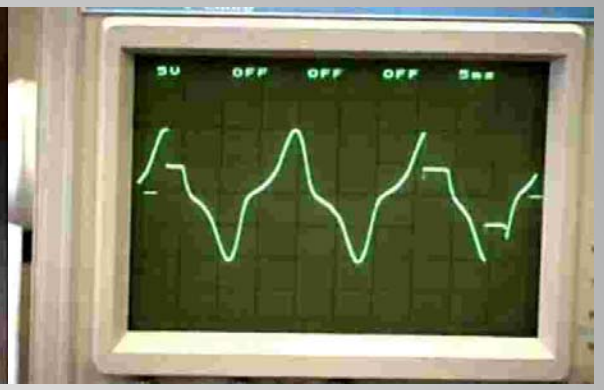
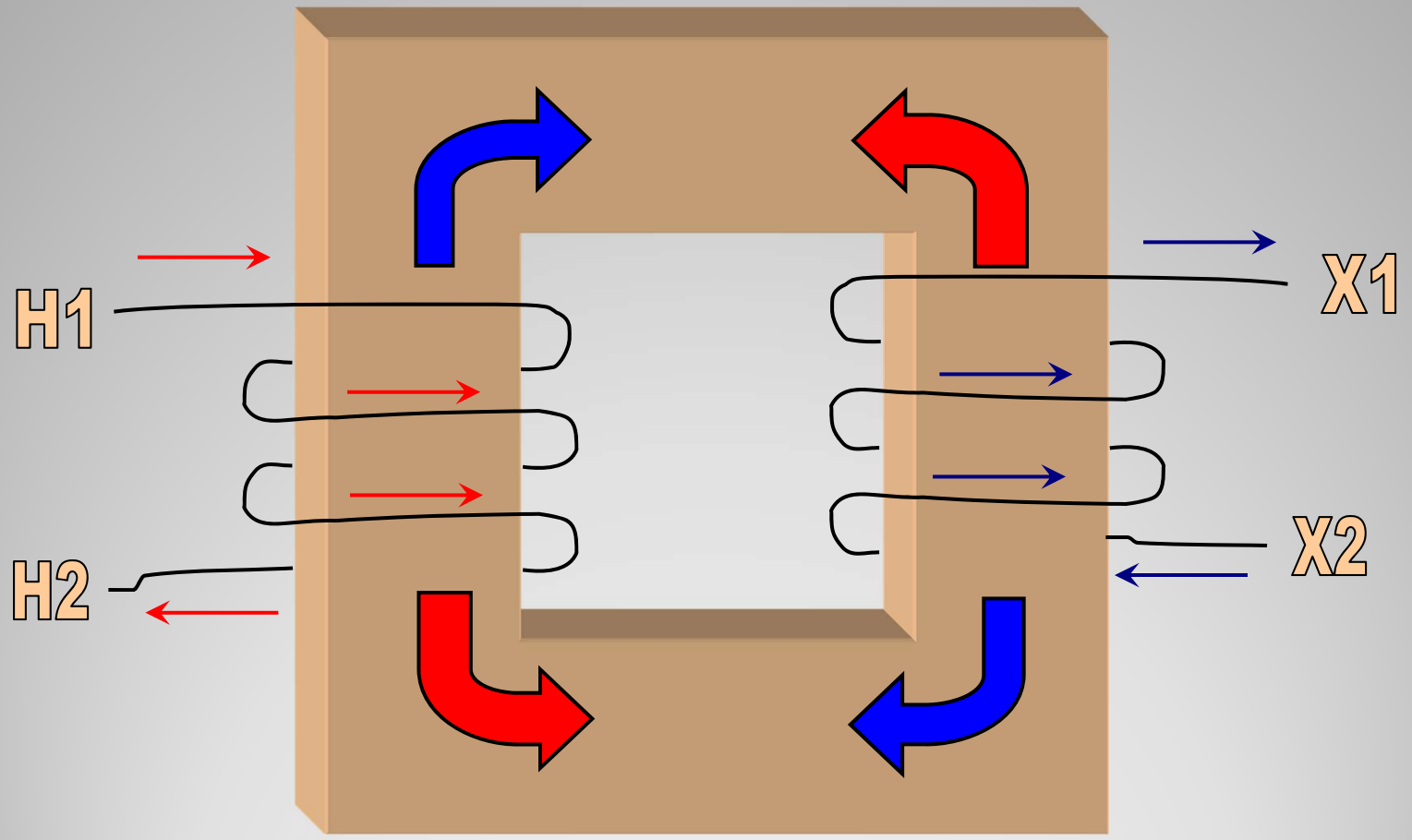
Current Transformers



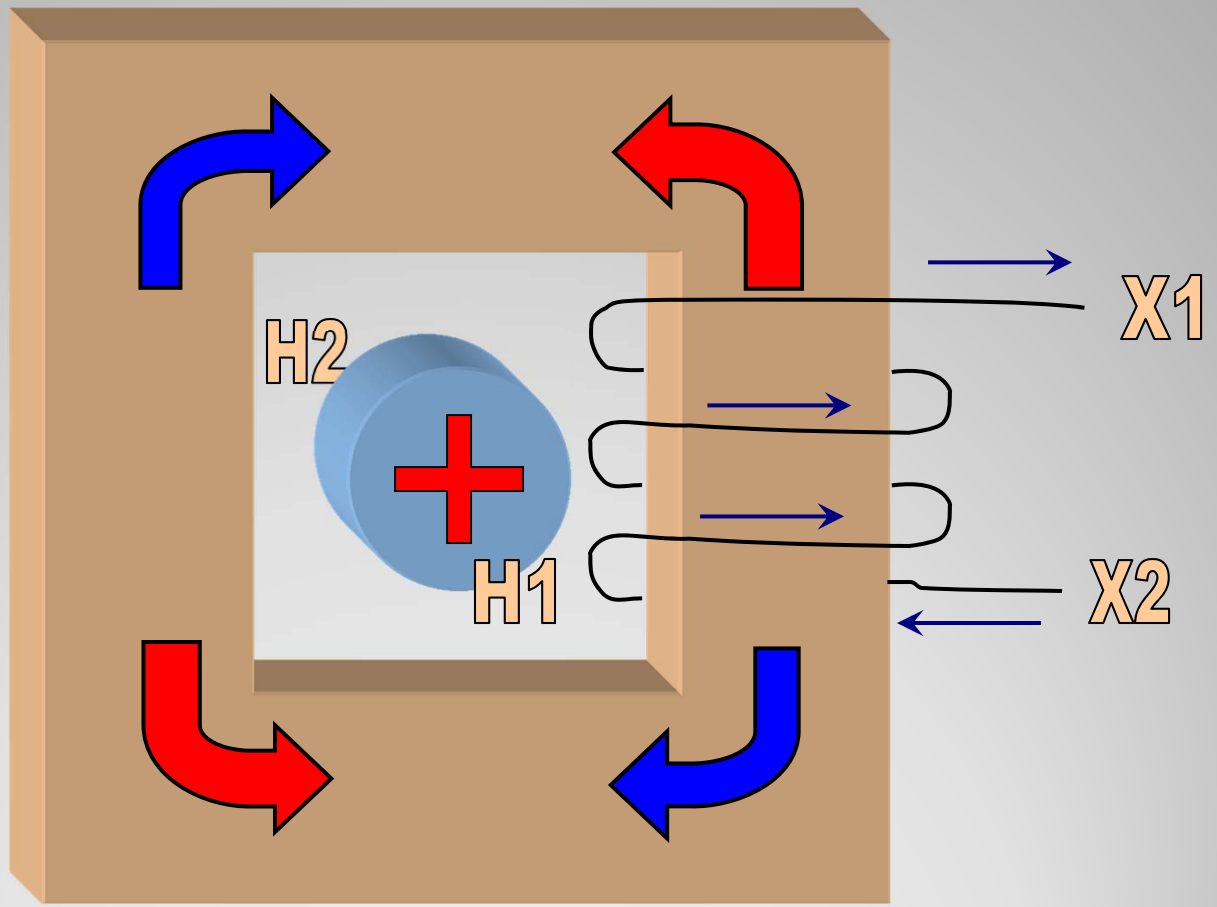


- **Bonneville Power Administration**
  - Steve Laslo
    - **For the Hands On Relay School (3-12)**
      - **Revision 1.1**

Basic Theory:

