

# Substation Inspections Following a Line Trip

Operating Committee  
Meeting

August 30, 2018



# Line Trip and Reclose Response



- VELCO has been dispatching a switchmen following a line protection trip event to gather relay targets and fault information, as well as inspect the associated substations
- Nearly all of our substations are now equipped with microprocessor-based protective relays having remote interrogation capabilities
  - Via SCADA can view 3-phase amps and voltages
- Most of the line relay target and fault information automatically retrieved within less than a minute and displayed in the SCADA system
- Very infrequent to find problems within a substation following a line trip event
- Most of our call-outs are related to circuits that serve the subtransmission systems
- Note that quite often we wait for normal business hours to dispatch a switchmen

# Line Trip and Reclose Response



- For substations without remote interrogation, we would continue to dispatch a switchmen (Barre, Berlin, Florence, Middlebury, South Hero and Windsor)
- Criteria for patrolling transmission and sub-T lines following “temporary” faults
  - Use of fault distance information
  - Balance 3-phase amps
  - Balanced 3 phase voltages
- For permanent faults, we all work together to expeditiously get the fault information for the field personnel
- Looking for feedback before moving forward with no longer dispatching a switchmen following a line trip

# Fault Analysis Tools

## SEL-321 Relay Record

- Example – Bennington K6 line
- Function – 21/67N
- Element Trip – Zone 1, Phase B-Ground
- Distance – 12.54 miles

BENNINGTON SUBSTATION K6 (LINE)									
#	DATE	TIME	EVENT	LOCAT	GRP	TARGETS	Date: 05/15/12 Time: 17:45:03.298		
1	05/15/12	16:05:52.630	BG	+12.54	1	INST ZONE1 EN G 50			
2	12/13/12	03:42:44.794	AG	+73.97	1	EN			
3	11/14/12	06:23:28.416	AG	+130.1	1	EN			
4	12/06/12	15:42:41.426	AG	+35.64	1	EN			
5	10/24/12	06:45:56.098	ER	\$\$\$\$\$\$	1	EN			
6	06/24/12	16:47:30.305	BG	+27.23	1	INST ZONE1 EN B C			
7	06/11/12	20:18:06.526	ER	\$\$\$\$\$\$	1	EN			
8	04/29/12	16:30:40.673	CG	+176.4	1	EN			
9	02/19/12	14:24:30.556	ER	\$\$\$\$\$\$	1	EN			
10	12/16/12	08:41:21.298	AG	+167.6	1	EN			

BENNINGTON SUBSTATION K6 (LINE)

