

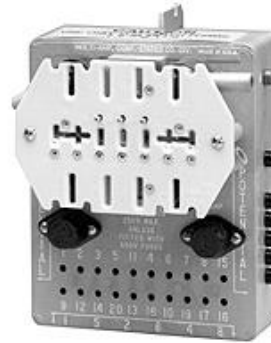


Verifying Transformer Rated Service Installations

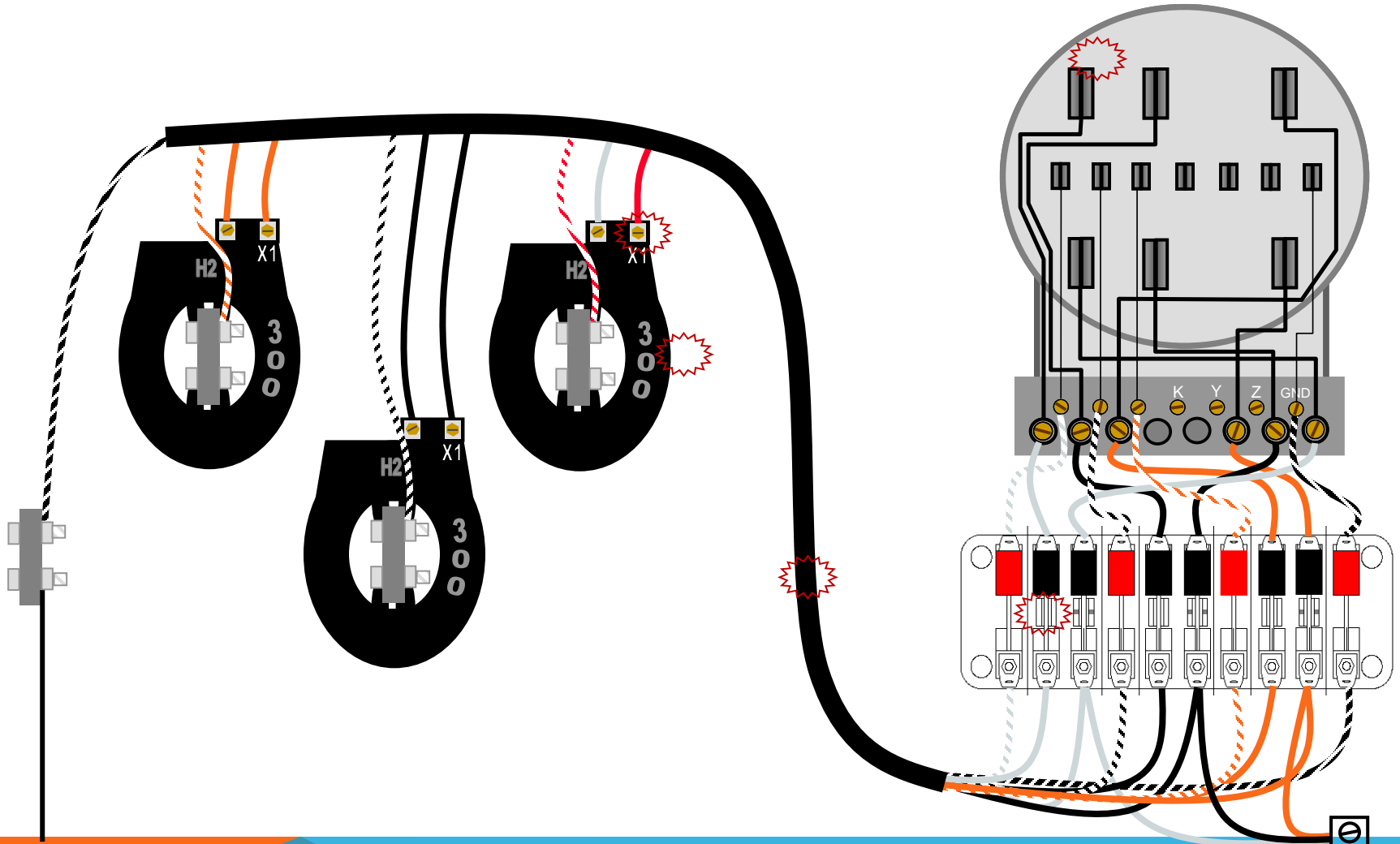
January 2019



Field Meter Testing Using Phantom Load



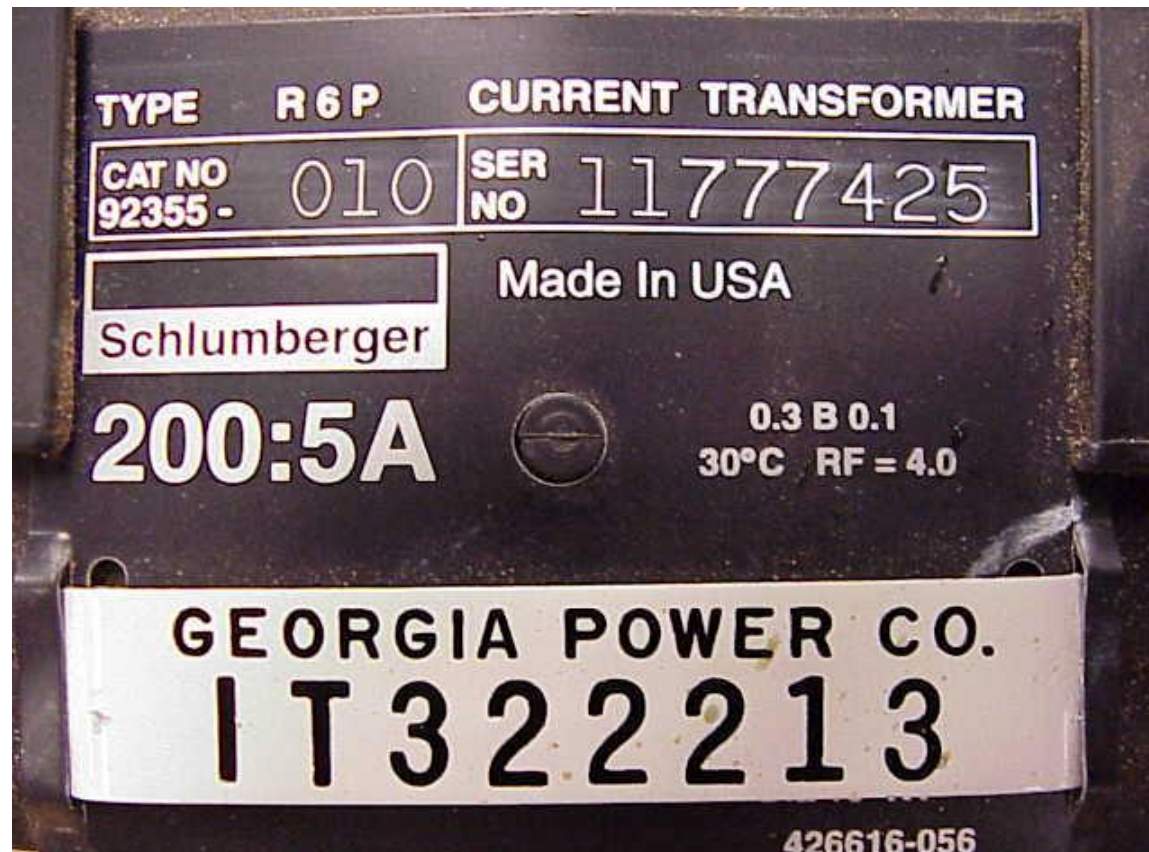
OPPORTUNITY FOR A PROBLEM BEYOND THE METER?



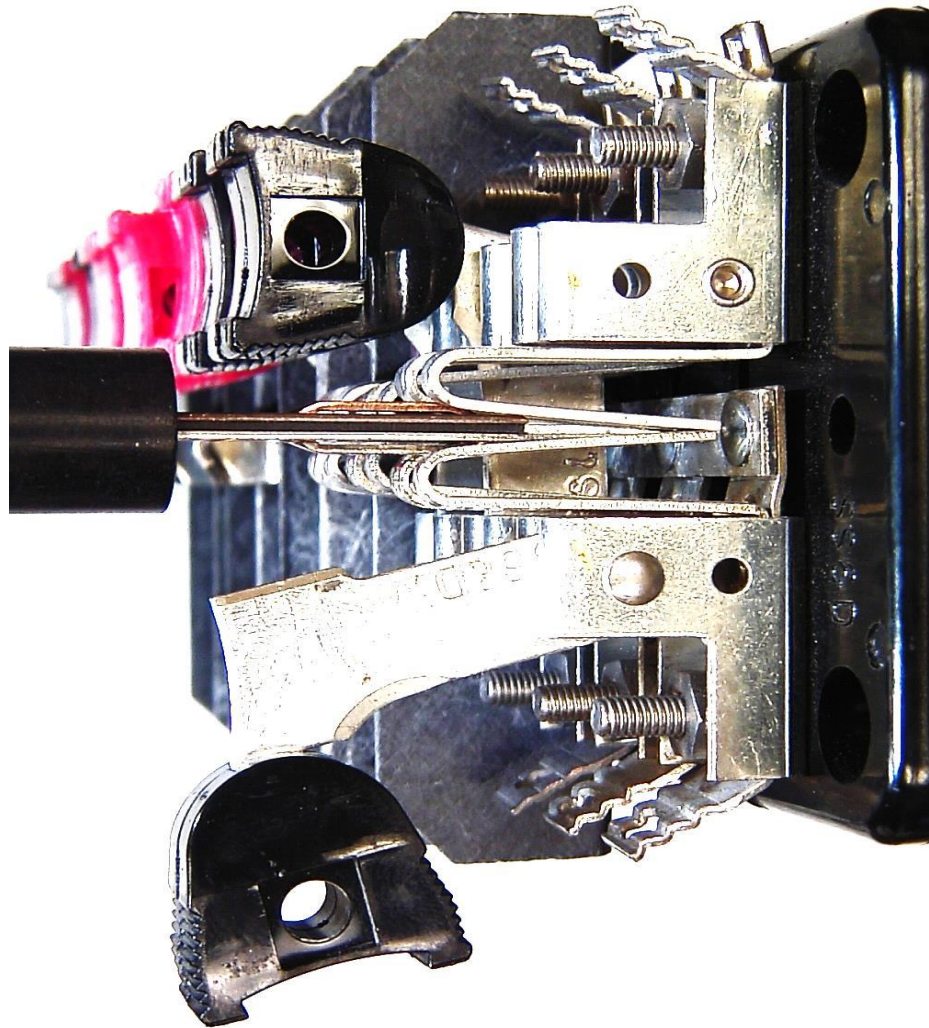
INSTRUMENT TRANSFORMERS



INSTRUMENT TRANSFORMERS



CURRENT RETURN SWITCHES



CURRENT RETURN SWITCHES



C Phase Current in open position

CURRENT RETURN SWITCHES



C Phase Current in closed position making contact with attachment screw for shunt buss.

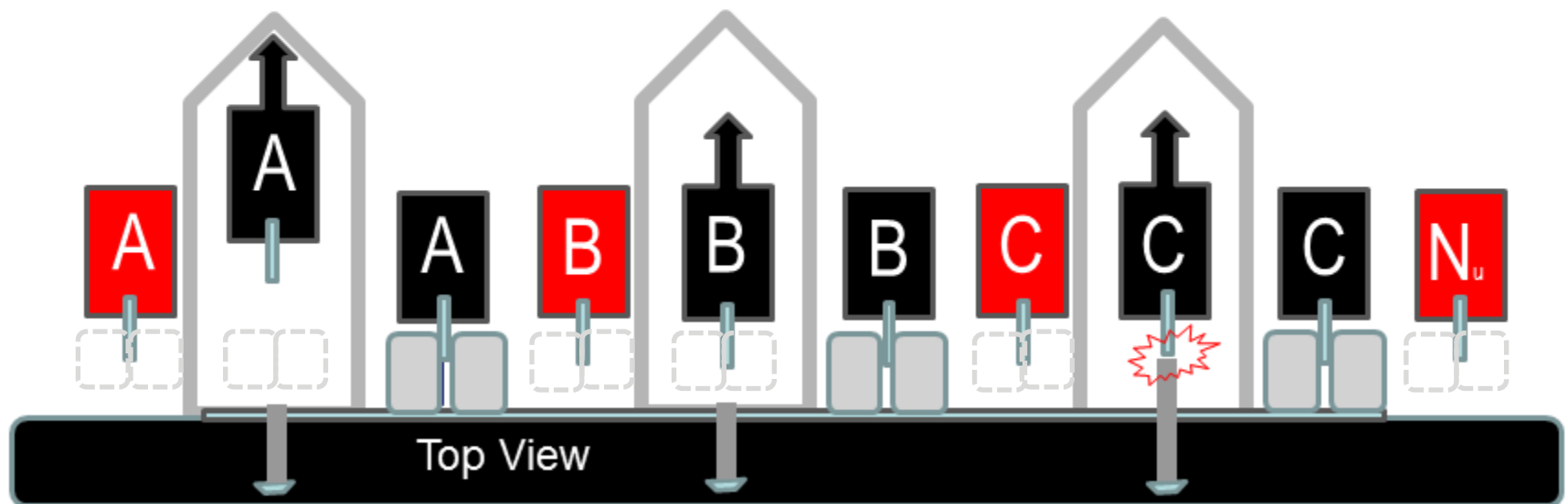
This re-routes current to by pass the meter.

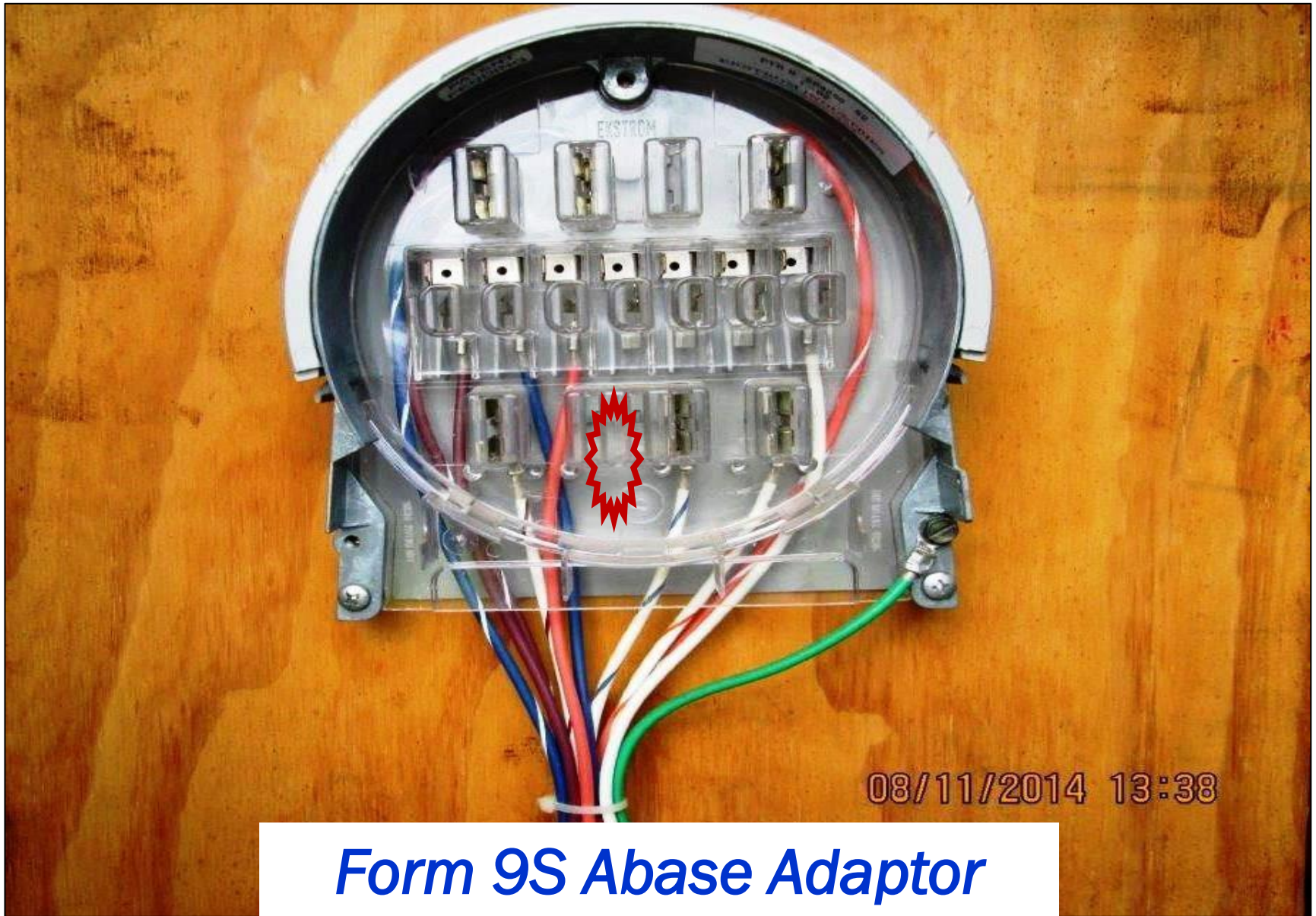
CURRENT RETURN SWITCHES

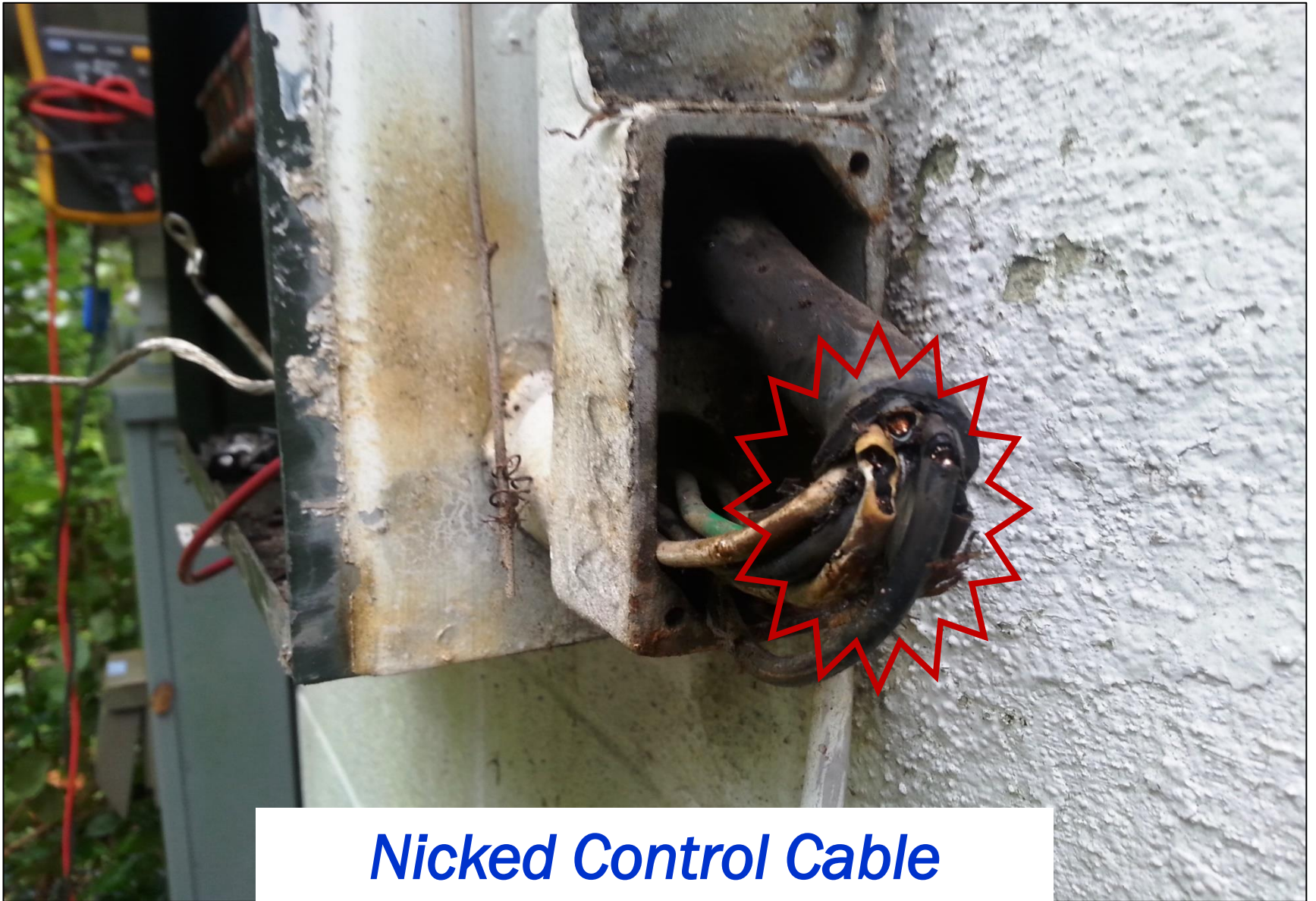
Test switch A in the open position, current circuit is shorted- meter bypassed

Test switch B in the closed position

Test switch C in the closed position, long screw makes improper contact, current circuit is shorted- meter bypassed







Nicked Control Cable

SYSTEM ANALYZERS

**Radian
RD31-221**



**Spinlab
Bird Dog Plus**



**testMET
Gold Miner**



**PowerMetrix
PowerMaster**



SYSTEM ANALYZER WE USE



Testing Options Available On the PowerMaster

 Integrated Site Test Setup

BETA TEST - 462384 - Selected Site: 101

Test Setup **NORMAL TEST** ▼

Meter Tests

☒ Customer Load

Test Mode **Wh** ▼

☐ Do Demand Test

Test Time **0** Seconds

Test Revs **2**

☐ Phantom Load

Phantom Load Setup **None** ▼

Transformer Testing

☒ CT Test Mode **Burden + Ratio** ▼

Max Burden **0.5** ▼

☐ PT Test Mode

Edit Setup

New Setup

Delete Setup

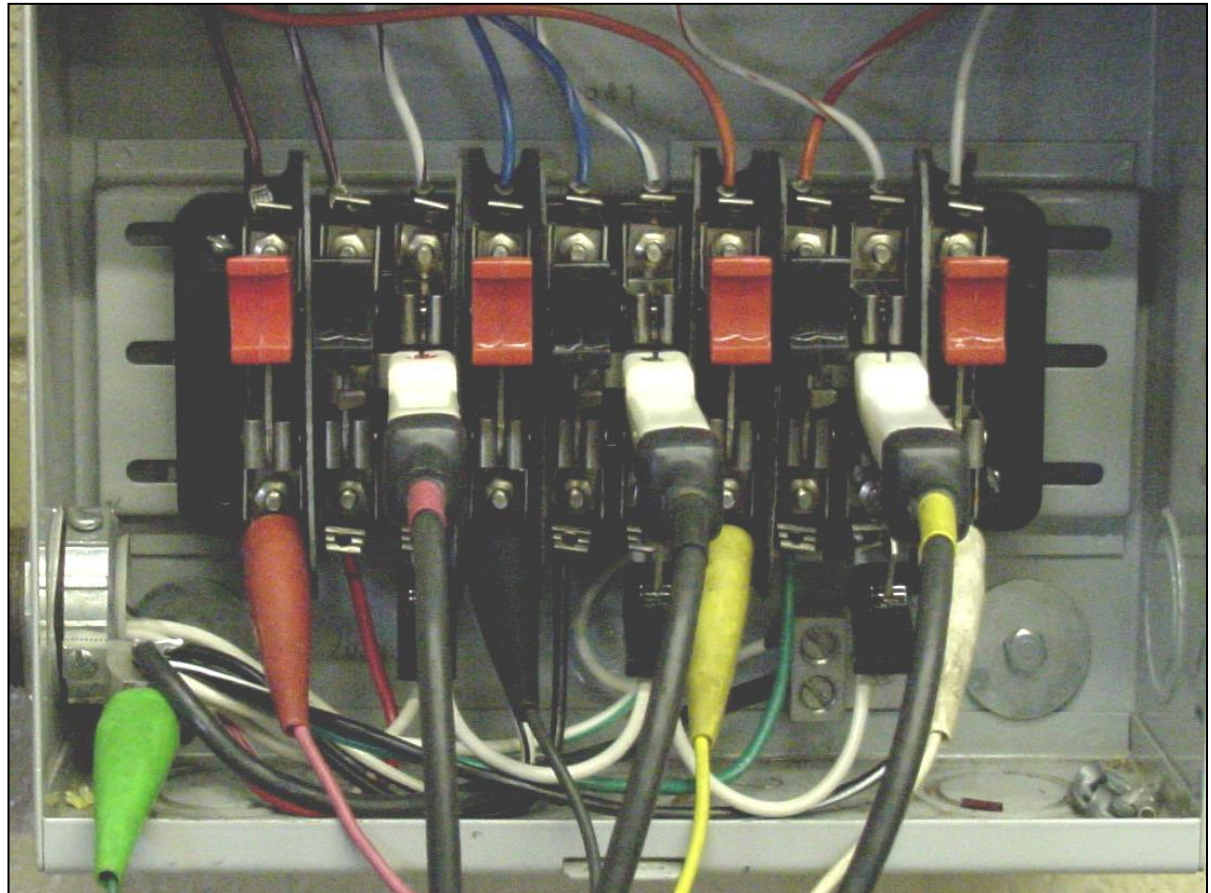
Select

Before Beginning the Integrated Site Scan The Following Steps Must be Performed

Proper PPE must be worn and all Safety Guidelines followed.

Install the Duckbill Current Leads

Connect the Potential Leads making sure they are matched to the proper current.



Select the Vector Analysis Option Before Starting



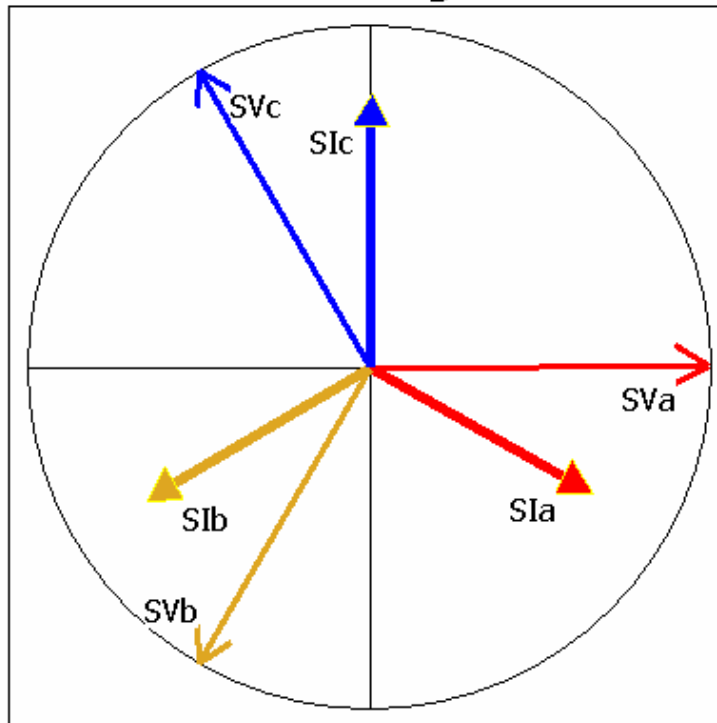
Why ?