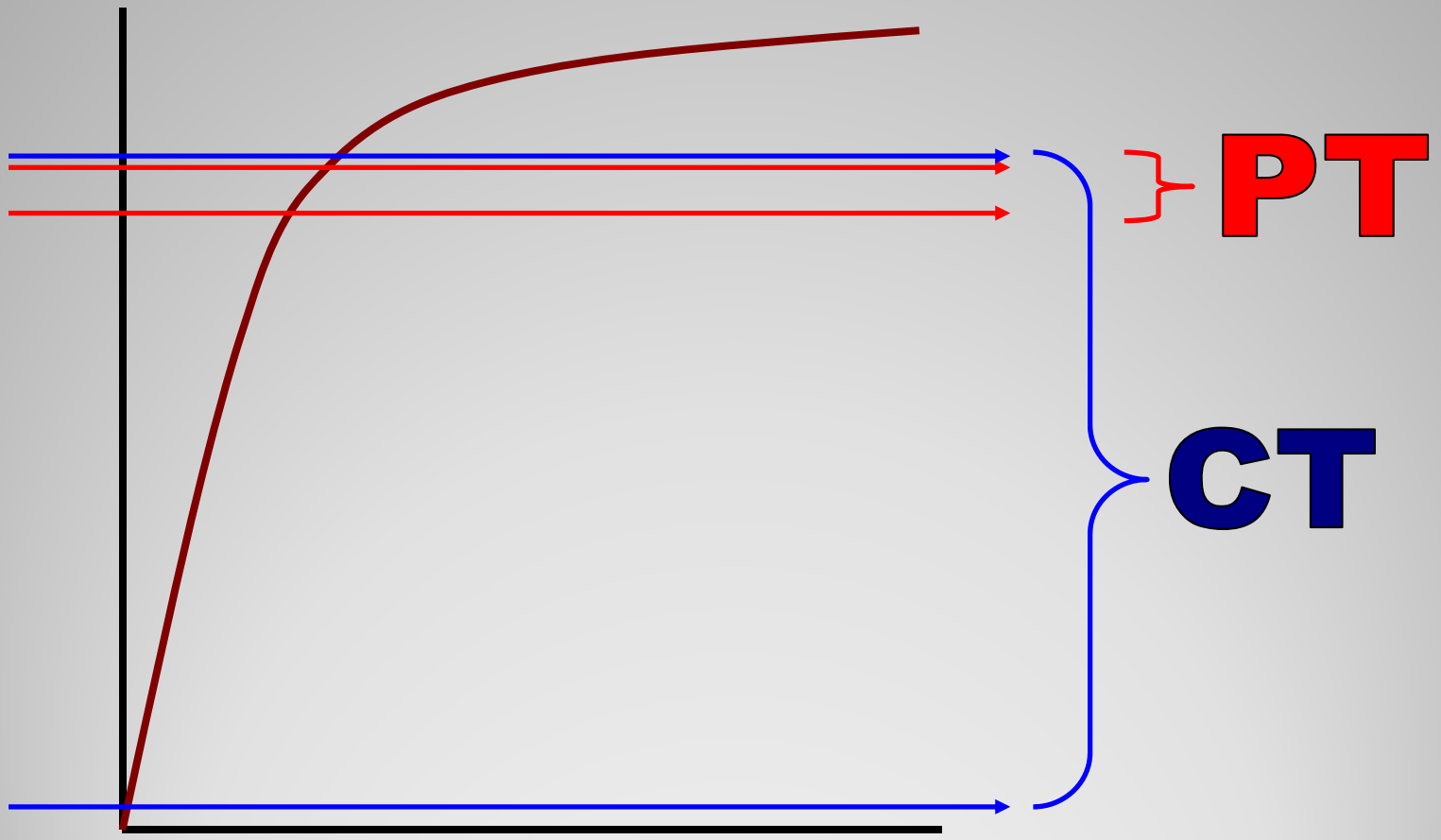


CT as a Voltage Transformer

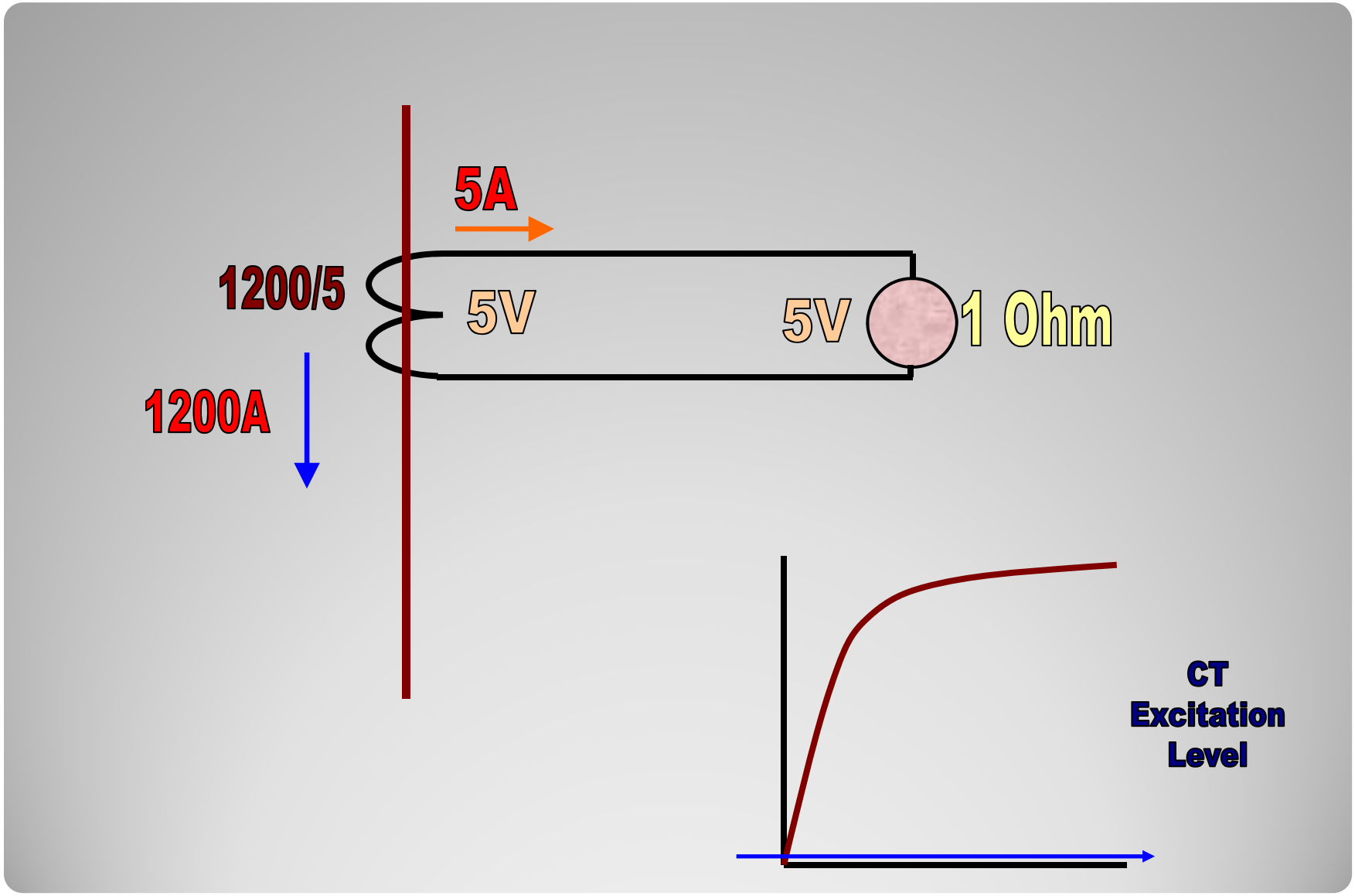


CT as a Voltage Transformer

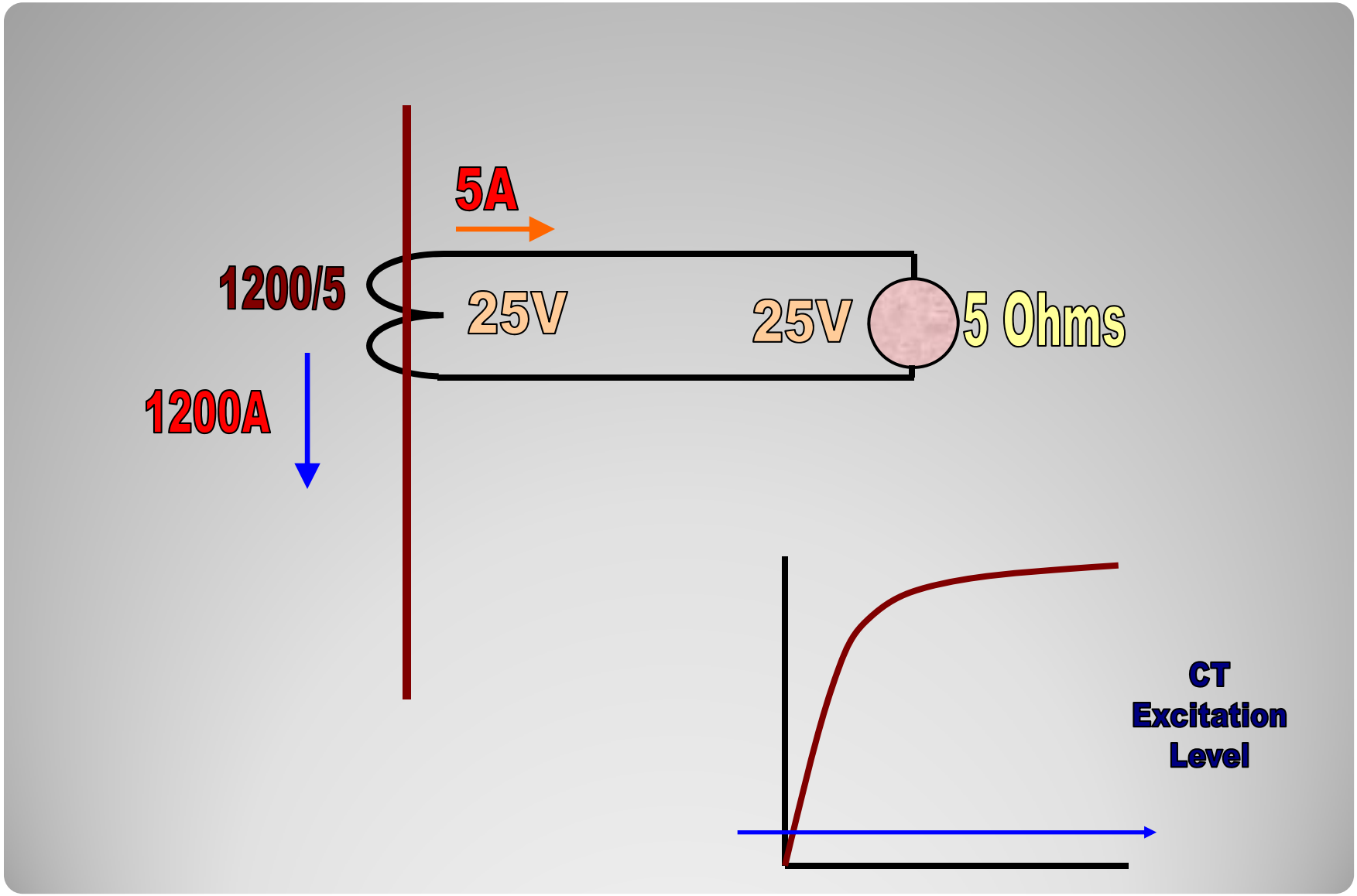
Working Range of (relative) flux levels on core:



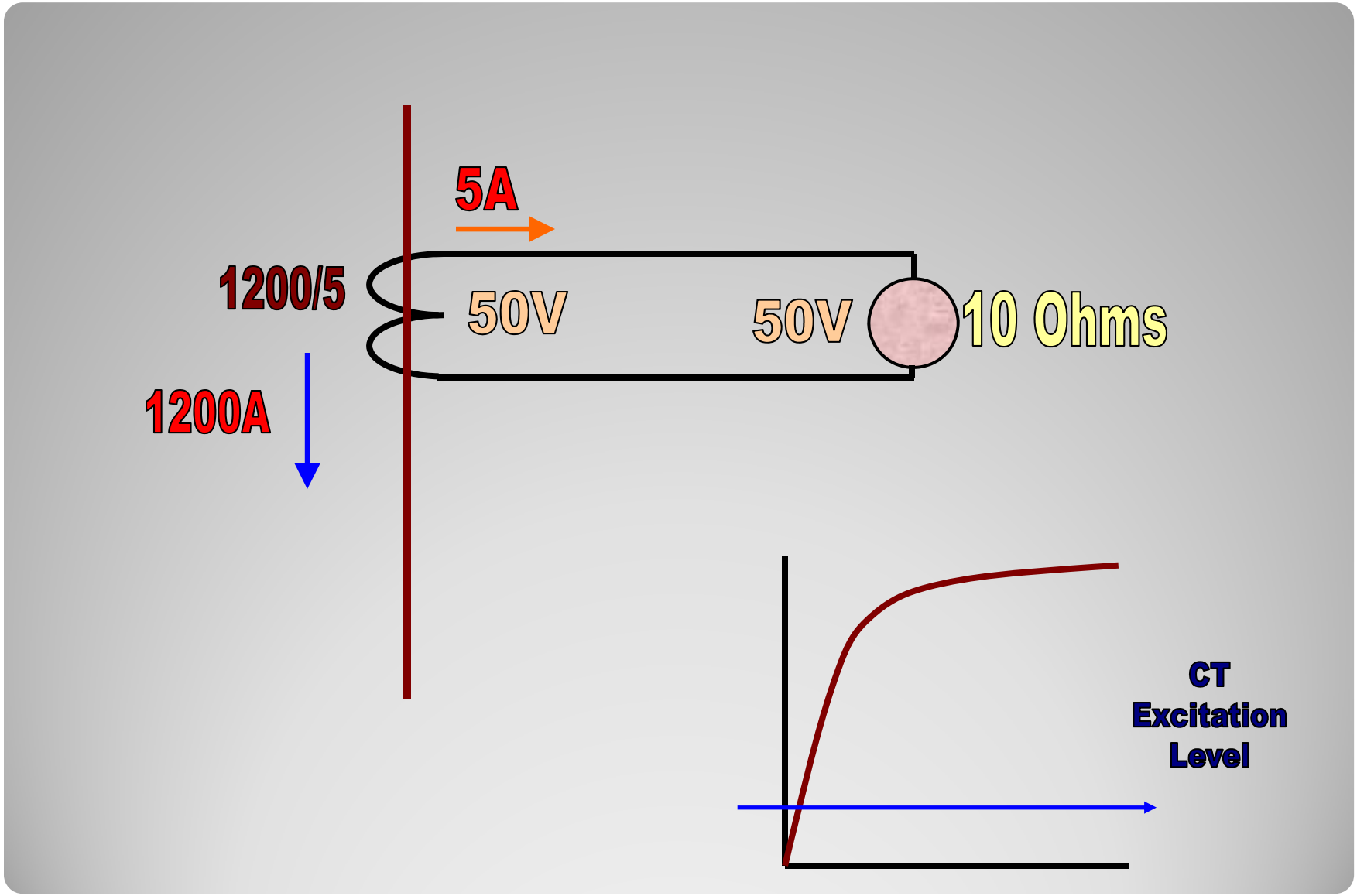
Saturation Curves



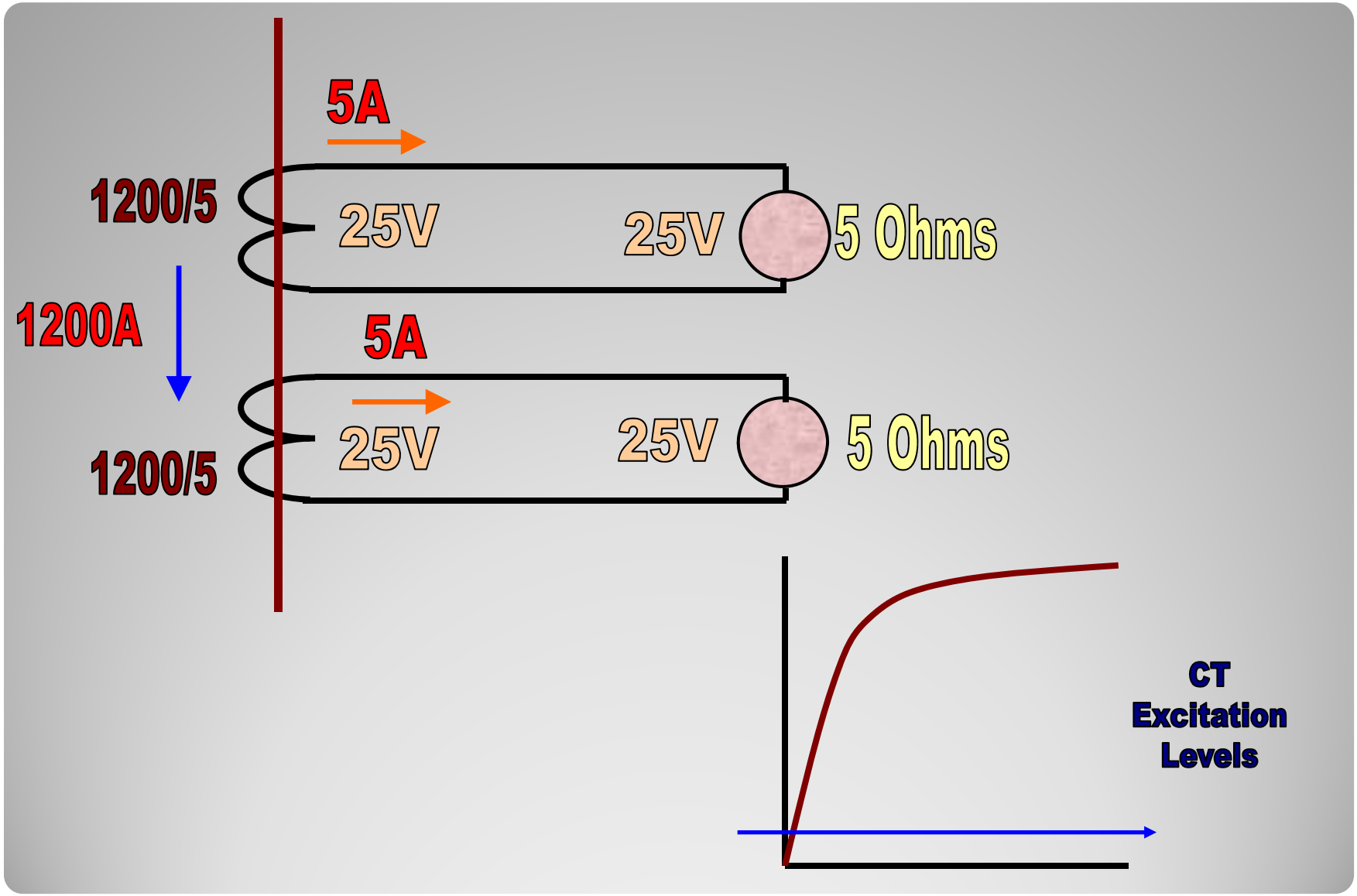
CT with varying burden



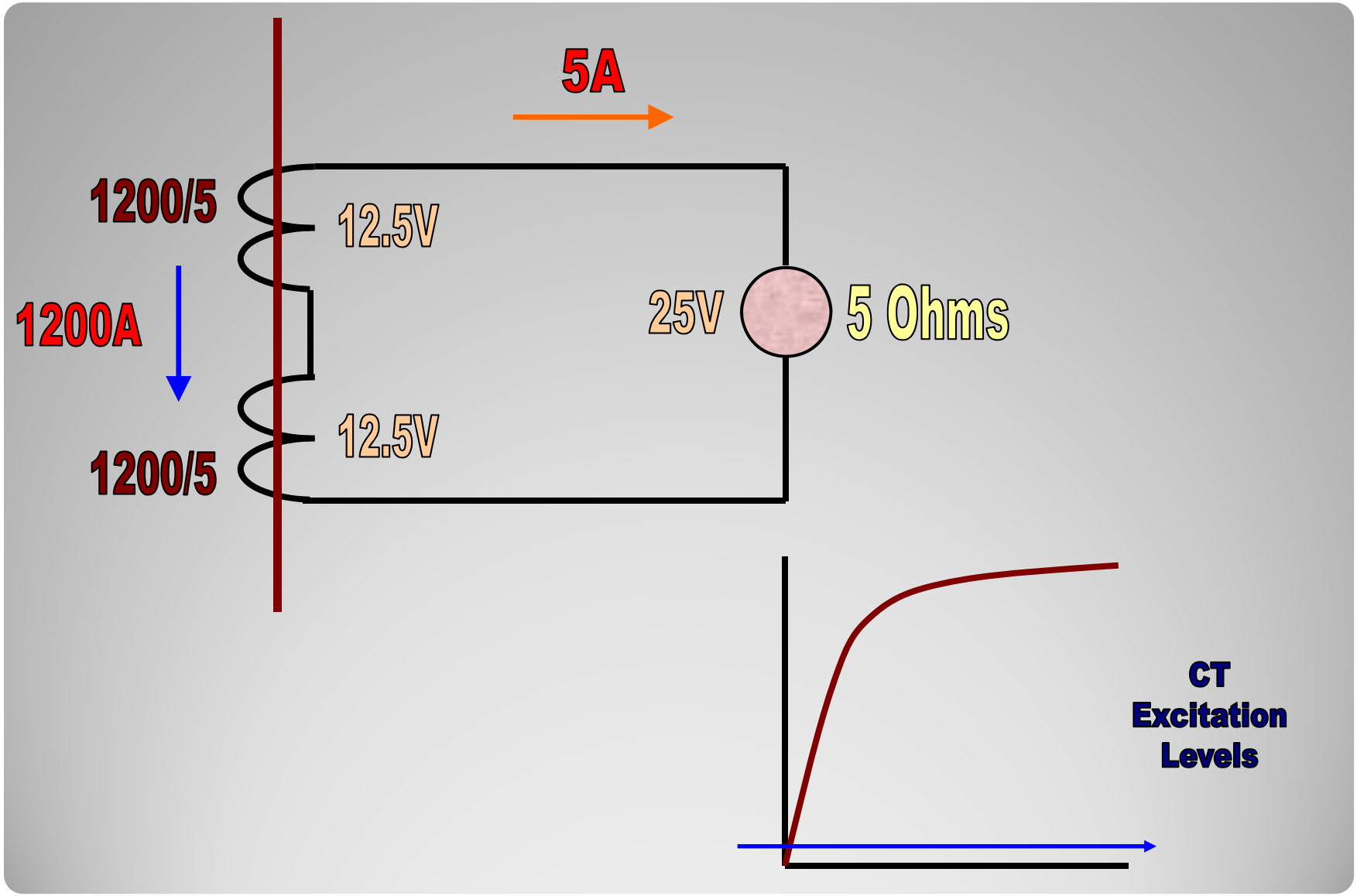
CT with varying burden



CT with varying burden

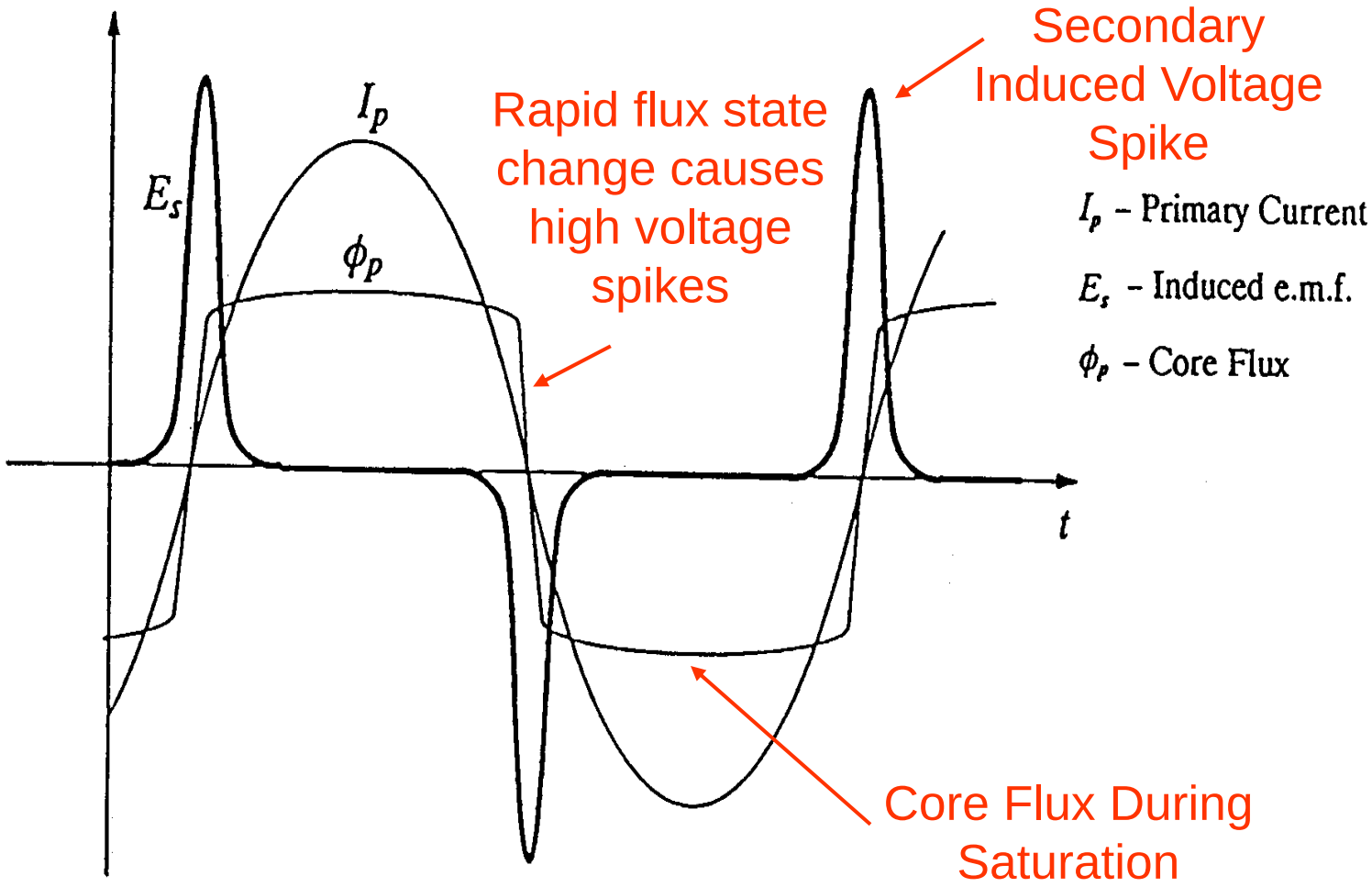

5A
1200/5
25V
25V
5 Ohms
1200A
5A
25V
25V
5 Ohms
1200/5
CT
Excitation
Levels

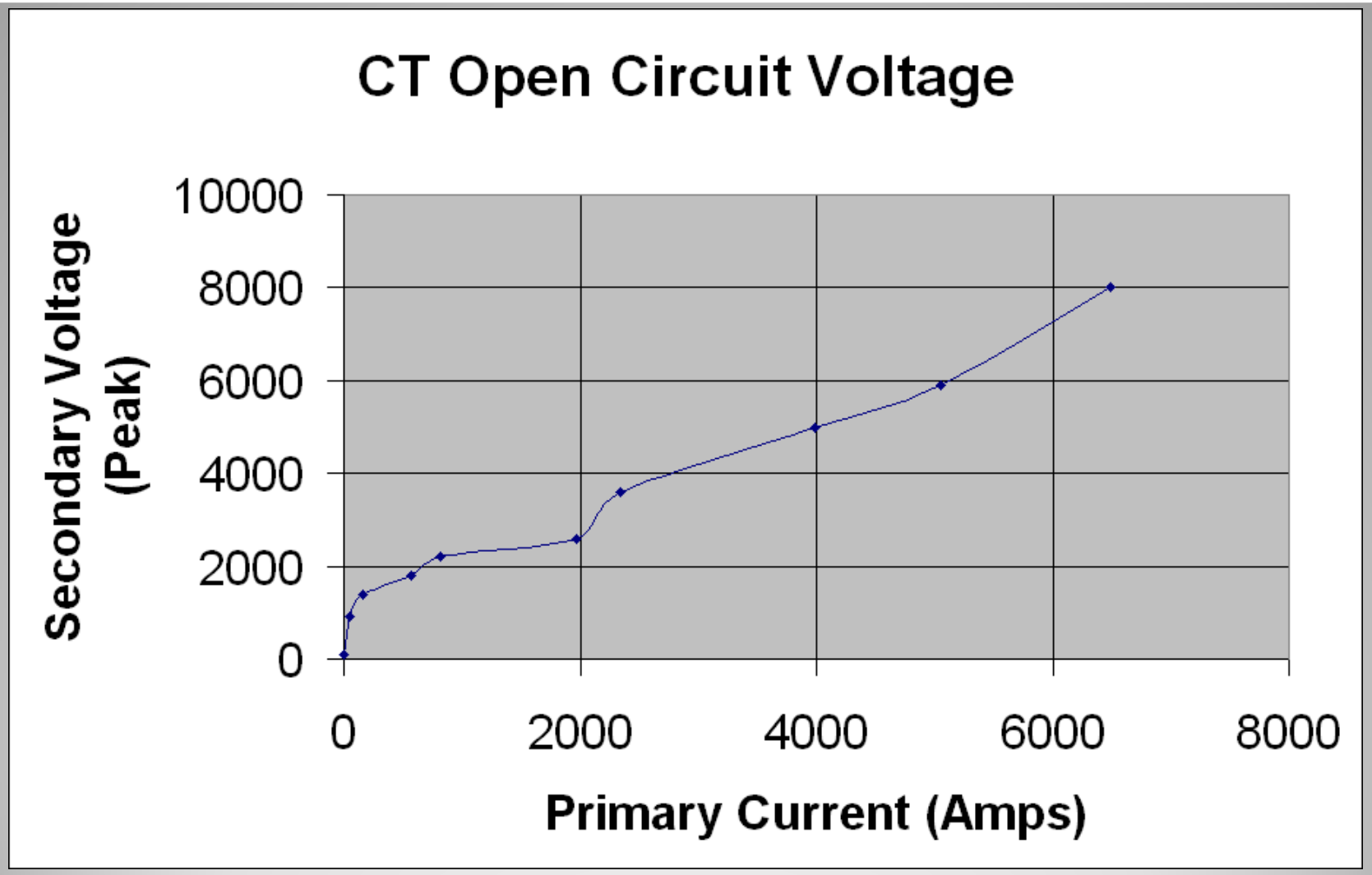
Single CT's



CT's in Series

Secondary open circuit wave shapes





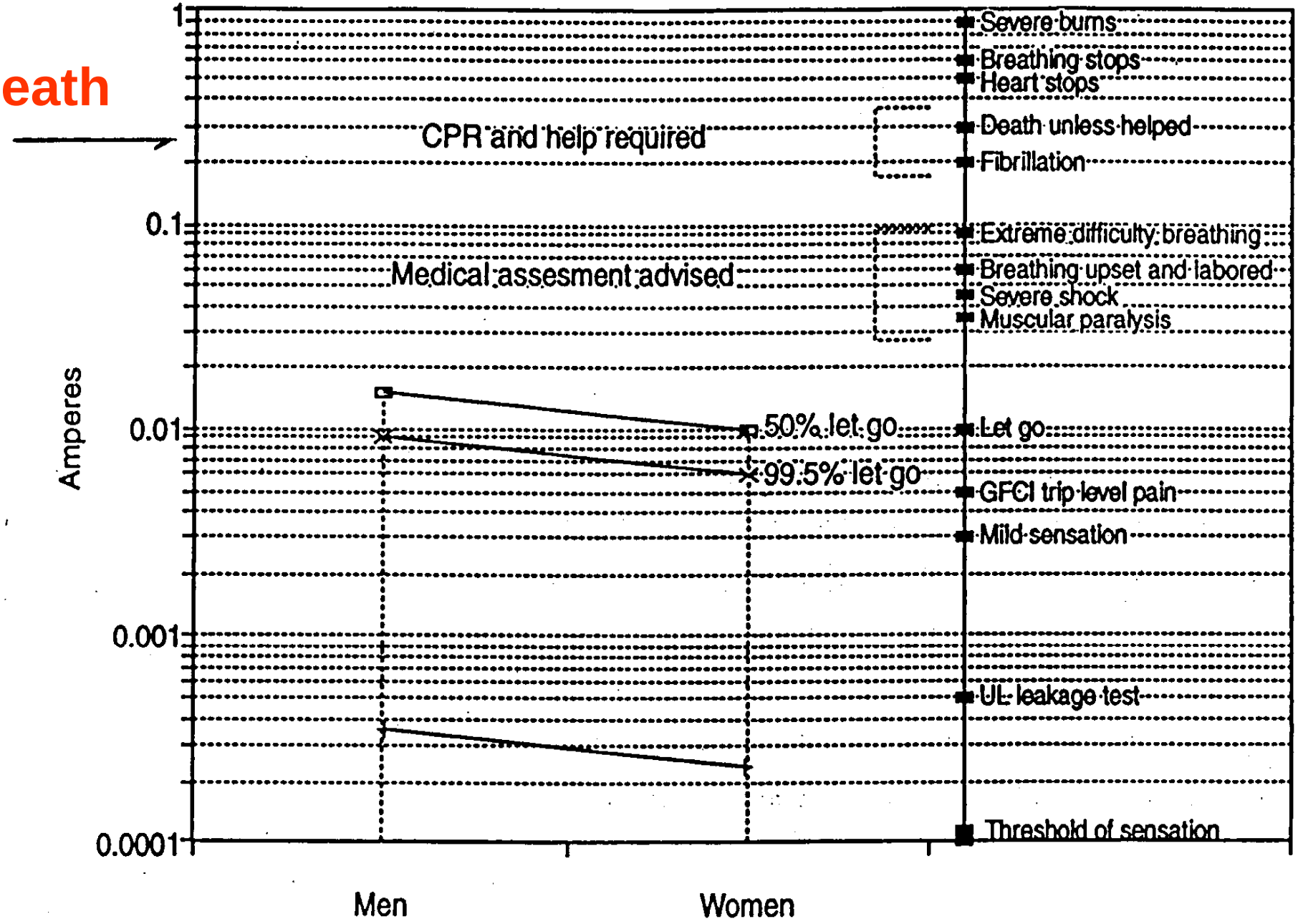
CT used was from a retired 500kV ITE SF6 PCB - BCT 3000/5 (Full Winding).
Test Equipment: TEK 20kV probe, ITE/Gould Digital Scope, Transrex high current supply.
Test Performed in BPA Mangan Lab - 7/16/02.
Note: Test Data are approximate values combined from two consecutive test runs.
- Added V/A Column 8-02 (SJL); formatting change (6-03).