Date: 05/15/12

Time: 16:05:52.630

FID=SEL-321-2-R407-V656112p2a-Z001001-D20000721

CURRENTS (pri)				VOLTAGES (kV pri)			RELAY ELEMENTS		OUT	IN
							ZZZZZZO	555566L	1357	1357
							ABCABCO	3111077O	8888	8888
							BCAGGGS	2NQPNNQ	2468	2468
IR	IA	IB	IC	VA	VB	VC				
-2	-102	-91	191	43.0	24.2	-67.2	.....	.....L...	.....	B...
6	168	-180	18	-51.9	63.4	-11.5	.....	.....L...	.....	B...
-1	101	90	-192	-43.0	-24.2	67.2	.....	.....L...	.....	B...
-10	-169	179	-19	51.9	-63.5	11.5	.....	.....L...	.....	B...
-2	-102	-91	191	43.0	24.2	-67.2	.....	.....L...	.....	B...
5	168	-180	17	-51.9	63.4	-11.5	.....	.....L...	.....	B...
-2	101	90	-193	-43.0	-24.2	67.2	.....	.....L...	.....	B...
-8	-169	179	-18	51.9	-63.5	11.5	.....	.....L...	.....	B...
-1	-102	-91	192	43.0	24.2	-67.2	.....	.....L...	.....	B...
5	168	-180	17	-51.9	63.5	-11.5	.....	.....L...	.....	B...
-2	101	90	-193	-43.0	-24.2	67.2	.....	.....L...	.....	B...
-8	-169	179	-18	51.9	-63.5	11.5	.....	.....L...	.....	B...
-1	-102	-91	192	43.0	24.2	-67.2	.....	.....L...	.....	B...
89	157	-91	23	-51.1	59.1	-11.7	.....	.....L...	.....	B...
670	-2	818	-146	-41.6	-27.1	67.5	.....	.....H...	.....	B...
-522	-139	-316	-67	47.1	-41.7	12.4	.....	Qp..H...	.....	B...
-1618	139	-1835	78	41.1	23.7	-68.3	3.....	Qp..H1..	BB5.	B...
823	138	583	102	-44.0	28.6	-13.0	3.....	Qp..H1..	BB5.	B...
1853	-168	2081	-60	-42.2	-17.2	68.7	....1..	Qp..H1..	BB5.	B...
-808	-142	-563	-103	43.9	-28.6	13.1	....1..	Qp..H1..	BB5.	B...
-1840	166	-2065	60	42.4	17.2	-68.6	....1..	Qp..H1..	BB5.	B...
809	140	565	103	-43.8	28.5	-13.2	....1..	Qp..H1..	BB5.	B...
1842	-167	2068	-59	-42.4	-17.1	68.6	....1..	Qp..H1..	BB5.	B...
-804	-143	-558	-103	43.7	-28.5	13.2	....1..	Qp..H1..	BB5.	B...
-1840	166	-2062	56	42.4	17.1	-68.9	....1..	Qp..H1..	BB5.	1...
762	146	544	72	-44.3	25.6	-14.2	....1..	Qp..H1..	BB5.	....
1334	-74	1436	-28	-44.1	-21.1	68.7	....1..	Qp..H1..	BB5.	....
-433	-154	-258	-22	51.6	-9.2	19.9	....1..	Qp..H...	BB5.	....
-420	-18	-401	-1	42.4	19.8	-70.0	....1..	Qp..H...	BB5.	....
74	76	0	-1	-59.2	-4.7	-25.1	....1..	Qp..H...	BB5.	....
6	6	0	0	-37.9	-14.2	72.2	.....	Q.....	BB5.	....
-1	0	-1	0	60.1	1.7	24.3	.....	.....	BB5.	....
-2	-1	0	-1	37.2	10.1	-73.1	.....	.....	BB5.	....
-1	-1	0	0	-60.7	17.1	-18.9	.....	.....	BB5.	....
-1	0	-1	0	-37.6	-12.8	71.9	.....	.....	BB5.	....
0	0	0	0	61.2	-33.0	14.6	.....	.....	BB5.	....



# Fault Analysis Tools

- Typical SEL microprocessor relay
- Relays are synchronized with GPS time clocks
- Provides voltage and current magnitude with angular relationship, as well as phasor and sequence elements for the Engineer to use

## Phasor and Sequence Elements

Relay/Terminal ID: ESSEX SUBSTATION K22(LINE)

Event date/time: Sunday, September 11, 2016 05:09:35.970000

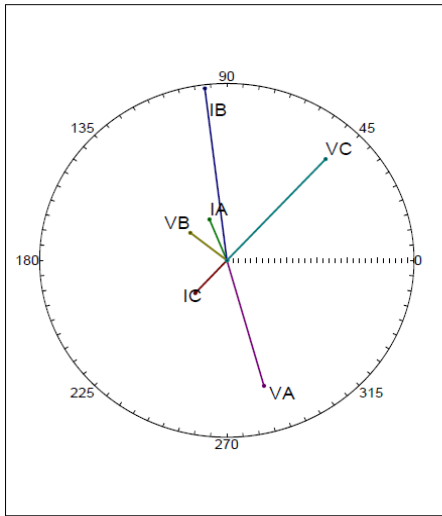
Printed: 10/4/2016 3:55:25 PM

Event Report File= L:\Diana\Ops Cycle Training\2016-9-11-K22 and K19\ESX K22 SEL321 EVE\_1 2016-9-11.CEV

