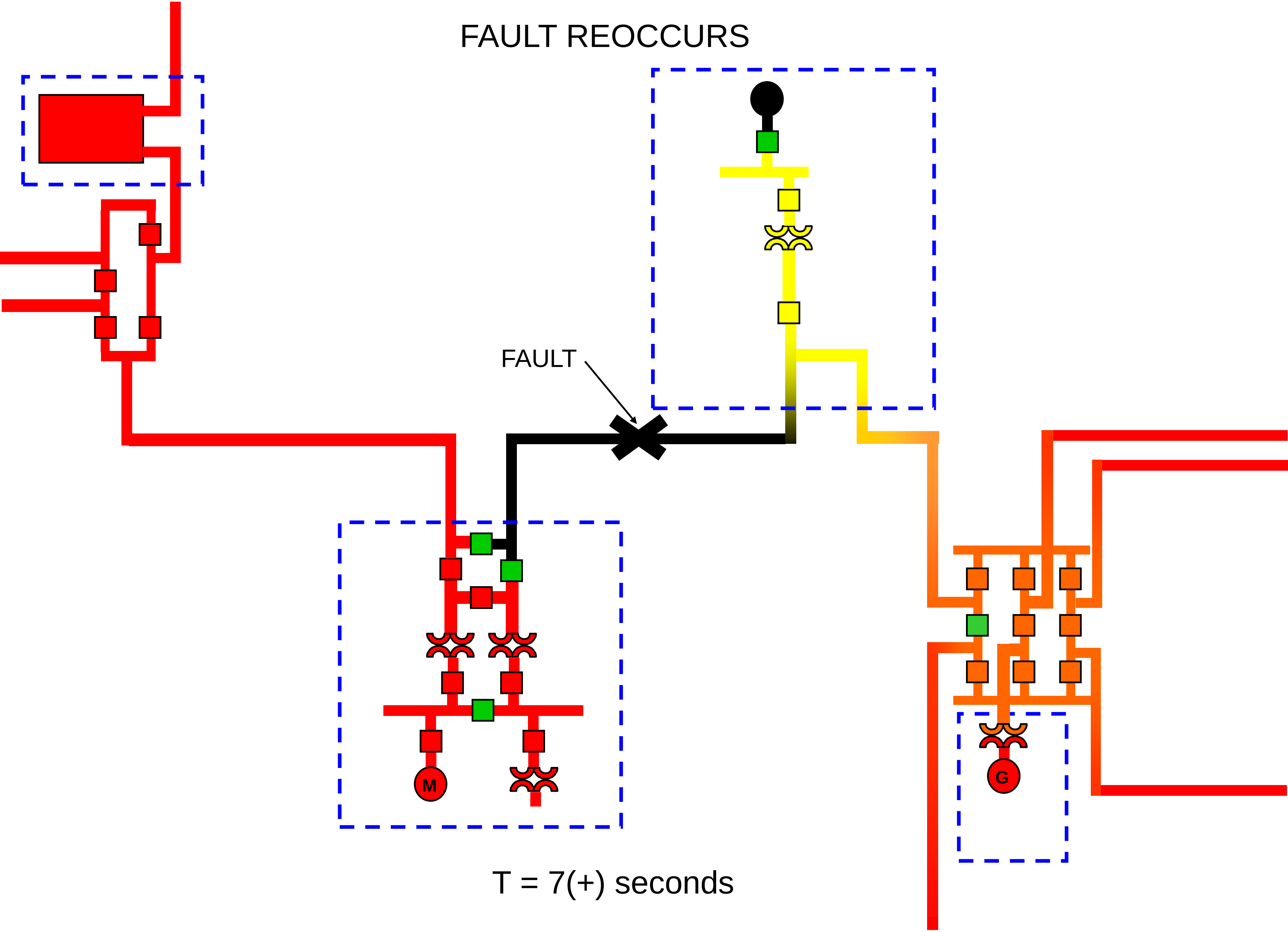
T = 1(+) second + 5 to 8 cycles

CIRCUIT BREAKER AUTOMATICALLY RECLOSES



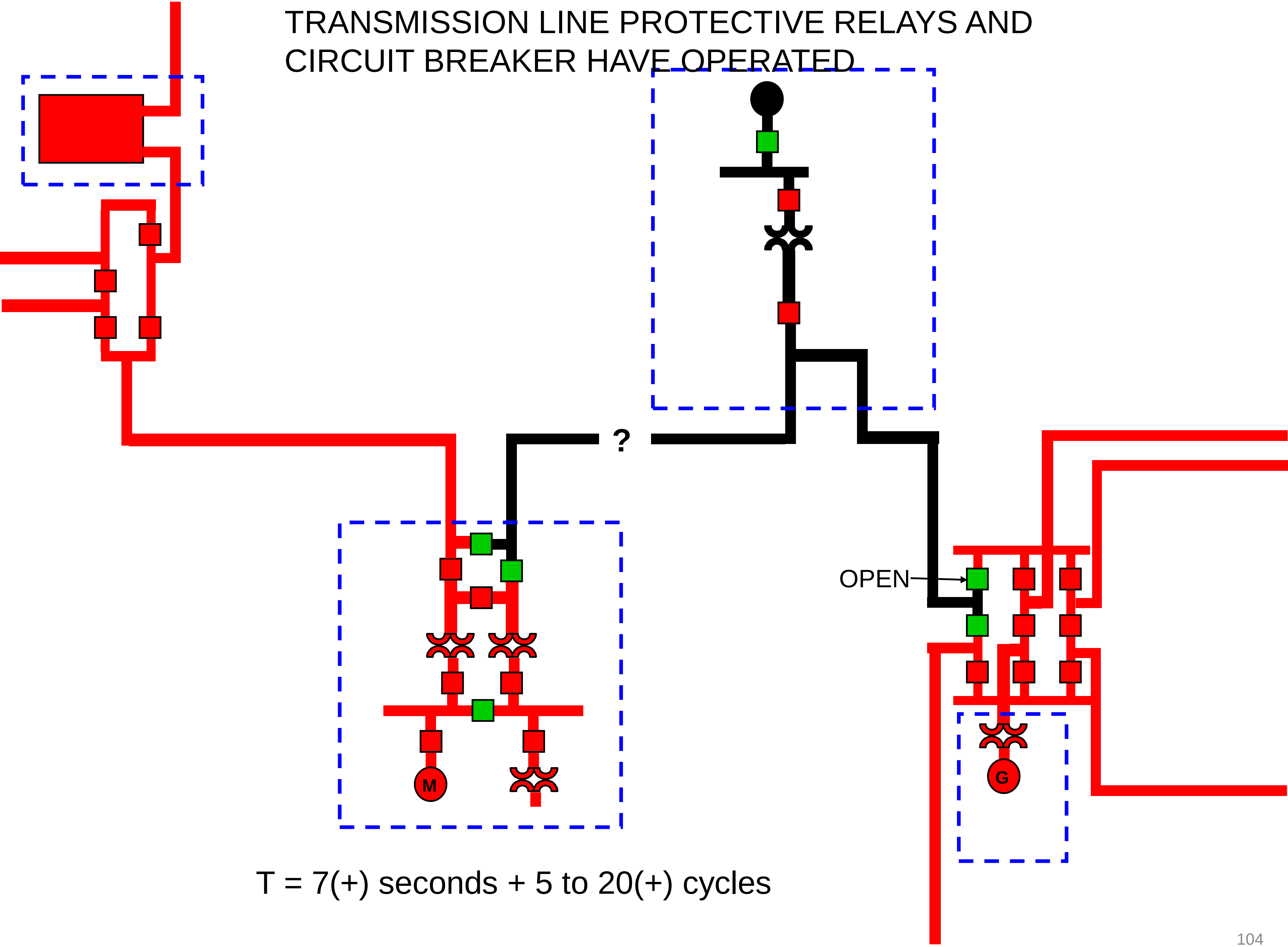
T = 7(+) seconds

