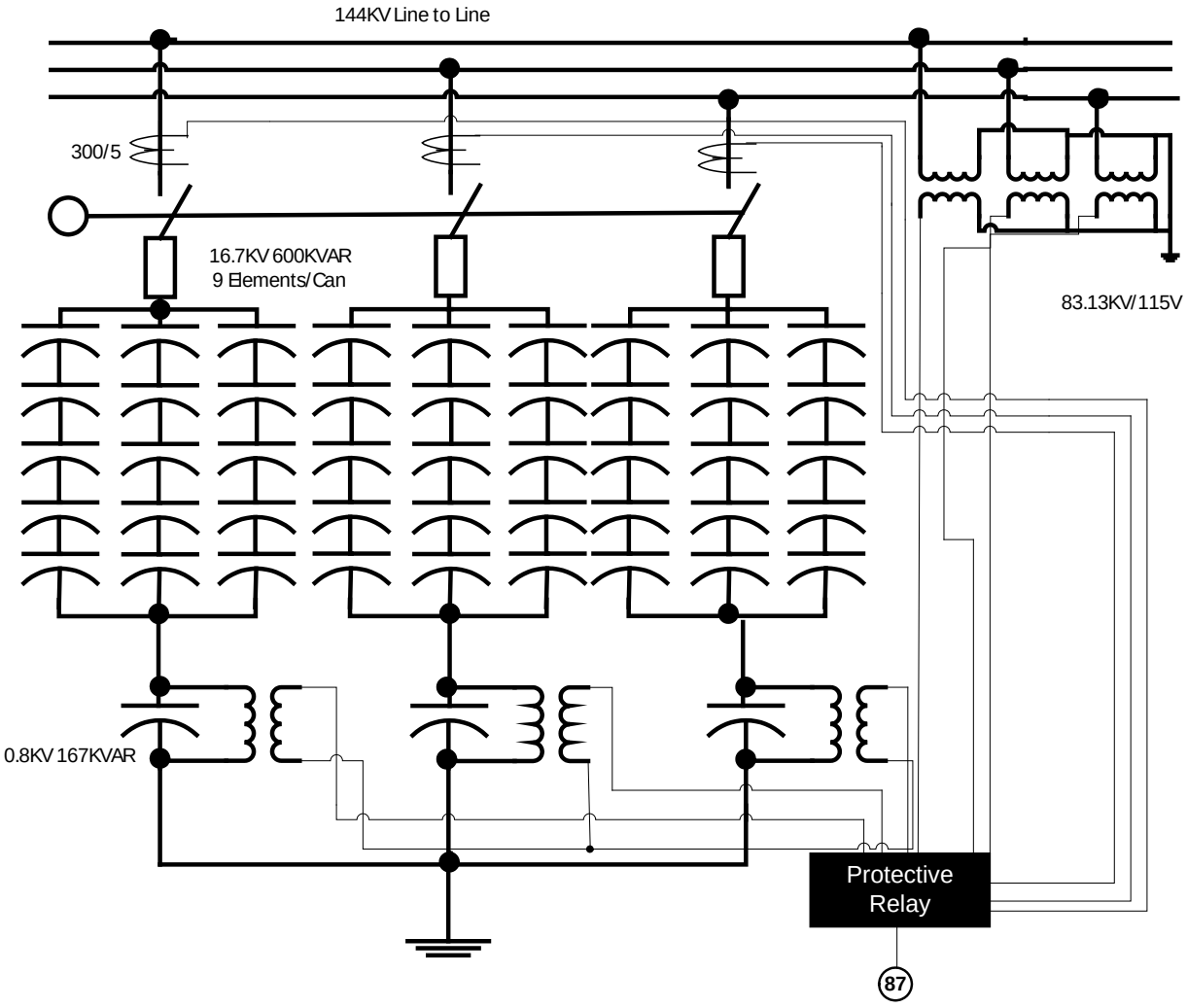
Odd Bus Voltage Fluctuations Causing Issues with Capacitor Bank Relay