BPA Lab Data

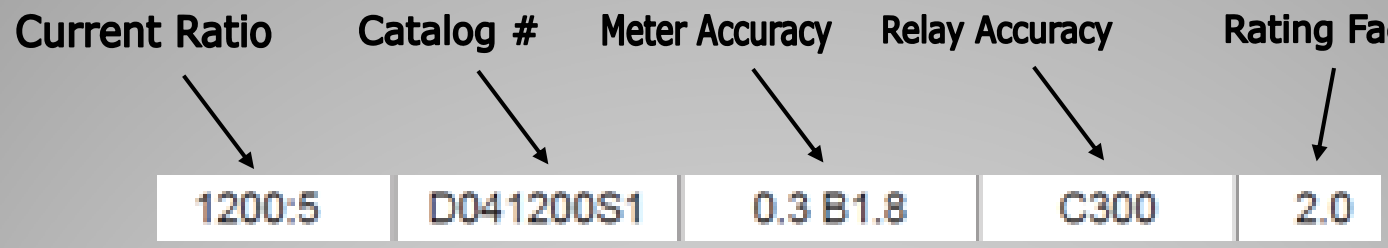
CT Open Circuit Voltage Test

7-16-02 Ron Denis / Steve Laslo

Primary Current (Amps)	Secondary Output Voltage (V_{PEAK})	V_{PEAK} / Amp	Comments
5	110	22	Sine Wave
49	900	18.37	Slight Distortion
167	1400	8.38	Marked Distortion
567	1800	3.17	
813	2220	2.73	Saturated – CT making significant noise
1967	2600	1.32	
2337	3600	1.54	Fully Saturated – Waveform primarily consisting of Voltage Spikes
3987	5000	1.25	Higher, Narrower Spikes
5047	5900	1.17	
6487	8000	1.23	CT noise level very high Waveform extremely peaked



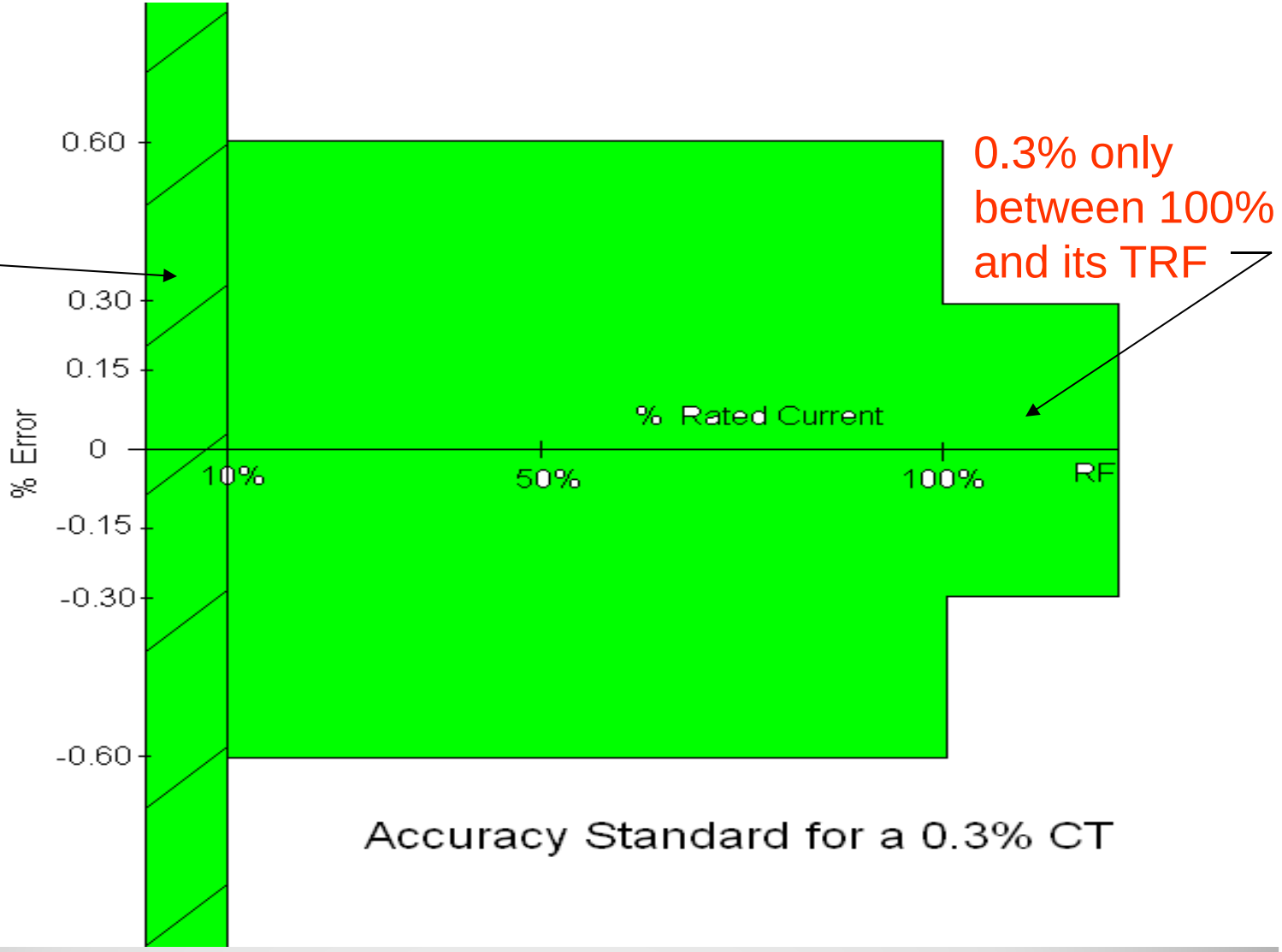
A CT can easily supply currents above lethal levels!



- Meter Accuracy:
  - Secondary Current will be within 0.3% accuracy at rated current and Burden levels of 1.8 ohms or less.
- Relay Accuracy:
  - Secondary Current will be within 10% accuracy at 1-20 x rated current with burden levels of 3 ohms or less.
  - Full winding output of the CT is essentially 300V, which can drive 100A secondary current through a 3 ohm burden (or less).
  - 'C' indicates accuracy can be calculated based on design of this CT. 'C' ratings are the most common.
    - Less common letter classes: K, T, H, L
- Rating Factor:
  - Up to 2 x rated current can be applied continuously with the CT staying within it's accuracy and thermal ratings.

Ratings of CT's

Note: No accuracy standards between 0% and 10%

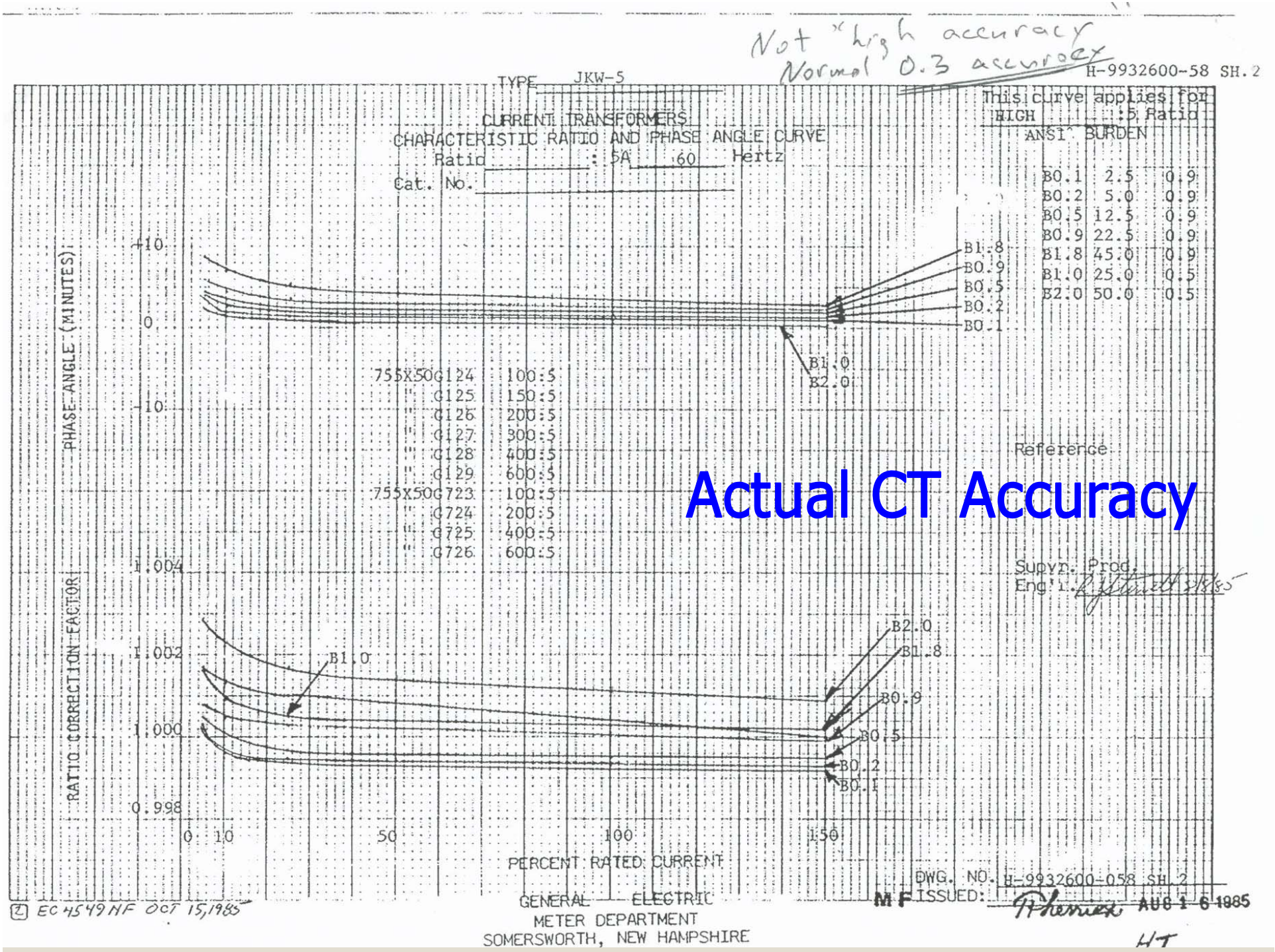


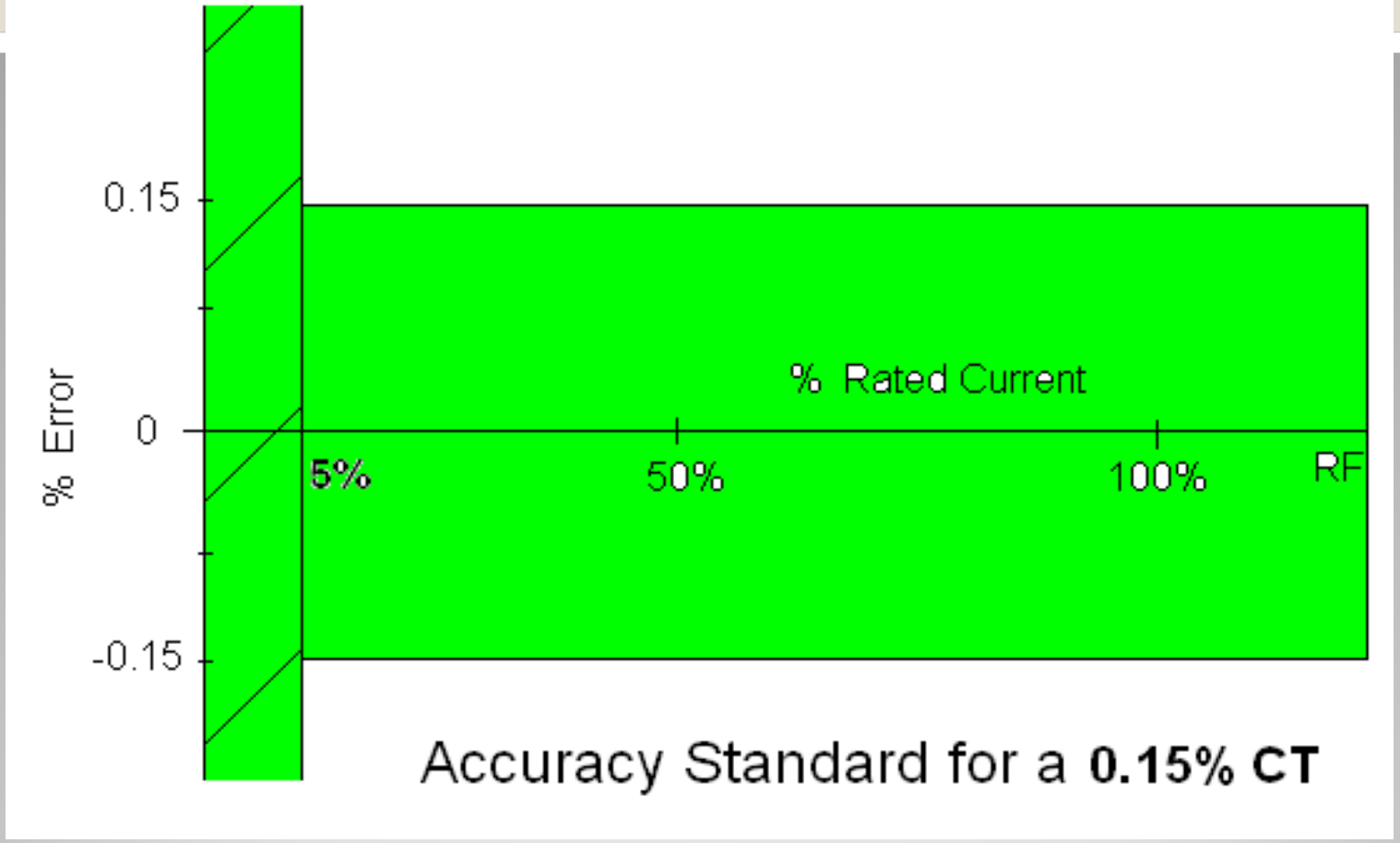
0.3% only between 100% and its TRF

Accuracy Standard for a 0.3% CT

By the IEEE Standard, does a 0.3% CT mean its 0.3% accurate?