FAULT REOCCURS



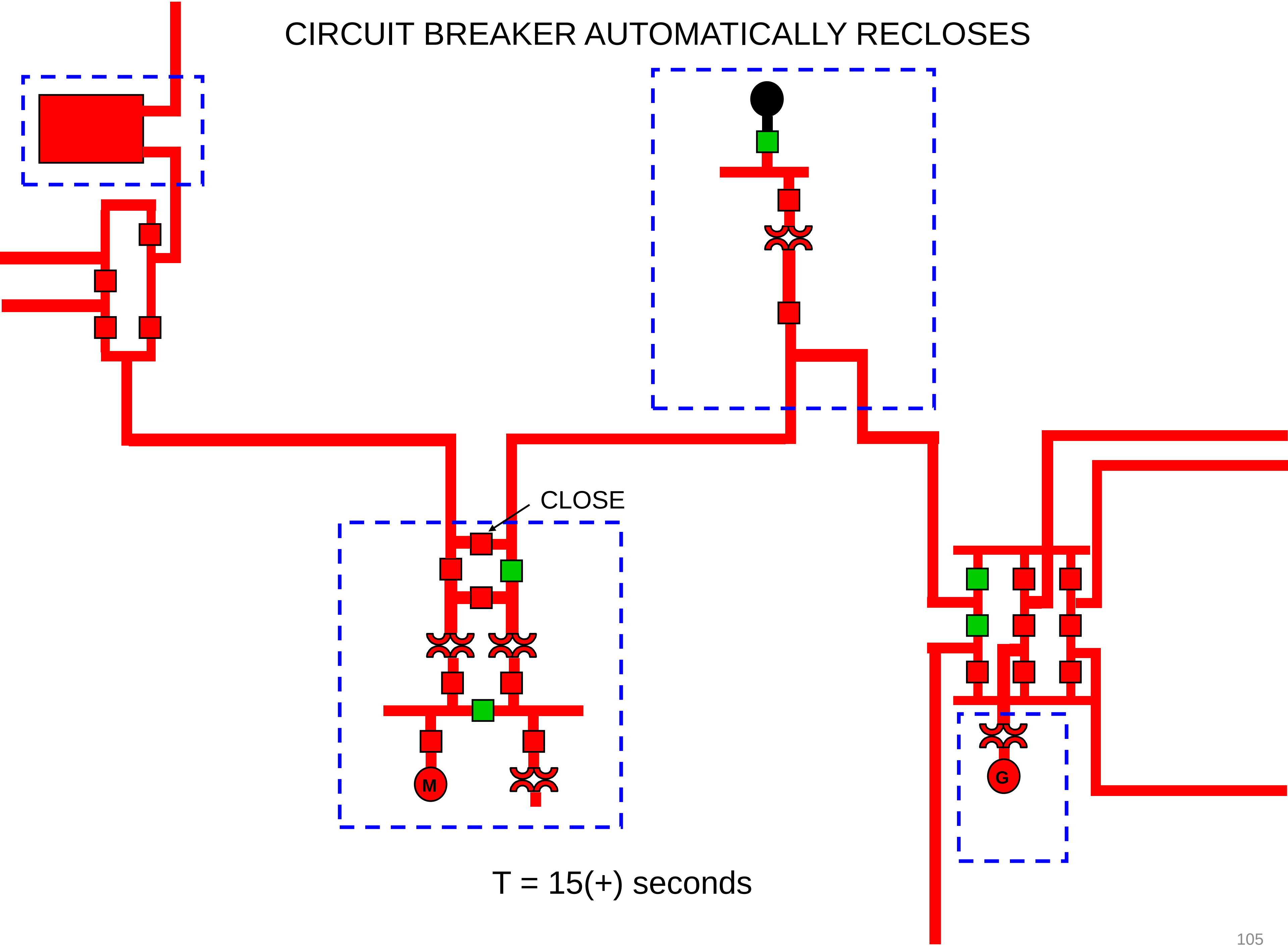
T = 7(+) seconds

TRANSMISSION LINE PROTECTIVE RELAYS AND CIRCUIT BREAKER HAVE OPERATED