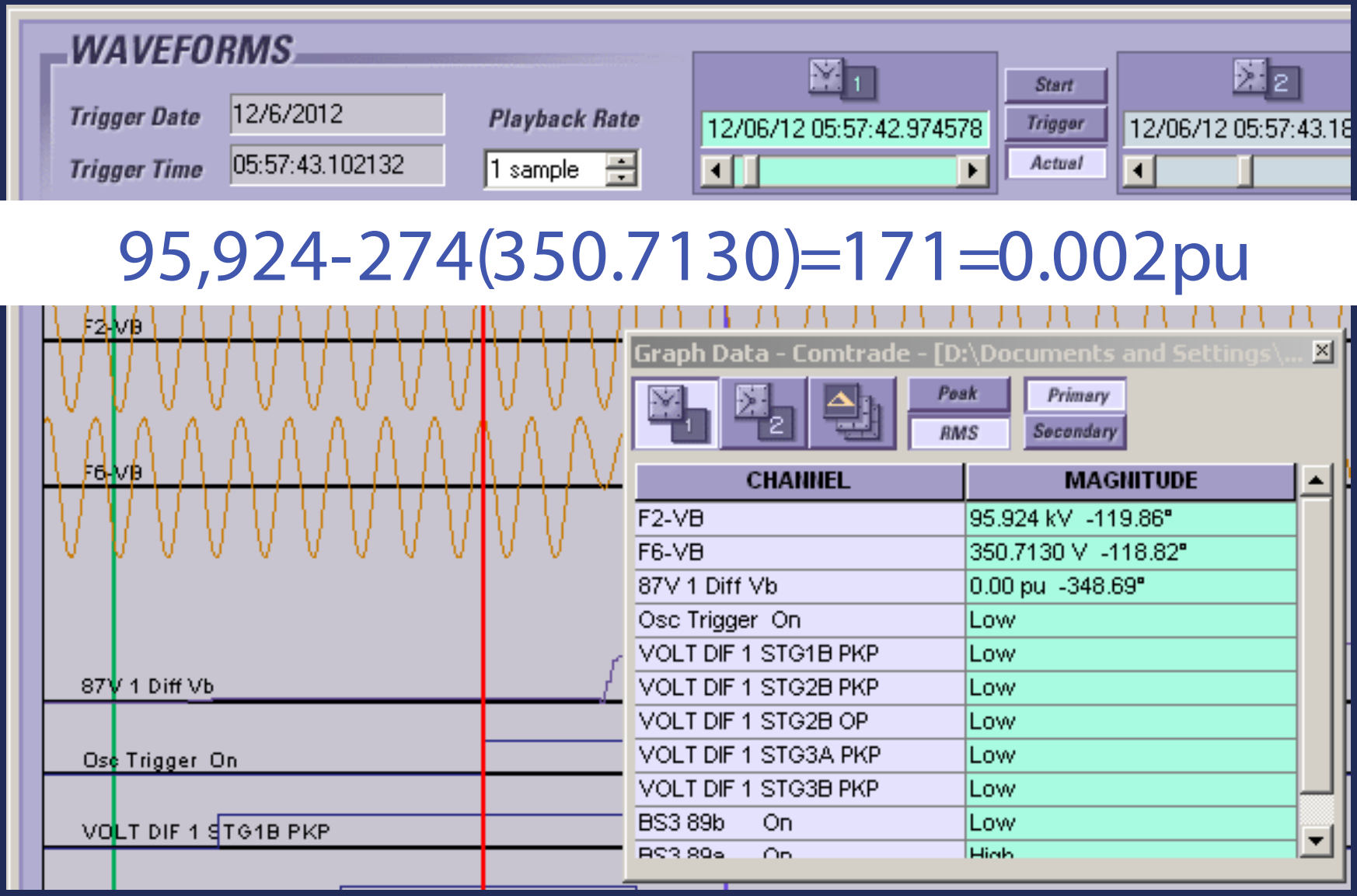
Terrence Smith

GE Digital Energy Multilin

Six Capacitor Banks – 2 Relays

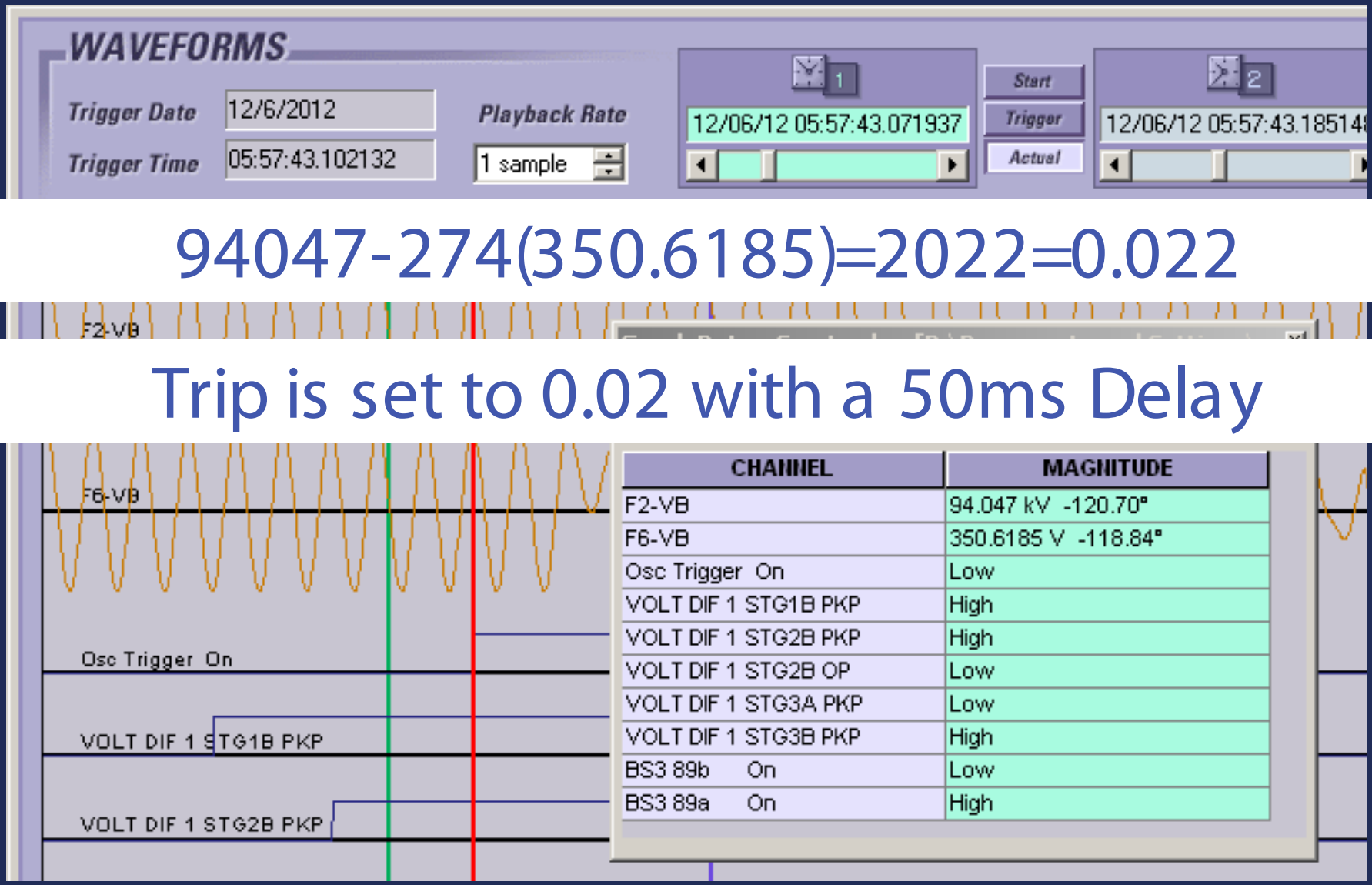


Pre-Fault Values of the Trip



95,924-274(350.7130)=171=0.002pu

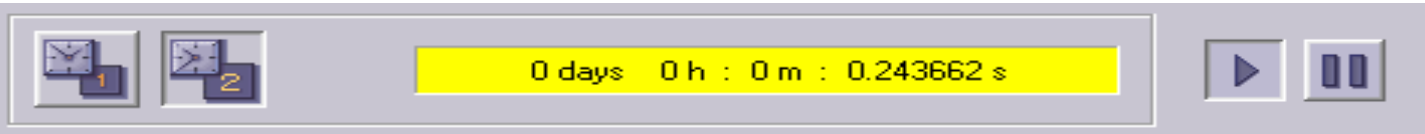
Fault Values of the Trip



94047-274(350.6185)=2022=0.022

Trip is set to 0.02 with a 50ms Delay

Event Records



Event Number	Date/Time	Cause	Data
14869	Dec 06 2012 09:39:10.059863	VOLT DIF 1 STG1B PKP	
14868	Dec 06 2012 09:39:10.057780	VOLT DIF 1 STG3B PKP	
14867	Dec 06 2012 09:34:42.158641	VOLT DIF 1 DPO	
14866	Dec 06 2012 09:34:41.939957	VOLT DIF 1 STG1B PKP	
14865	Dec 06 2012 09:34:41.937874	VOLT DIF 1 STG3B PKP	
14864	Dec 06 2012 09:09:40.170983	VOLT DIF 1 DPO	