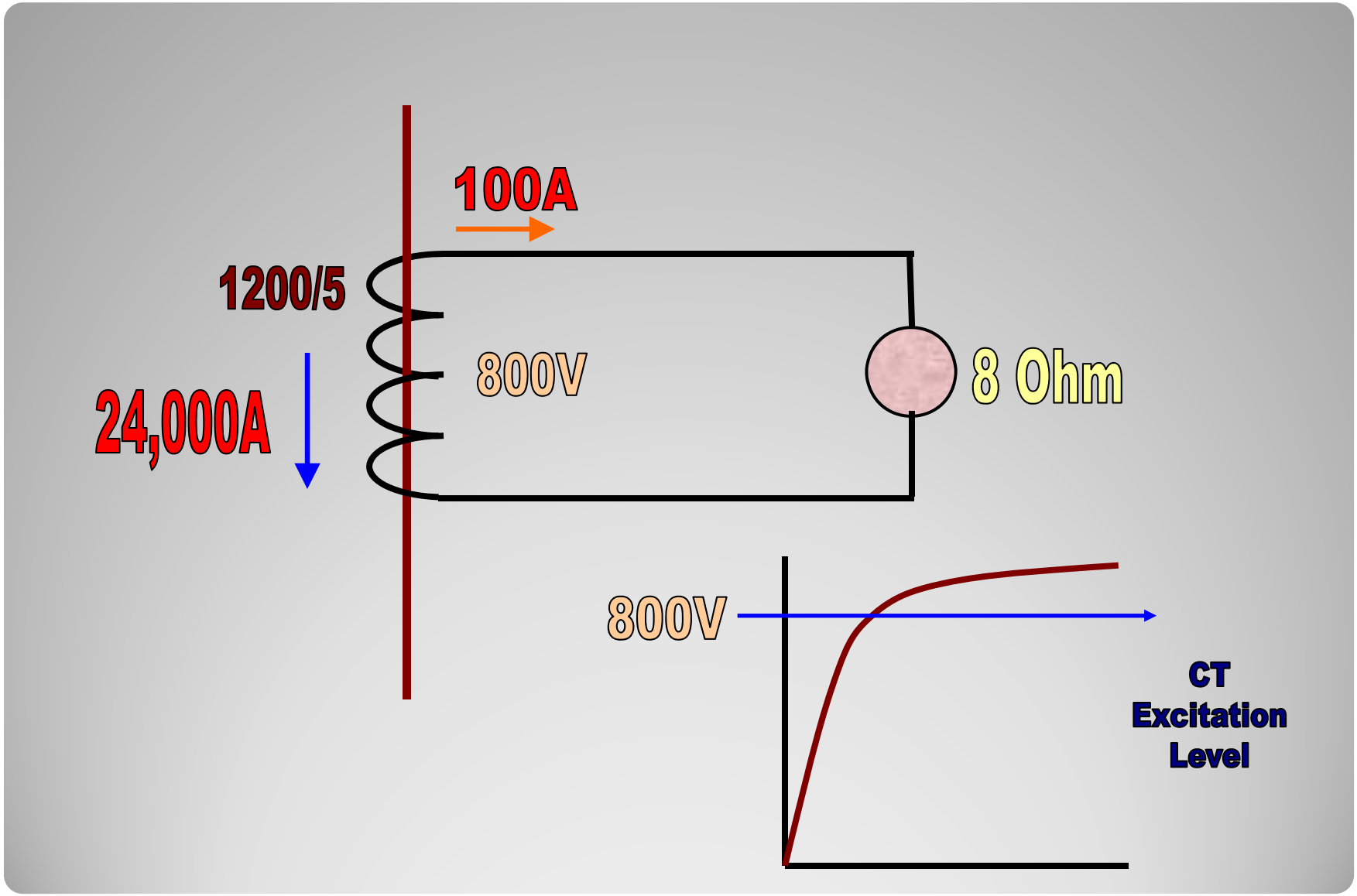
IEEE Standard


Not "high accuracy
Normal 0.3 accuracy
H-9932600-58 SH. 2
TYPE JKW-5
CURRENT TRANSFORMERS
CHARACTERISTIC RATIO AND PHASE ANGLE CURVE
Ratio : 5A 60 Hertz
Cat. No.
This curve applies for HIGH :5 Ratio
ANSI BURDEN
B0.1 2.5 0.9
B0.2 5.0 0.9
B0.5 12.5 0.9
B0.9 22.5 0.9
B1.8 45.0 0.9
B1.0 25.0 0.5
B2.0 50.0 0.5
B1.8
B0.9
B0.5
B0.2
B0.1
B1.0
B2.0
755X50G124 100:5
" G125 150:5
" G126 200:5
" G127 300:5
" G128 400:5
" G129 600:5
755X50G723 100:5
" G724 200:5
" G725 400:5
" G726 600:5
Reference
Actual CT Accuracy
Supvn. Prod. Eng'l.
PHASE ANGLE (MINUTES)
RATIO CORRECTION FACTOR
+10
0
-10
1.004
1.002
1.000
0.998
0 10 50 100 150
PERCENT RATED CURRENT
DWG. NO. H-9932600-058 SH. 2
M F ISSUED: AUG 16 1985
EC 4549 NF OCT 15, 1985
GENERAL ELECTRIC
METER DEPARTMENT
SOMERSWORTH, NEW HAMPSHIRE
HT



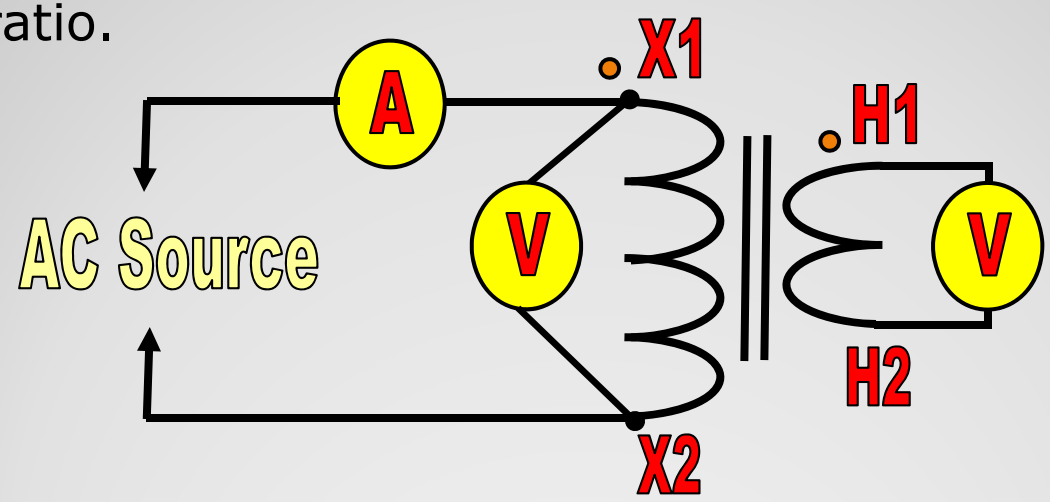
- New supplement to IEEE Standard
  - C57.13.6-2005
  - Creates a new 0.15% accuracy class
    - With an extended, ***consistent*** range between 5% and TRF

New Extended Accuracy Range CT's



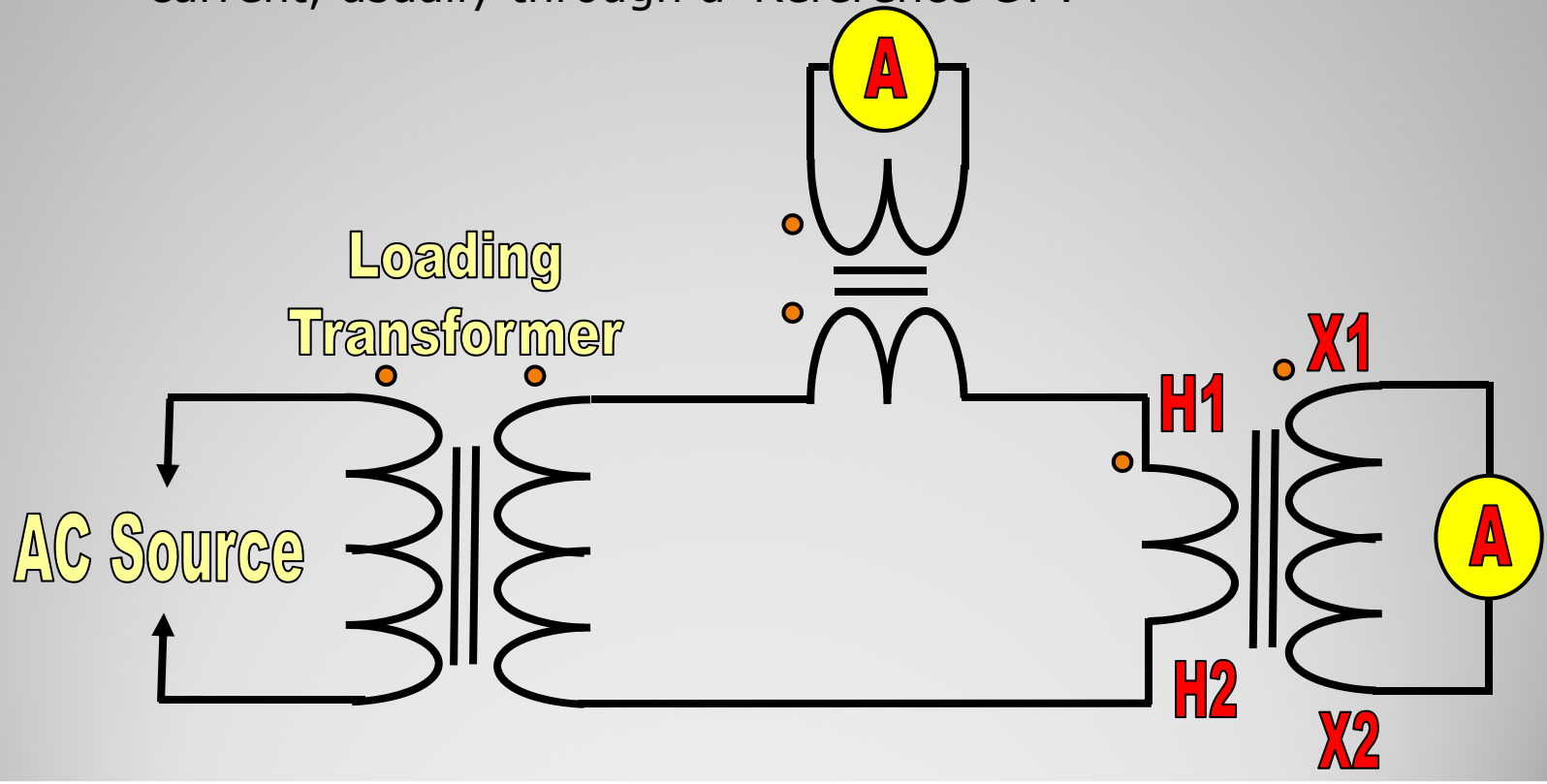
Multi-ratio issues

- Ratio Test
  - Two commonly used out-of-service methods to test:
    - Voltage Method
      - CT is essentially tested as a voltage transformer by applying voltage to the CT Secondary and measuring the primary voltage.
      - The turns ratio is approximately equal to the voltage ratio.



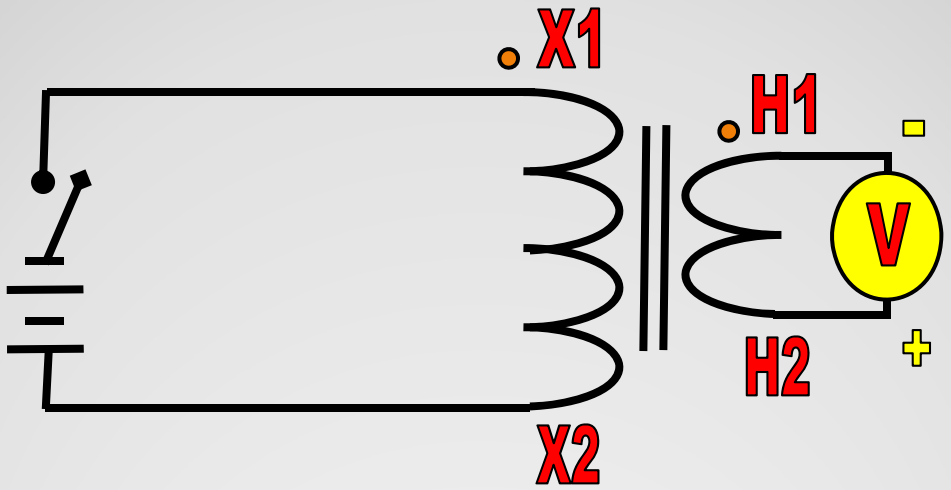
Testing CT's

- Ratio Test
  - Current Method
    - Some form of 'loading gear' is used to push current through the CT primary. Secondary current is compared to primary current, usually through a 'Reference CT'.

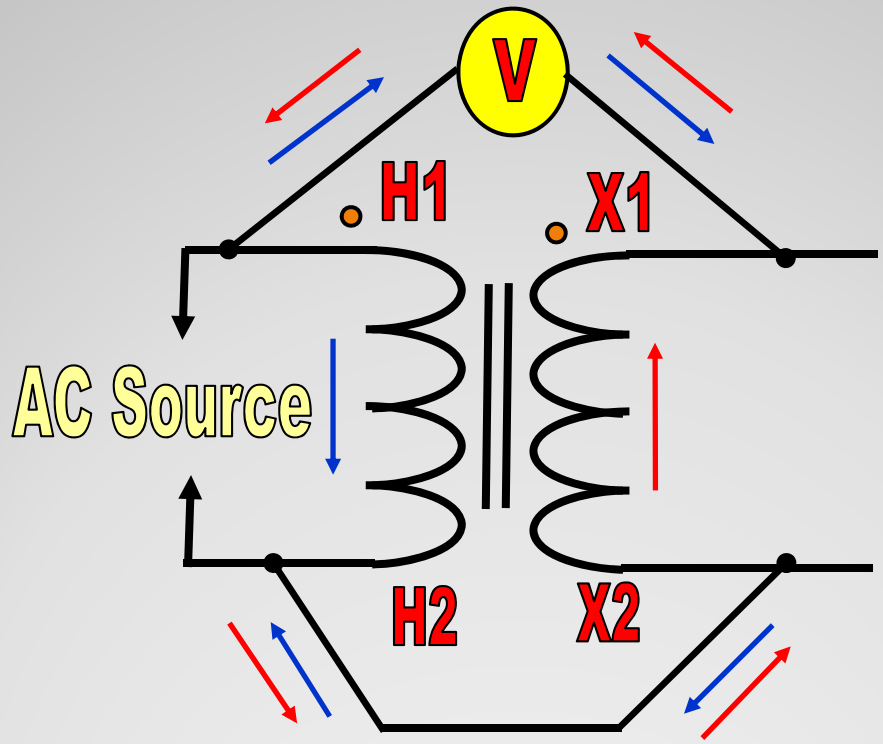


Testing CT's

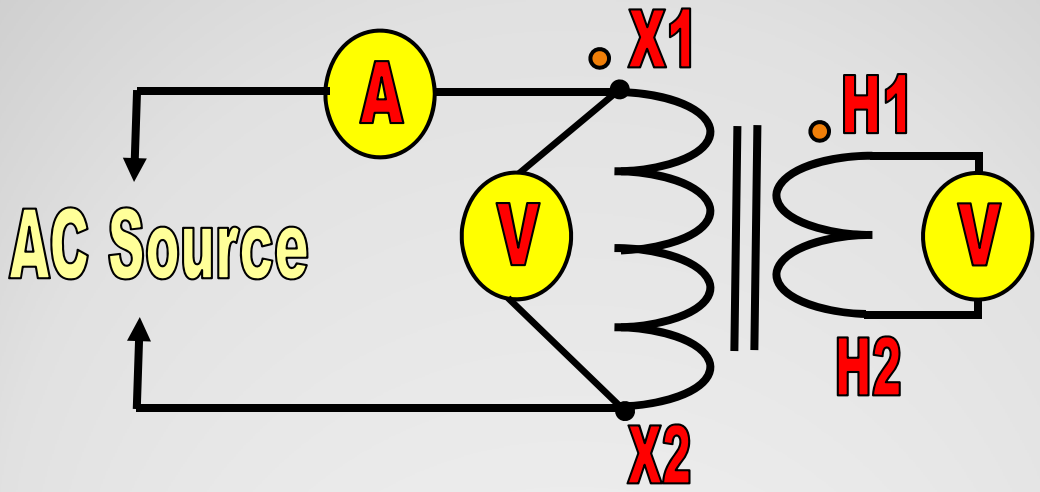
- Polarity Test
  - Four commonly used out-of-service methods to test:
    - DC Flash Method
      - A lantern battery or equivalent DC source is momentarily connected to the CT Secondary and the primary voltage is monitored with a voltmeter.