View the Vector to Verify your Connections ...

Vector Graph

Selected Site: 3PH 4W WYE (100:5 CT)

Vector Diagram



Φ SVaSIa

SVa	118.747	0.00°
SIa	2.478	29.39°
PF =	0.871	29.39°
Lag		

Φ SVbSIb

SVb	119.579	119.92°
SIb	2.504	149.03°
PF =	0.874	29.11°
Lag		

Φ SVcSIc

SVc	119.885	240.00°
SIc	2.645	270.54°
PF =	0.861	30.54°
Lag		

SYS

Vsys =	119.404
Isys =	2.542
PF =	0.869
ROT =	ABC

Measurement: Live Test, Sec V/Sec I, Instantaneous

Reference

Connect View

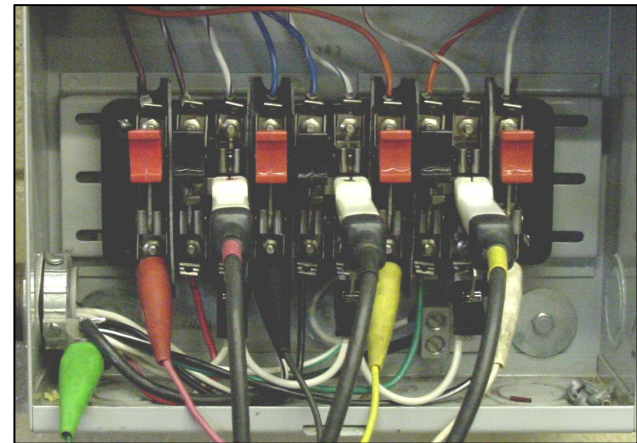
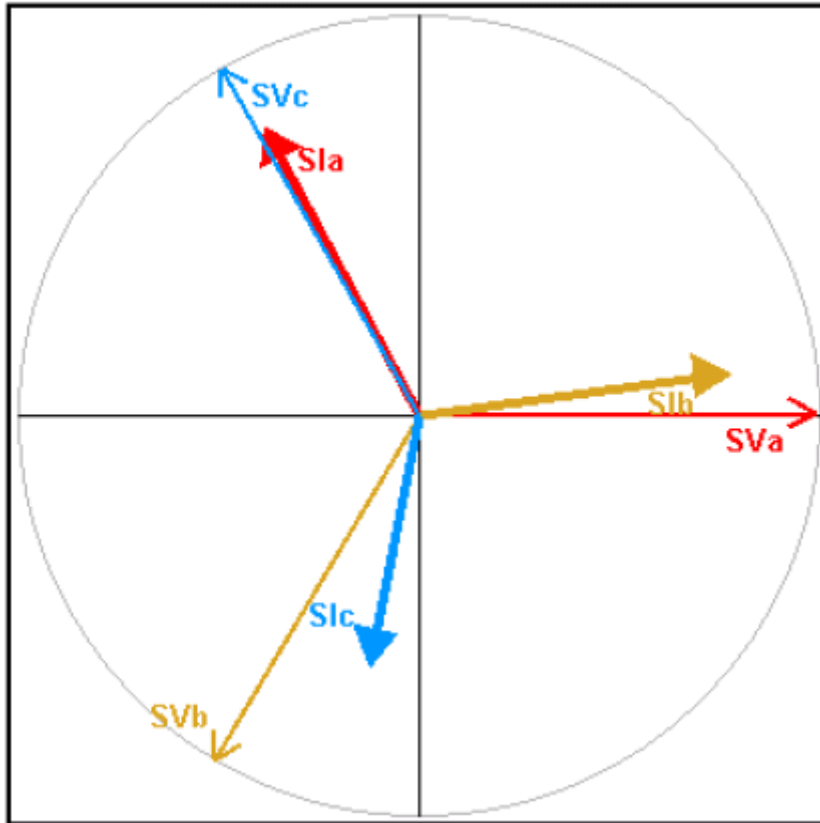
Interval

Sec V/Pri I

Stop

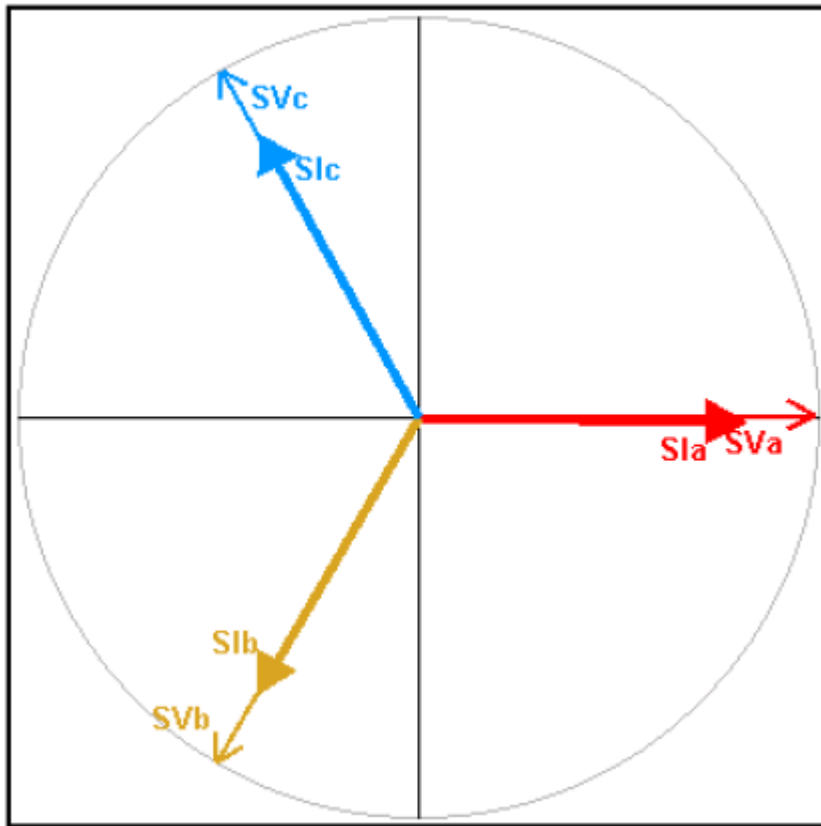
View the Vector to Verify your Connections ...

Meter Vector Diagram



4 Wire Wye Service at Unity Power Factor

Meter Vector Diagram



Waveform Report



Site ID: SCREEN CAPS

Customer:

Test Date: Thursday, January 31, 2013 2:34:17 AM (UTC+05:00)

Service: 3-Phase, 4-Wire, Wye (3V, 3C) TR

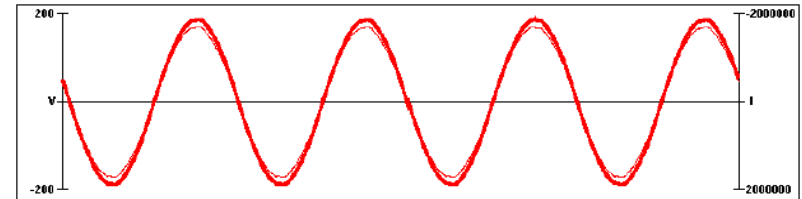
Account No:

Tech 1:

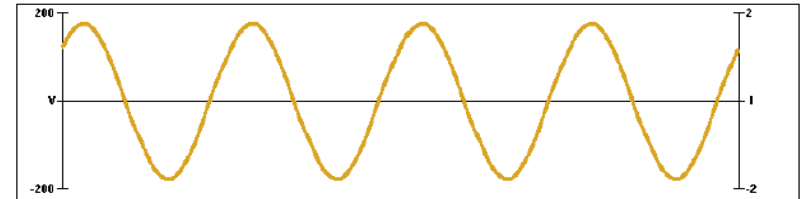
Tech 2:

Sys ID: 7332-130003

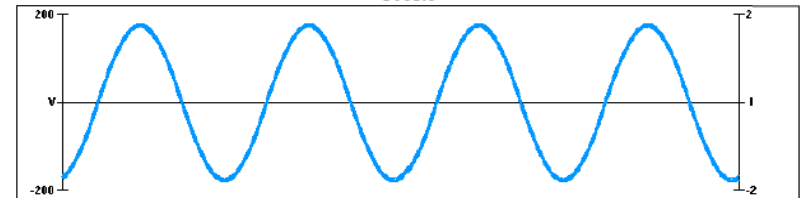
SVaSIa



SVbSIb

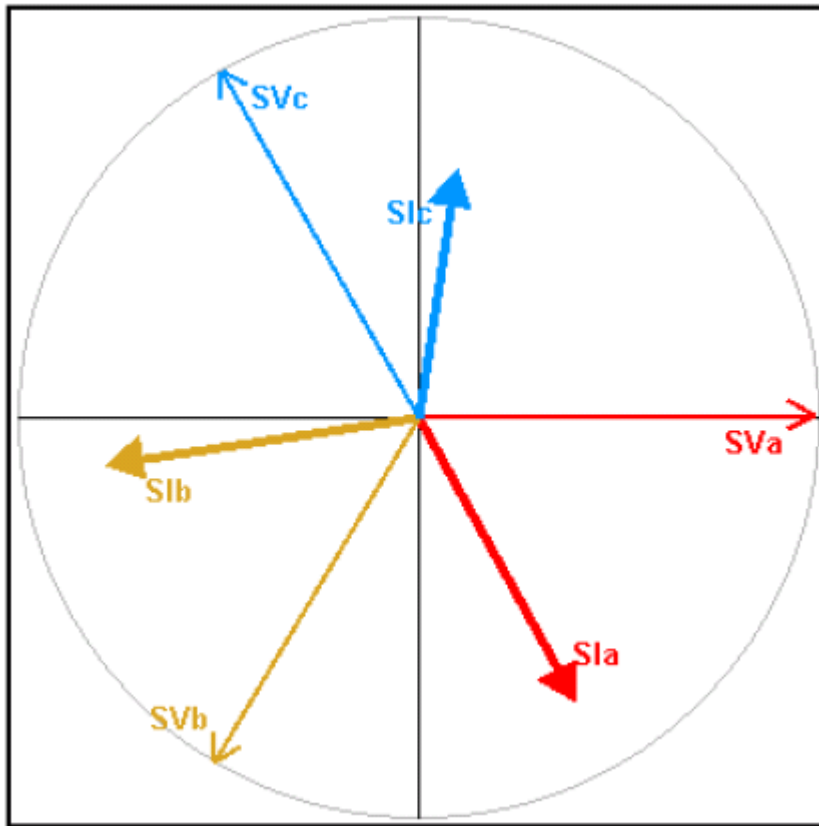


SVcSIc



4 Wire Wye Service at 50% Power Factor

Meter Vector Diagram

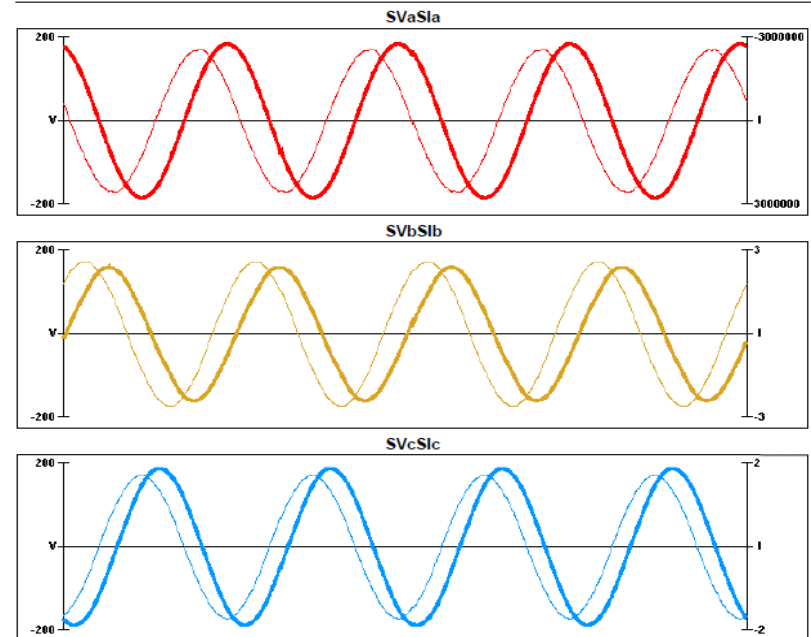


Waveform Report



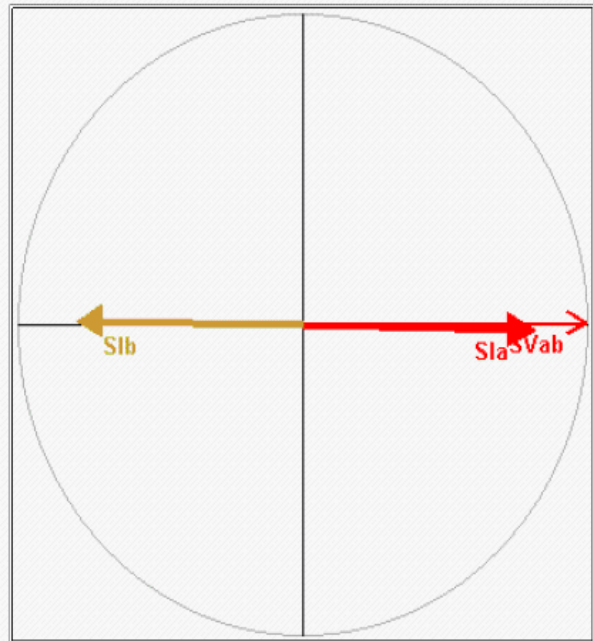
Site ID: SCREEN CAPS
Customer:
Test Date: Thursday, January 31, 2013 2:35:30 AM (UTC+05:00)
Service: 3-Phase, 4-Wire, Wye (3V, 3C) TR

Account No:
Tech 1:
Tech 2:
Sys ID: 7332-130003



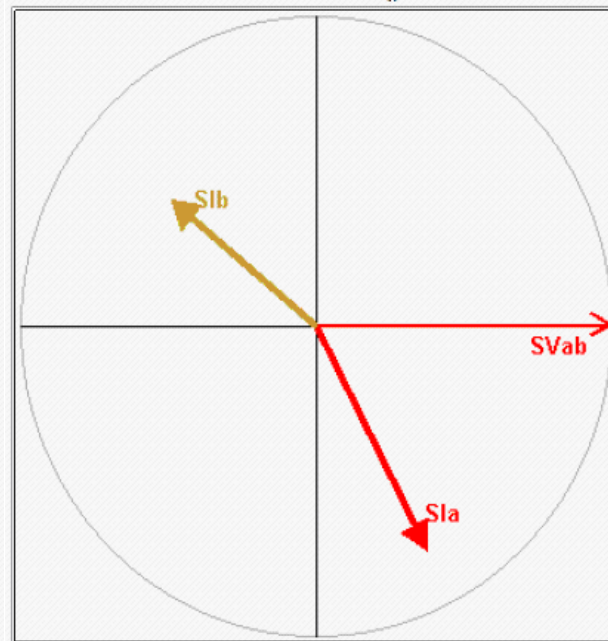
Single Phase Service

Motor Vector Diagram



Unity

Motor Vector Diagram



50% PF

Waveform Report



Site ID: 1PHASE

Account No:

Customer:

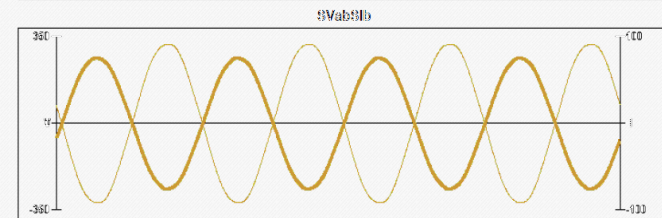
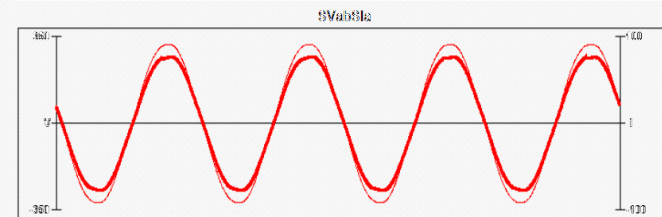
Tech 1:

Test Date: Thursday, January 31, 2013 1:54:22 AM (UTC-05:00)

Tech 2:

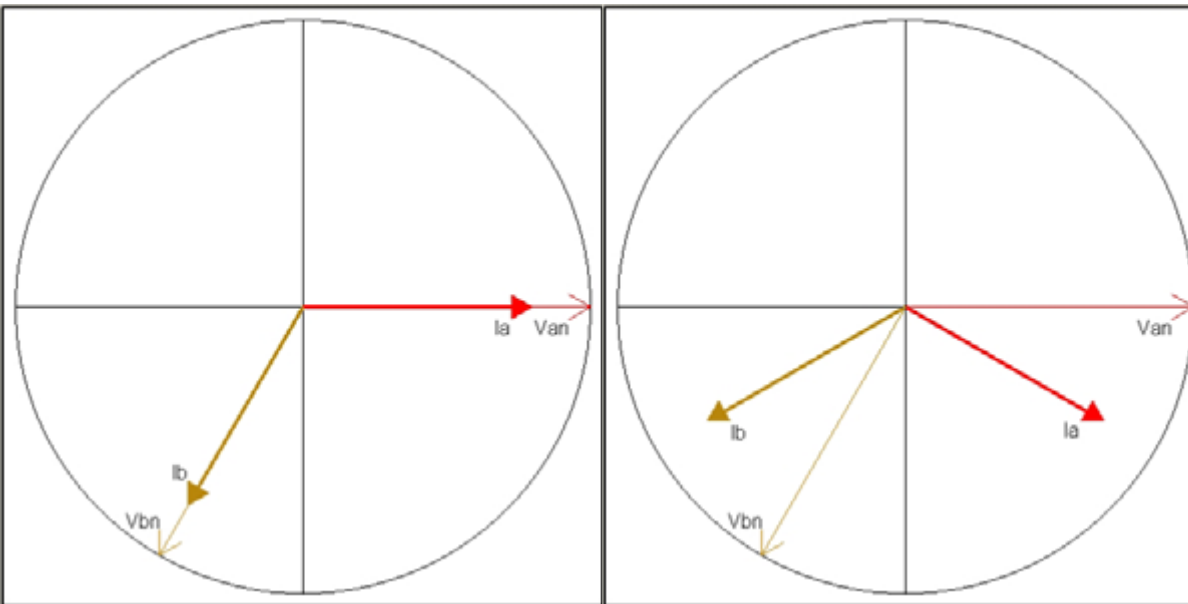
Service: 1-Phase, 3-Wire (1V, 2C) RT

Sys ID: 7332130003



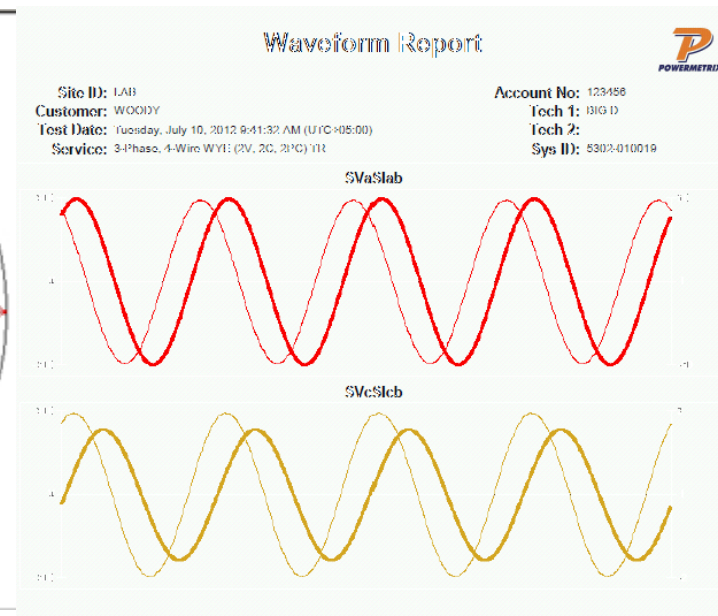
Unity

Three Wire Three Phase Network Service



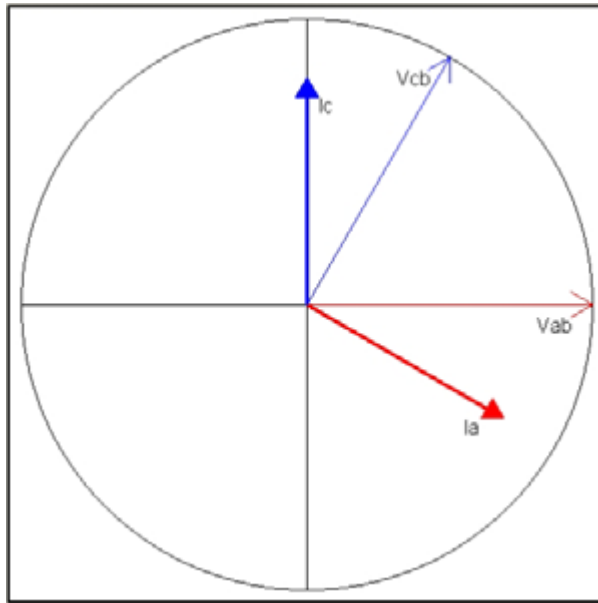
No Lag (1.00 PF)

30° Lag (0.866 PF)

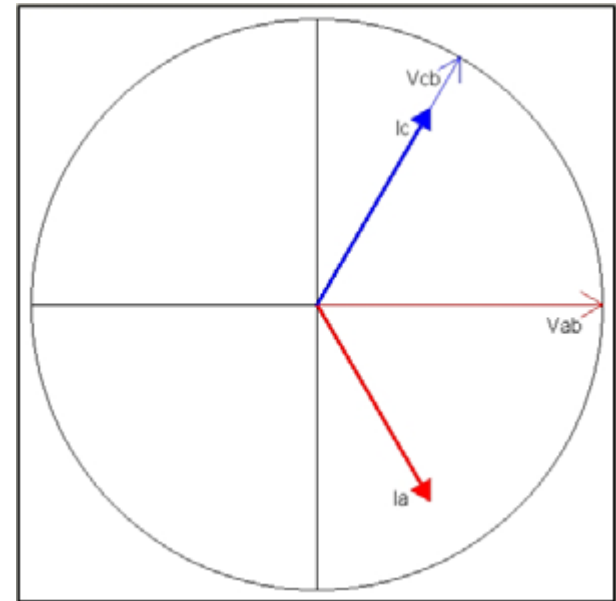


Waveform

Three Wire Three Phase Delta Service

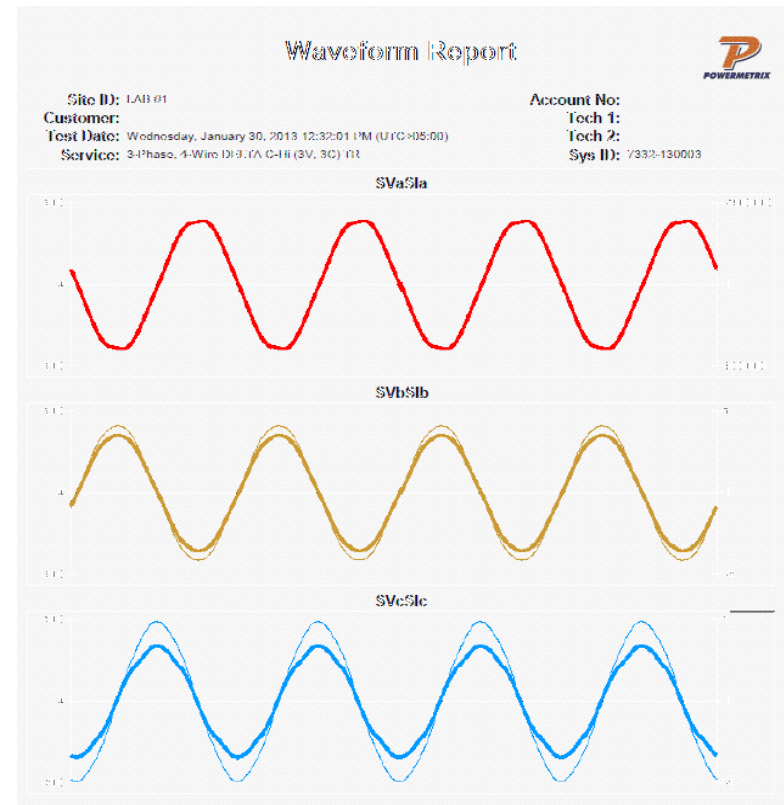
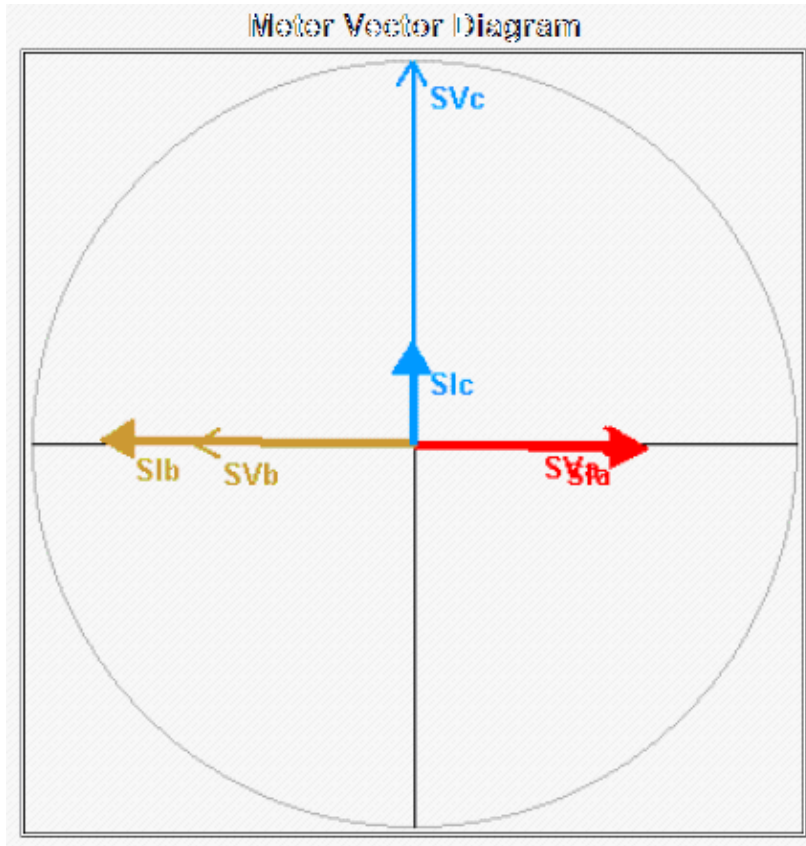


No Lag (1.00 PF)