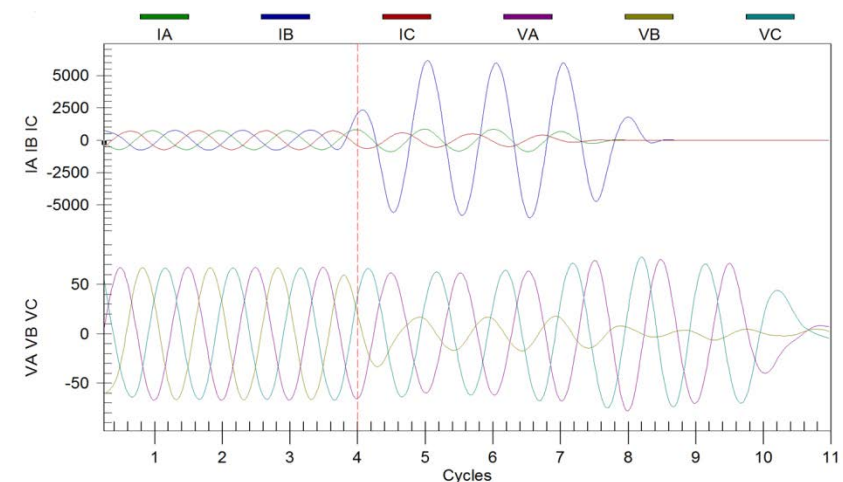
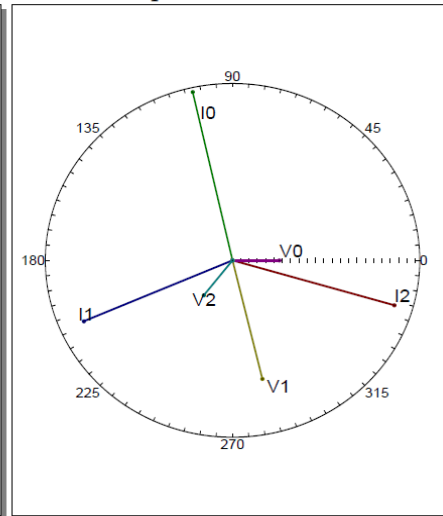
Cycles: 5.000000  
Reference Phase: A

Channel	Mag	Angle	Scale	Show	Ref
IR	6592.8	102.6	1	0	
IA	858.6	112.0	1	1	
IB	6099.7	96.9	1	1	
IC	564.8	227.6	1	1	
VA	59.7	285.6	1	1	
VB	17.8	141.4	1	1	
VC	63.1	47.3	1	1	
I0	2197.6	102.6	1	1	
I1	1950.7	203.5	1	1	
I2	2029.5	343.6	1	1	
V0	15.0	0.0	1	1	1
V1	46.4	283.4	1	1	
V2	15.7	232.1	1	1	