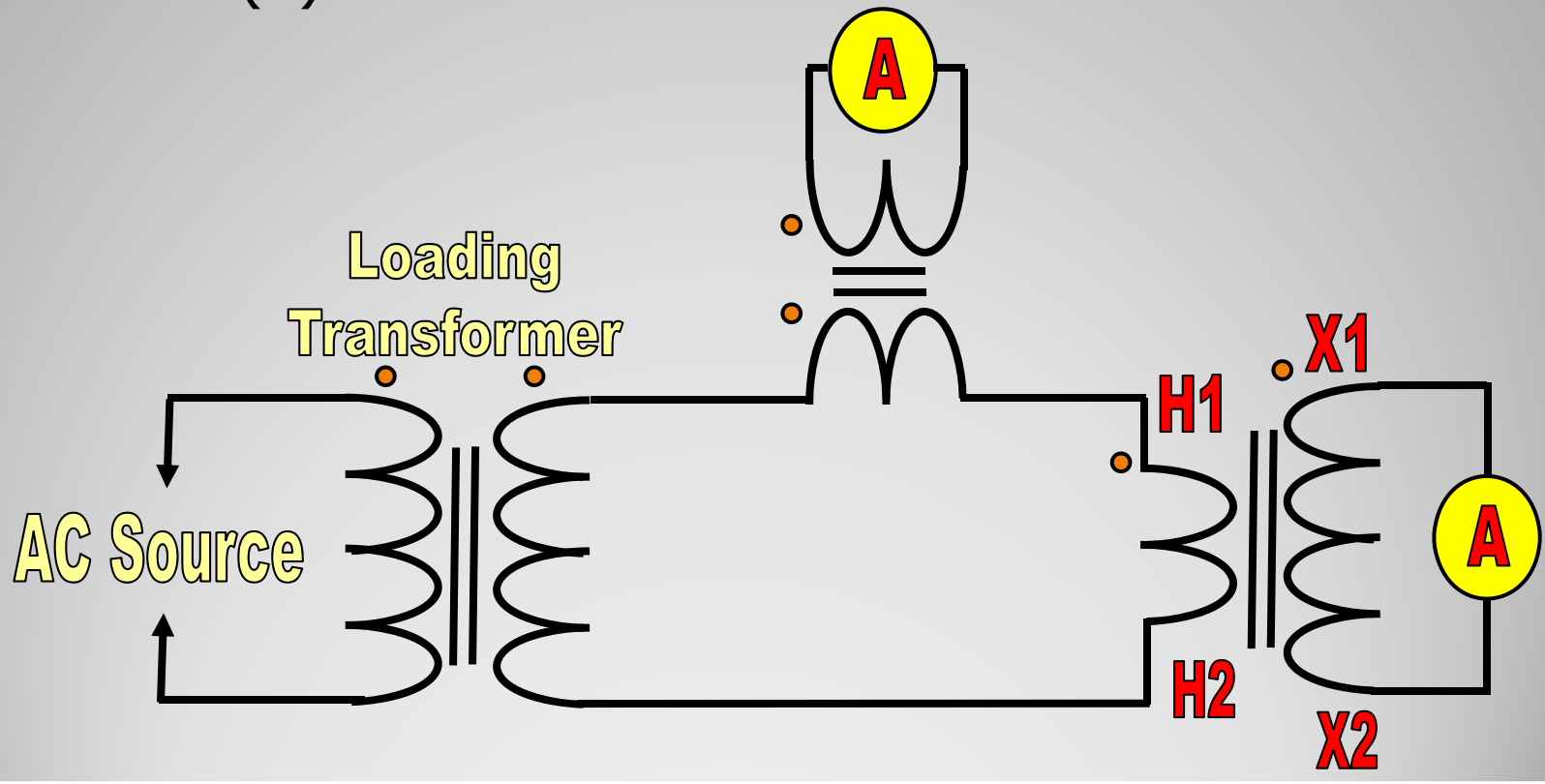
- Classical Polarity Test
  - Voltage Method
    - This test is performed in the same manner as a voltage transformer polarity test.



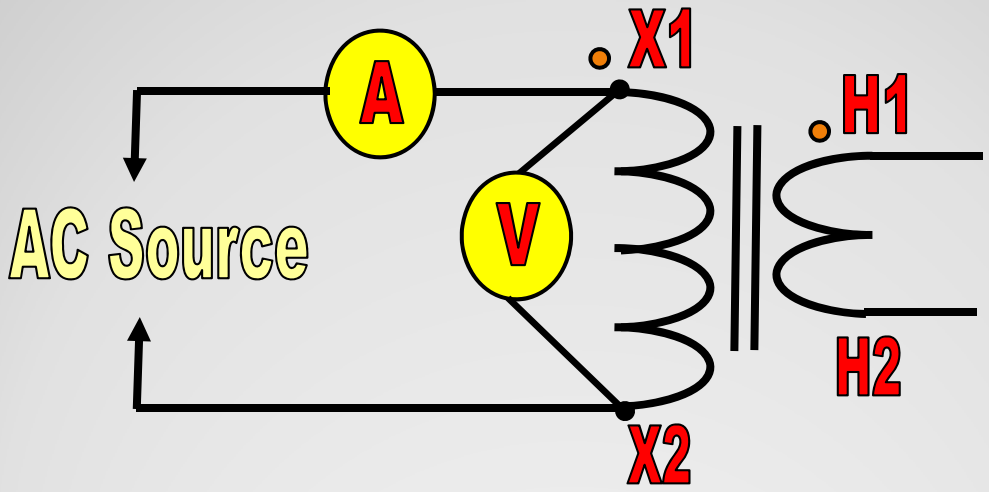
- Ratio/Polarity Test using voltage method:
  - While performing ratio check, phase angle of both voltages is compared using phase angle meter(s).



- Ratio/Polarity Test using Current Method
  - While performing ratio check, phase angle of both voltages is compared using phase angle meter(s).



- Excitation Test
  - Secondary Excitation Method
    - Secondary voltage is applied and exciting current is measured
    - Voltage / Current are plotted and compared to manufacturer's information



Testing CT's

CT-1?
PART

TYPICAL EXCITATION CURVES

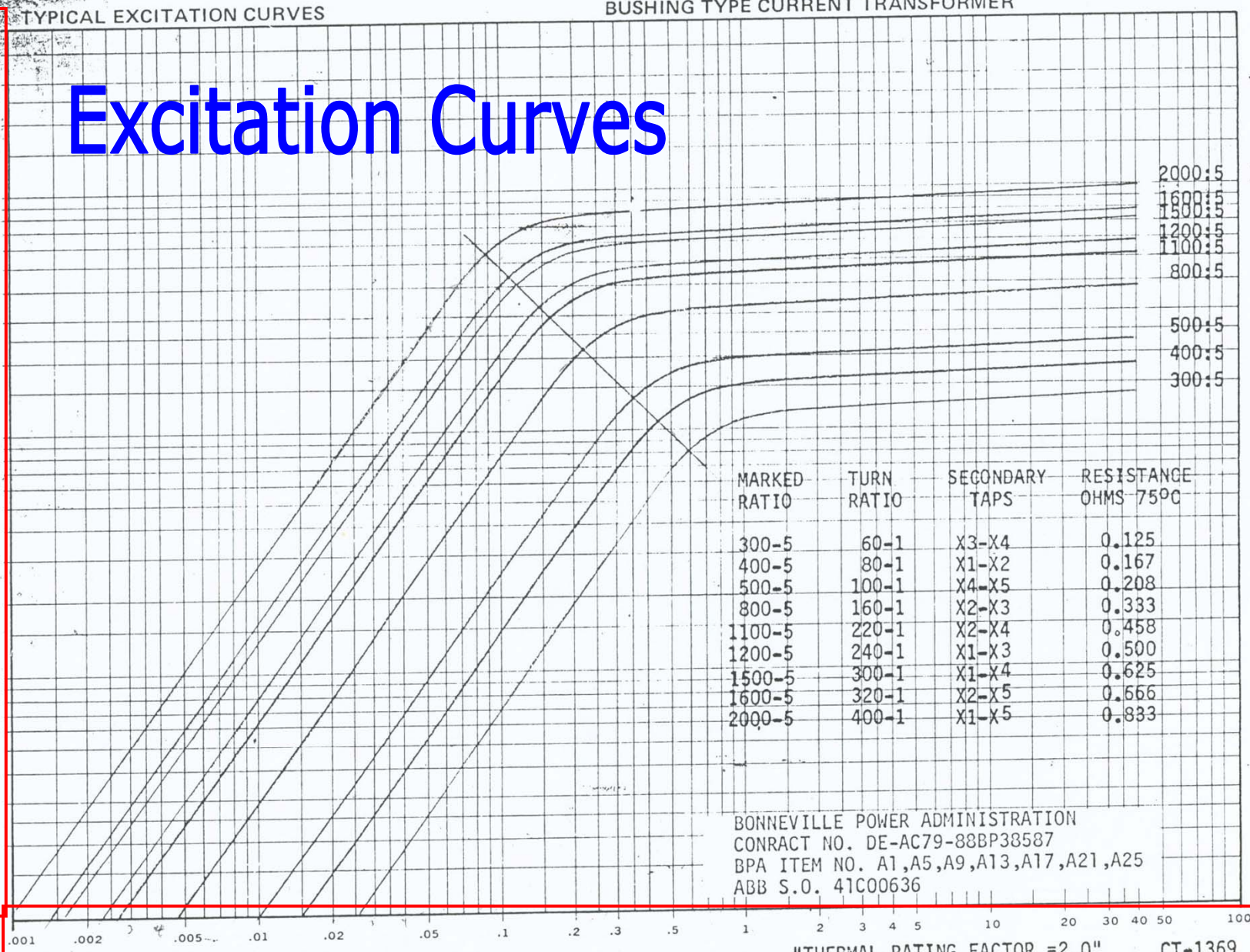
BUSHING TYPE CURRENT TRANSFORMER

Excitation Curves

Power Systems Division
P.O. Box 98, Greensburg, Pa. 15601
Telephone (412) 834-3300

Manufacturer of I.T.E Equipment

BBC Brown Boveri Electric, Inc.
BROWN BOVERI



MARKED RATIO	TURN RATIO	SECONDARY TAPS	RESISTANCE OHMS 75°C
300-5	60-1	X3-X4	0.125
400-5	80-1	X1-X2	0.167
500-5	100-1	X4-X5	0.208
800-5	160-1	X2-X3	0.333
1100-5	220-1	X2-X4	0.458
1200-5	240-1	X1-X3	0.500
1500-5	300-1	X1-X4	0.625
1600-5	320-1	X2-X5	0.666
2000-5	400-1	X1-X5	0.833

BONNEVILLE POWER ADMINISTRATION
CONRACT NO. DE-AC79-88BP38587
BPA ITEM NO. A1,A5,A9,A13,A17,A21,A25
ABB S.O. 41C00636

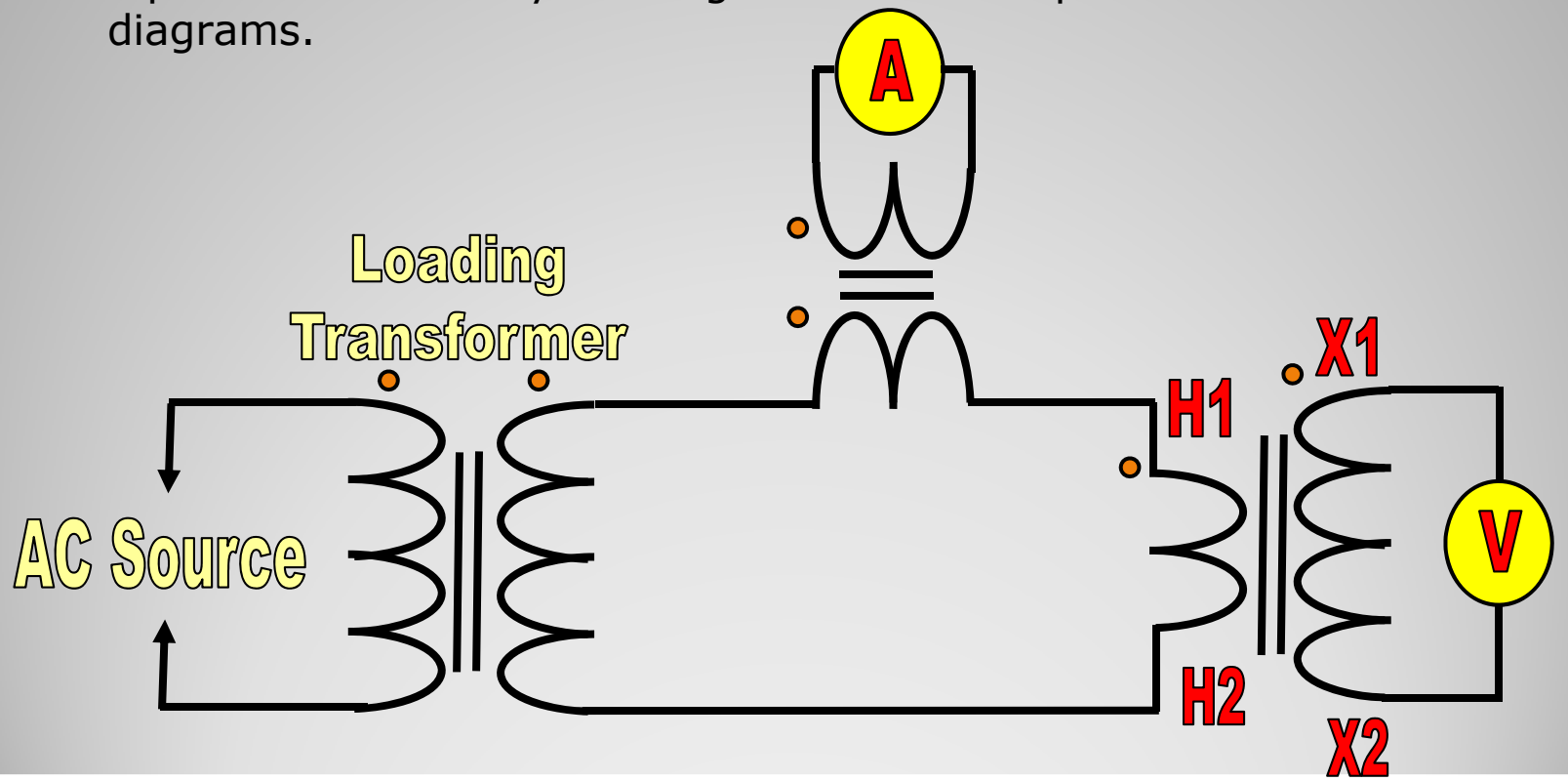
BBC TYPE-BR RELAYING CT
BBC NO. 939A600-01 (02)