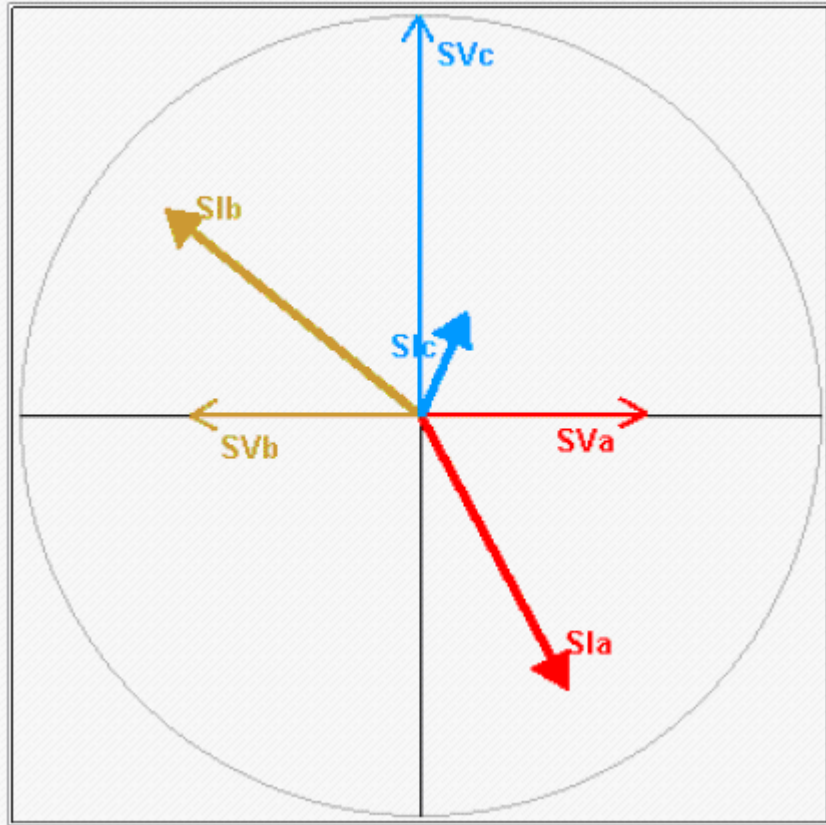
30° Lag (0.866 PF)

Delta Service at Unity Power Factor



Delta Service at 50% Power Factor

Meter Vector Diagram



Waveform Report



Site ID: LAB 01

Customer:

Test Date: Wednesday, January 30, 2013 12:30:14 PM (UTC+05:00)

Service: 3-Phase, 4-Wire 120/208V, C-H (3V, 3C) 100

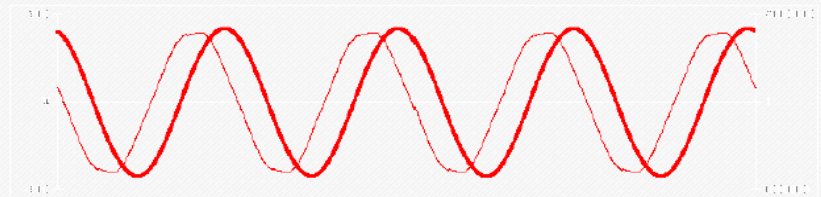
Account No:

Tech 1:

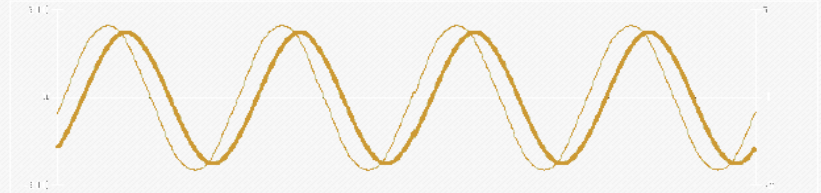
Tech 2:

Sys ID: 7332-130003

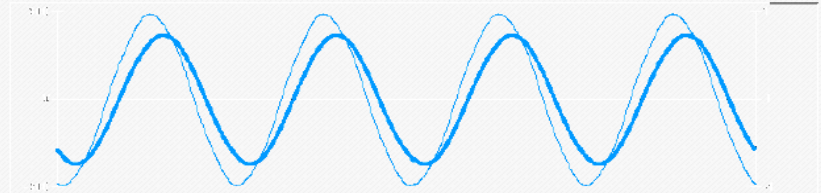
SVaSIa



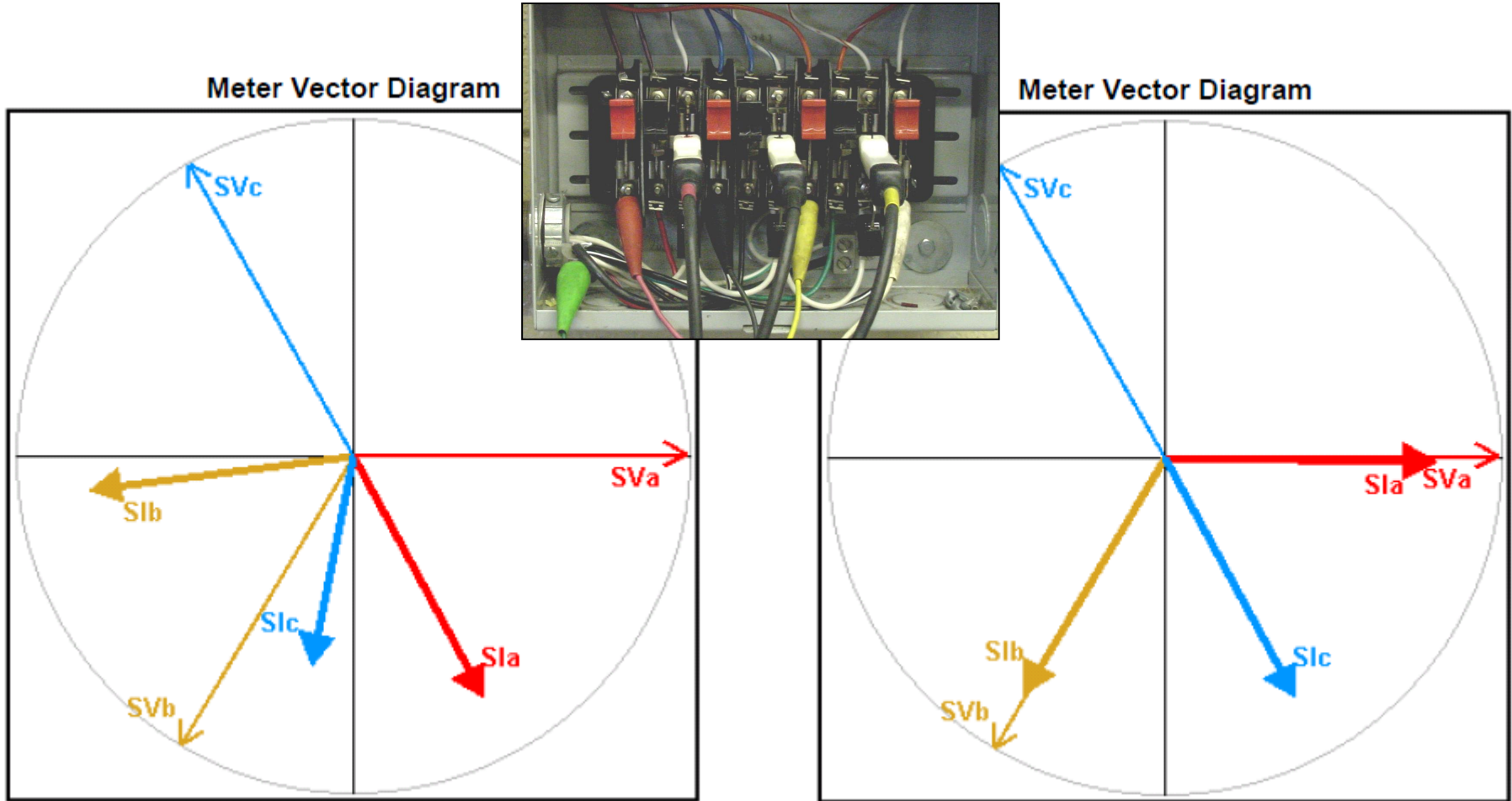
SVbSIb



SVcSIc

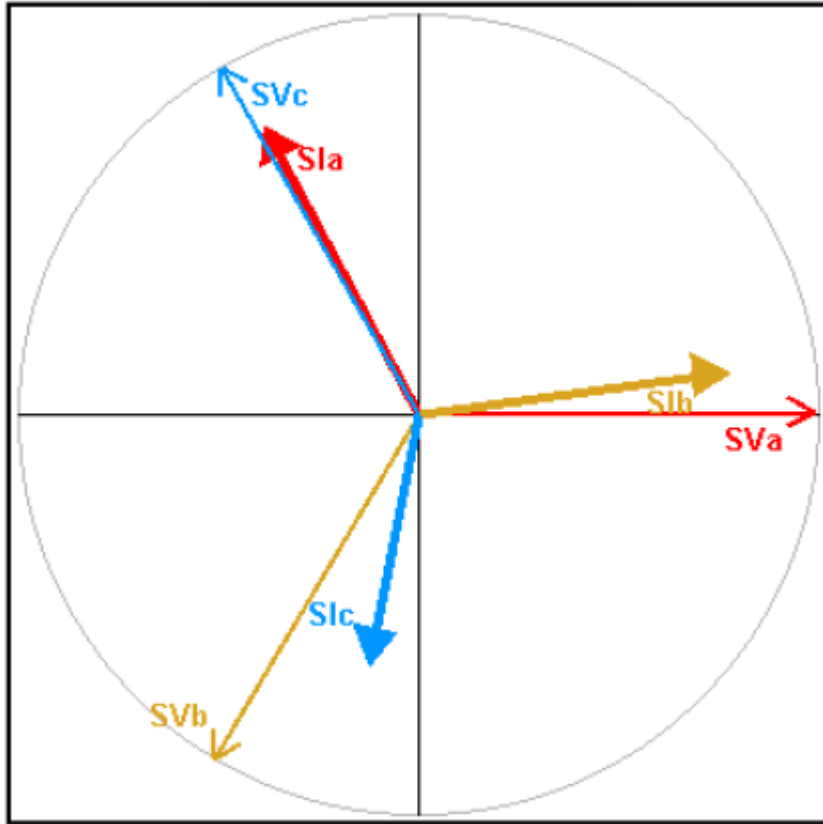


VIEW THE VECTOR TO VERIFY YOUR CONNECTIONS ...

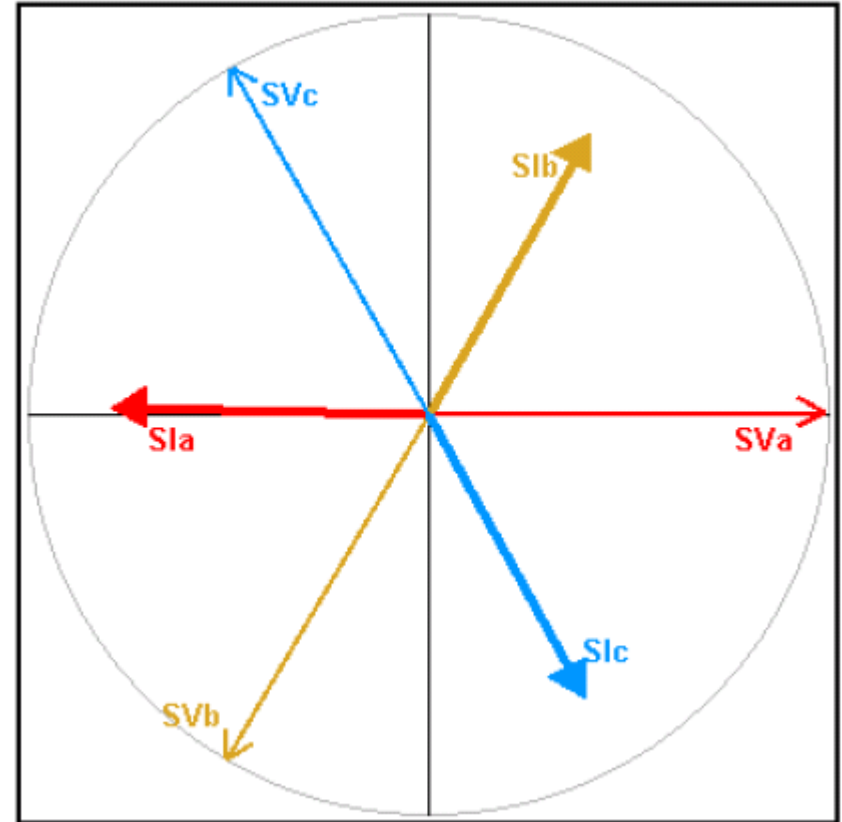


View the Vector to Verify your Connections ...

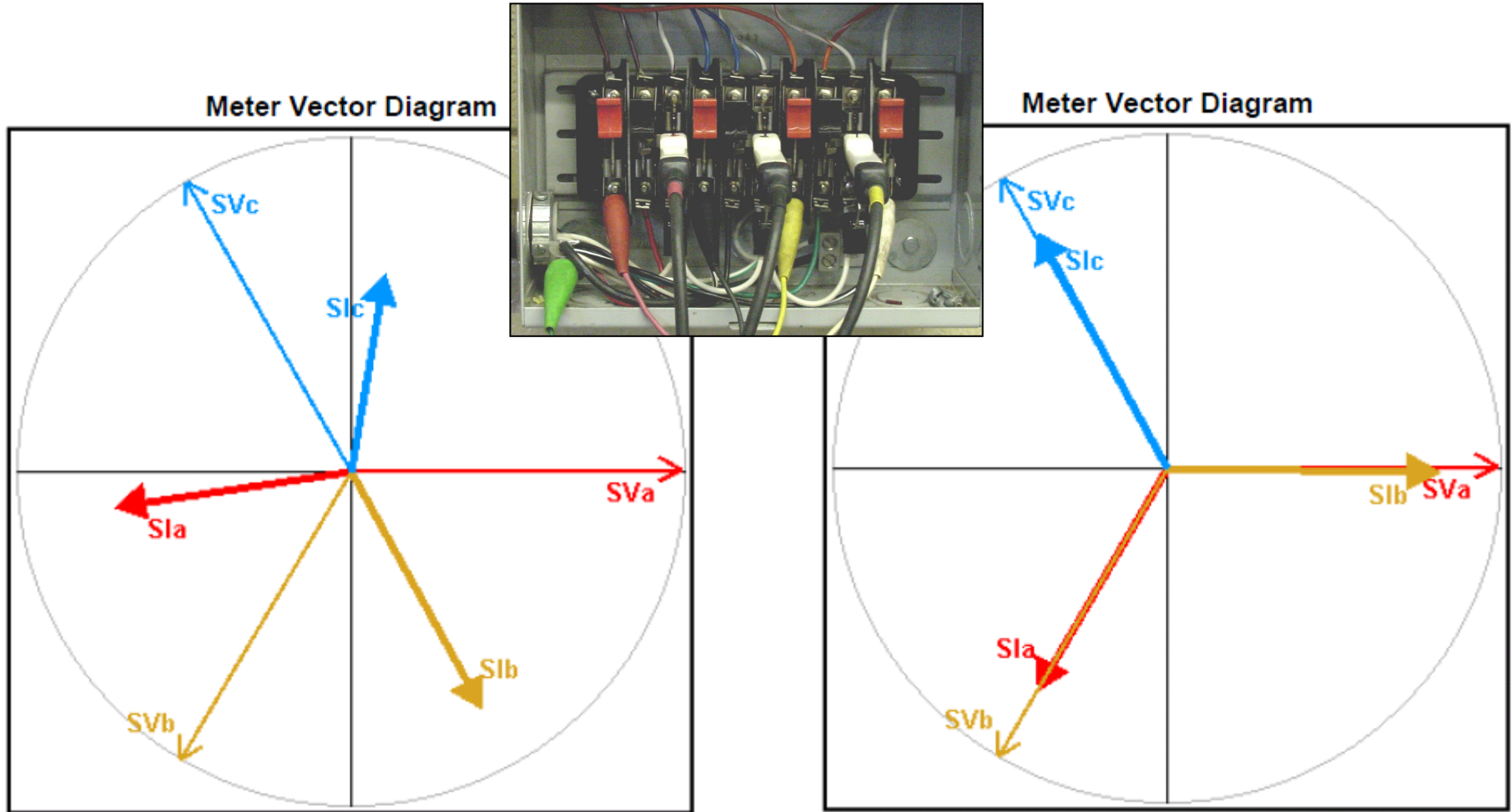
Meter Vector Diagram



Meter Vector Diagram



View the Vector to Verify your Connections ...

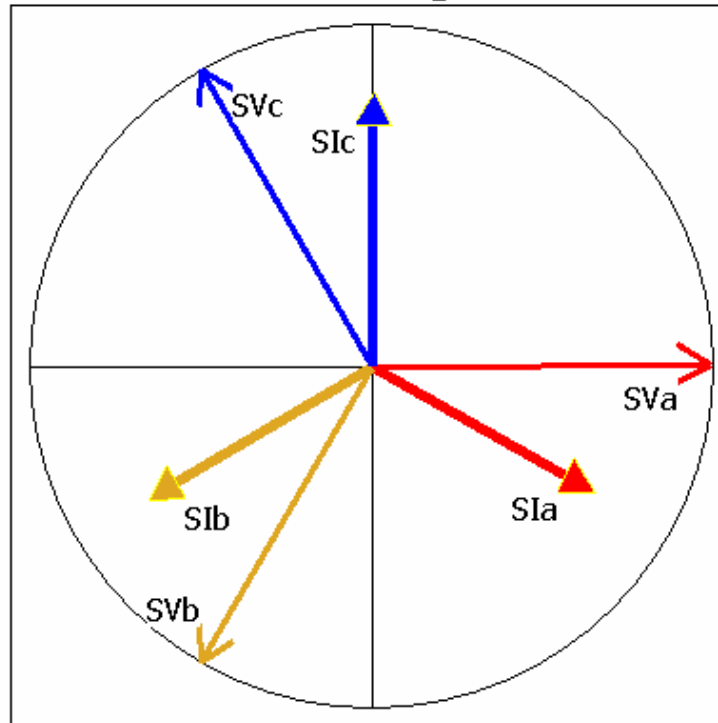


What your Looking For!

Vector Graph

Selected Site: 3PH 4W WYE (100:5 CT)

Vector Diagram



Φ SVaSIa

SVa	118.747	0.00°
SIa	2.478	29.39°
PF =	0.871	29.39°
Lag		

Φ SVbSIB

SVb	119.579	119.92°
SIB	2.504	149.03°
PF =	0.874	29.11°
Lag		

Φ SVcSIC

SVc	119.885	240.00°
SIC	2.645	270.54°
PF =	0.861	30.54°
Lag		

SYS

Vsys =	119.404
Isys =	2.542
PF =	0.869
ROT =	ABC

Measurement: Live Test, Sec V/Sec I, Instantaneous

Reference

Connect View

Interval

Sec V/Pri I

Stop

**Correct Vector
Potentials and Currents Match.
Start the Scan**

INTEGRATED SITE TEST

- P** Main Menu BETA TEST - p19.00M/v16.94M/c#326.13K - Selected Site: 9S
- 1** Select Site
 - 2** Integrated Site Test
 - 3** Meter Testing
 - 4** Instrument Transformer Testing
 - 5** Data Trending
 - 6** Transducer Testing
 - 7** Deselect Site
 - 8** Utilities
 - 9** Recall Data

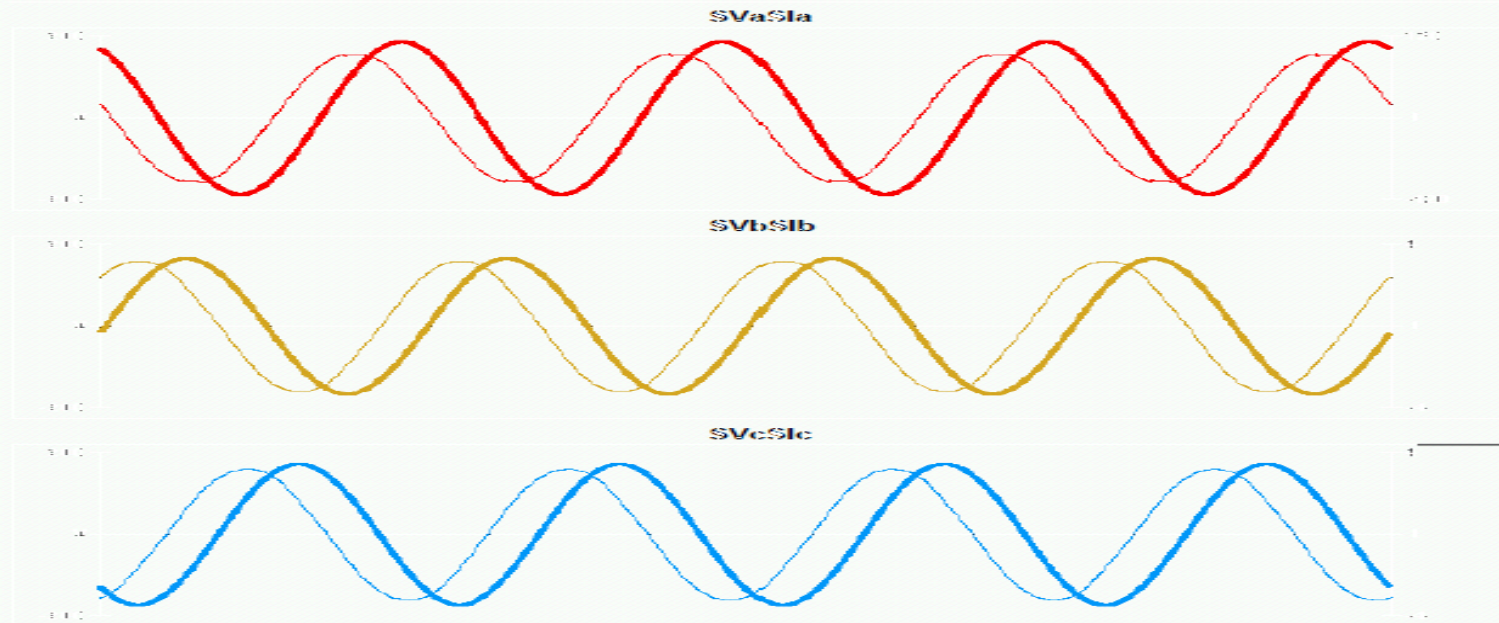
Capture of Sine Waves of Amps & Volts

Waveform Report



Site ID: BIG DADDY'S
Customer: BIG D
Test Date: Friday, September 07, 2012 9:57:59 AM (UTC+05:00)
Service: 3-Phase, 4-Wire, Wyo (3V, 3C) 112

Account No: 007
Tech 1: BIG D
Tech 2: BIG G
Sys ID: 5302-010019

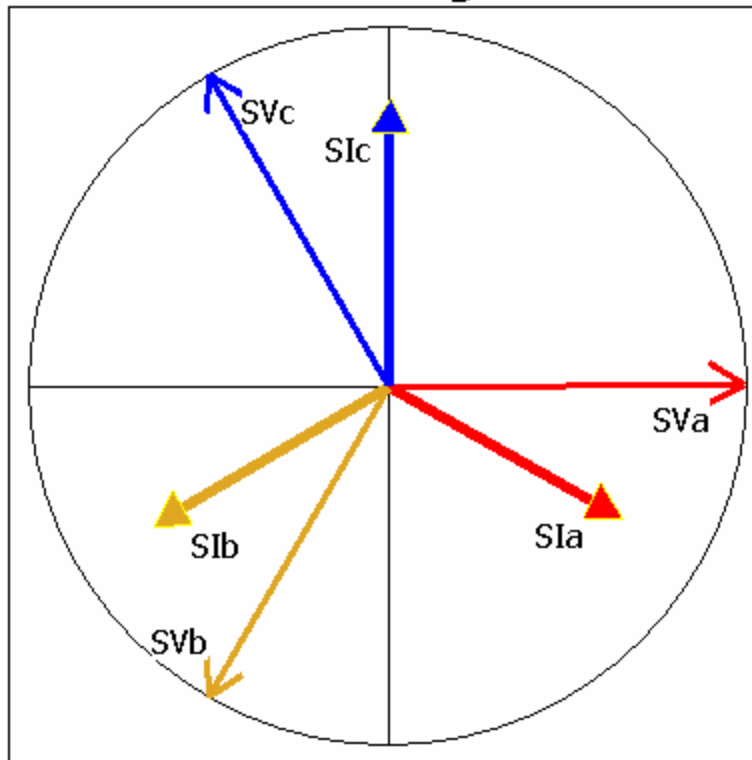


Capture of Vector

Vector Graph

Selected Site: 3PH 4W WYE (100:5 CT)

Vector Diagram



Φ SVaSIa

SVa	118.747	0.00°
SIa	2.478	29.39°
PF =	0.871	29.39°
Lag		

Φ SVbSIb

SVb	119.579	119.92°
SIb	2.504	149.03°
PF =	0.874	29.11°
Lag		

Φ SVcSIc

SVc	119.885	240.00°
SIc	2.645	270.54°
PF =	0.861	30.54°
Lag		

SYS

Vsys =	119.404
Isys =	2.542
PF =	0.869
ROT =	ABC

Measurement: Live Test, Sec V/Sec I, Instantaneous

Reference

Connect View

Interval

Sec V/Pri I

Stop

Captures System Overall Summary

“Breakdown Of Vector”

Power Meter

Selected Site: 4W Y 3V 3C S000F09

SYSTEM OVERALL SUMMARY

	Φ SVaSIa	Φ SVbSIb	Φ SVcSIc	SYSTEM
V(FDRMS)	118.5935	119.4417	119.7183	119.2512
V(Fund)	118.5872	119.4416	119.7181	119.2490
I(FDRMS)	2.506571	2.544676	2.672775	2.574674
A(Fund)	2.506556	2.544665	2.672768	2.574663
$V\theta$	0.0000°	119.8656°	239.9556°	
$I\theta$	359.9395°	119.8011°	241.0687°	
DPF θ	-0.060506°	-0.064425°	1.113085°	
PF(PF1a)	0.999999	0.999999	0.999811	0.999937
W(P1)	297.2454	303.9387	319.9184	921.1025
VA(S1)	297.2456	303.9389	319.9788	921.1633
VAR(Q1)	-0.314487	-0.341550	6.216074	5.560037
THD V	1.030761%	0.125475%	0.173148%	0.443128%
THD I	0.337406%	0.297266%	0.238195%	0.290956%
FREQ	60.00011	60.00008	60.00012	60.00011