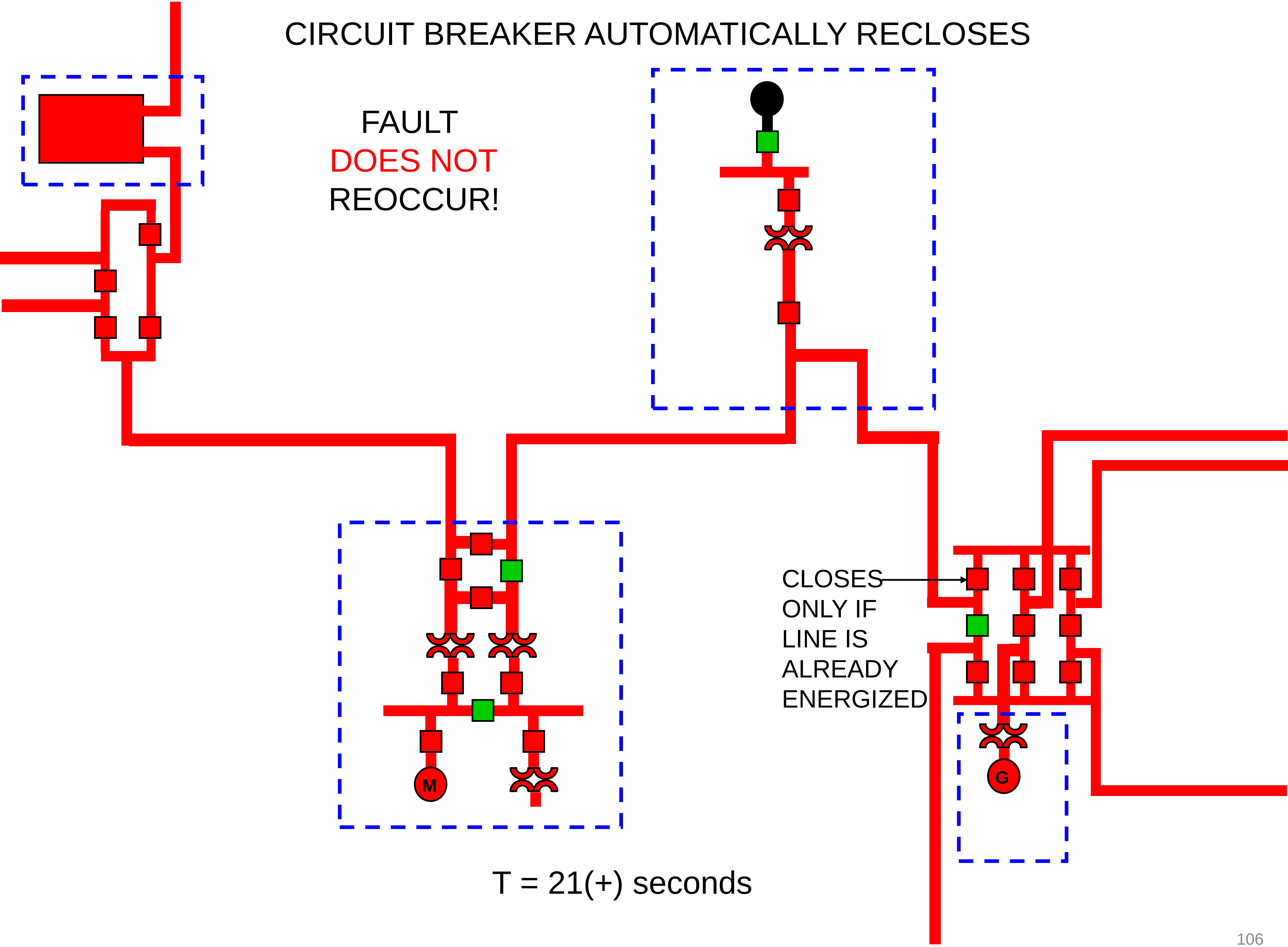
T = 7(+) seconds + 5 to 20(+) cycles

CIRCUIT BREAKER AUTOMATICALLY RECLOSES



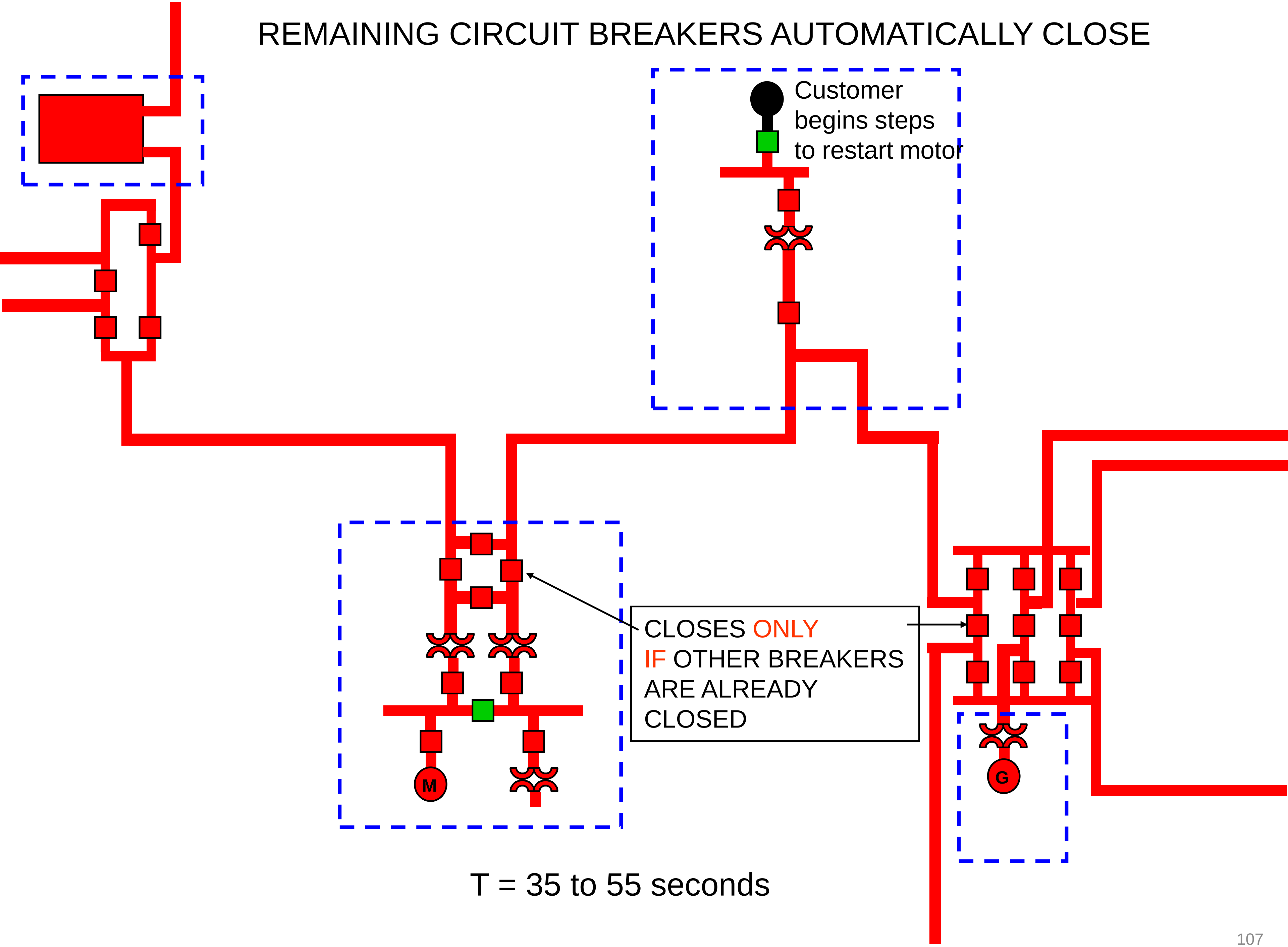
T = 15(+) seconds

