Reinhold Environmental Ltd.

2009 APC Round Table & Expo Presentation

July 12-14, 2009, in The Woodlands, TX

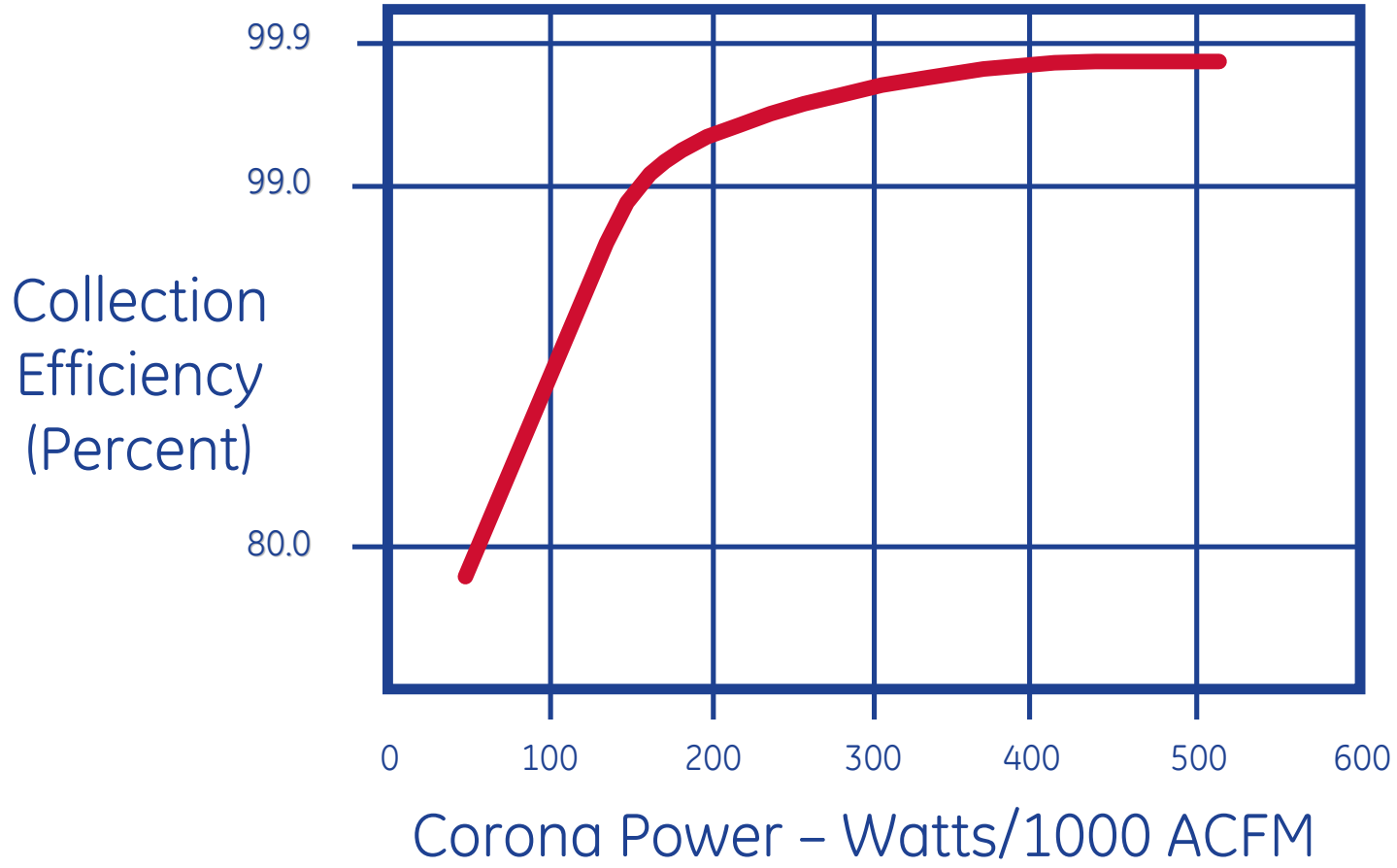