Measurement: Live Test, Sec V/Sec I, Instantaneous

Connect.View

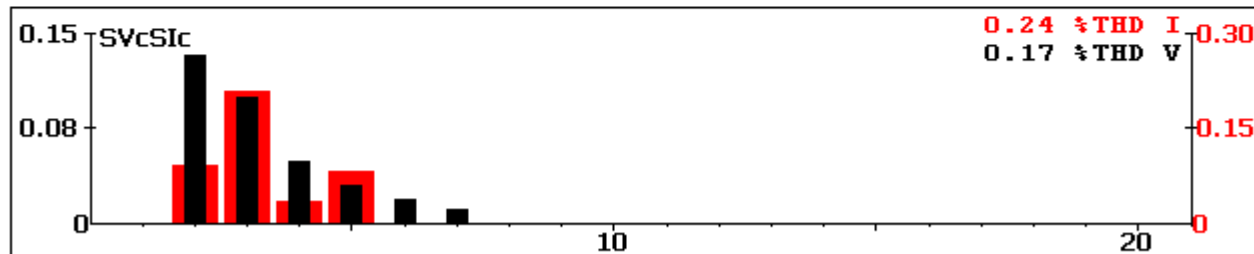
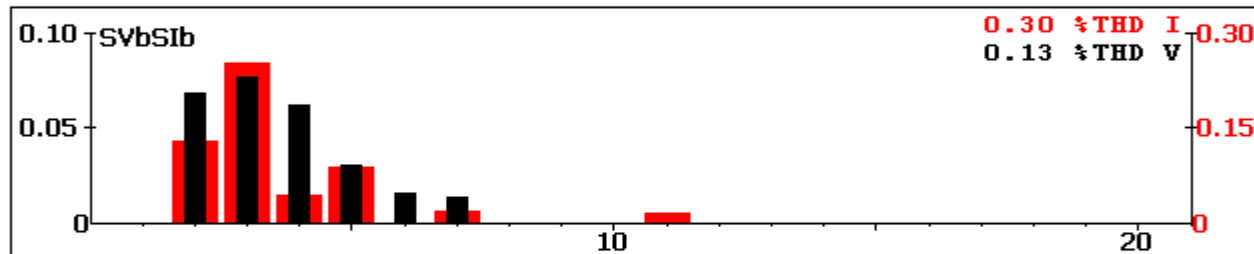
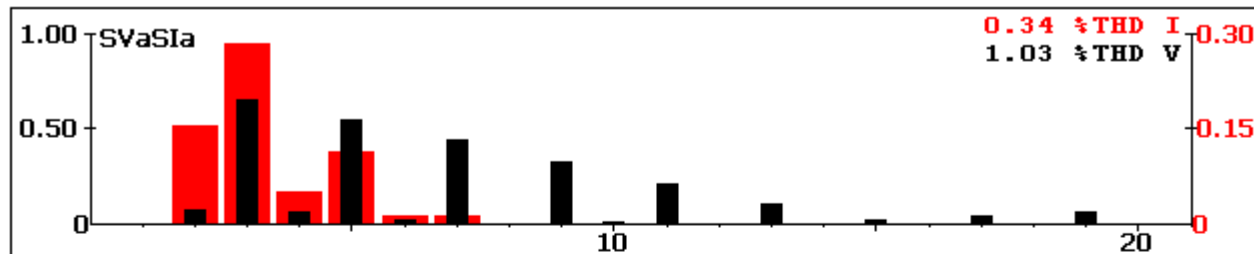
Interval

Sec V/Pri I

Stop

Harmonics for Amp And Volts

Harmonic Analysis Selected Site: 4W Y 3V 3C S000F09



Measurement: Live Test, Sec V/Sec I, Instantaneous

Details Connect.View Interval Sec V/Pri I Amplitude Stop

Amps

Volts

Harmonics

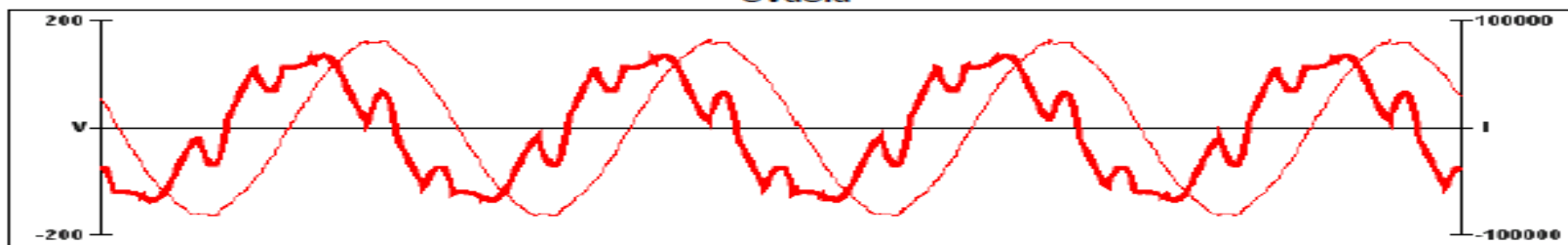
Waveform Report



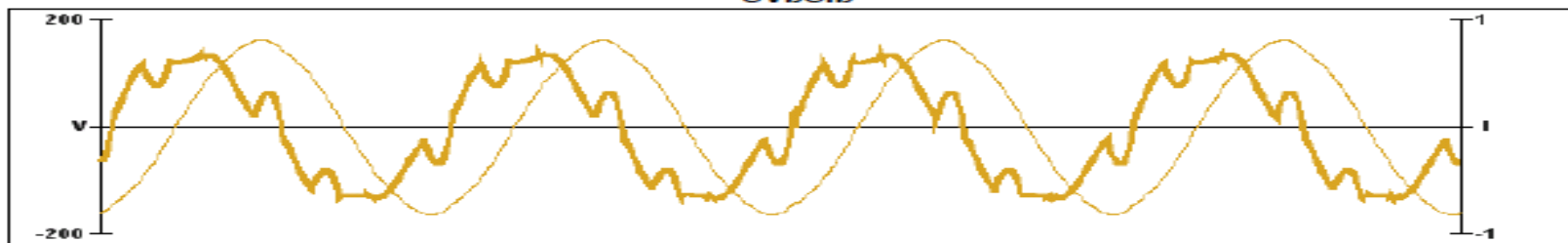
Site ID: CIRCUIT4 5 CONCOURSE PKY
Customer: CONCOURSE V ASSOC
Test Date: Thursday, January 24, 2013 1:57:36 PM (UTC+05:00)
Service: 3-Phase, 4-Wire, Wye (3V, 3C) TR

Account No: 3386301
Tech 1: BOB HENRY
Tech 2:
Sys ID: 5302-010025

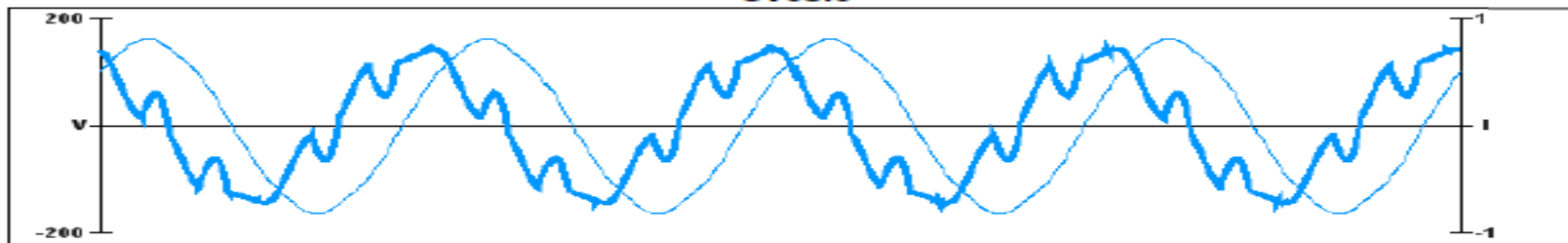
SVaSIa



SVbSIb



SVcSIc



CAUSES OF HARMONICS

Harmonics are caused by devices that use an irregular current sinewave when the normal sinewave voltage is applied

LINEAR LOADS (Few Harmonics)

- Incandescent Lights
- Heating Loads (Resistive)
- Some Motors

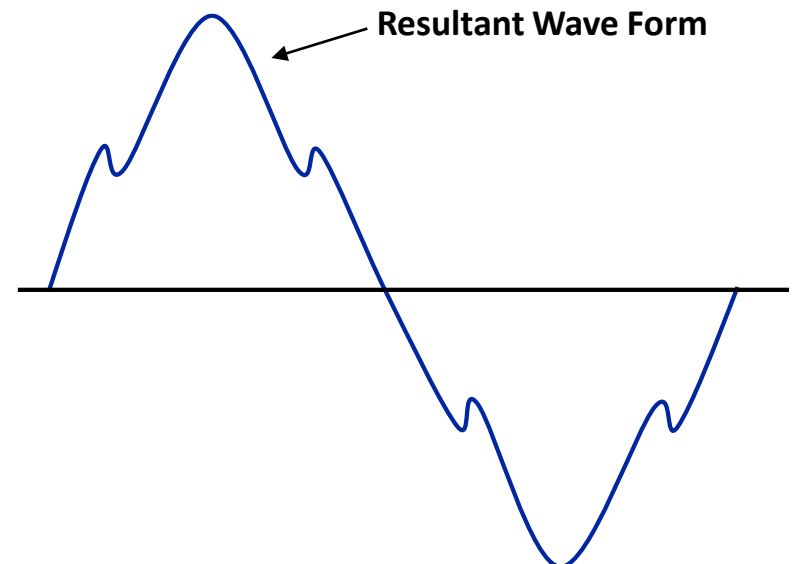
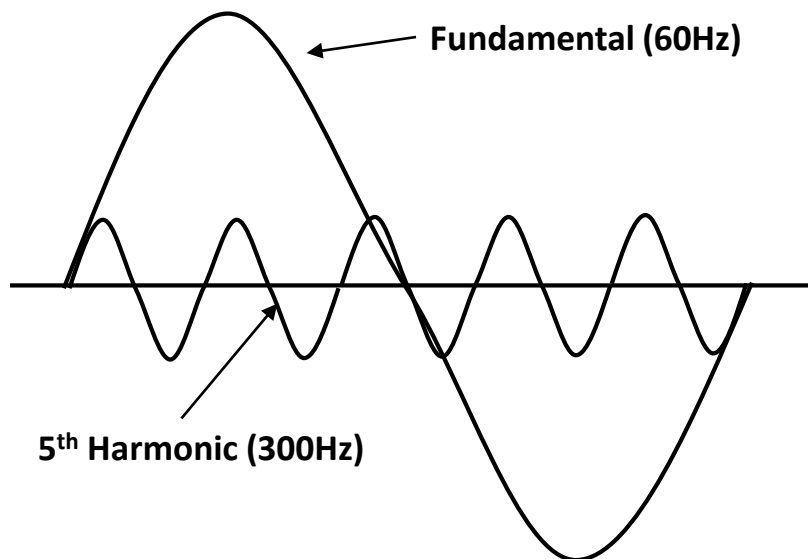
NON-LINEAR LOADS (Harmonics)

- DC Drives
- Power Rectifiers
- Compact Fluorescent Bulbs

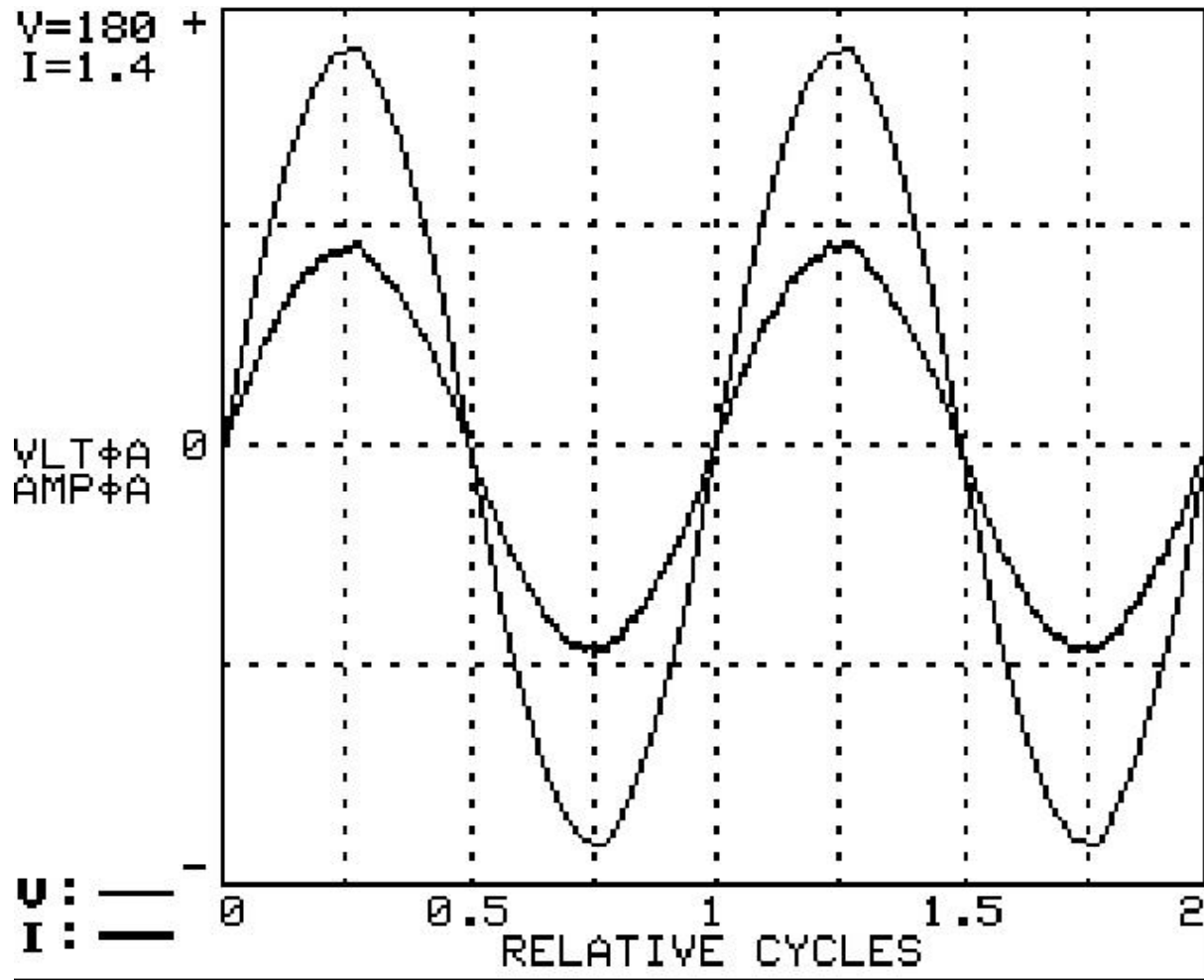
HARMONIC DISTORTION

Harmonic waveforms are simply multiples of the fundamental waveform.

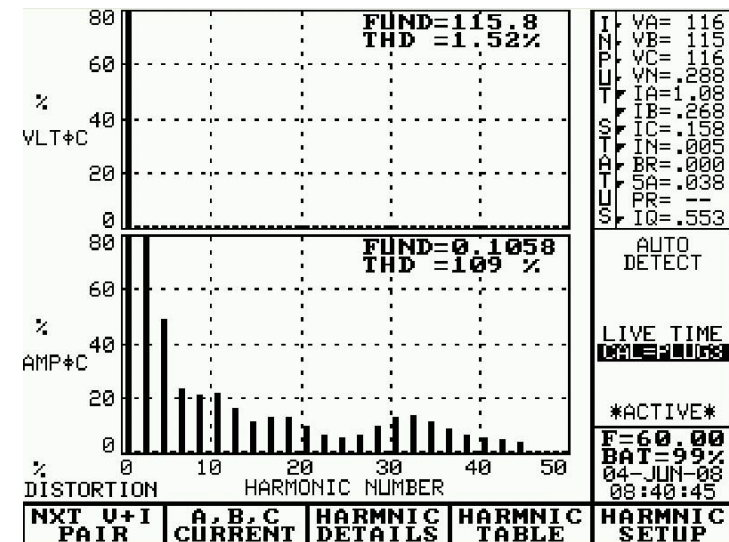
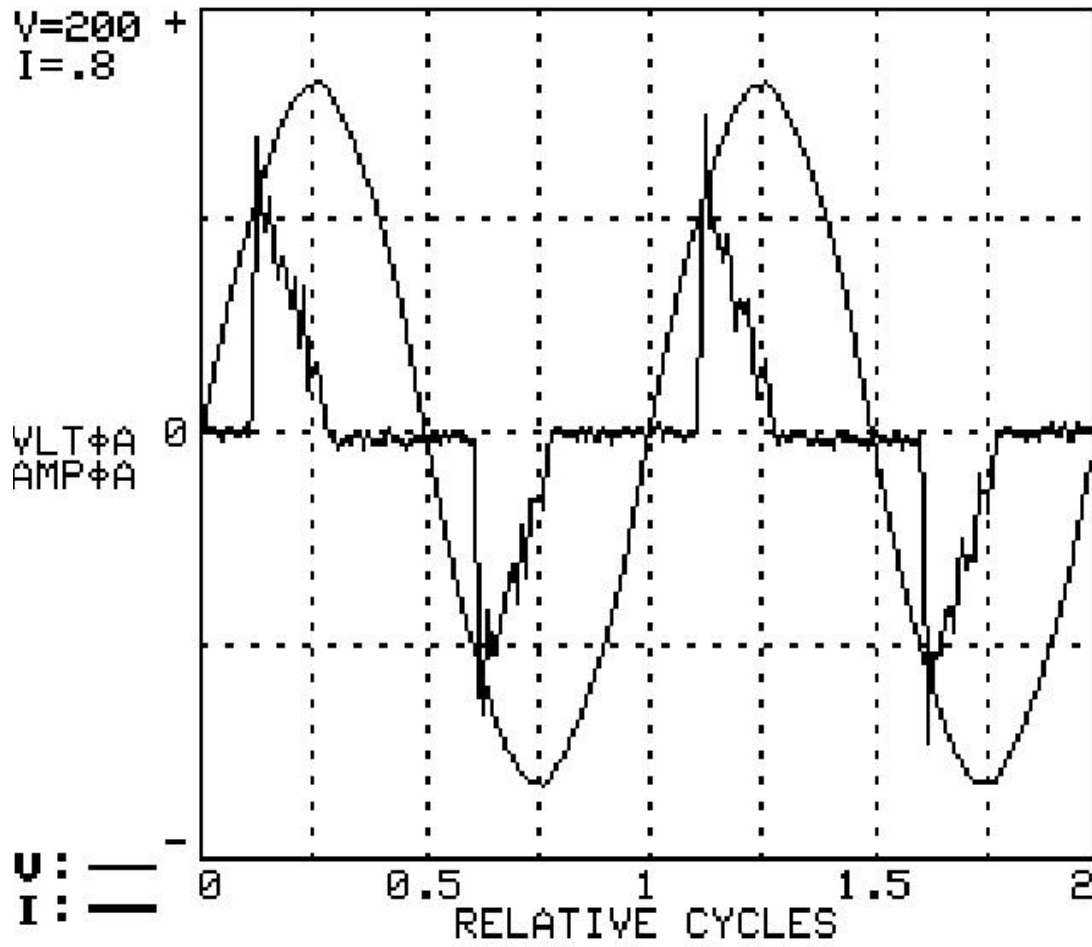
The graphs below show the relationship between a fundamental (60 Hz) current waveform and a 5th harmonic (300 Hz) component with about 25% peak deviation.



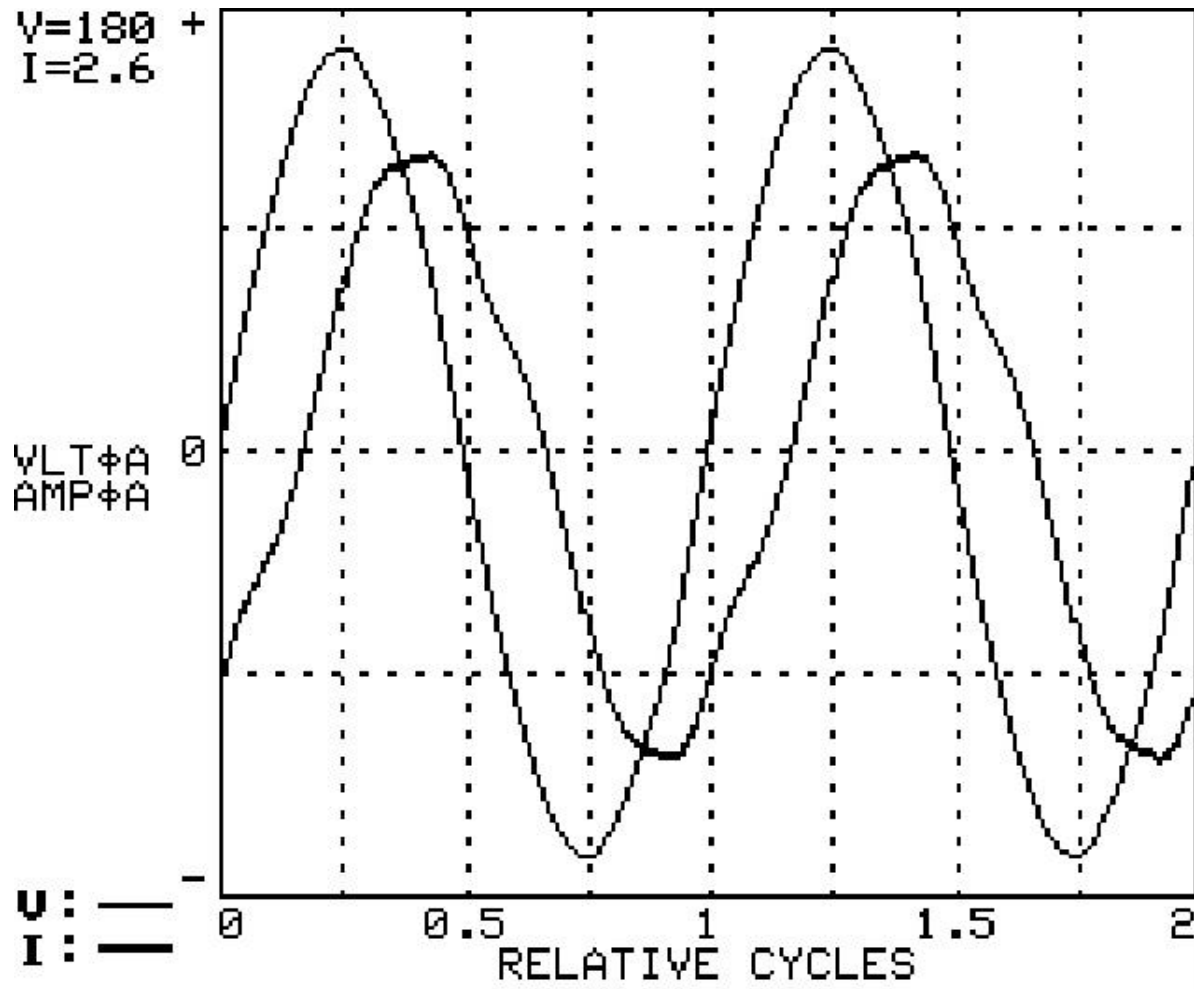
INCANDESCENT BULB



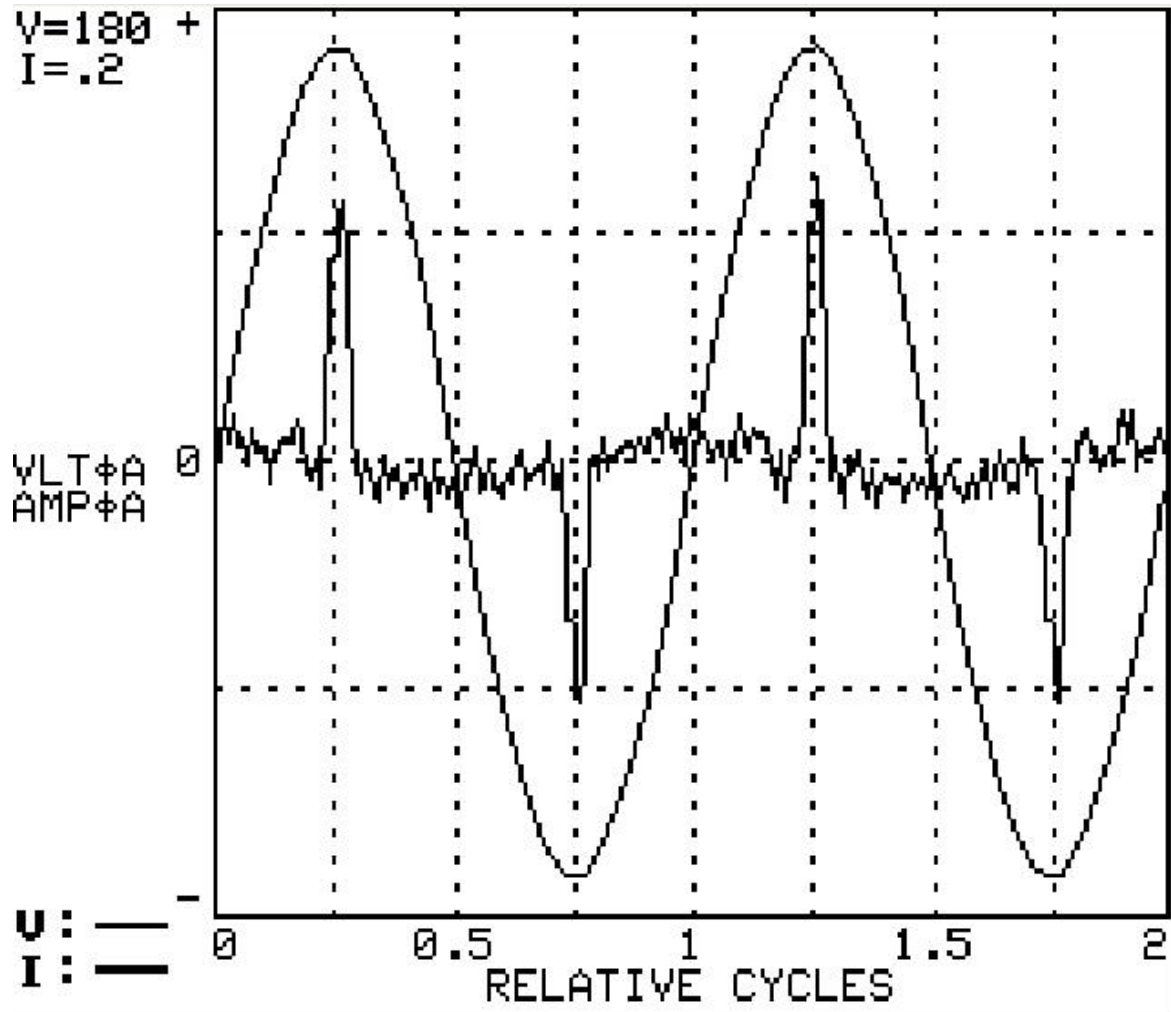
COMPACT FLUORESCENT BULB



MOTOR



POWER SUPPLY FOR LAP TOP COMPUTER



Meter Accuracy Test

 Main Menu BETA TEST - p19.00M/v16.94M/c#326.13K - Selected Site: 9S

1 Select Site

2 Integrated Site Test

3 Meter Testing

4 Instrument Transformer Testing

5 Data Trending

6 Transducer Testing

7 Deselect Site

8 Utilities

9 Recall Data

Meter Accuracy Test

Customer Load Test Results

Selected Site: HIGH SCHOOL

Customer Load Meter Test Wh Test

% Registration 100.055

Test Info

Sys Info

Time(sec)	20.275	Wh	5.3971
Time Left	0.000	VAh	5.3973
Pulses Exp	2.9984	VARh	-0.0435
Pulses Act	3.0000	V	119.473
Meter PF	1.0000	I	2.6770