CIRCUIT BREAKER AUTOMATICALLY RECLOSES



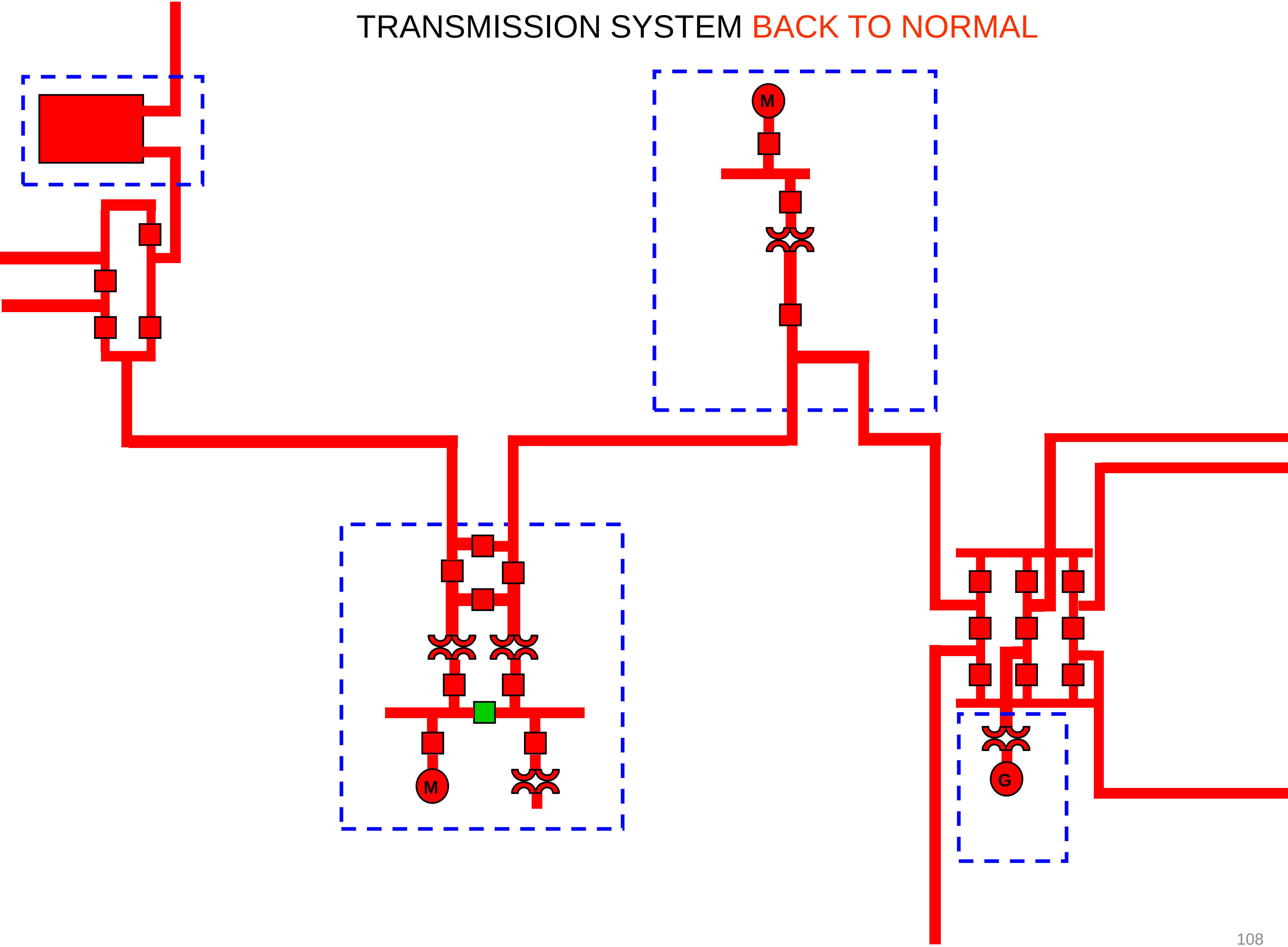
T = 21(+) seconds

REMAINING CIRCUIT BREAKERS AUTOMATICALLY CLOSE