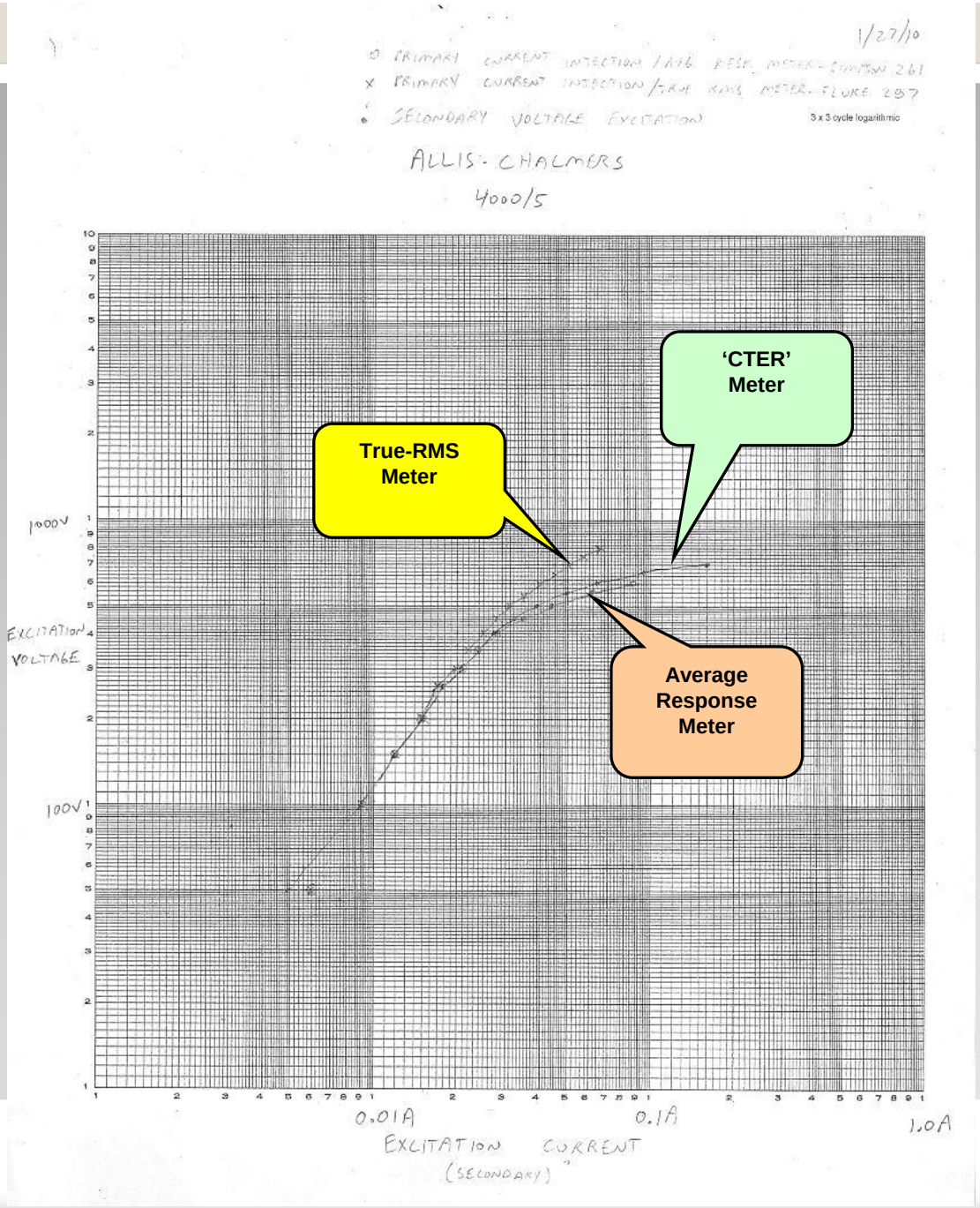
5-20-80

"THERMAL RATING FACTOR =2.0"
RATIO - 2000:5
ACCURACY - 2.5L800 (C800)

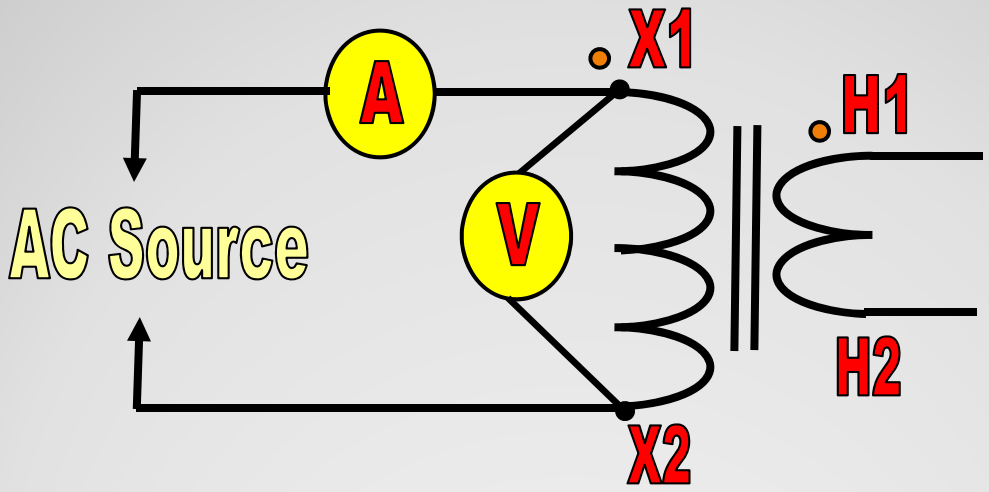
CT-1369
PART 1

- Excitation Test using Primary Current Injection
  - Primary Current is measured along with secondary voltage
  - Primary exciting current is divided by the CT ratio to determine equivalent secondary exciting current to compare to manufacturer's diagrams.




1/27/10
○ PRIMARY CURRENT INJECTION / AVG RESP. METER - SIMPSON 261
× PRIMARY CURRENT INJECTION / TRUE RMS METER - FLUKE 287
• SECONDARY VOLTAGE EXCITATION
3 x 3 cycle logarithmic
ALLIS-CHALMERS
4000/5
'CTER' Meter
True-RMS Meter
Average Response Meter
1000V
100V
EXCITATION VOLTAGE
0.01A
0.1A
1.0A
EXCITATION CURRENT
(SECONDARY)

- The easiest way to demagnetize a CT is to apply test current at a level that approaches it's excitation 'knee', then slowly decrease the input current to zero.
  - This can be done with secondary excitation or primary current injection.



Magnetization of CT's

From Kuhlman/ABB Brochure

A ground shield should be used on the unit as it is normally mounted in an area of high lightning incidence, the strike-over zone of the bushing or close to the bottom of the porcelain. The ground shield lead should be routed on the same side of the CT where the mounting hardware is located (see Figures 1, 2 & 3).

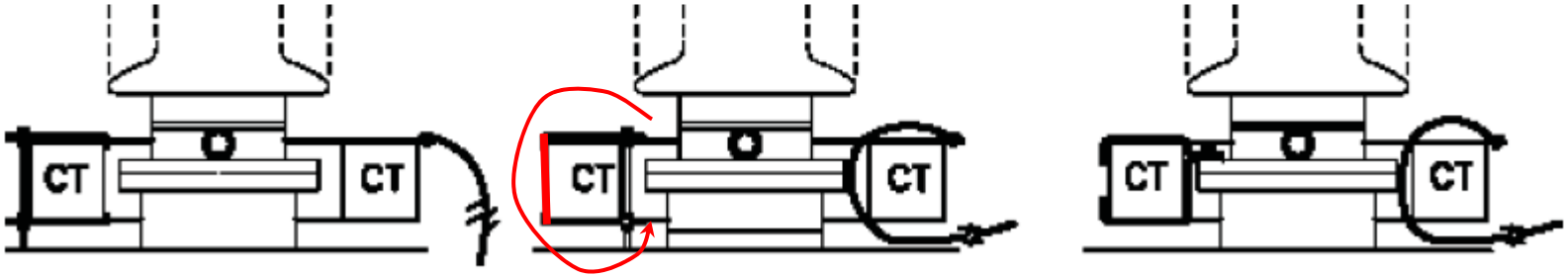
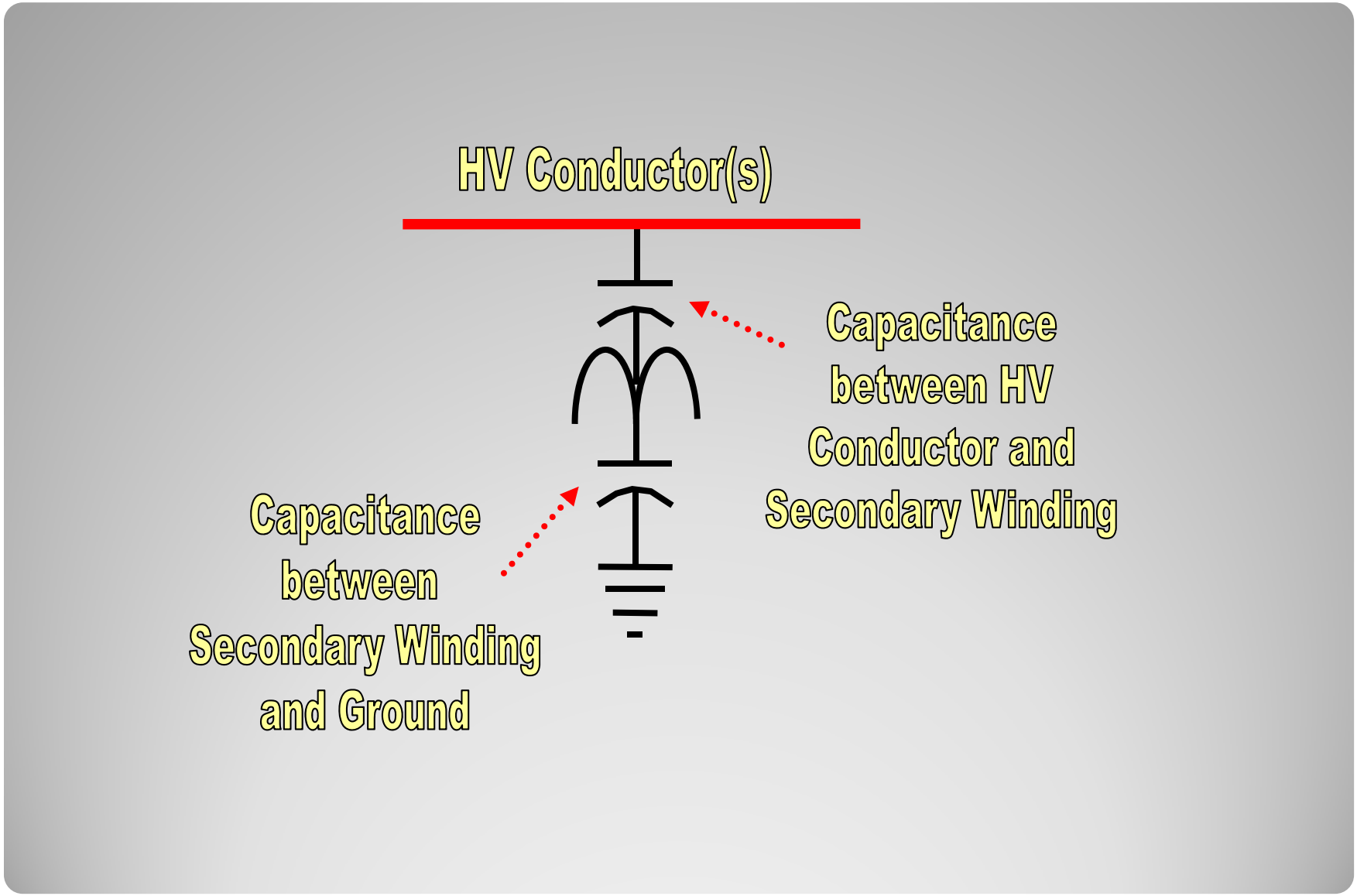


Figure 1 Figure 2 Figure 3

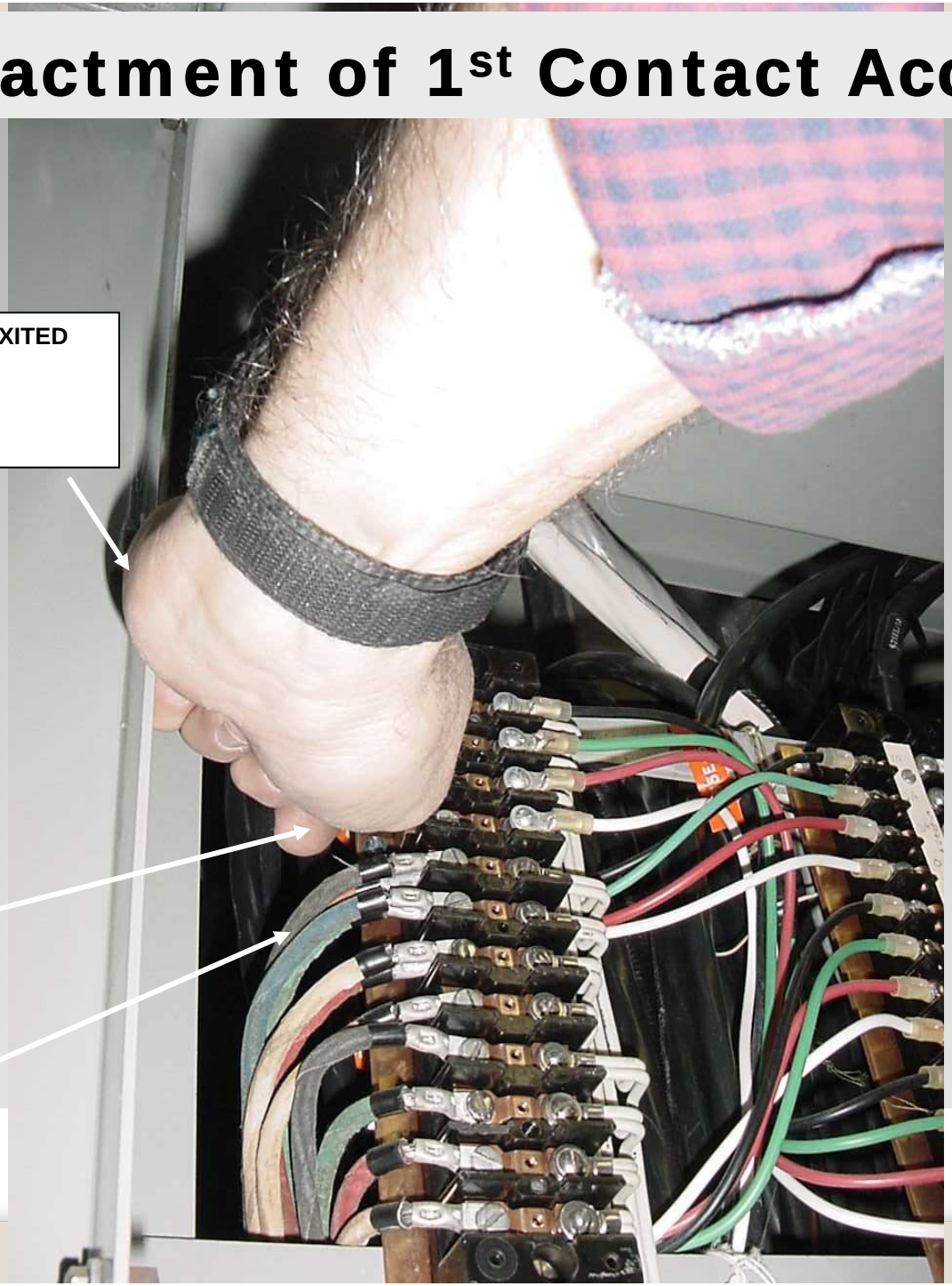
- If shield systems are improperly mounted, induced current will flow through the CT, causing ratio errors.