Phasor Elements



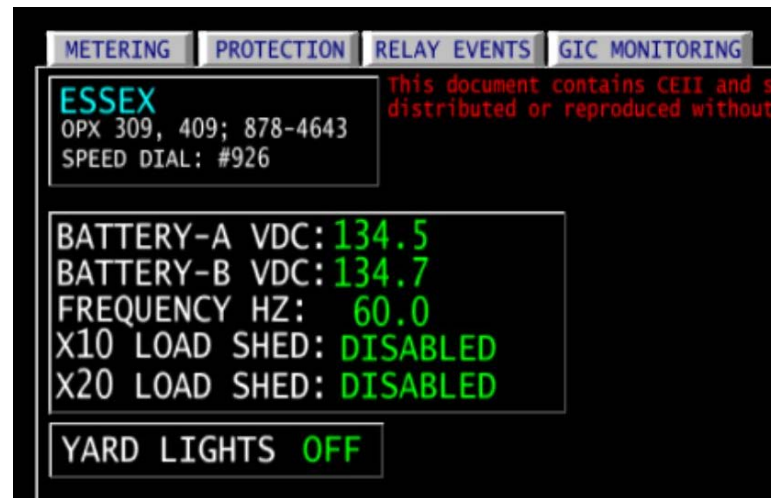
Sequence Elements



# Fault Analysis Tools

## VELCO Automatic Retrieval of Relay Event Information

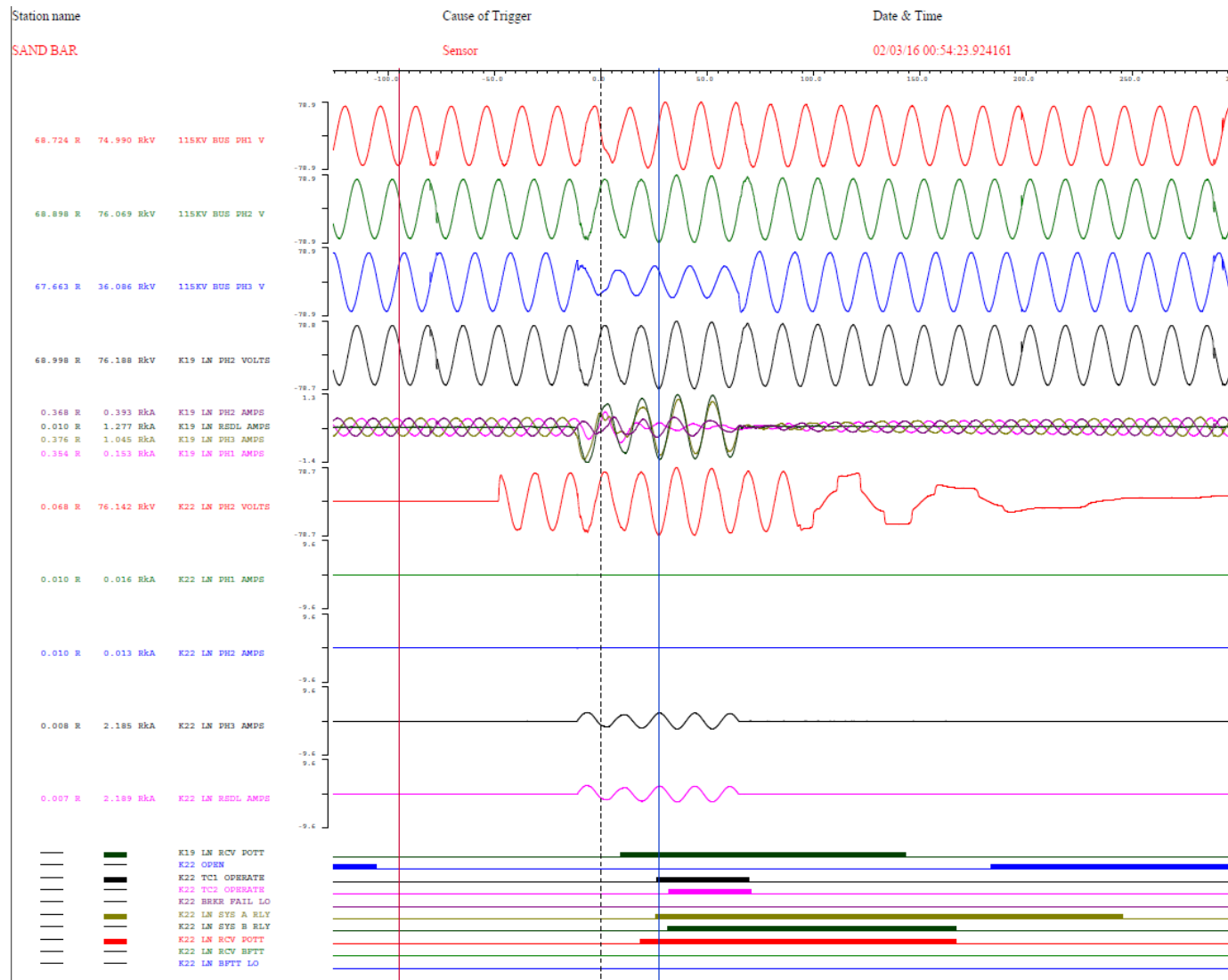
- Protective relay event data provides improved situational awareness following a transmission or subtransmission line trip event
  - Relay targets
  - Fault type and phases involved
  - Relay element that operated, e.g. instantaneous or time delayed, high-speed communication-aided, overcurrent, stepped distance with zone, SOTF and line differential
  - Relay calculated fault distance
- Information can be viewed on the SCADA “Relay Events” display