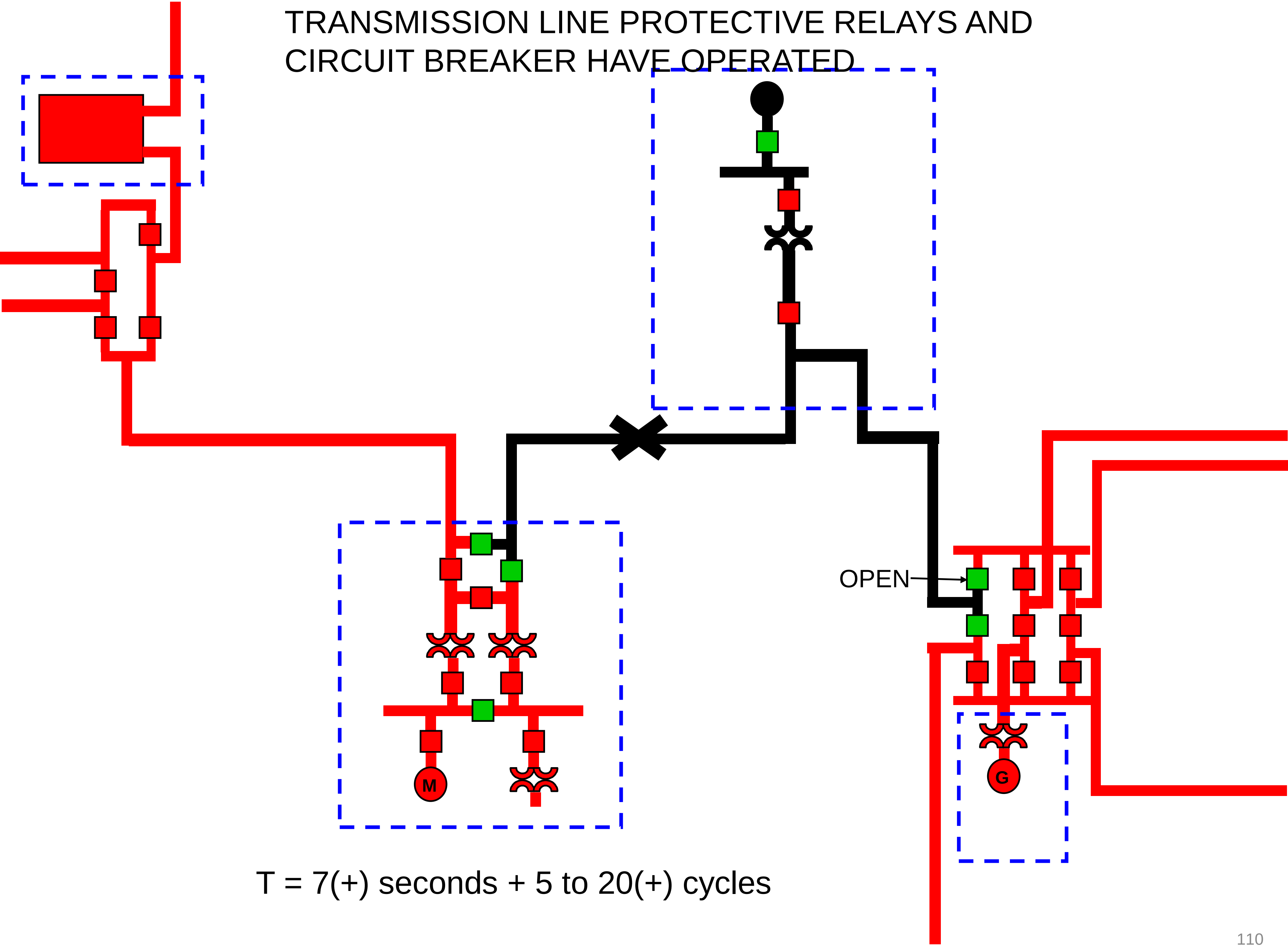
T = 35 to 55 seconds

TRANSMISSION SYSTEM BACK TO NORMAL



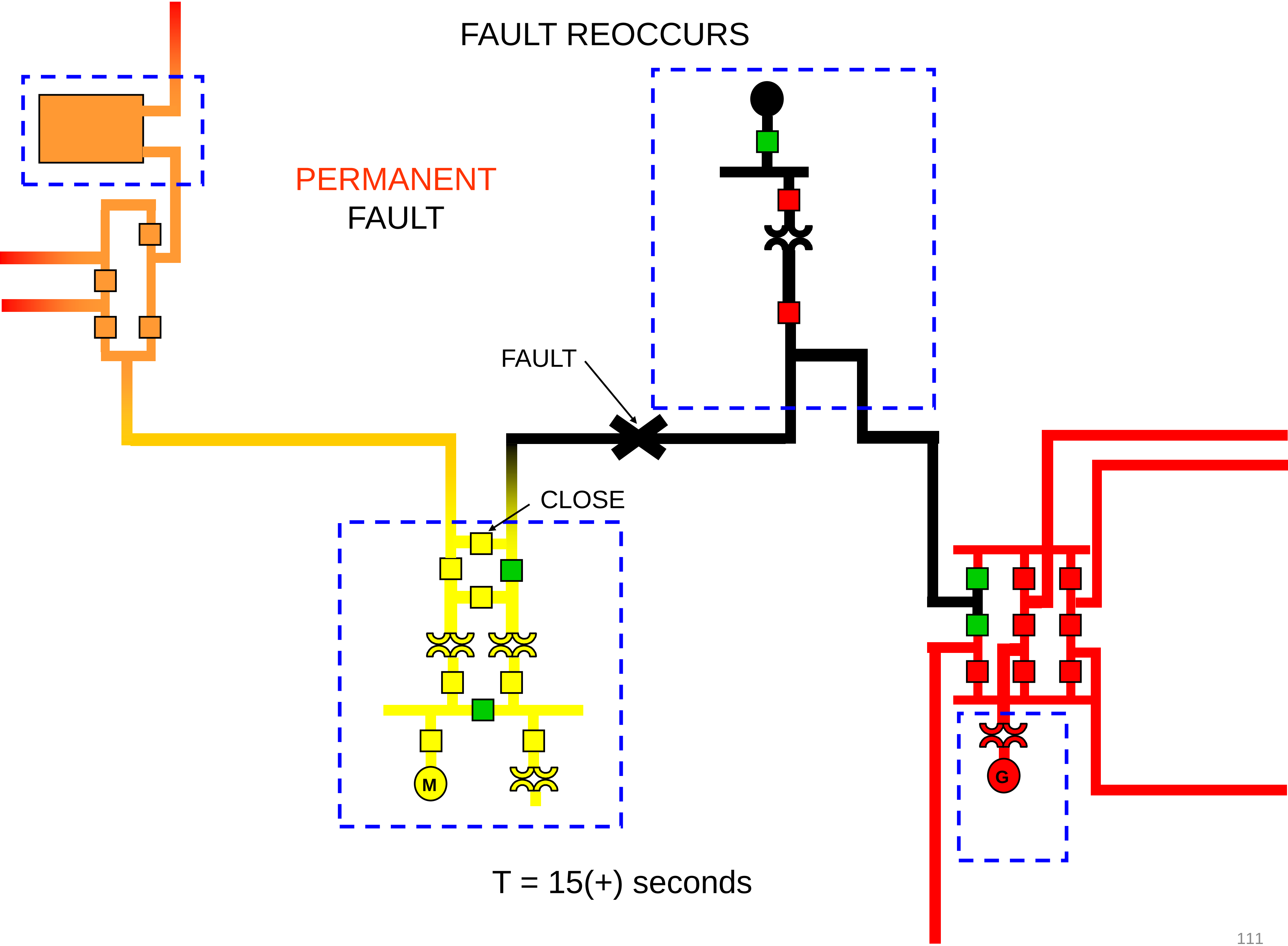
BUT WHAT IF THE FAULT WAS PERMANENT ?