14863	Dec 06 2012 09:09:39.941888	VOLT DIF 1 STG1B PKP	
14862	Dec 06 2012 09:09:39.937723	VOLT DIF 1 STG3B PKP	
14861	Dec 06 2012 09:04:47.548600	VOLT DIF 1 DPO	
14860	Dec 06 2012 09:04:47.340254	VOLT DIF 1 STG1B PKP	
14859	Dec 06 2012 09:04:47.334000	VOLT DIF 1 STG3B PKP	
14858	Dec 06 2012 08:30:45.022783	VOLT DIF 1 DPO	
14857	Dec 06 2012 08:30:44.824911	VOLT DIF 1 STG1B PKP	
14856	Dec 06 2012 08:30:44.818661	VOLT DIF 1 STG3B PKP	
14855	Dec 06 2012 08:25:36.661146	VOLT DIF 1 DPO	
14854	Dec 06 2012 08:25:36.409093	VOLT DIF 1 STG1B PKP	
14853	Dec 06 2012 08:25:36.402841	VOLT DIF 1 STG3B PKP	
14852	Dec 06 2012 08:10:57.612625	VOLT DIF 1 DPO	
14851	Dec 06 2012 08:10:57.441826	VOLT DIF 1 STG1B PKP	
14850	Dec 06 2012 08:10:57.435578	VOLT DIF 1 STG3B PKP	
14849	Dec 06 2012 08:07:05.098656	VOLT DIF 1 DPO	
14848	Dec 06 2012 08:07:04.861241	VOLT DIF 1 STG1B PKP	
14847	Dec 06 2012 08:07:04.854994	VOLT DIF 1 STG3B PKP	
14846	Dec 06 2012 07:46:07.766480	VOLT DIF 1 DPO	
14845	Dec 06 2012 07:46:07.581104	VOLT DIF 1 STG1B PKP	
14844	Dec 06 2012 07:46:07.574854	VOLT DIF 1 STG3B PKP	
14843	Dec 06 2012 06:36:56.390804	VOLT DIF 1 DPO	
14842	Dec 06 2012 06:36:56.147116	VOLT DIF 1 STG1B PKP	
14841	Dec 06 2012 06:36:56.140867	VOLT DIF 1 STG3B PKP	
14840	Dec 06 2012 06:30:17.260222	VOLT DIF 1 DPO	
14839	Dec 06 2012 06:30:17.064404	VOLT DIF 1 STG1B PKP	
14838	Dec 06 2012 06:30:17.058150	VOLT DIF 1 STG3B PKP	