Phantom Load Results

Selected Site: None

FL

99.902

Phase	Voltage	Current	PF	Time	Pulses
All	120.01	30.009	1.000	36.03	4

PF

99.866

Phase	Voltage	Current	PF	Time	Pulses
All	120.01	30.035	0.500	35.98	2

LL

99.909

Phase	Voltage	Current	PF	Time	Pulses
All	120.01	3.037	1.000	88.97	1

Test Complete

Restart

View Trend

Done

Retest

Retest All

Next Page

Done

Page 1 / 2

Customer or Phantom Load Test

 Meter Testing

Selected Site: TEST

1 Customer Load

2 Phantom Load

3 Phantom Load with MTA15Z

Meter Accuracy Test Setup

Customer Load Test Setup

Selected Site: 101 Phantom Load Setup

Selected Site: TEST

Service Type 3-Phase, 4-Wire, Wye (3V, 3C) TR

Test Setup DEFAULT 3

Test Mode Wh Kt 1.80

☐ Do Demand Test

Test Time 20 Seconds

Test Revs 0

Meter Model KV

Mfr.SN 3214

Meter No 4213

Setup Name ANSI 2.5 AMP FL, PF, LL

Kt 1.8

Test	Phase	Label	Mode	Voltage	Current	PF	Lead/Lag	Flow	Pulses	Time	Rotation	Harm
1	All	FL	Wh	120V	2.5	1	Lag	DLV	10	30	ABC	
2	All	FL PF	Wh	120V	2.5	0.5	Lag	DLV	10	30	ABC	
3	All	LL	Wh	120V	0.25	1	Lag	DLV	10	30	ABC	

Setup changes will apply to this test only

Reset

Next

Edit

Select

Meter Test Results

kWH

 Customer Load Test Results

Selected Site: HIGH SCHOOL

Customer Load Meter Test

Wh Test

% Registration 100.055

Test Info

Time(sec)	20.275
Time Left	0.000
Pulses Exp	2.9984
Pulses Act	3.0000
Meter PF	1.0000

Sys Info

Wh	5.3971
VAh	5.3973
VARh	-0.0435
V	119.473
I	2.6770

Test Complete

Restart

View Trend

Done

Phantom Load Tests Results

 Phantom Load Results Selected Site: 4WIRE WYE TEST 5:5ct

FL **100.42**

Phase	Voltage	Current	PF	Time	Pulses	
All	119.67	5.01	1.00	32.28	9	

FL PF **100.03**

Phase	Voltage	Current	PF	Time	Pulses	
All	119.74	5.00	0.48	37.23	5	

LL **100.07**

Phase	Voltage	Current	PF	Time	Pulses	
All	120.32	0.50	1.00	35.75	1	



Page 1 / 1

Retest

Retest All

Done

VERIFYING CT ACCURACY

 Main Menu

BETA TEST - p19.00M/v16.94M/c#326.13K - Selected Site: 9S

1 Select Site

2 Integrated Site Test

3 Meter Testing

4 Instrument Transformer Testing

5 Data Trending

6 Transducer Testing

7 Deselect Site

8 Utilities

9 Recall Data

SETUP SCREEN FOR VERIFYING CT ACCURACY

 CT Testing

Selected Site: 101

CT Test Setup

Service Type

CT Mode

Maximum Burden

Transformer Specs for Phase A

Manufacturer

Model

Accuracy Class

Catalog #

Burden Class

Serial No

Nameplate Ratio :5

Rating Factor

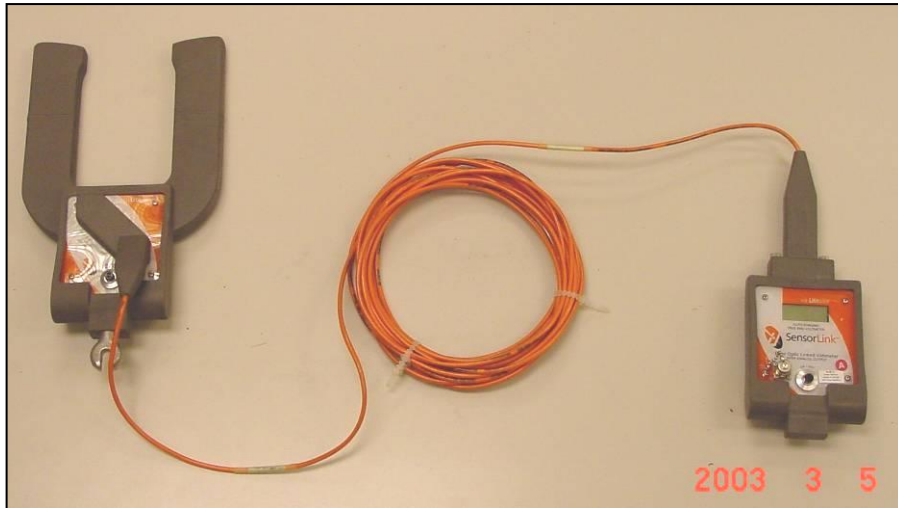
Φ A

Φ B

Φ C

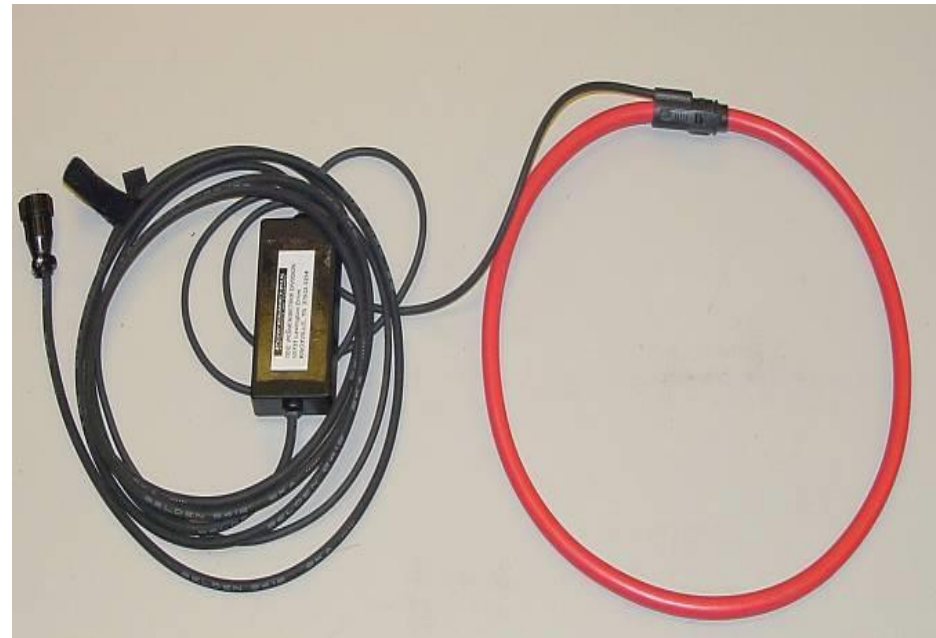
Start Test

DEVICES USED TO MEASURE THE CT'S "PRIMARY" CURRENT (CUSTOMER LOAD)

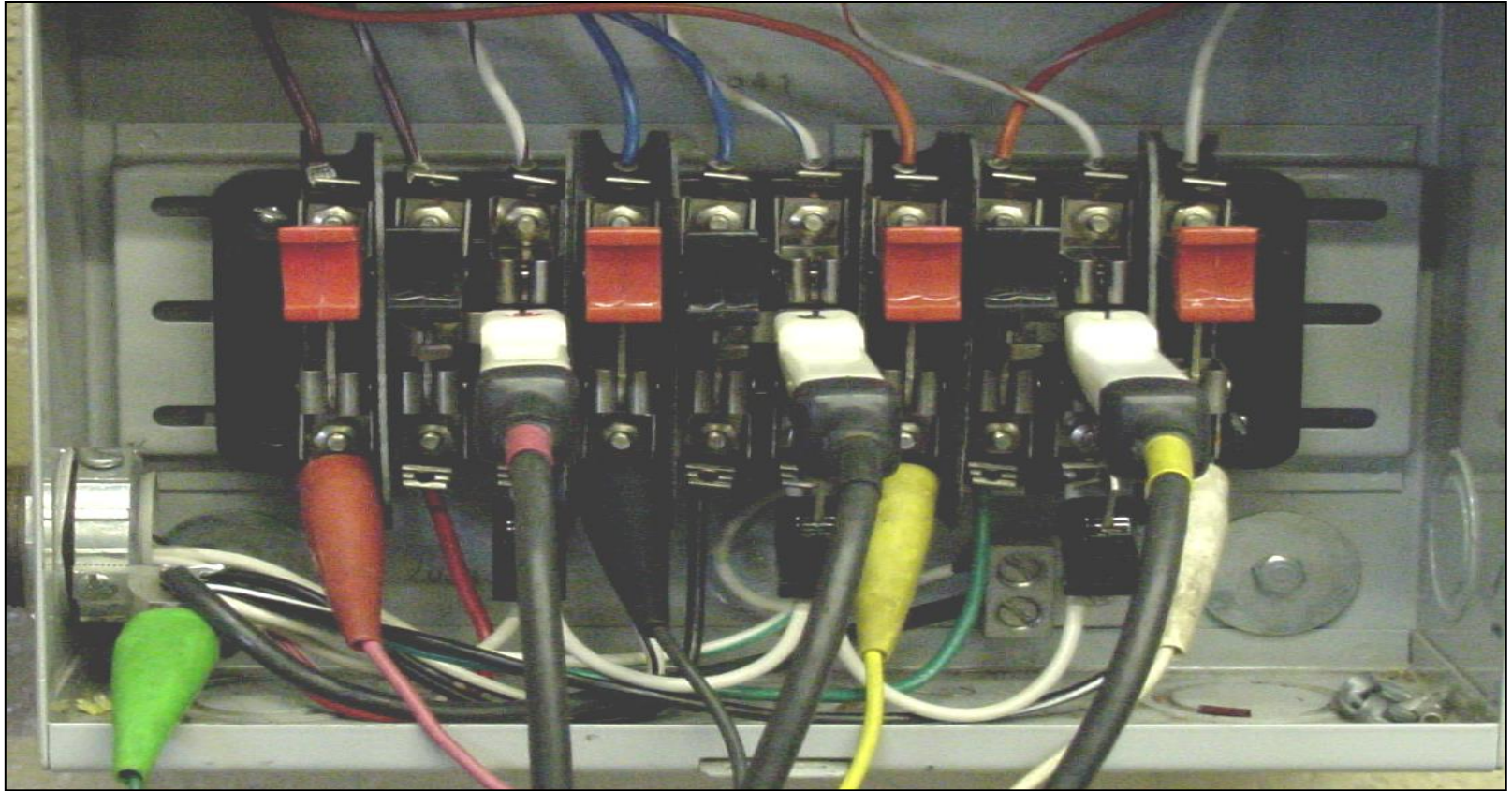


**High Voltage Fiber Optic
Probe
Used on Primary and Overhead
Secondary Services**

Flex 36 for Services 600 Volts or Less



MEASURING SECONDARY CURRENT



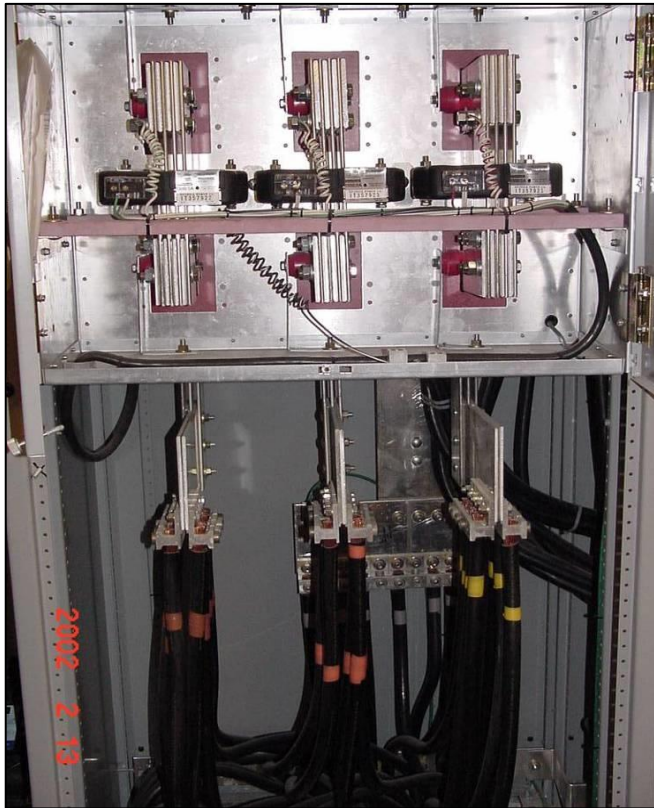
VERIFYING CT ACCURACY ON 600 VOLTS OR LESS




FLEX PROBE MEASURING CT'S "PRIMARY" CURRENT IN AN U.G. TRANSFORMER



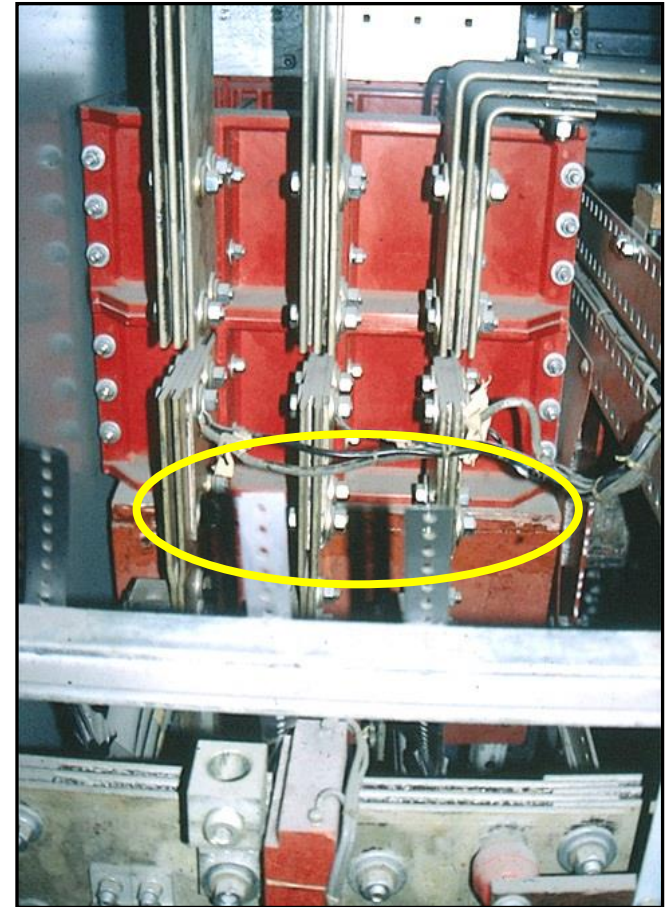
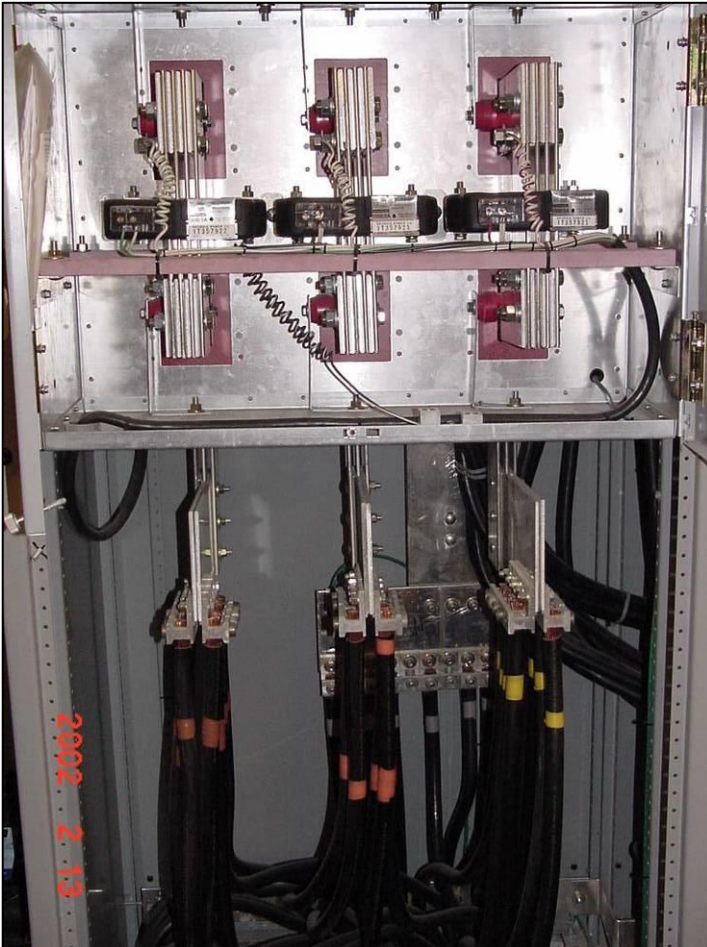
FLEX PROBE MEASURING CT'S "PRIMARY" CURRENT IN SWITCHGEAR



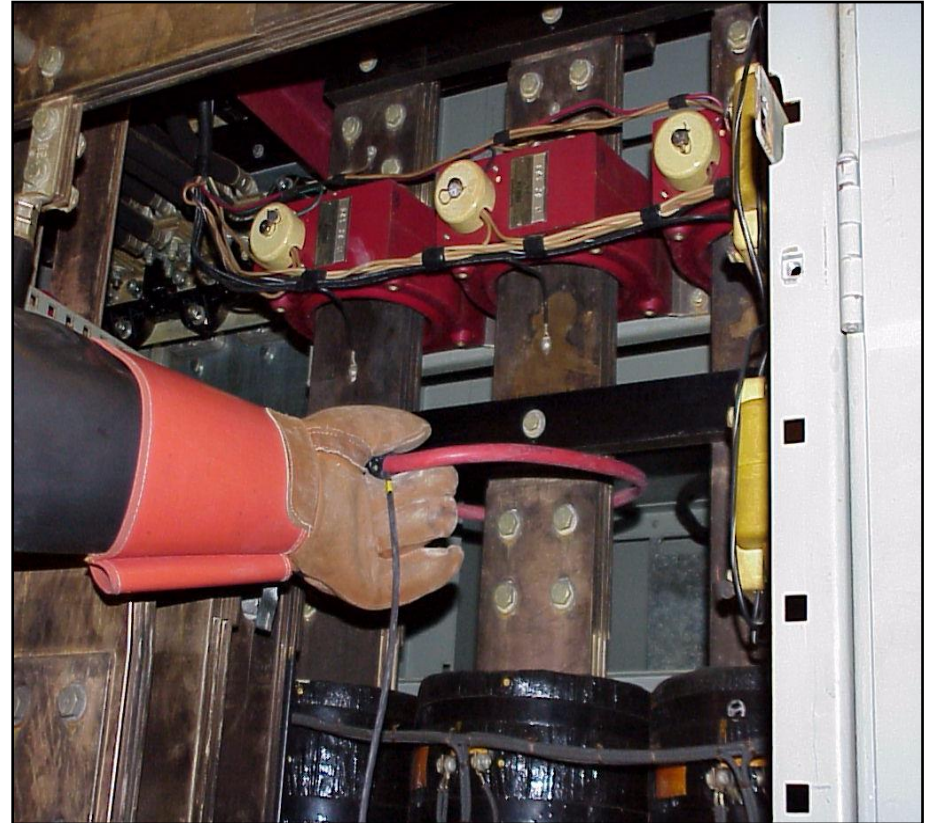
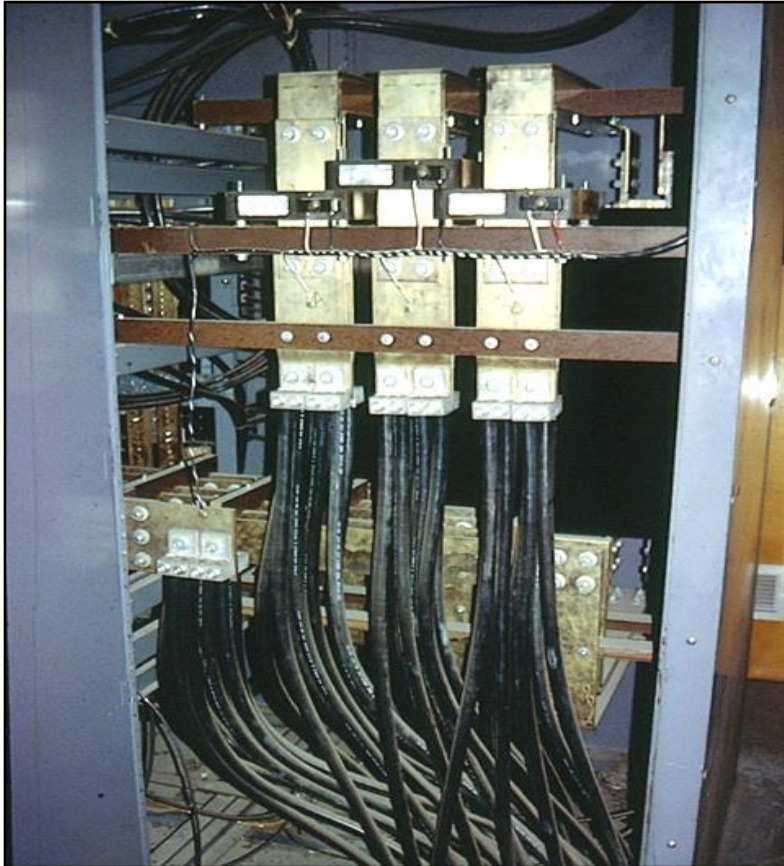
 DANGER	
NO SAFE PPE EXISTS ENERGIZED WORK PROHIBITED	
FLASH PROTECTION	SHOCK PROTECTION
Flash Hazard Category D	Shock Hazard when cover is removed 480 VAC
Min. Arc Rating: 306 cal/cm²	Limited Approach: 42 in
Flash Protection Boundary: 528 in	Restricted Approach: 12 in
PPE <ul style="list-style-type: none">■ No FR Category Found■ Do not work on LIVE!	Prohibited Approach: 1 in
SWBD MSB-4	1/6/13
By: Phillips Consulting Engineers, LLC	

IMPORTANT NOTE GET AHEAD OF THE CTS...

WHY?



Do your best to get close to the source as possible...

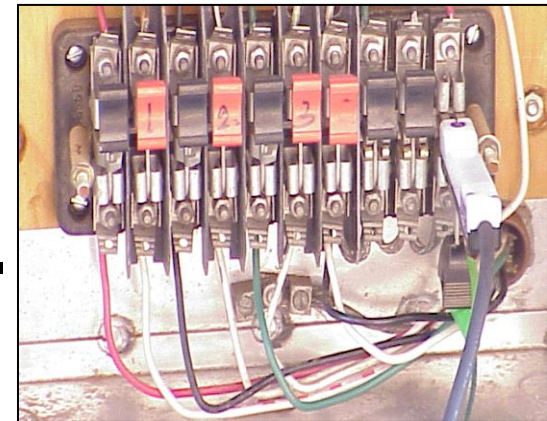


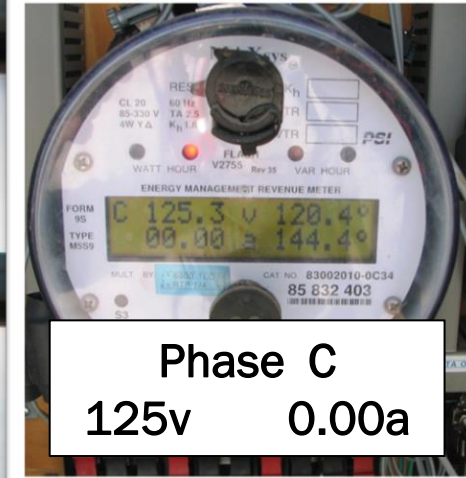
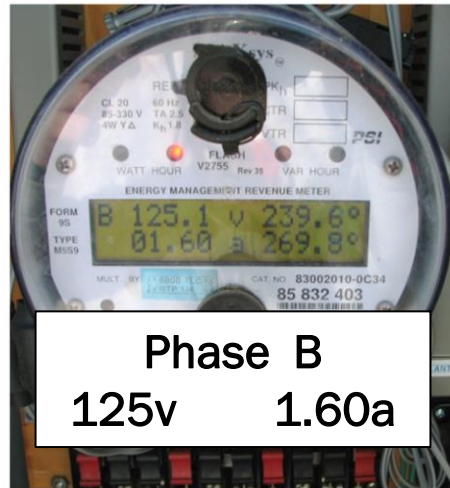
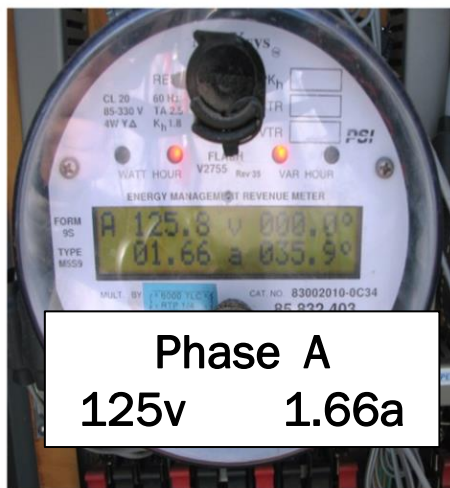
But do it SAFE!