TRANSMISSION LINE PROTECTIVE RELAYS AND CIRCUIT BREAKER HAVE OPERATED



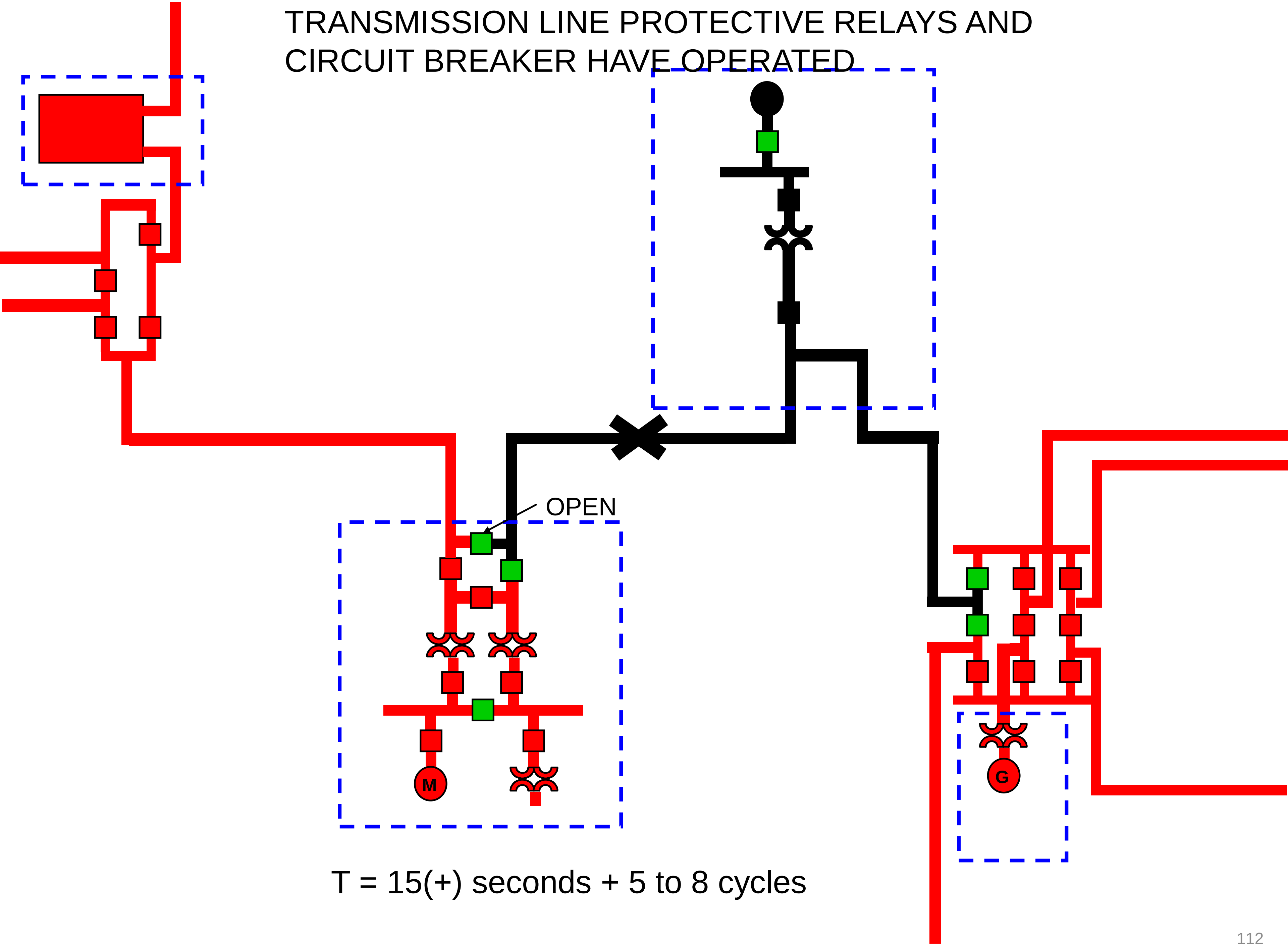
T = 7(+) seconds + 5 to 20(+) cycles

FAULT REOCCURS



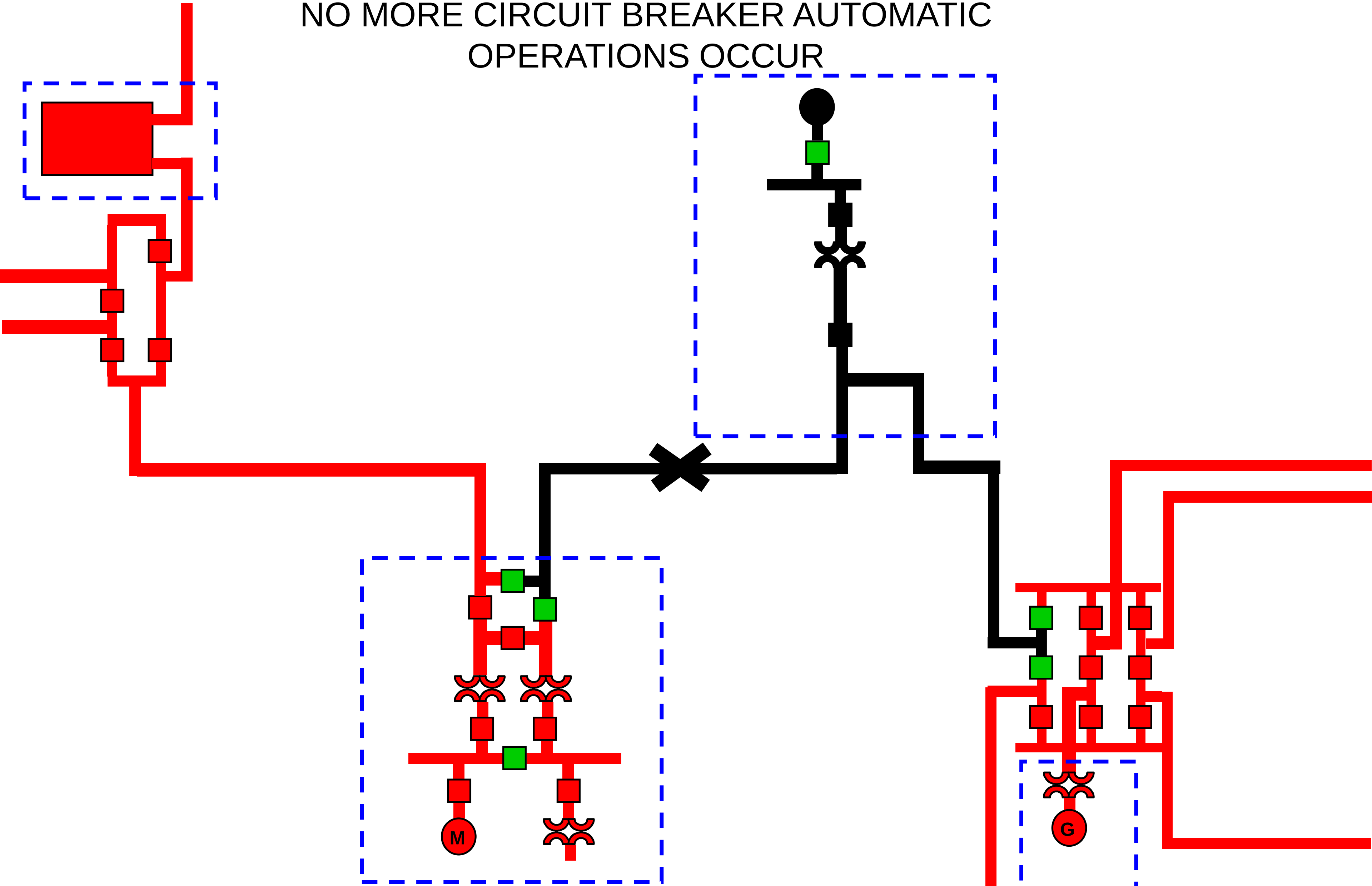
T = 15(+) seconds