Possible Ground Loop Traps



Floating Secondary Issues

Re-enactment of 1st Contact Accident



Quote from the Accident Report:

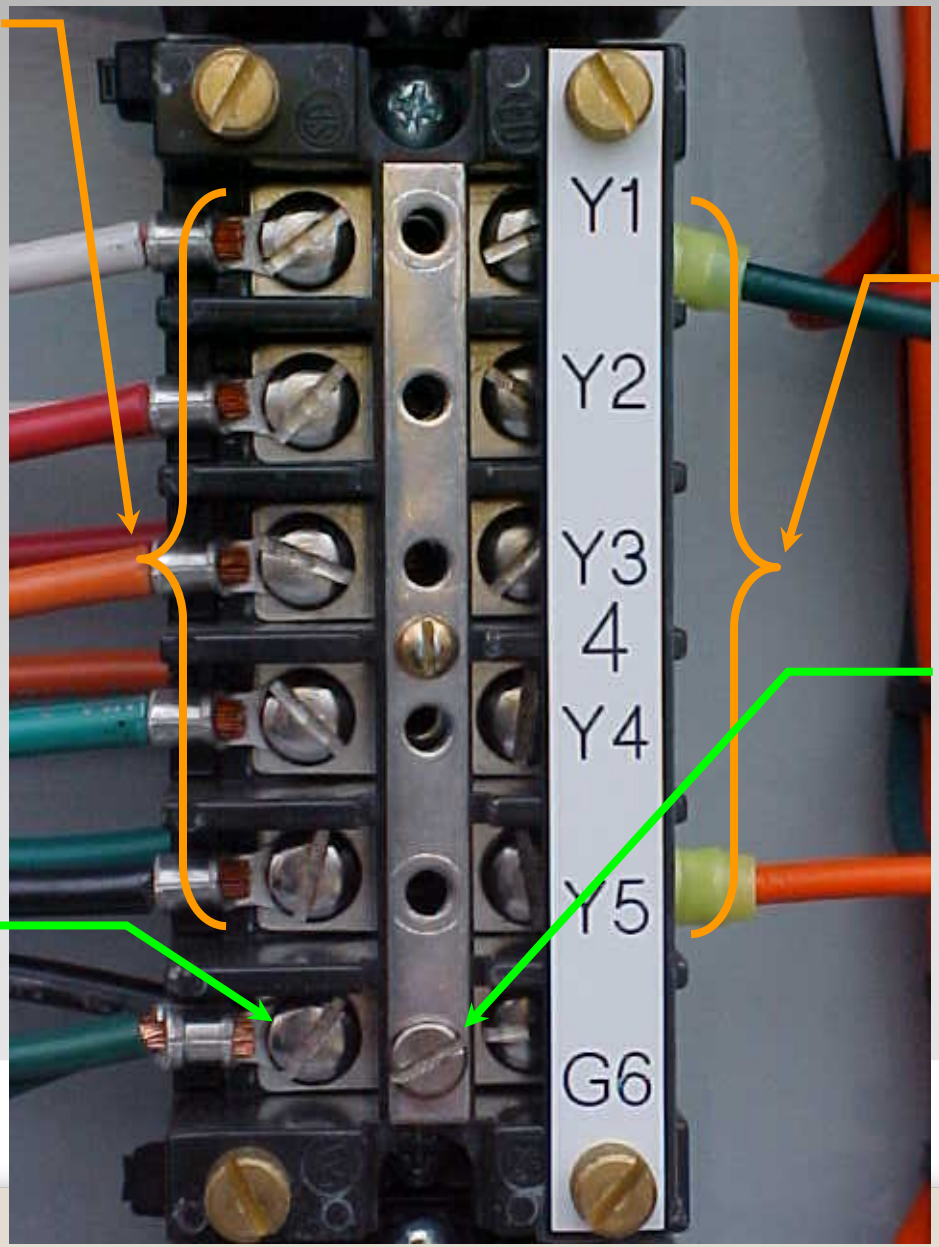
"The Electrician said he could smell his flesh burning"

‘Single-Phase’ Type CT Shorting Block

CT ratio tap wiring from one individual CT

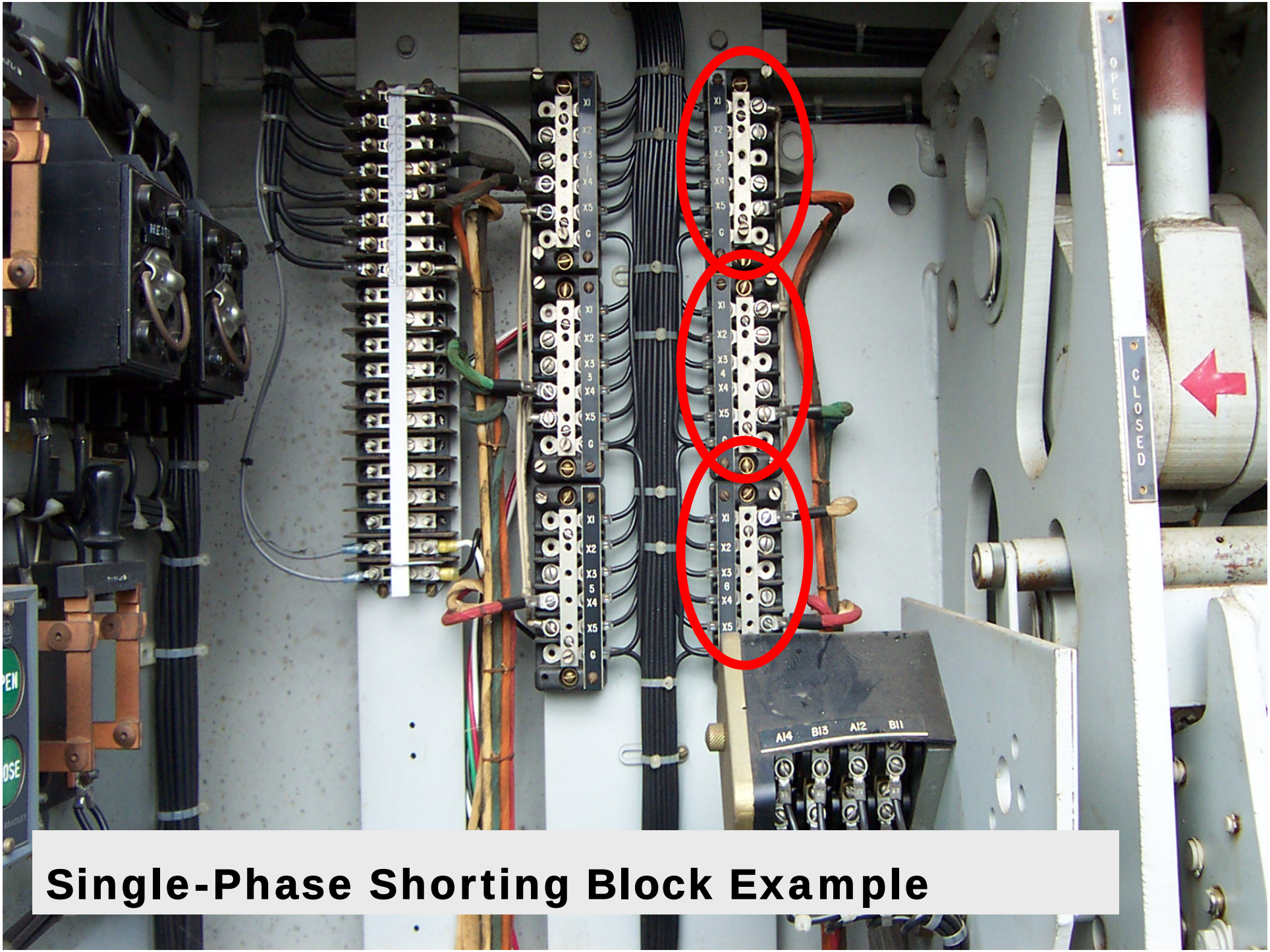
Note that a **minimum** of **two** screws are needed to short this 1 CT – if the full winding is shorted (Y1-Y5 in this case).

Shorting Block Ground



Single-Phase wiring from individual CT to relays, instruments, etc.

Ground screw connection normally left in-place.



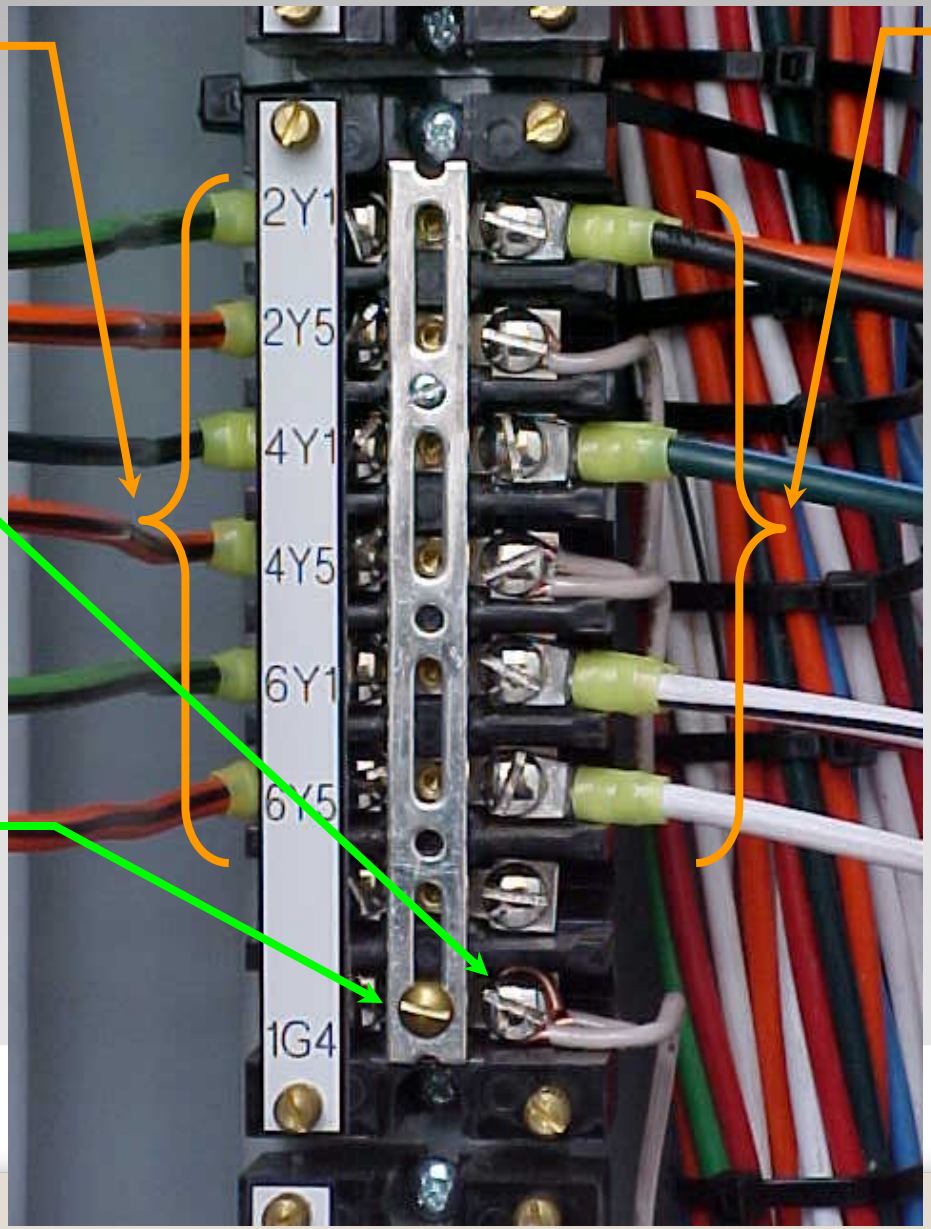
Single-Phase Shorting Block Example

‘Three-Phase’ Type CT Shorting Block

CT wiring from three single-phase individual CT’s (three pairs)

Shorting Block Ground

Ground screw connection normally left in-place.



Three-Phase wiring to relays, instruments, etc.

Note that it takes a **minimum** of **four** screws to short this set of 3 CT’s – (**2Y1**, **4Y1**, **6Y1**, and **one** of 2Y5, 4Y5, and 6Y5 in this case) – as long as the Wye connection is intact – white wiring here.

- CT Circuits can easily provide enough voltage and associated current to inflict lethal wounds if open-circuited while primary current is flowing.
- Before working on CT Circuitry a Job Briefing should be held, and the Circuits positively Identified and Tested.
- Good work practices can help avoid injury in the event a current circuit does become open-circuited.
- Take whatever time is necessary to perform the job properly and safely.

Safety Summary