Fiber Optic Horseshoe Probe used on Primary Services (above 600 volts)



Fiber Optic Horseshoe Probe used on Primary Service (above 600 volts)





Fiber Optic Horseshoe Probe used on Primary Service (above 600 volts)





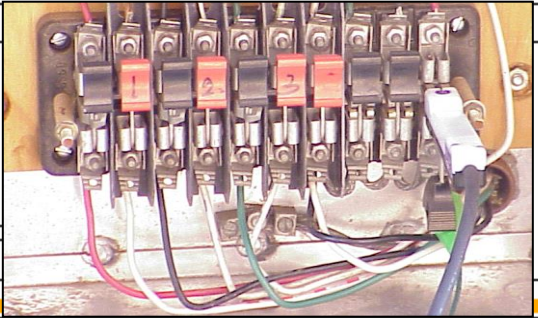
Fiber Optic Horseshoe Probe can also be used on Over Head Secondary Service



CT Ratio Test Information Results

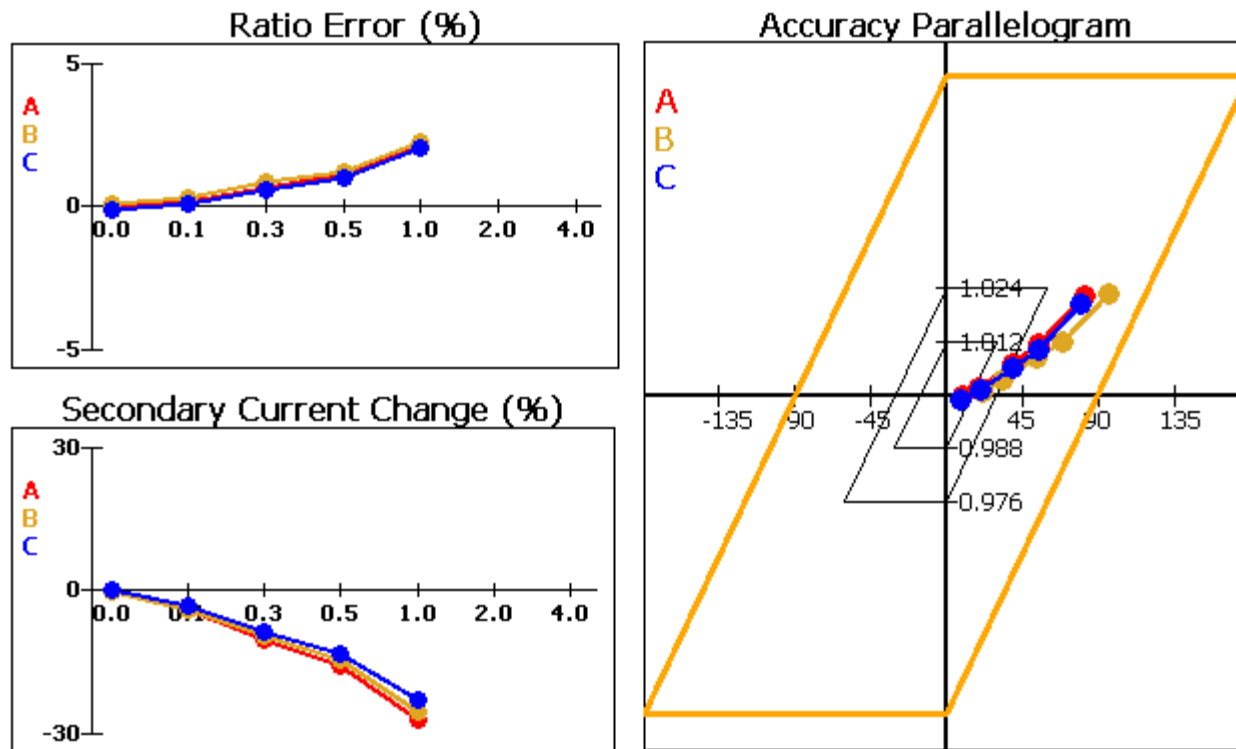
Possible Errors will be in **RED**, this appears to be a CT running backwards.

If you didn't check the vector before starting, this is probably your probe installed in reverse. Check the probe and retest the phase in question.

CT Testing Results		Selected Site: TEST WCM			
Measured Ratio: 99.84		FAIL	A		
Nameplate Ratio: 100 : 5		Primary Amps: 50.54			
Ratio Error (%): -0.16%		Secondary Amps: 2.531			
Phase Error (degrees): 179.844°		Phase Error (minutes): 179° 50' 38"			
Measured Ratio: 99.77					
Nameplate Ratio: 100 : 5					
Ratio Error (%): -0.23%					
Phase Error (degrees): -0.149°					
Measured Ratio: 99.65		PASS	C		
Nameplate Ratio: 100 : 5		Primary Amps: 53.74			
Ratio Error (%): -0.35%		Secondary Amps: 2.696			
Phase Error (degrees): -0.205°		Phase Error (minutes): -12' 17"			
Test Complete					
Retest	Retest All	Demagnetize	Graphs	Data	Done

CT Ratio Test Information Results

CT Testing Results Graphs BETA TEST - p10.37M/v10.19M/c#353.97K - Selected Site: TEST



Φ A Φ B Φ C All Data

RESULTS FOR RATIO ONLY

P CT Testing Results **BETA TEST - p19.43M/v18.50M/c#288.20K - Selected Site: DELETE ME**

Measured Ratio: 99.67

PASS

A

Nameplate Ratio: 100 : 5

Primary Amps: 19.97

Ratio Error (%): -0.33%

Secondary Amps: 1.002

Phase Error (degrees): -0.045°

Phase Error (minutes): -2' 42"

Measured Ratio: 99.66

PASS

B

Nameplate Ratio: 100 : 5

Primary Amps: 19.95

Ratio Error (%): -0.34%

Secondary Amps: 1.001

Phase Error (degrees): -0.044°

Phase Error (minutes): -2' 38"

Measured Ratio: 99.68

PASS

C

Nameplate Ratio: 100 : 5

Primary Amps: 19.97

Ratio Error (%): -0.32%

Secondary Amps: 1.002

Phase Error (degrees): -0.053°

Phase Error (minutes): -3' 9"

Test Complete

Retest

Retest All

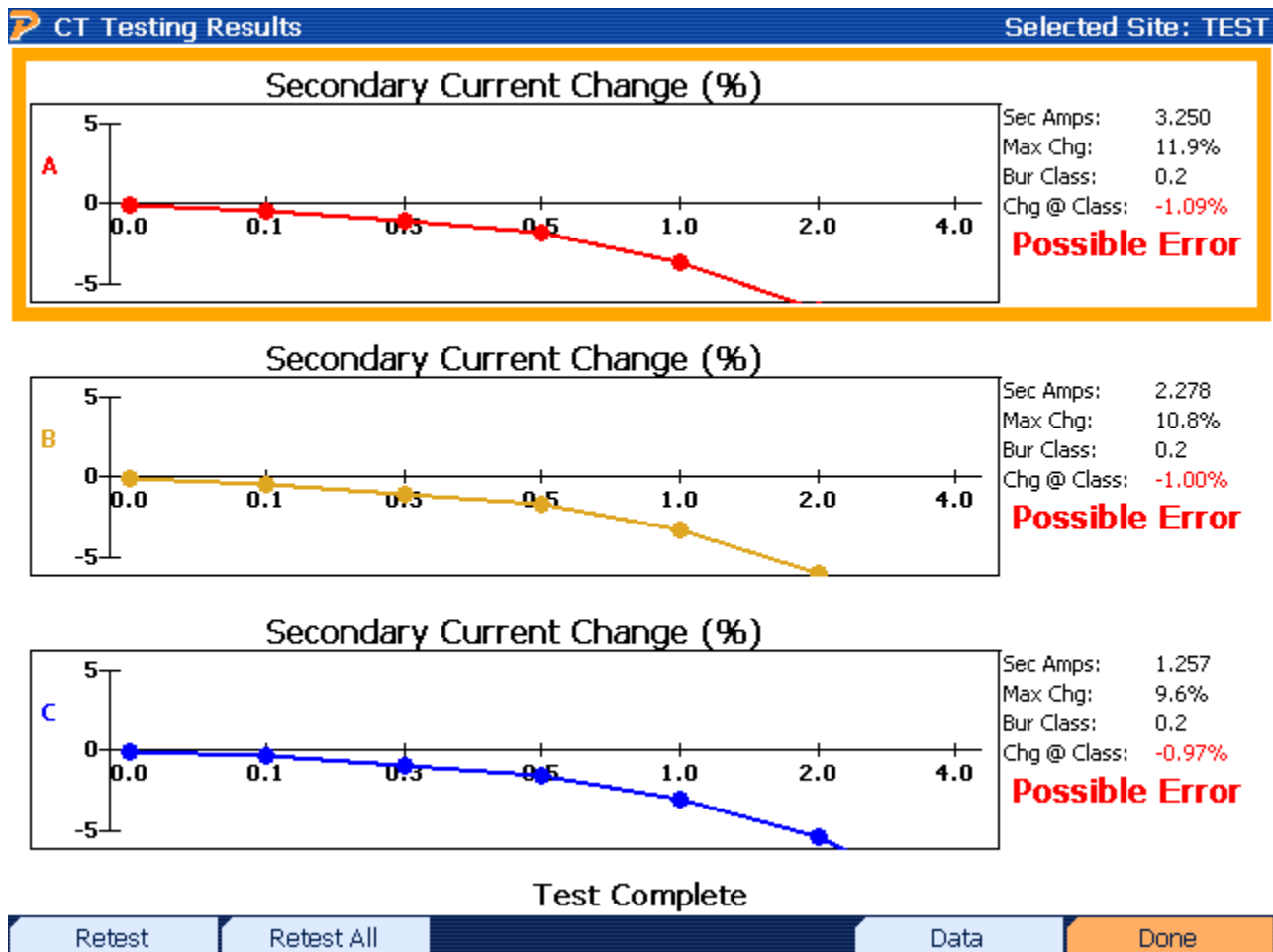
Demagnetize

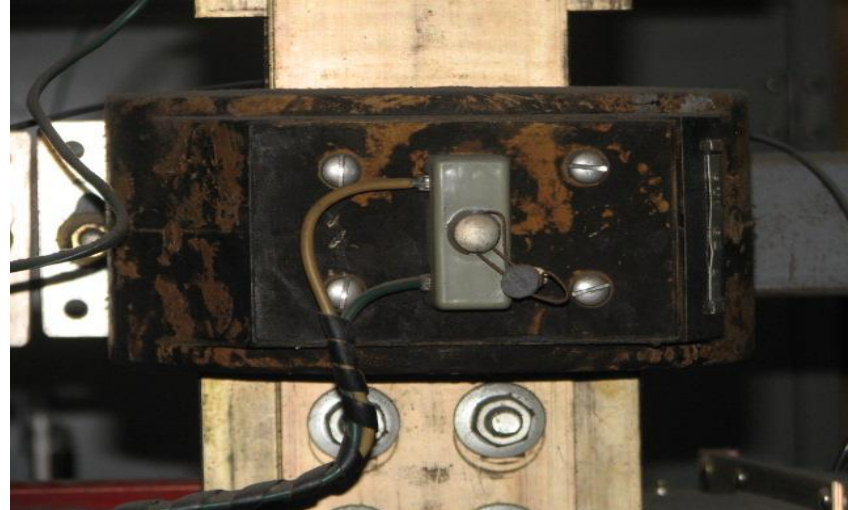
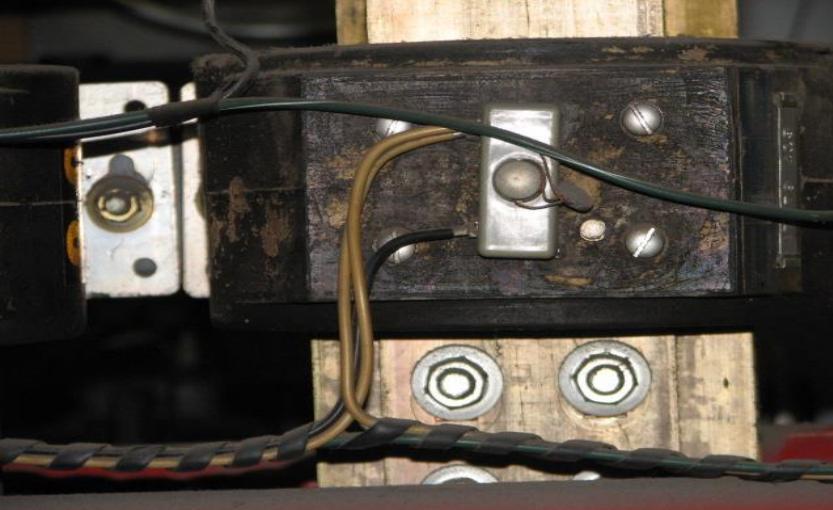
Graphs

Data

Done

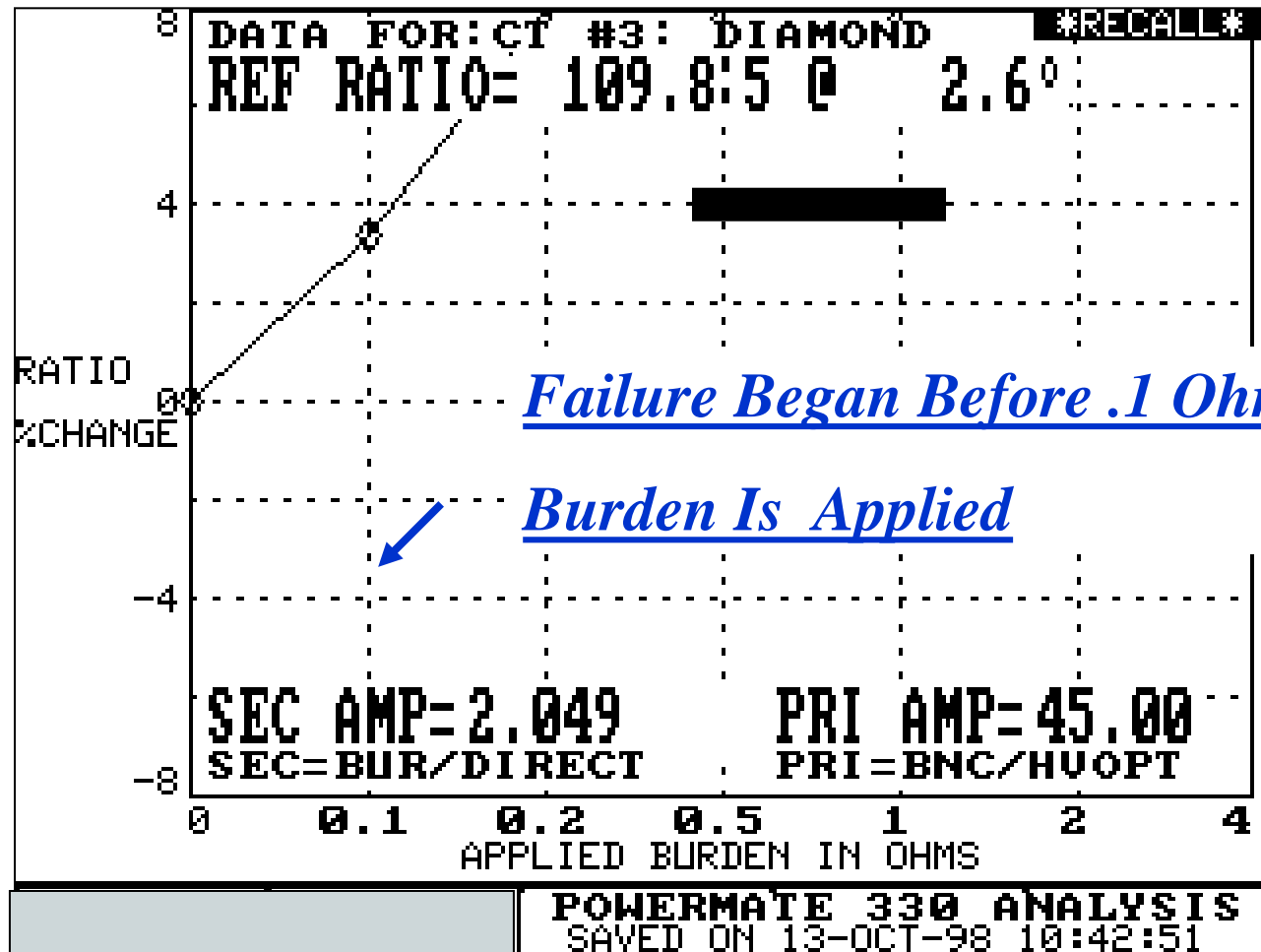
Results for Burden Only





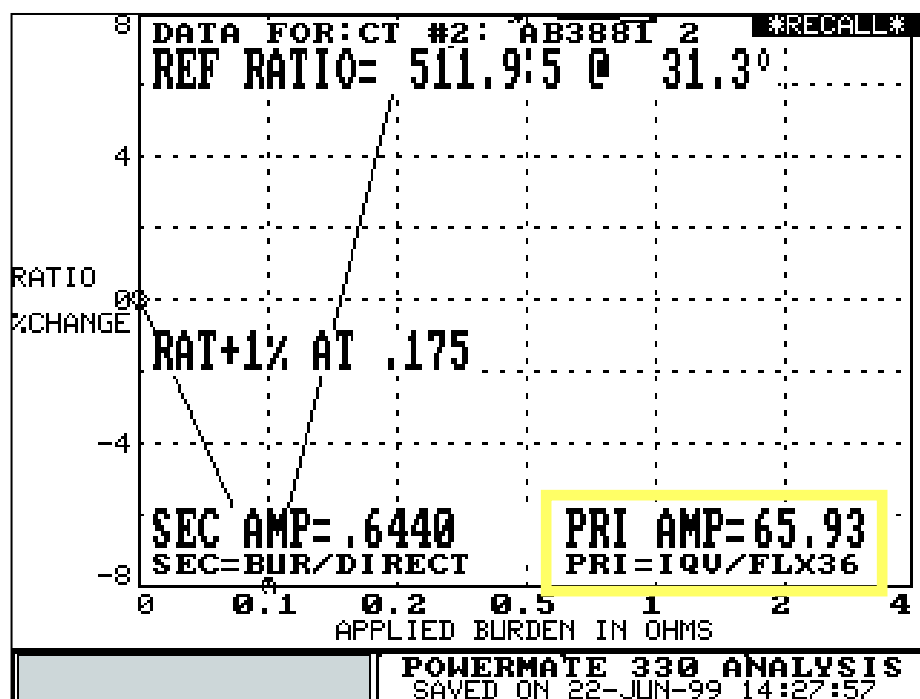
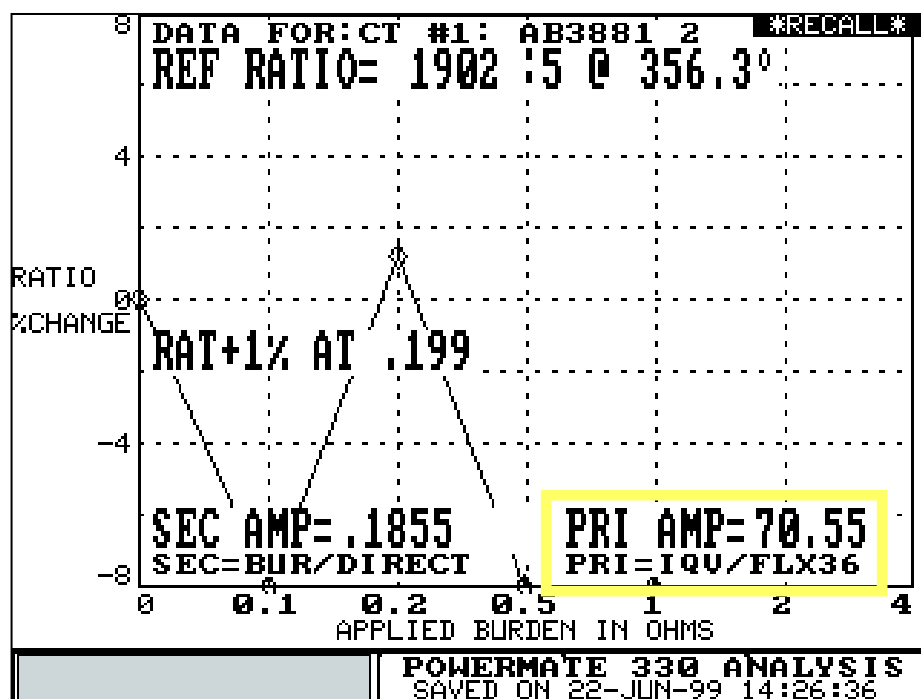


Bad CT



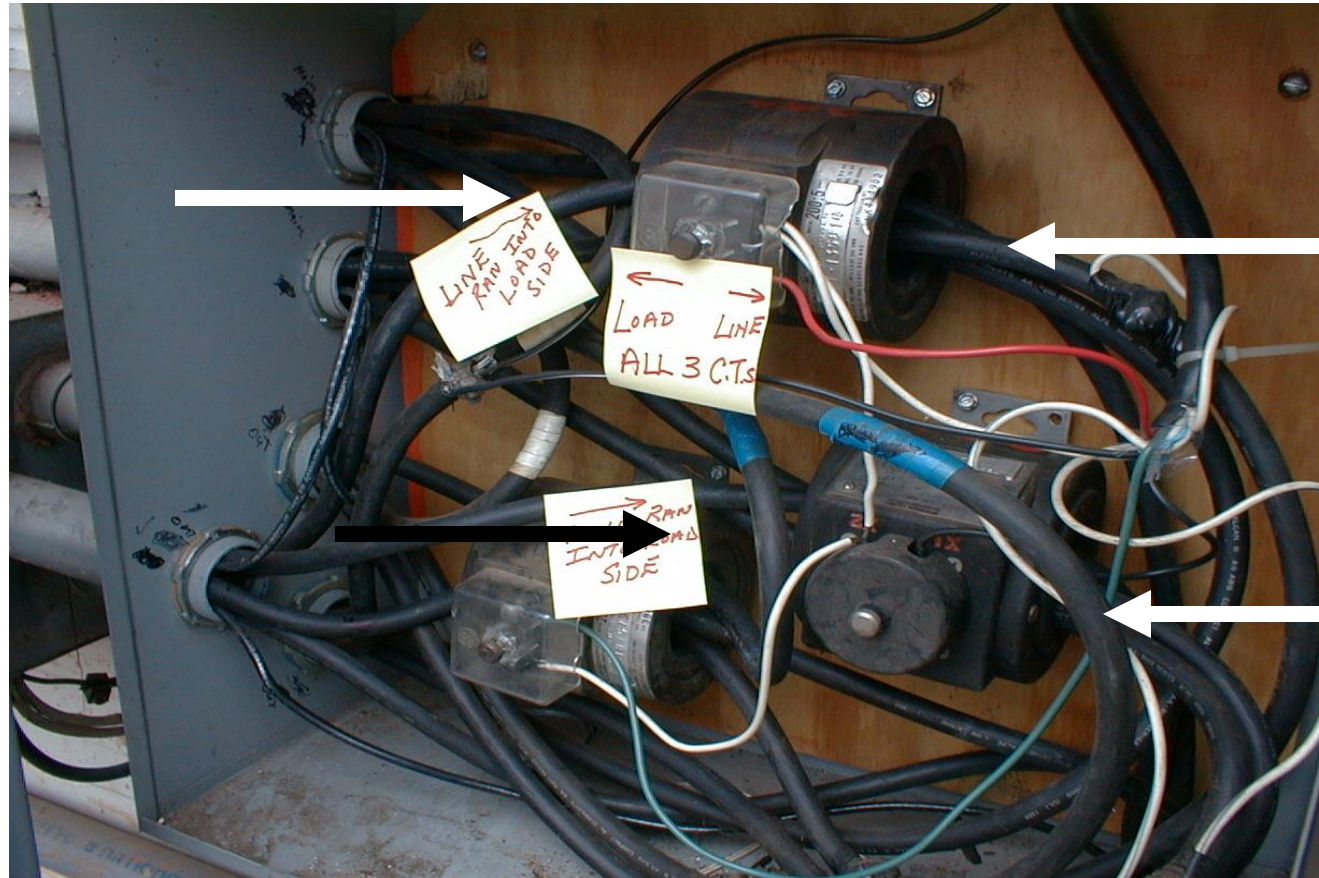
Bad CT ?

Ratio Should Be 200 : 5



No, Just A Bad Electrician

Additional run of wire installed and pulled through Two CTs backwards

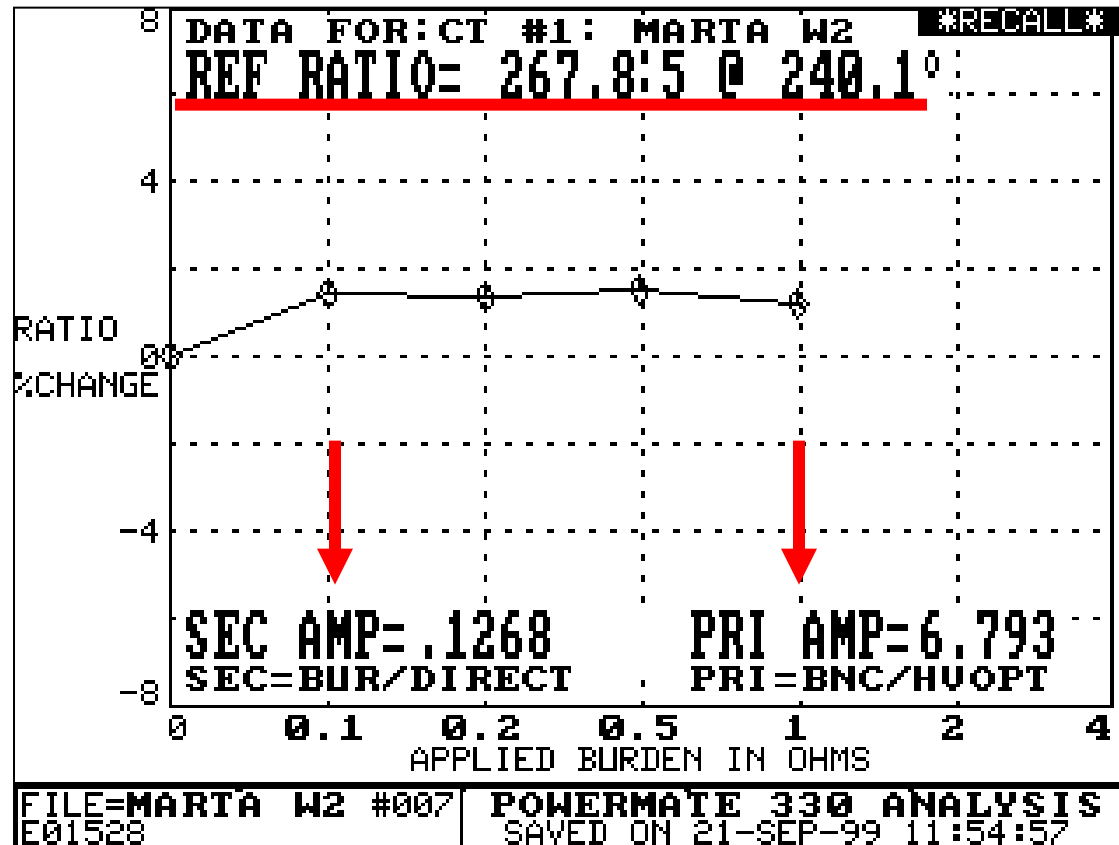


Current Flow

Current Flow

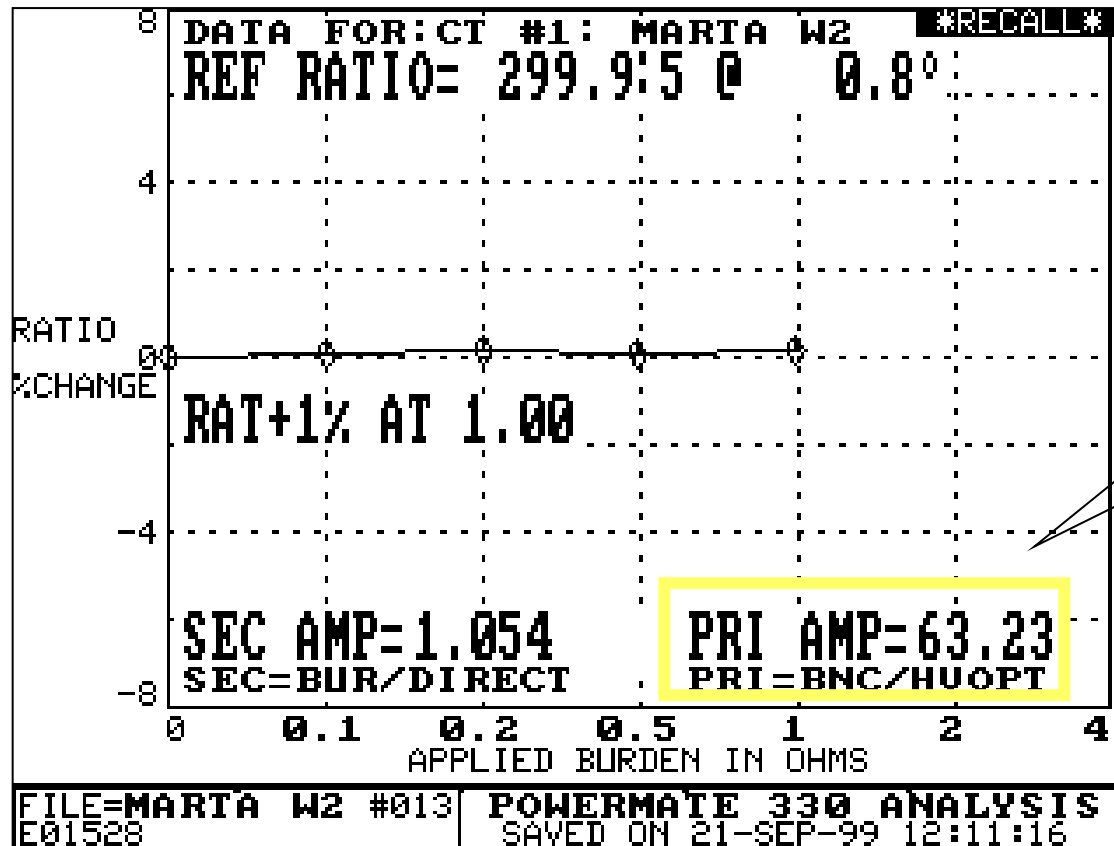
Bad CT ?