TRANSMISSION LINE PROTECTIVE RELAYS AND CIRCUIT BREAKER HAVE OPERATED



T = 15(+) seconds + 5 to 8 cycles

NO MORE CIRCUIT BREAKER AUTOMATIC OPERATIONS OCCUR



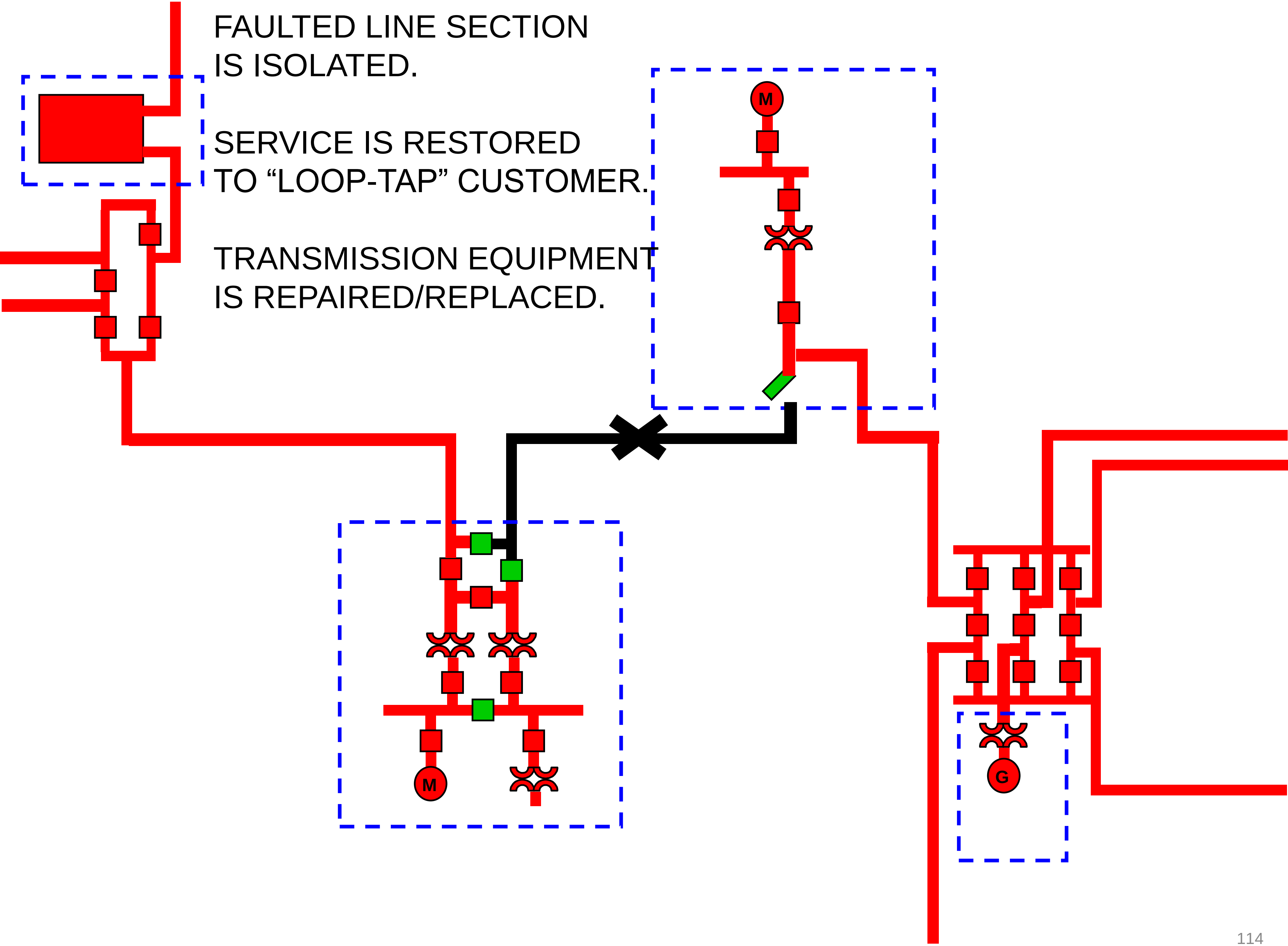
T = 1(+) MINUTE

CenterPoint Energy SYSTEM DISPATCHER DIRECTED RESTORATION PROCESS BEGINS