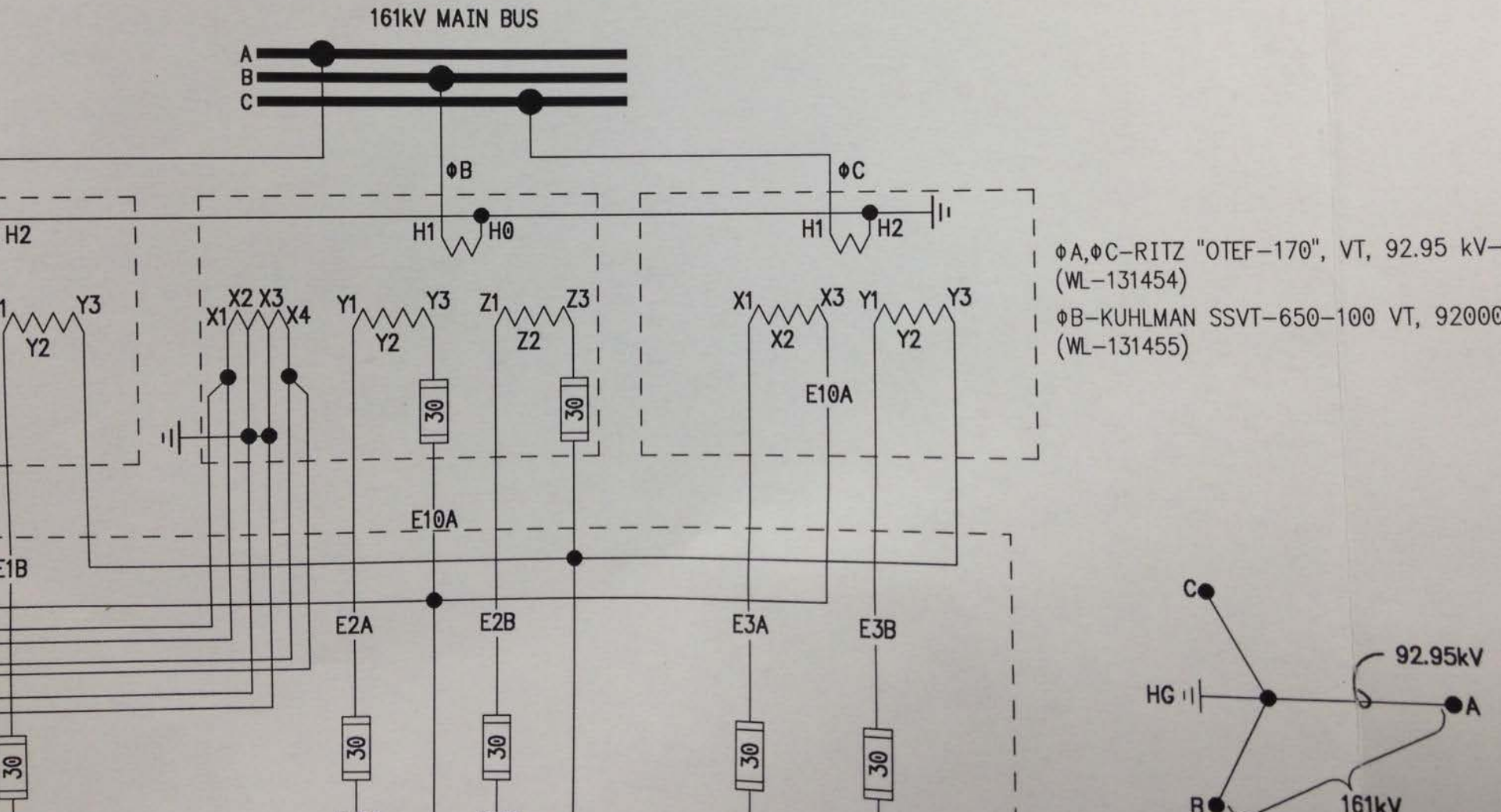
Event Records

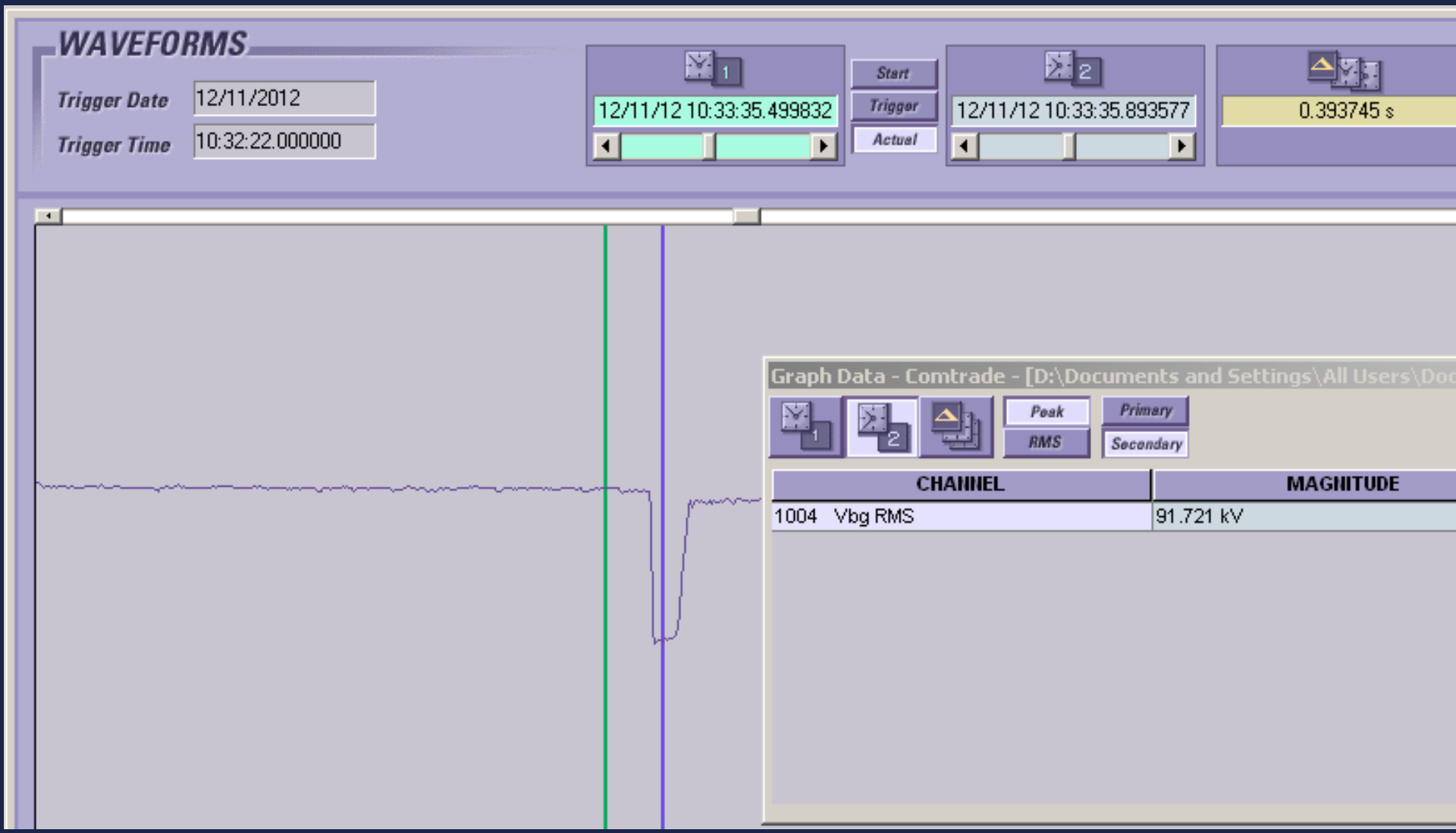
14846	Dec 06 2012 07:46:07.766480	VOLT DIF 1 DPO	
14845	Dec 06 2012 07:46:07.581104	VOLT DIF 1 STG1B PKP	
14844	Dec 06 2012 07:46:07.574854	VOLT DIF 1 STG3B PKP	
14843	Dec 06 2012 06:36:56.390804	VOLT DIF 1 DPO	
14842	Dec 06 2012 06:36:56.147116	VOLT DIF 1 STG1B PKP	
14841	Dec 06 2012 06:36:56.140867	VOLT DIF 1 STG3B PKP	
14840	Dec 06 2012 06:30:17.260222	VOLT DIF 1 DPO	
14839	Dec 06 2012 06:30:17.064404	VOLT DIF 1 STG1B PKP	
14838	Dec 06 2012 06:30:17.058150	VOLT DIF 1 STG3B PKP	

407	Dec 06 2012 07:46:07.766474	VOLT DIF 1 DPO	
406	Dec 06 2012 07:46:07.581100	VOLT DIF 1 STG1B PKP	
405	Dec 06 2012 07:46:07.579020	VOLT DIF 1 STG3B PKP	
404	Dec 06 2012 06:36:56.386634	VOLT DIF 1 DPO	
403	Dec 06 2012 06:36:56.149212	VOLT DIF 1 STG1B PKP	
402	Dec 06 2012 06:36:56.142947	VOLT DIF 1 STG3B PKP	
401	Dec 06 2012 06:30:17.253968	VOLT DIF 1 DPO	
400	Dec 06 2012 06:30:17.070645	VOLT DIF 1 STG1B PKP	
399	Dec 06 2012 06:30:17.064396	VOLT DIF 1 STG3B PKP	

One of these things isn't like the others!