300 : 5 Primary CTs Ratio Results at 112%



Same CT 15 Minutes Later

What Happened ?



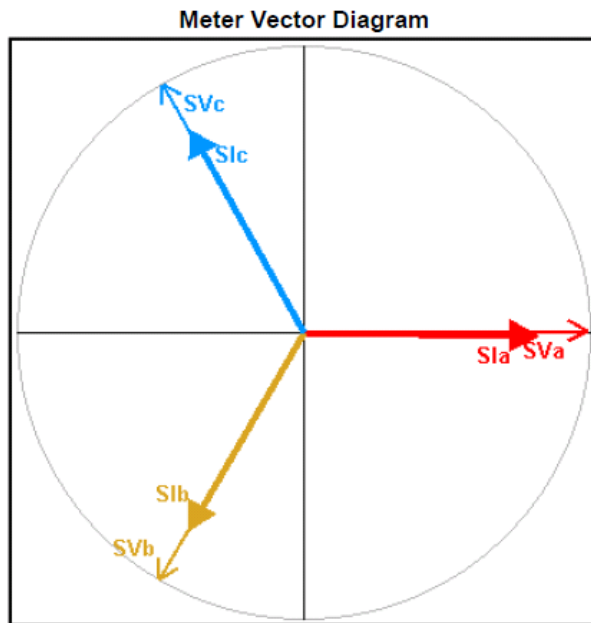
Best Resolution Achieved If Secondary Amps
Are At Least 10% of CT Value

Vectors

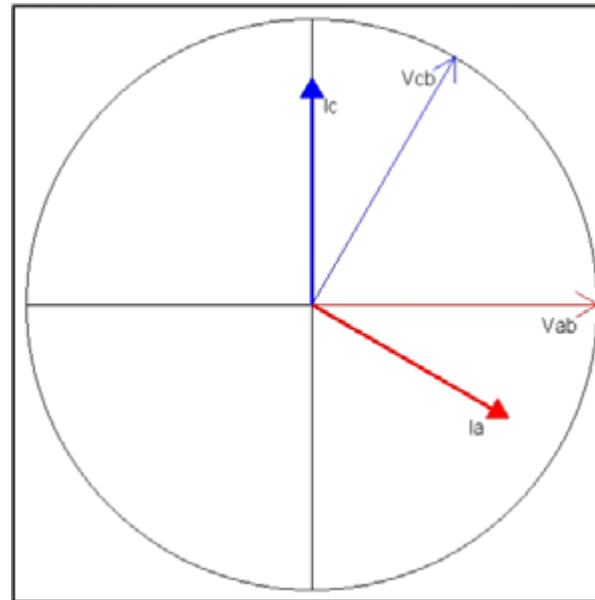
What Do We Look For ?

Services At Unity Power Factor

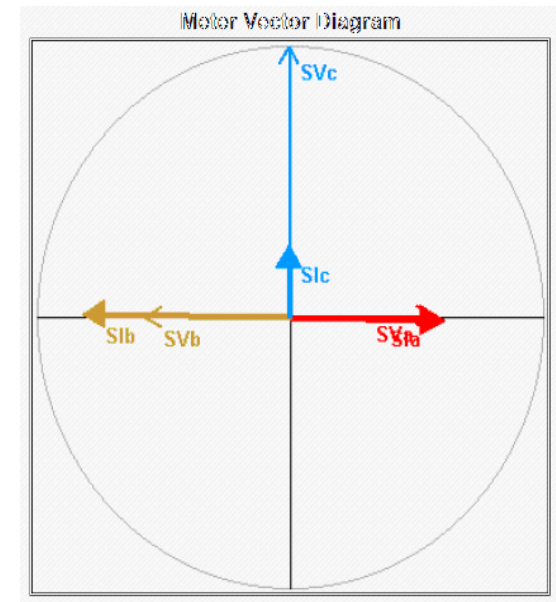
4 wire WYE



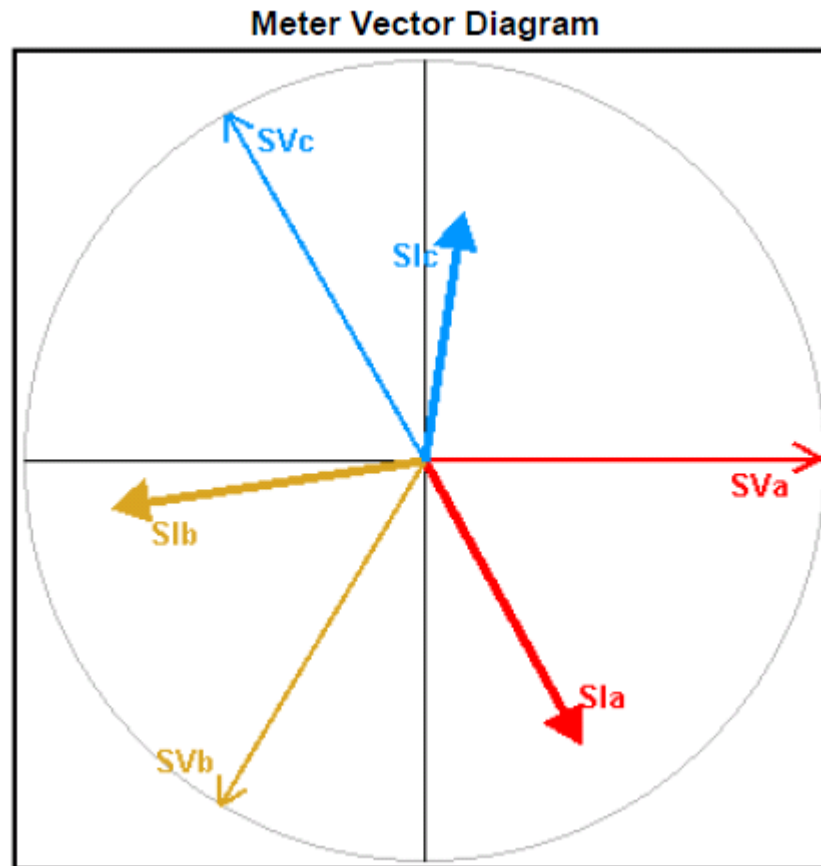
3 wire Delta



4 wire Delta

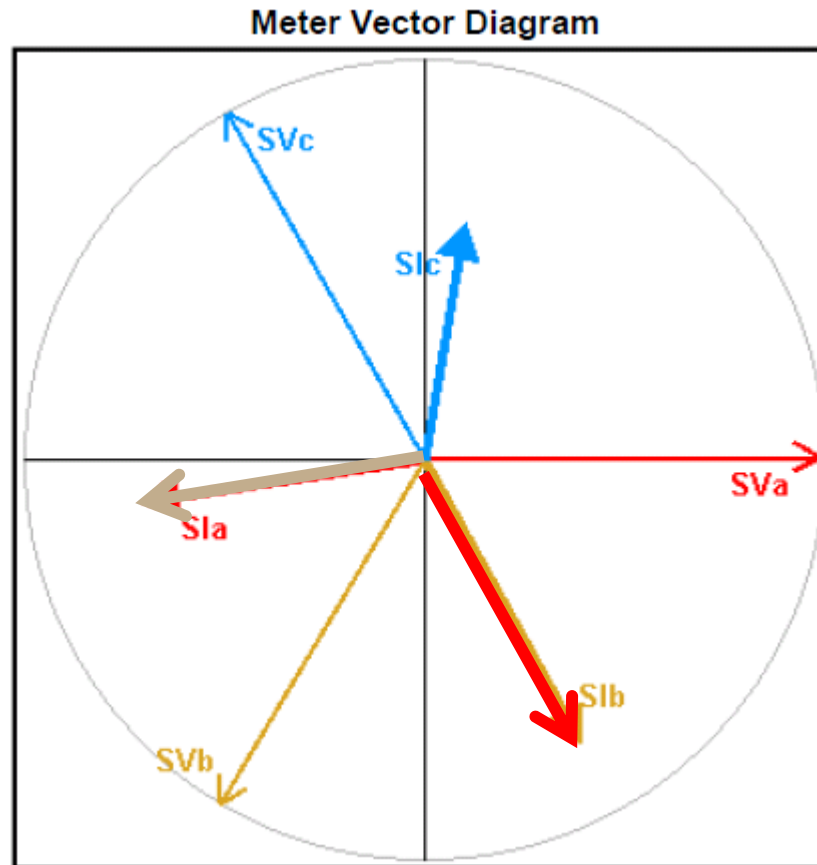


Typical WYE Service



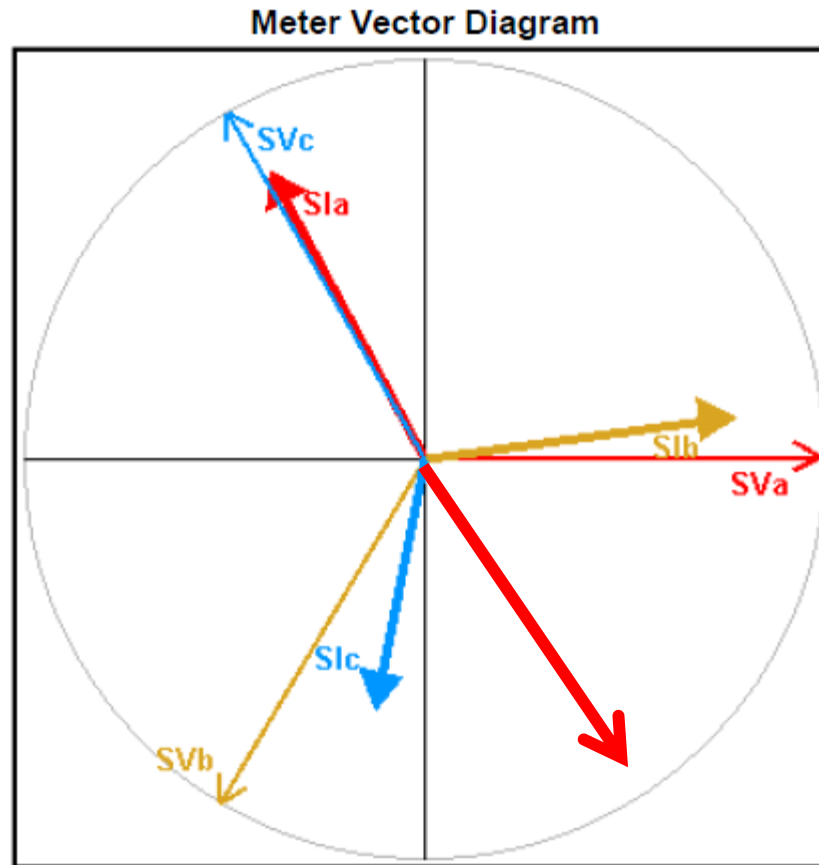
Problem ?

A Phase and B Phase Current Crossed

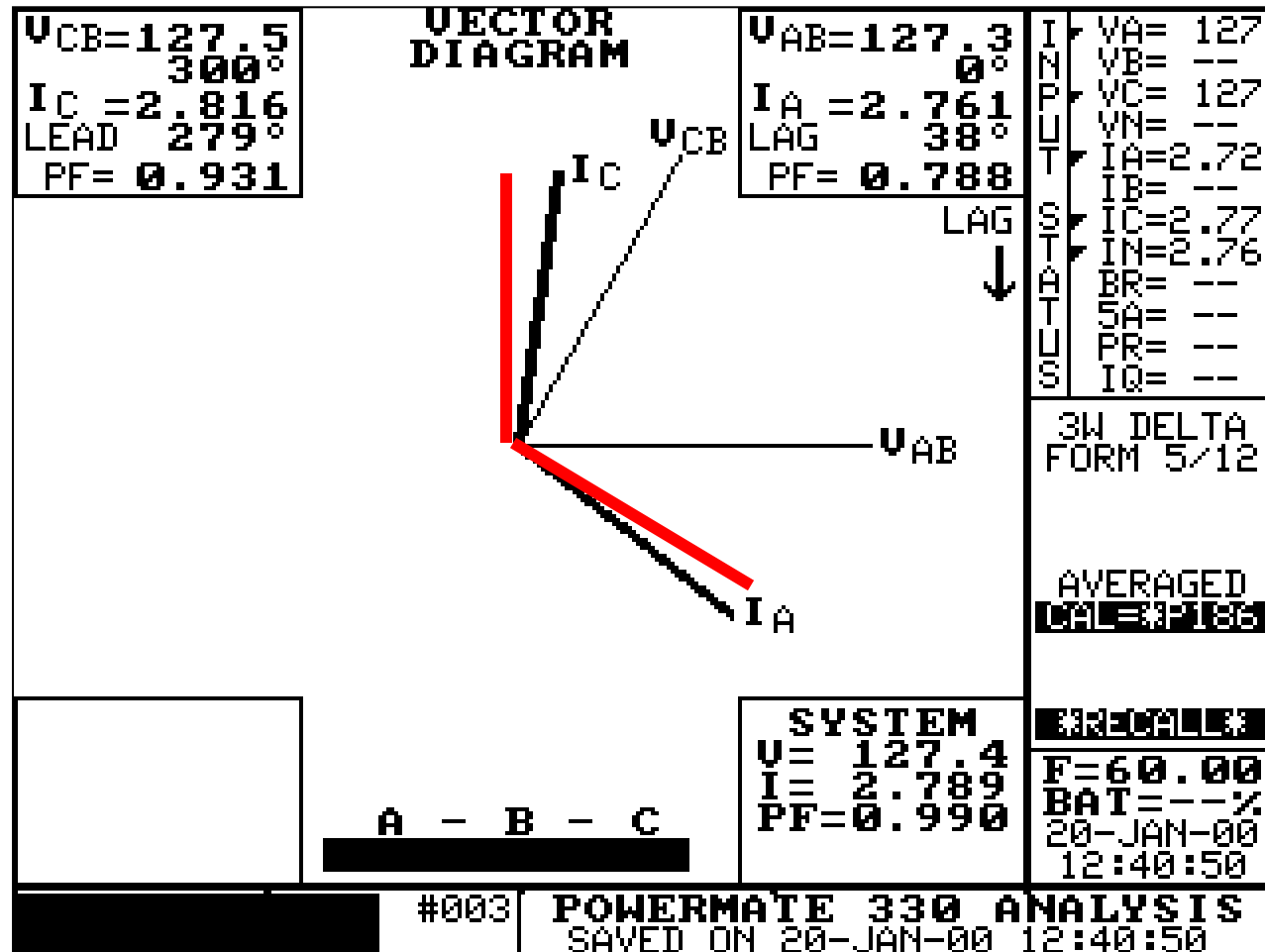


Problem ?

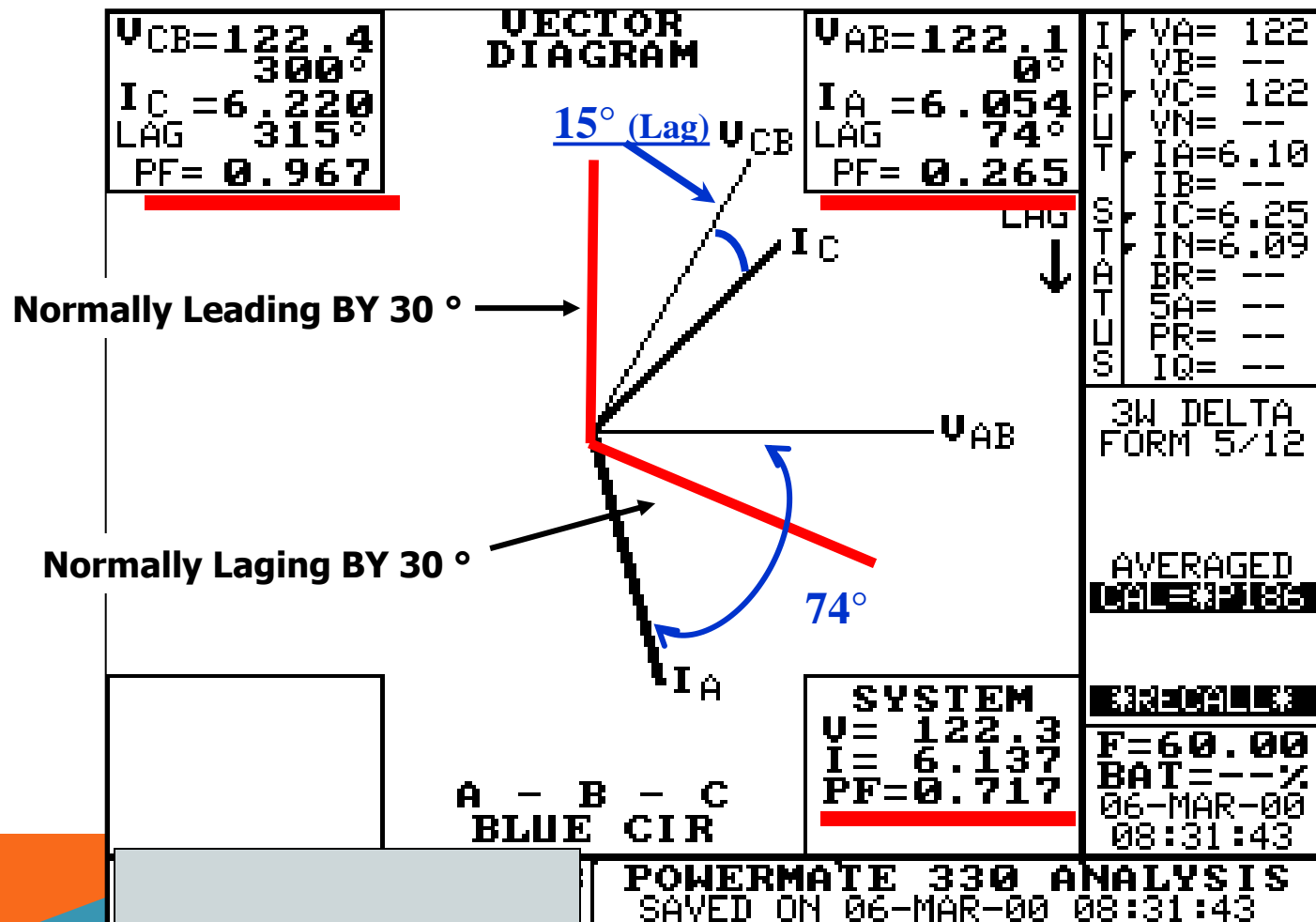
CTs Wired Backwards



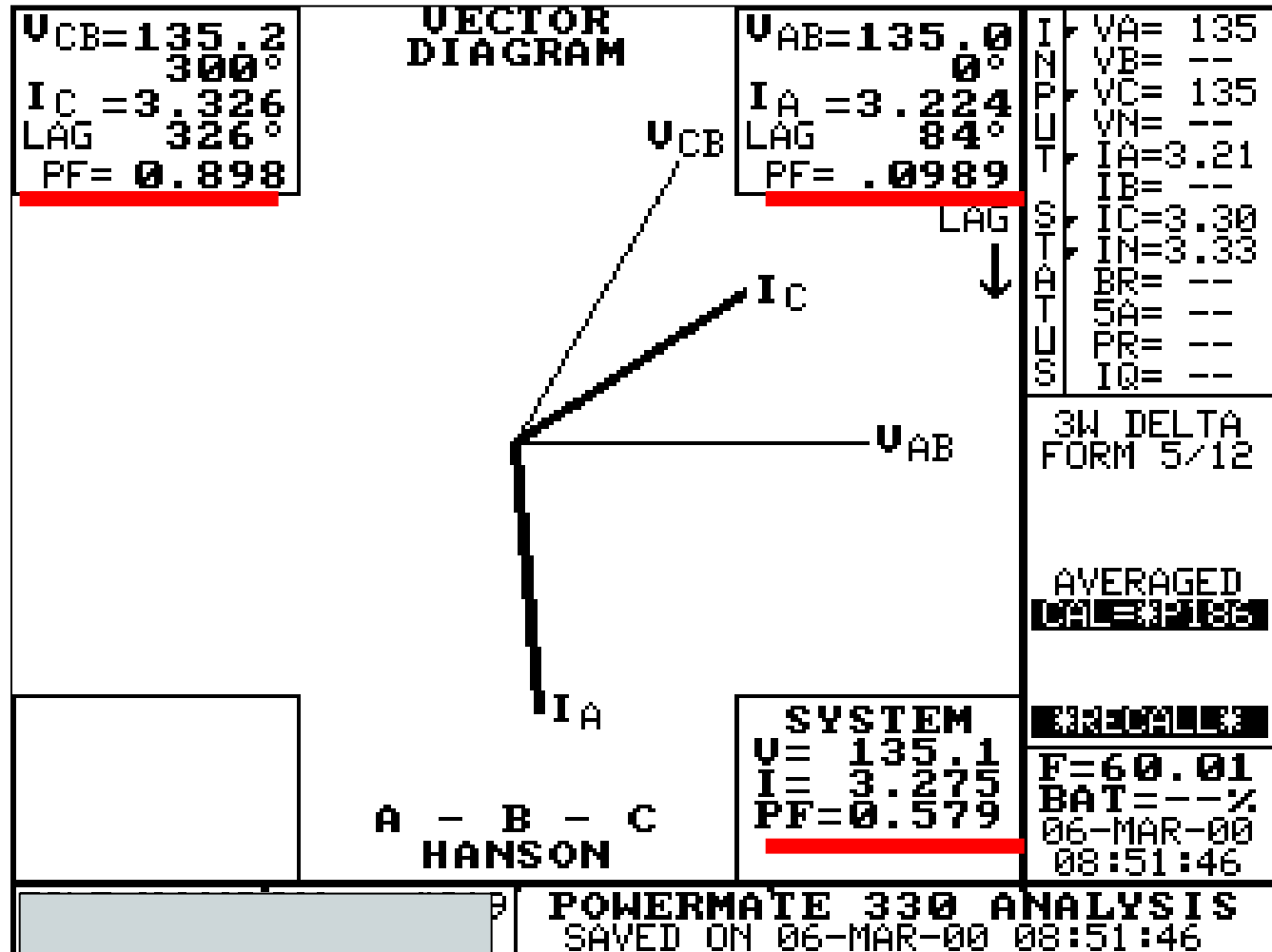
Three Wire Three Phase Delta Service



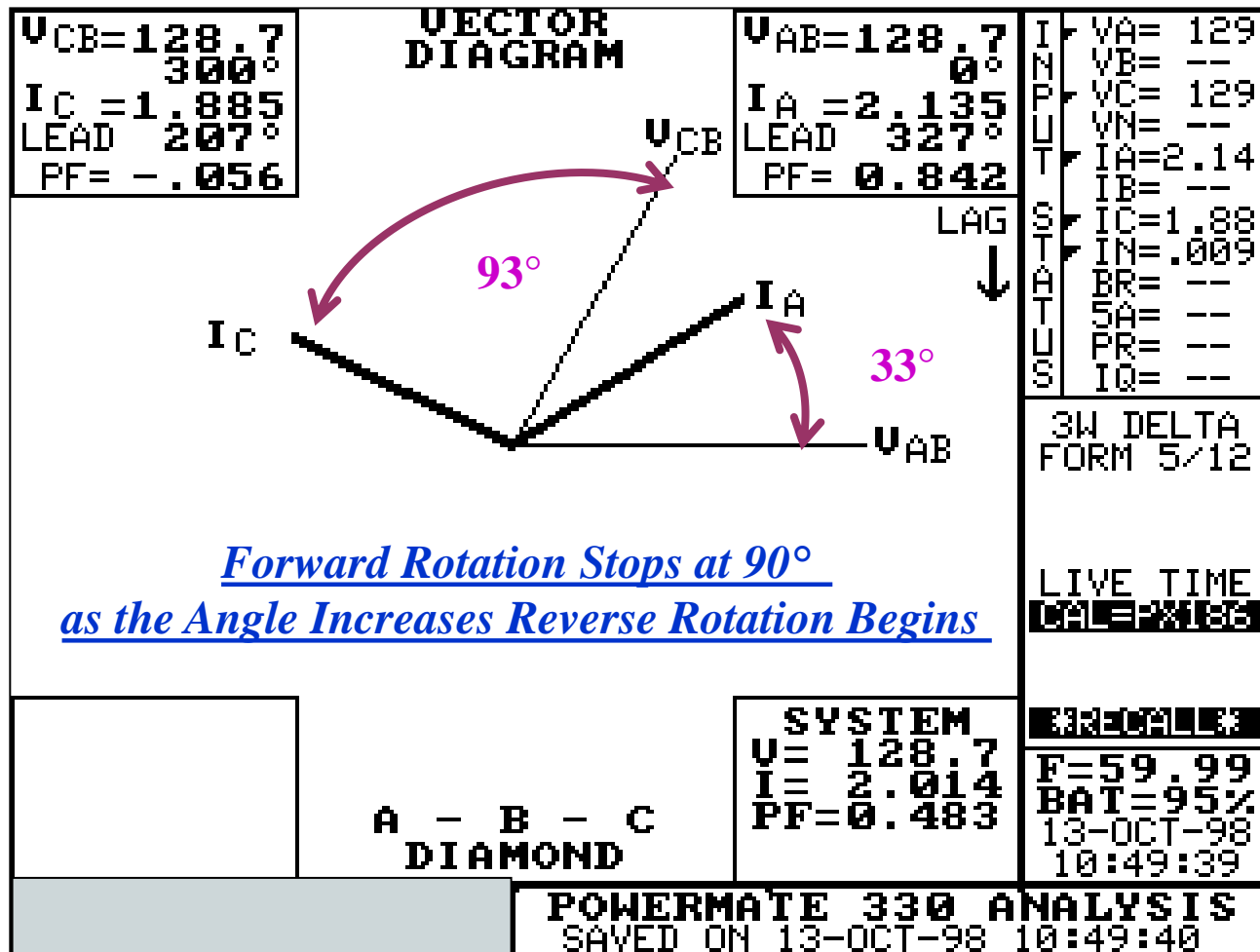
Three Wire Three Phase Delta Bad Power Factor