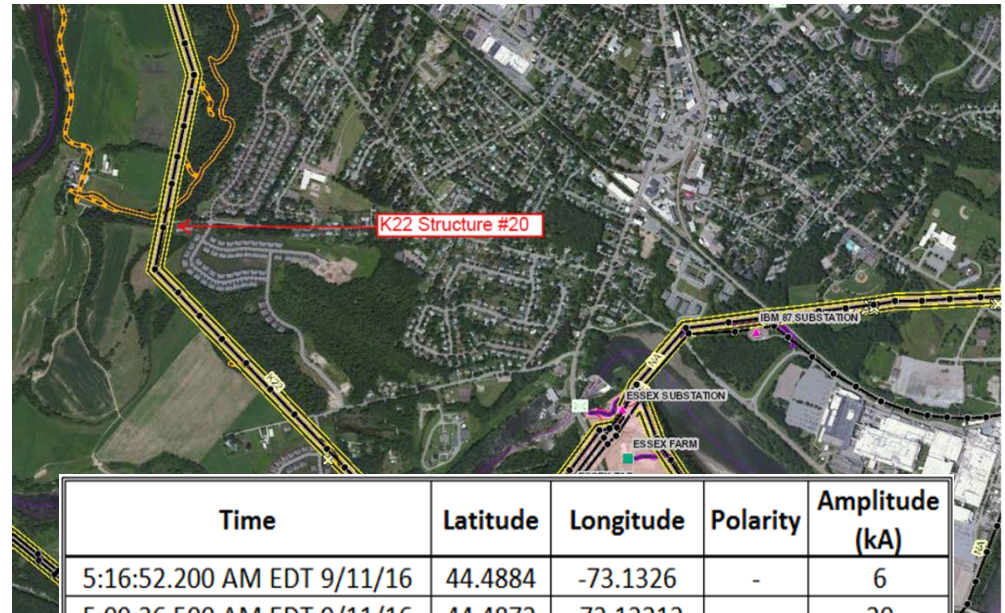
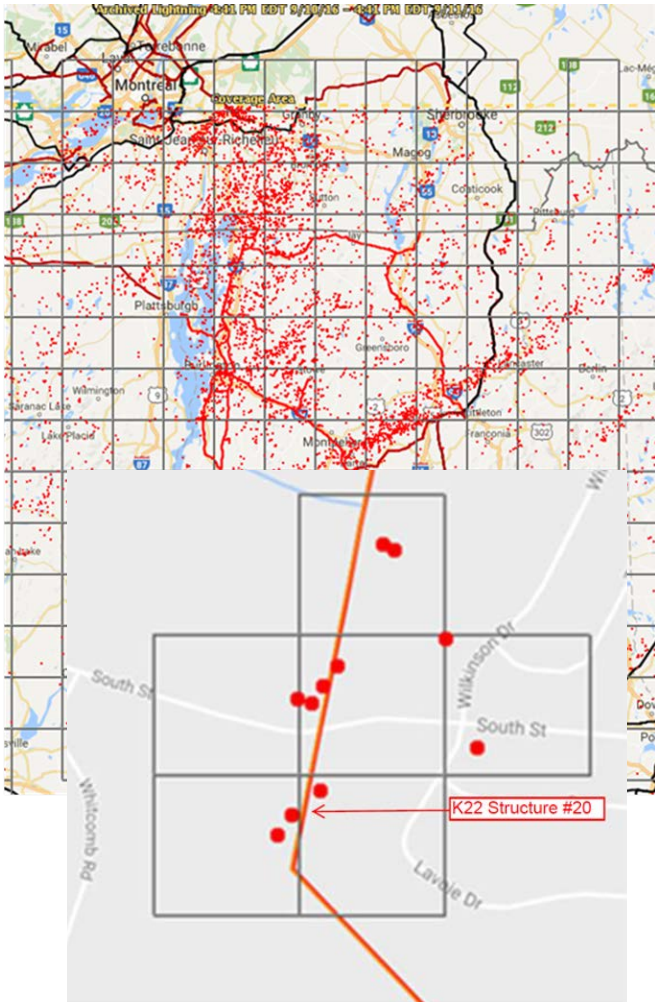
# Fault Analysis Tools

- DFR data – Feb 3, 2016 Essex to Sand Bar K22 event



# Fault Analysis Tools

- Schneider DTN Weather Sentry® Lightning Detection
  - Accuracy of detection network 0.09-0.12 miles