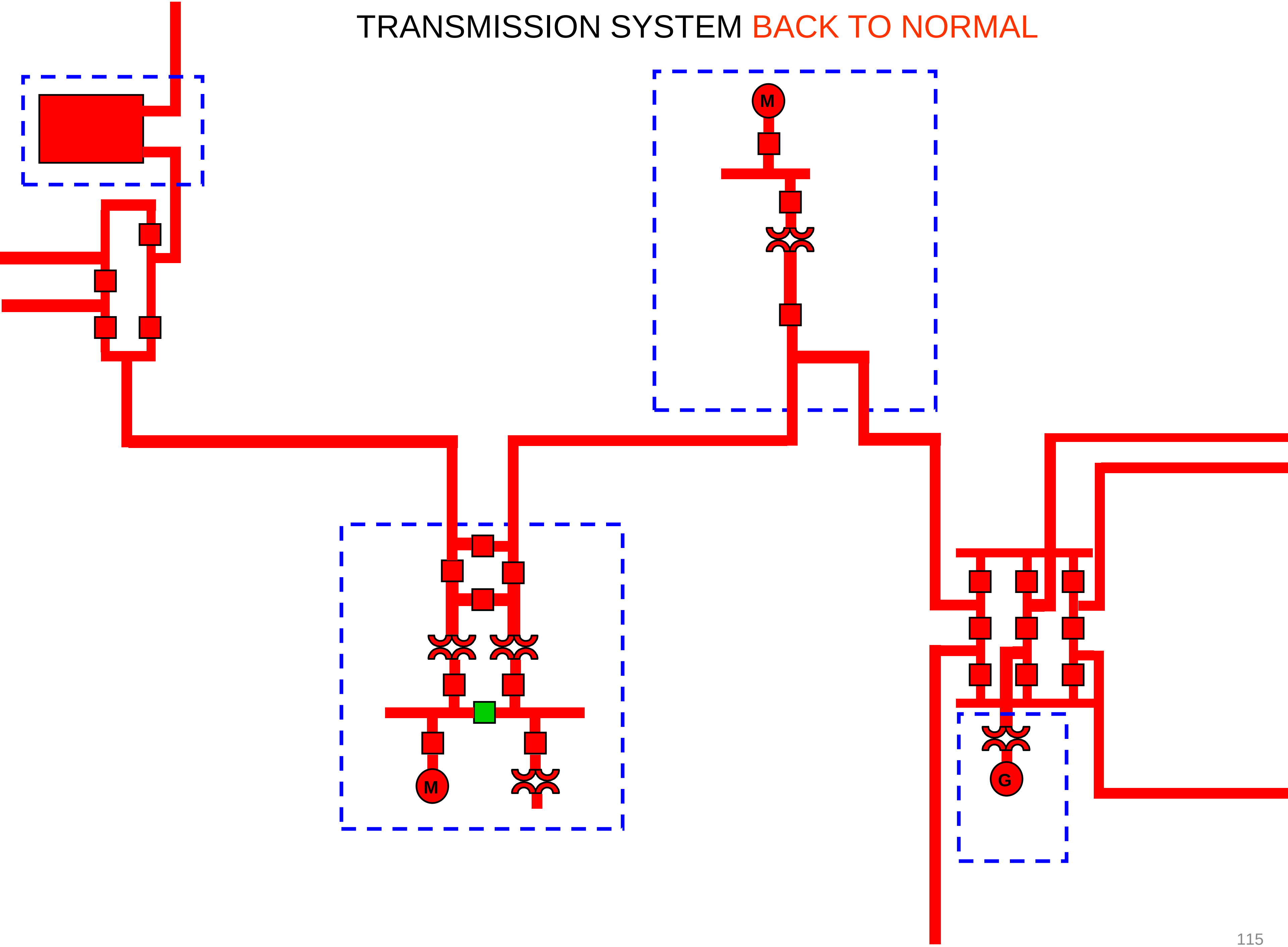
FAULTED LINE SECTION
IS ISOLATED.

SERVICE IS RESTORED
TO “LOOP-TAP” CUSTOMER.

TRANSMISSION EQUIPMENT
IS REPAIRED/REPLACED.



TRANSMISSION SYSTEM BACK TO NORMAL



END