Three Wire Three Phase Delta with Worse Power Factor

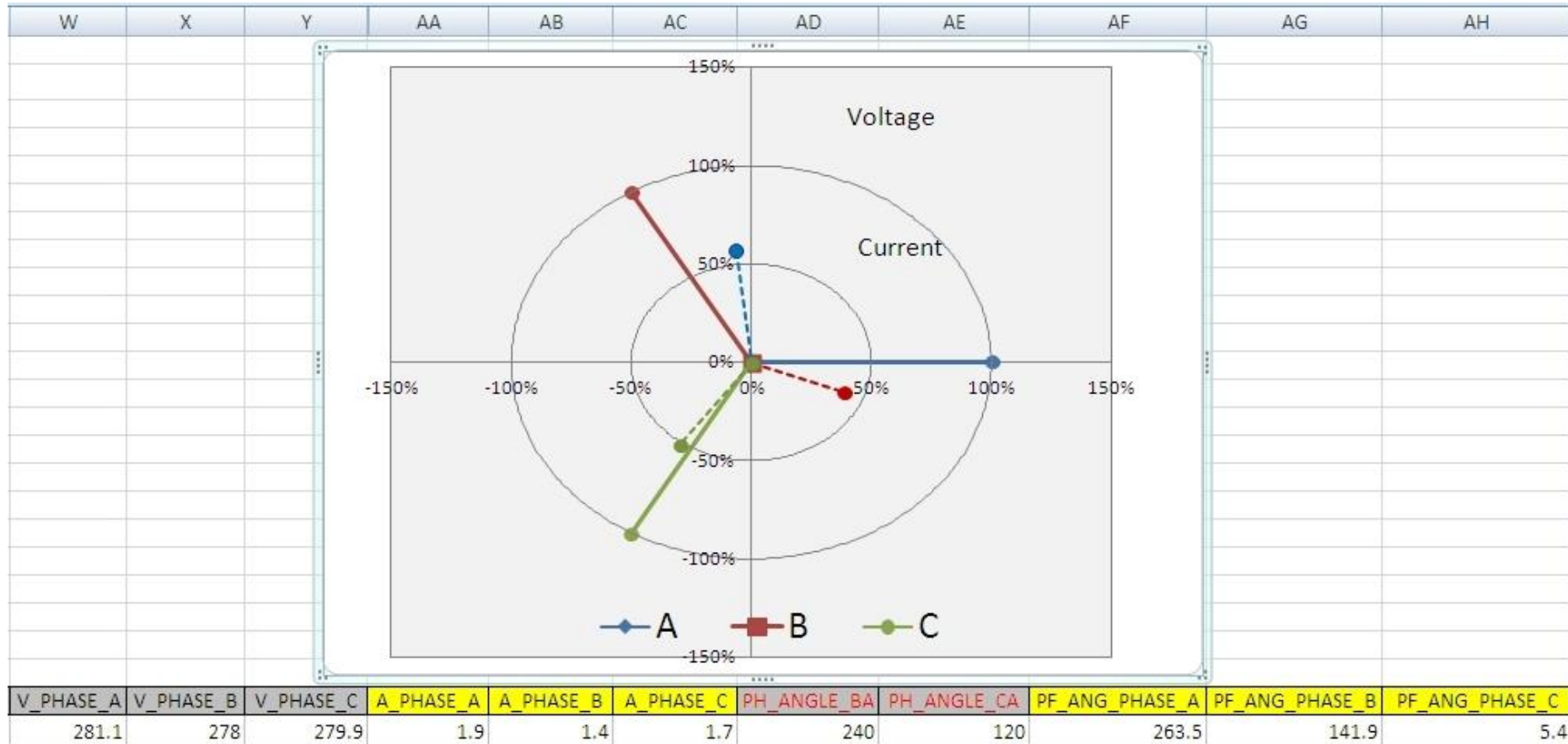


Three Wire Three Phase Delta with Even Worse Power Factor



Problem- Crossed Potentials?

It looks like A-phase current is matched with B-phase potential, and B-phase current with A-phase potential.

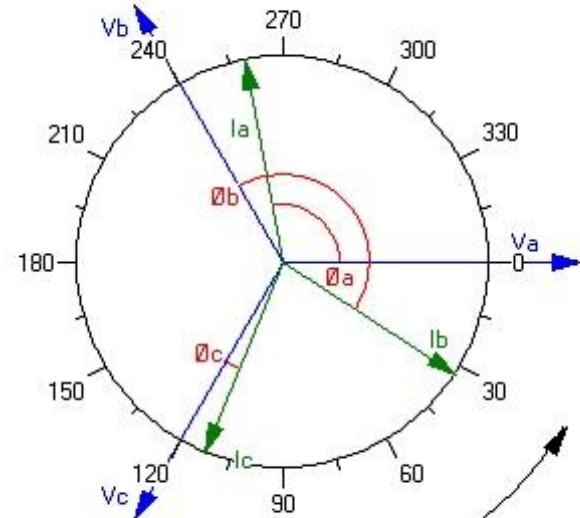


Problem- Crossed Potentials?

Instrumentation data from the Metercat Diagnostic Read agreed with data reported from the AMI meter.

	Phase A	Phase B	Phase C	System
Voltage	283.84	281.12	283.29	
Voltage Phase Angle	0.00	240.00	120.00	
Current	2.14	1.34	1.48	
Current Phase Angle	259.27	33.19	112.48	
Power Factor (1)	-0.19	0.89	-0.99	-0.07
Power Factor Angle	259.27	153.19	352.48	265.99
kW	-0.11	-0.34	0.41	-0.03
kVAR	-0.60	0.17	-0.05	-0.48
kVA	0.61	0.38	0.42	0.48
Line Frequency				59.99

locked, 277.0V 4W wye, CBA phase rotation



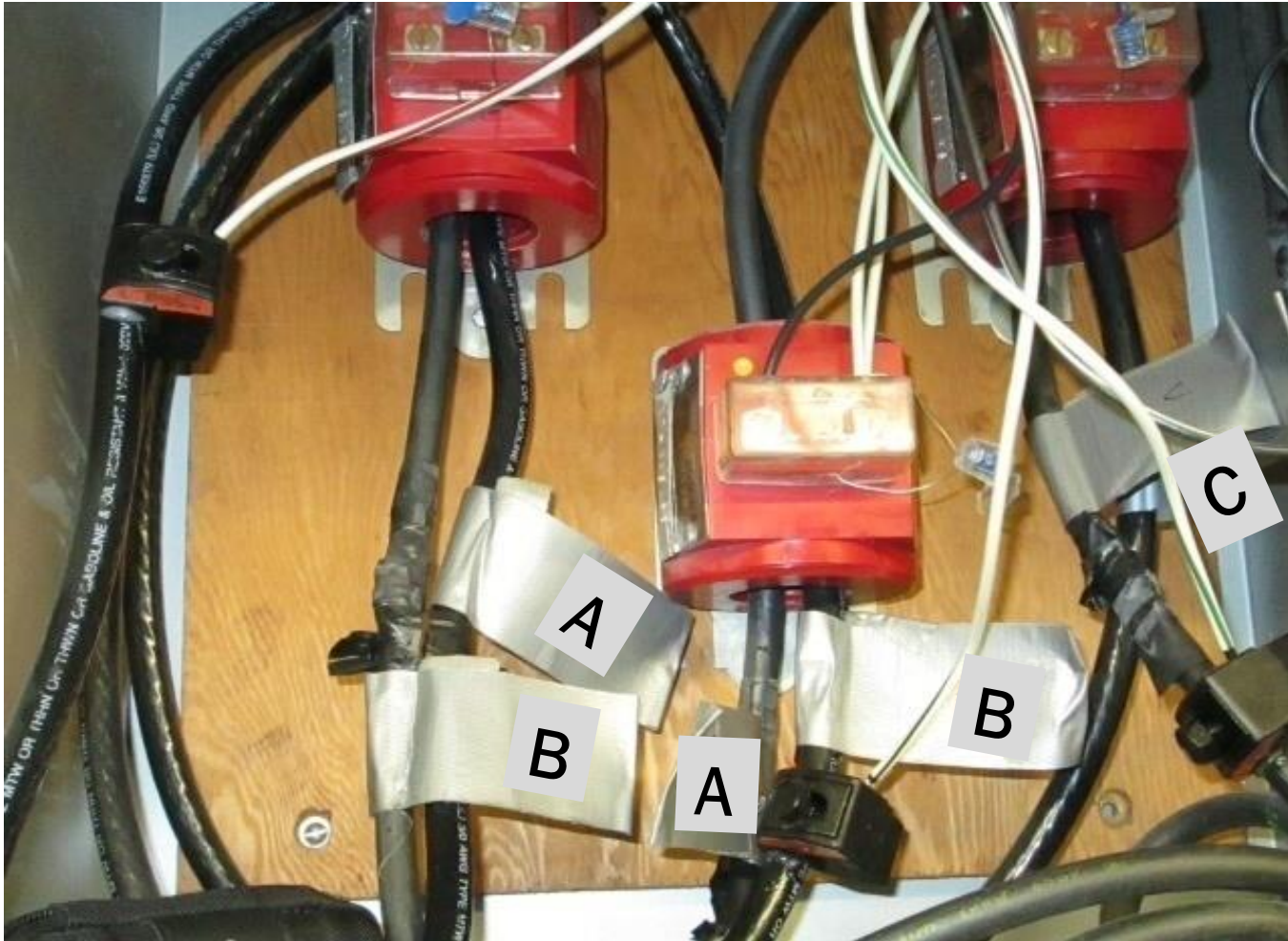
1/29/2013 9:08:08 AM

Phase rotation



As the load changed, the meter would alternate between forward energy flow and reverse energy flow.

The actual problem was found to be non-brothered service conductors through two of the current transformers. Phase-C current transformer on the far right was correct.



C-phase CT

Measured 9.5 amps and 49.1 amps



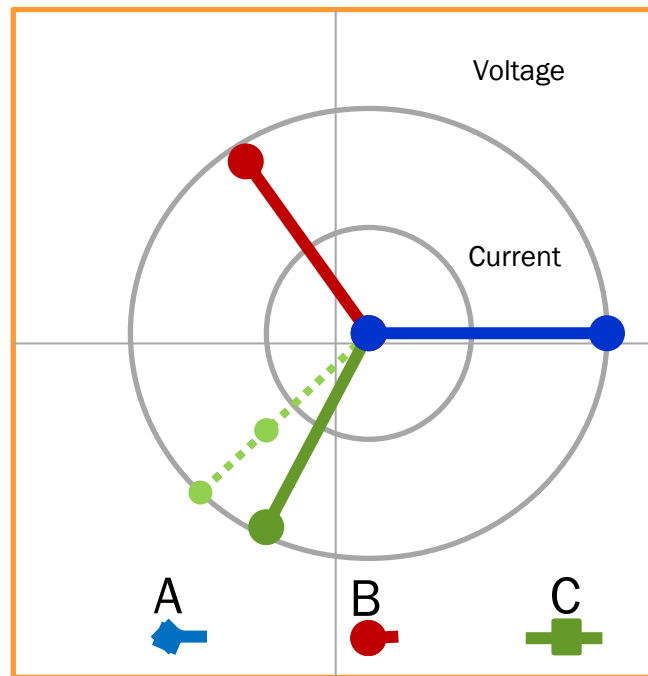
C-phase CT

Total current measured by C-phase CT was 58.6 amps

Vectors with the same angle simply add together



Total current measured



A-phase CT

Measured 92.3 amps on B-phase and 15.4 amps on A-phase



A-phase CT

Total current measured by A-phase CT was 85.3 amps

How does 92.3 and 15.4 add up to be 85.3 ?



B-phase CT

Measured 12.5 amps on B-phase and 56.9 amps on A-phase



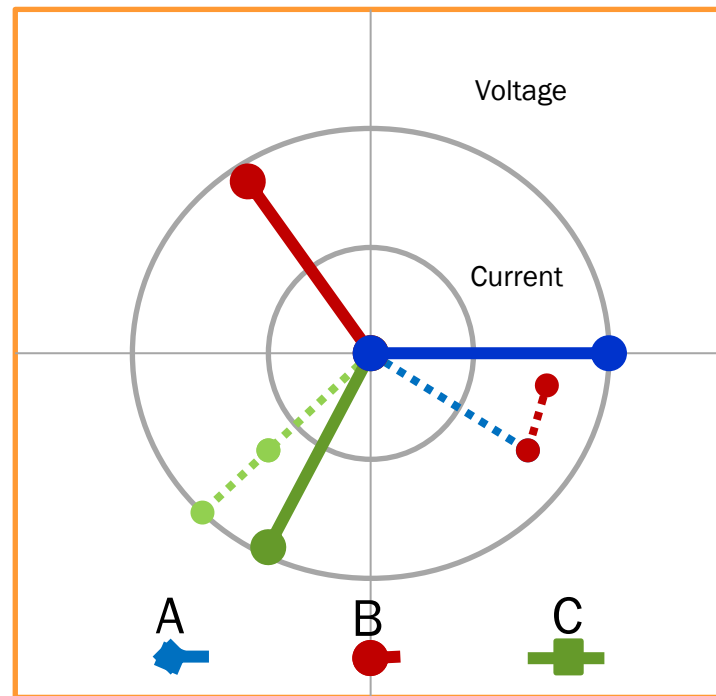
B-phase CT

Total current measured by A-phase CT was 47.2 amps

How does 12.5 and 56.9 add up to be 47.2 ?



Total current measured



A complex number can be visually represented as a pair of numbers (a, b) forming a vector on a diagram, representing the complex plane. "Re" is the real axis, "Im" is the imaginary axis, and i is the imaginary unit

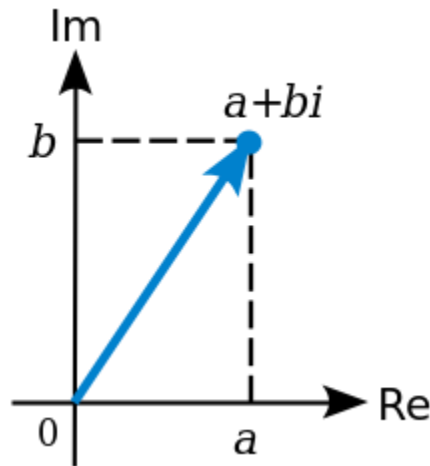
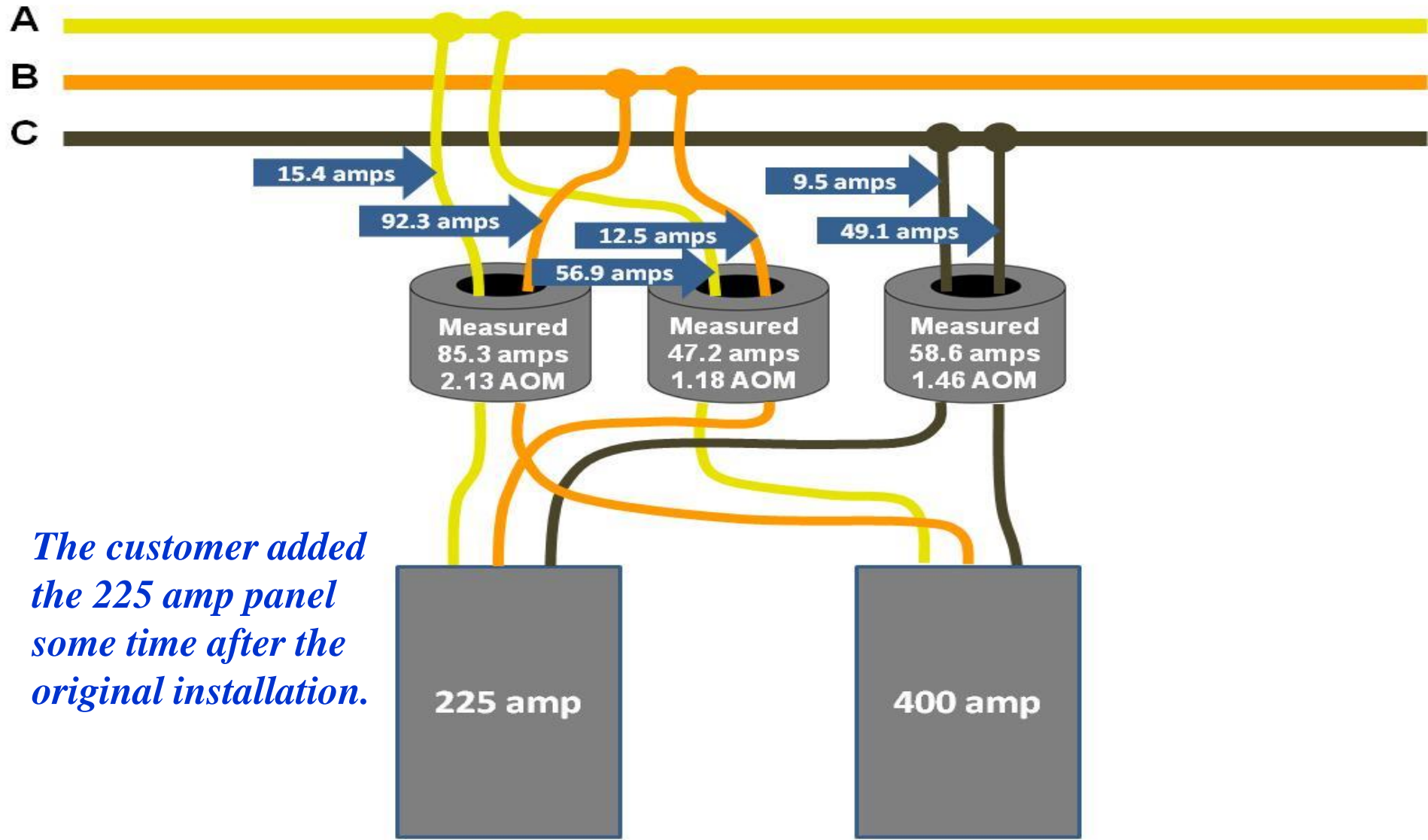


Illustration of on-site measurements

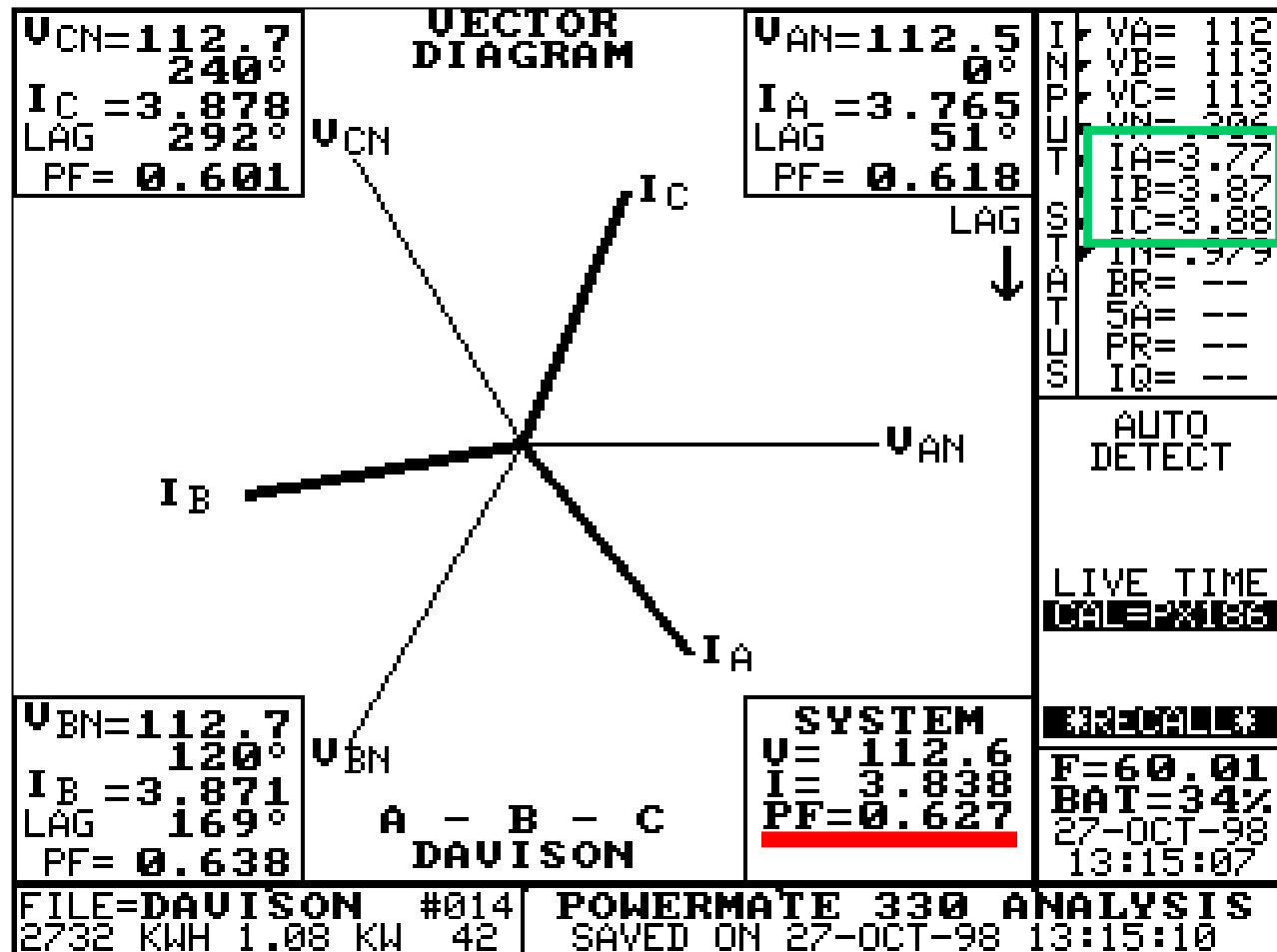


The customer added the 225 amp panel some time after the original installation.

Metering Problem ?

Opportunity to Bill for Excessive Reactive Load

Bad Power Factor

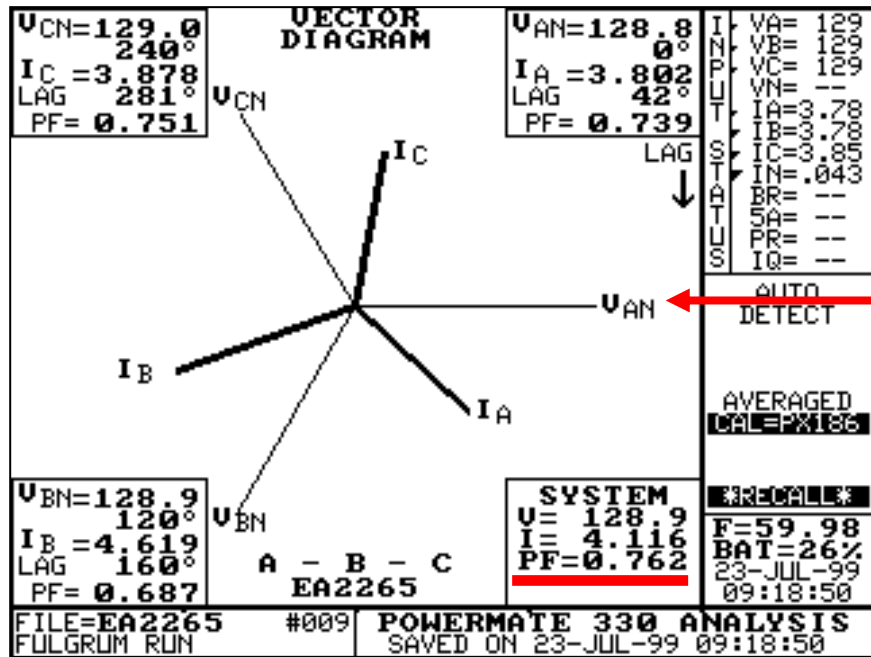


***WHAT CAN A CUSTOMER OR
UTILITY DO ABOUT BAD FACTOR?***

VARs Compensator

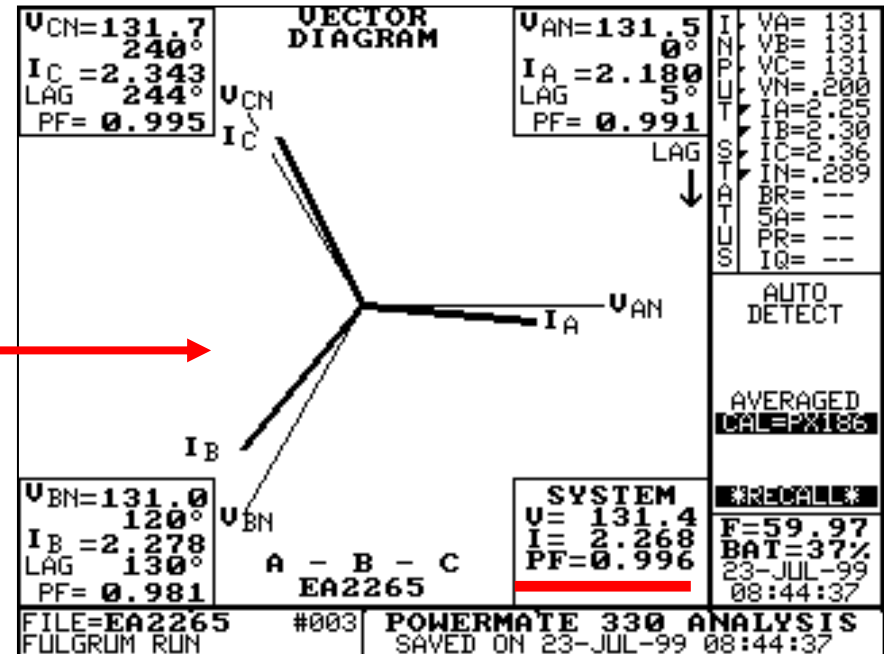


Site With VARs Compensator Installed



Vars Compensator Off

Vars Compensator On



SAFETY +

IS THE ABSOLUTE NUMBER ONE PRIORITY

- **Hardhat**
- **Eye Protection**
- **FR Clothing**
- **Rubber gloves with “Grabbit” gloves or Leather outer protectors**