3 4 5 6 7


161kV MAIN BUS
A
B
C
ΦB
ΦC
H2
H1
H0
H1
H2
X1
X2
X3
X4
Y1
Y2
Y3
Z1
Z2
Z3
30
E10A
E1B
E2A
E2B
E3A
E3B
ΦA,ΦC-RITZ "OTEF-170", VT, 92.95 kV-
(WL-131454)
ΦB-KUHLMAN SSVT-650-100 VT, 92000
(WL-131455)
C
HG
92.95kV
A
B
161kV


WAVEFORMS
Trigger Date
12/11/2012
Trigger Time
10:32:22.000000
1
12/11/12 10:33:35.499832
Start
Trigger
Actual
2
12/11/12 10:33:35.893577
0.393745 s
Graph Data - Comtrade - [D:\Documents and Settings\All Users\Doc
Peak
RMS
Primary
Secondary
CHANNEL
MAGNITUDE
1004 Vbg RMS
91.721 kV

( )W48H1-A0Z	WMCB-08A	230/208	60	1	58	60	N/A
( )W48H1-A04	EHWH04-A04	230/208	60	1	63	70	37/26
( )W48H1-A05	EHWH42-A05	230/208	60	1	89	90	37/52
(X)W48H1-A10BPXXXE	EHWH42-A10	230/208	60	1	89	90	37/52
( )W48H1-A15	EHWH42-A15	230/208	60	1	111	125	59/52
( )W48H1-A20	EHWH04-A20	230/208	60	1			

SHORT-CIRCUIT CURRENT: 5KA RMS SYMMETRICAL

BRANCH CIRCUIT SELECT CURRENT 23.1 OPERATING VOLTAGE RANGE: 197 VAC MIN. 253 VAC MA

SERIAL NUMBER 343D122899483-02

SUITABLE FOR OUTDOOR USE ALL MOTORS ARE THERMALLY PROTECTED

-- ELECTRICAL RATINGS --

	VAC	HZ	PH	HP	FLA	LRA	RLA
COMPRESSOR	230/208	60	1			131/131	19.5/21.2
OUTDOOR MOTOR	230/208	60	1	1/3	2.5		
INDOOR MOTOR	230/208	60	1	1/2	3.3		
WERV-A5A	230/208	60	1		2.2	(OPTIONAL)	
HEATER PACKAGE				KW	FLA		
EHWH04-A04	240/208	60	1	4/3	16.7/14.4		
EHWH42-A05	240/208	60	1	5/3.75	20.8/18.1		
EHWH42-A10	240/208	60	1	10/7.5	41.6/36.2		
EHWH42-A15	240/208	60	1	15/11.25	62.5/54.1		
EHWH04-A20	240/208	60	1	20/15	83.2/72.1		