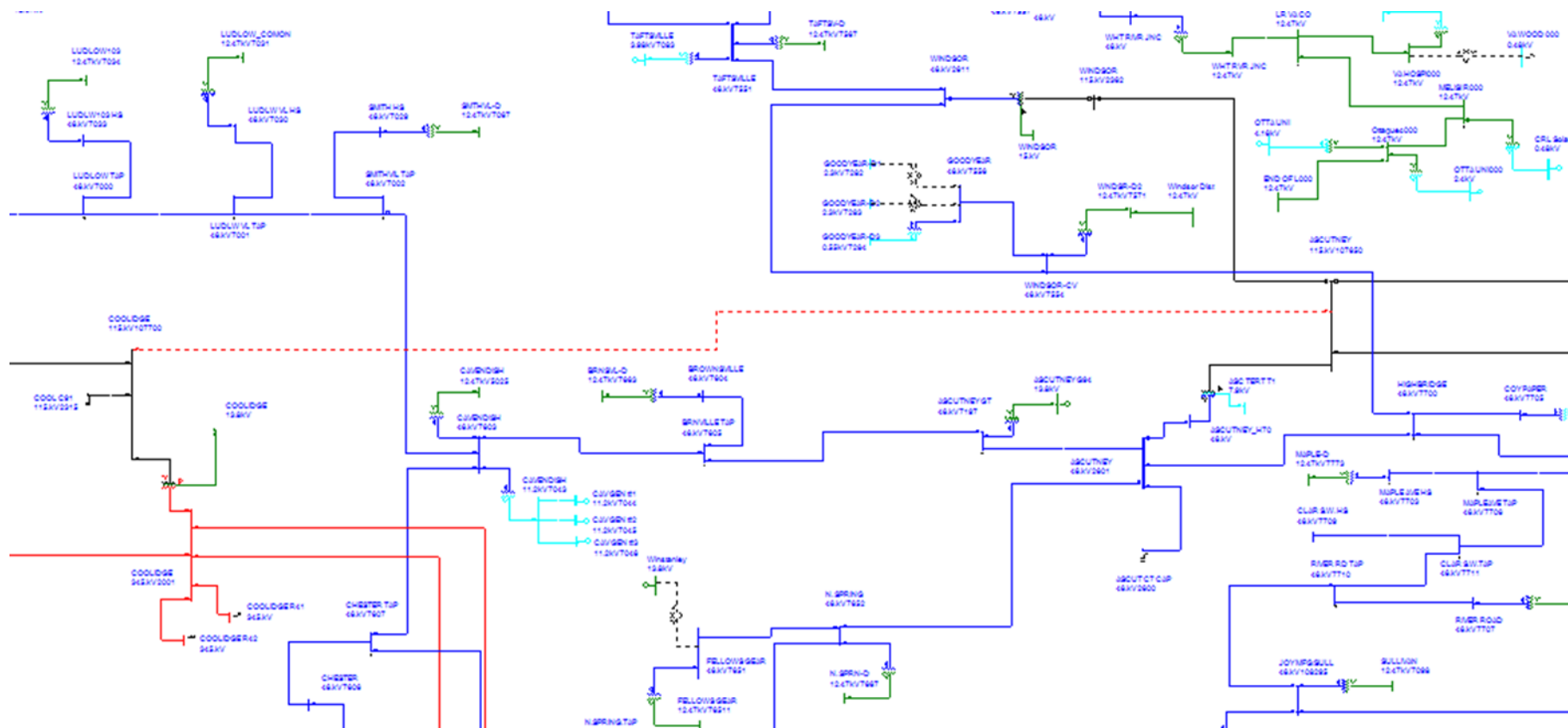


Time	Latitude	Longitude	Polarity	Amplitude (kA)
5:16:52.200 AM EDT 9/11/16	44.4884	-73.1326	-	6
5:09:36.500 AM EDT 9/11/16	44.4872	-73.13212	-	20
5:09:36.400 AM EDT 9/11/16	44.4867	-73.13448	-	6
5:09:36.200 AM EDT 9/11/16	44.4894	-73.13354	-	30
5:09:36.100 AM EDT 9/11/16	44.4877	-73.13483	-	6
5:09:36.000 AM EDT 9/11/16	44.4877	-73.13461	-	8
5:09:35.900 AM EDT 9/11/16	44.4893	-73.13337	-	14
5:09:35.800 AM EDT 9/11/16	44.4865	-73.13491	-	6
5:09:35.700 AM EDT 9/11/16	44.4881	-73.13423	-	14
5:09:35.700 AM EDT 9/11/16	44.4879	-73.13444	-	6
5:09:35.600 AM EDT 9/11/16	44.4863	-73.13513	-	8



# Fault Analysis Tools

- *ASPEN OneLiner*<sup>TM</sup> short circuit and relay coordination program
  - Widely used in North America



# Fault Analysis

## Blissville H30 (W. Rutland line) 8/22/2017 operation

- Total line mileage = 12.49 miles
- Fault distance provided by Blissville relay = 10.27 miles