-- FACTORY REFRIGERANT --

FACTORY CHARGED R410A: 144 OZ. DESIGN PRESSURE PSIG 449 HIGH 238 LOW

-- CLEARANCES --

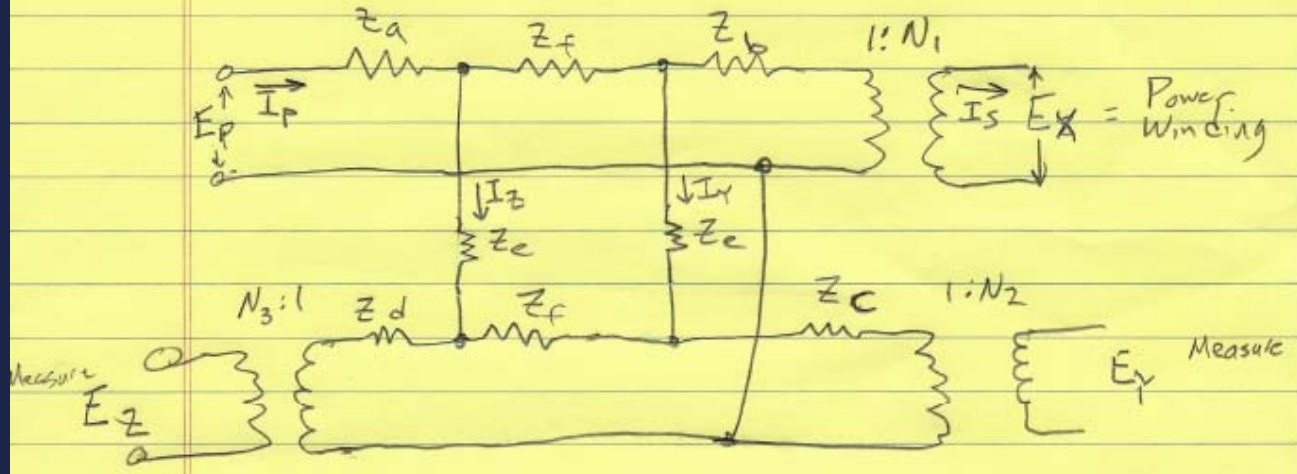
UNIT CASING SUITABLE FOR 0 INCH CLEARANCE.

OUTLET DUCT CLEARANCE 1/4 INCH MINIMUM FOR AT LEAST FIRST 3 FEET OF DUCT. REFER TO INSTALLAT
INSTRUCTIONS FOR ADDITIONAL CLEARANCE INFORMATION. MAXIMUM OUTLET AIR TEMPERATURE: 200
THIS MODEL HAS BEEN TESTED AT STATIC PRESSURES FROM 0 TO .5 IN. WATER COLUMN. CONSULT
INSTALLATION INSTRUCTIONS FOR MAXIMUM PERMITTED STATIC PRESSURE FOR SPECIFIC EQUIPMENT APPL

INSTALLER: WHEN INSTALLING OPTIONAL BARD HEATER PACKAGE: PERMANENTLY MARK THIS SERIAL PLA
SHOW THE INSTALLED HEATER PACKAGE.

(1) ONLY BARD HEATER PACKAGES LISTED ABOVE ARE SUITABLE FOR USE WITH THIS UNIT. USE OF AN

Four Winding Xfmr equivalent circuit
(comes from section 55 of Westinghouse T&D Reference Book)



Assume I_Z and I_Y are magnitizing only (since they are measurement windings) $I_Z = I_Y \to 0$

$$E_Z = \frac{E_P - Z_a I_P - \cancel{I_Z}^{\,0}(Z_d + Z_e)}{N_3} = \frac{E_P - Z_a I_P}{N_3}$$

$$E_Y = \frac{E_P - Z_a I_P - Z_f(I_P - \cancel{I_Z}^{\,0}) - \cancel{I_Y}^{\,0}(Z_e + Z_e)}{N_2} = \frac{E_P - Z_a I_P - Z_f I_P}{N_2}$$

if $I_Z = I_Y \to 0$ then $I_S = I_P N_1$ or $I_P = I_S / N$
if I_S increases, so does I_P
Therefore E_Z and E_Y decrease as I_S increases.

What can I do to prevent nuisance trips when the heat pump kicks on?

- Capacitor Bank Protection is set very sensitive. In this case at 2%.
- Can interlock the heat pump contactor with an 89B contact (humor intended)
- Can add a standard VT to provide voltages for protection.

How would this effect other relaying

- Phase and Ground Distance Protection:
  - Could cause an element to over-reach if a fault occurred at the same instance of a heat pump start.
  - Probably wouldn't affect steady state conditions unless extremely heavily loaded line.

How would this effect other relaying

- Bus Under-voltage:
  - Probably would be unaffected because of the duration.

Lessons Learned

- Capacitor Bank Protection requires very sensitive settings.
- VT error can influence those setting.
- We still spend most of our time talking about instrument transformers.

Thanks for the Time