BLISSVILLE		BLISSVILLE RELAY EVENTS SUMMARY																			
																		ZONE			
	epoch	msec	A	B	C	GND	TRIP	DIST(mi)	Inst	TIME	Comm	SOTF	87L	50/51	1	2	3	4			
K7	07/31/17	01:41:38.420	.	.	C	GND	.	10.69	.	.	.	.	.	.	.	.	.	.			
SEL_321	07/19/17	11:34:00.650	A	.	.	GND	.	33.86	.	.	.	.	.	.	.	.	.	.			
09/12/17	07/18/17	08:39:52.400	.	B	.	GND	.	33.41	.	.	.	.	.	.	.	.	.	.			
11:41	06/07/17	12:06:05.613	.	B	.	GND	.	14.87	.	.	.	.	.	.	.	.	.	.			
K34	07/25/15	04:22:33.156	.	B	.	GND	.	43.70	.	.	.	.	.	.	.	.	.	.			
SEL_321	09/09/99	05:09:00.565	.	.	C	GND	.	0.63	INST	.	.	.	.	OC	Z1	.	.	.			
09/12/17	09/09/99	05:09:00.041	.	.	C	GND	.	22.63	.	.	.	.	.	.	.	.	.	.			
11:41	09/09/99	05:09:00.814	A	.	.	GND	.	11.35	.	.	.	.	.	.	.	.	.	.			
H76	08/22/17	04:56:35.773	A	B	.	.	.	0.00	.	.	.	.	.	.	.	.	.	.			
SEL_321	08/12/17	16:54:46.538	.	.	.	.	.	0.00	.	.	.	.	.	.	.	.	.	.			
09/12/17	08/04/17	16:59:03.620	.	.	.	.	.	0.00	.	.	.	.	.	.	.	.	.	.			
11:41	07/31/17	01:41:38.427	.	.	.	.	.	0.00	.	.	.	.	.	.	.	.	.	.			
H29	09/12/17	06:19:31.887	.	.	.	.	.	0.00	.	.	.	.	.	.	.	.	.	.			
SEL_311C	09/01/17	08:07:11.536	.	.	.	.	.	0.00	.	.	.	.	.	.	.	.	.	.			
09/12/17	08/31/17	08:04:08.029	.	.	.	.	.	0.00	.	.	.	.	.	.	.	.	.	.			
11:41	08/30/17	07:52:26.365	.	.	.	.	.	0.00	.	.	.	.	.	.	.	.	.	.			
H30	08/22/17	04:56:45.888	.	.	.	.	.	0.00	.	.	.	.	.	.	.	.	.	.			
SEL_311C	08/22/17	04:56:35.788	A	B	.	.	TR	10.27	.	.	.	.	.	.	Z1	.	.	.			
09/12/17	07/25/17	14:12:06.313	.	.	.	.	.	0.00	.	.	.	.	.	.	.	.	.	.			
11:41	07/25/17	07:51:17.919	.	.	.	.	.	0.00	.	.	.	.	.	.	.	.	.	.			

# Fault Analysis

## Blissville H30 (W. Rutland line) 8/22/2017 operation

- DFR record provides phase voltage and current values

### Fault Voltage

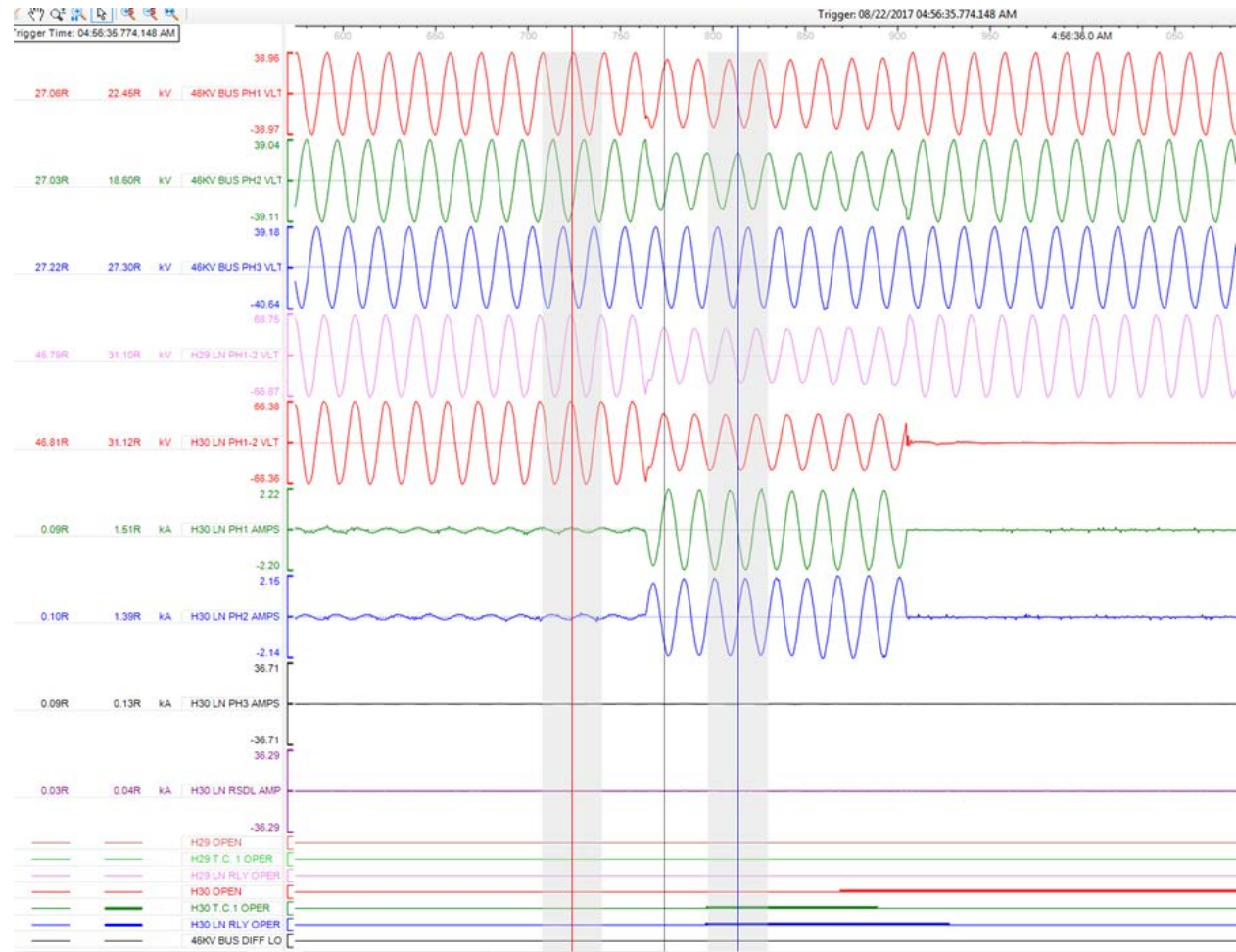
- Ph1 = 22.42kV
- Ph2 = 18.06kV
- Ph3 = 27.25kV

### Fault Current

- Ph1 = 1,490A
- Ph2 = 1,410A
- Ph3 = 130A
- **Residual = 40A**

### Pre-fault Current

- Ph1 = 90A
- Ph2 = 100A
- Ph3 = 90A
- **Residual = 30A**



# Fault Analysis

Blissville H30 (W. Rutland line) 8/22/2017 operation

- Three phase amps were verified balanced
- Recorded in the Operator's event database



BLISSVILLE		BLISSVILLE METER SUMMARY									
	MWATT	MVAR	AMPS1	AMPS2	AMPS3	VOLTS1	VOLTS2	VOLTS3	THD1	THD2	THD3
115kv											
K34	-14.7	8.1	75.4	84.4	91.1	66.9	67.0	67.2	1.8	1.9	1.8
K7	4.6	-9.5	43.6	54.0	61.5	66.9	67.0	67.2	1.8	1.9	1.8
PST	4.4	-7.1									
46kv											
H29	5.3	0.2	60.1	70.2	68.6	26.7	26.7	26.8	1.6	1.8	1.6
H30	4.5	1.1	55.9	61.0	57.9	26.7	26.8	26.8	1.6	1.8	1.6
H76	-9.9	-1.2	115.2	130.7	125.8	26.7	26.7	26.8	1.6	1.8	1.6

# Fault Analysis

## Blissville Metering Display

- Three phase amps were verified balanced

### 8.5 Automatic Breaker Operations Resulting in a Successful Reclose

In the interest of public safety the System Operator will, given available information (e.g. Historical data from PI, three phase amps and volts as indicated on SCADA or from field personnel, neighboring VDU or LCC knowledge), determine if a possible concern for public safety exists. A possible indication may be an imbalance of three phase amps of >15% on transmission assets (greater tolerance for imbalance is accepted on lightly loaded, load serving, and lower voltage lines). This imbalance may indicate an open circuit or high impedance fault condition. VELCO Engineering or other support staff may provide more information as requested by the Operator. If it is determined that a public safety condition exists, the line may need to be de-energized. Notify ISO-NE and any affected BA, LCC, or VDU, prior to opening the line if possible or immediately thereafter.

### 8.6 Automatic Breaker Operations resulting in a Permanent Fault

#### 8.6.3 Under 115kV

During normal business hours, make verbal notifications to the contacts below. During non-business, hours make email notifications to the contacts below:

- ❖ [Operations](#)
- ❖ [Engineering](#)

If the affected VDU(s) requests assistance in locating the fault, verbally notify to the engineering contact above and request he or she attempt to determine the fault distance, fault type, and phase(s) involved.