2009 APC/PCUG CONFERENCE

Understanding ESP Controls

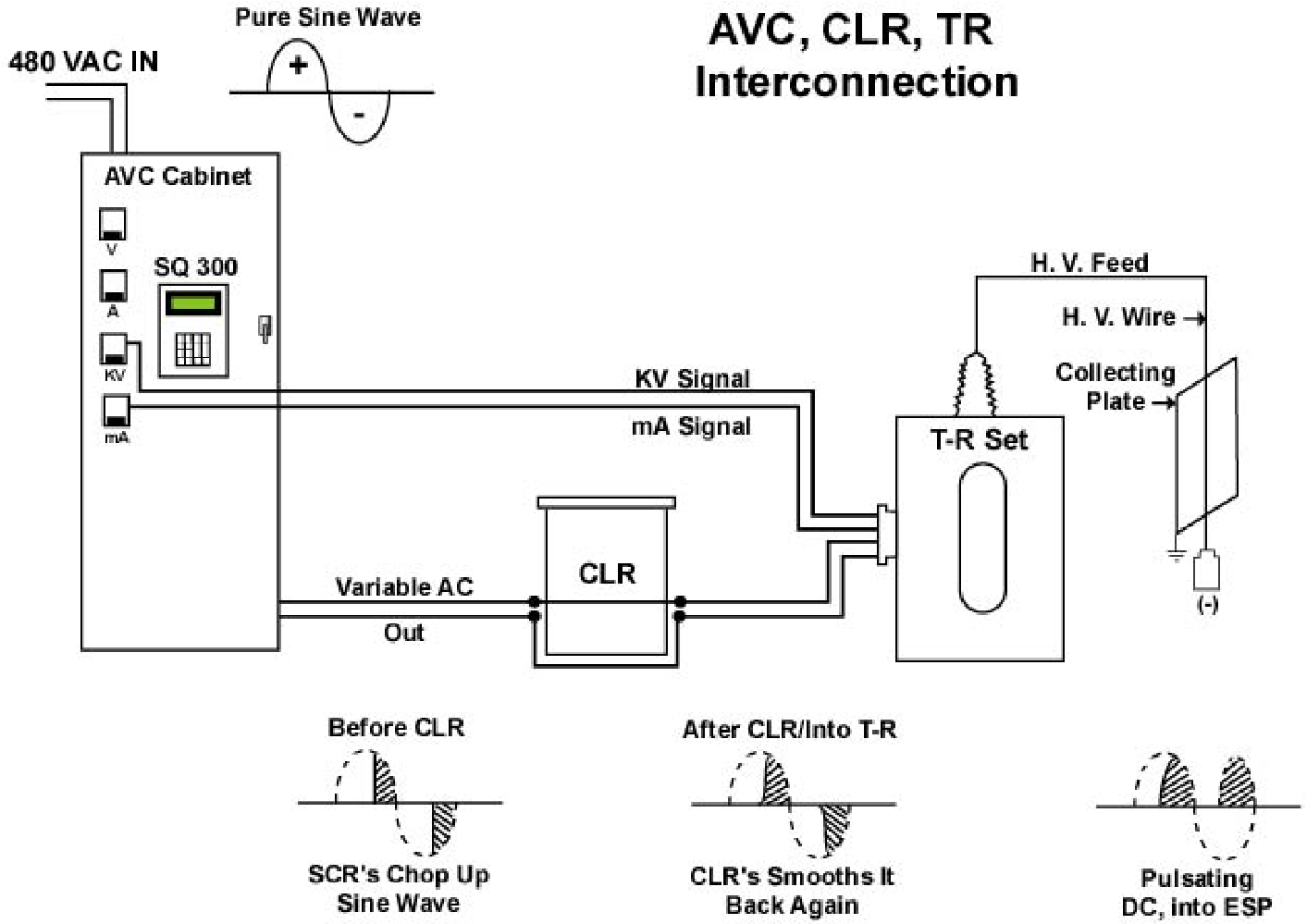
By John Knapik

Efficiency vs. Specific Corona Power

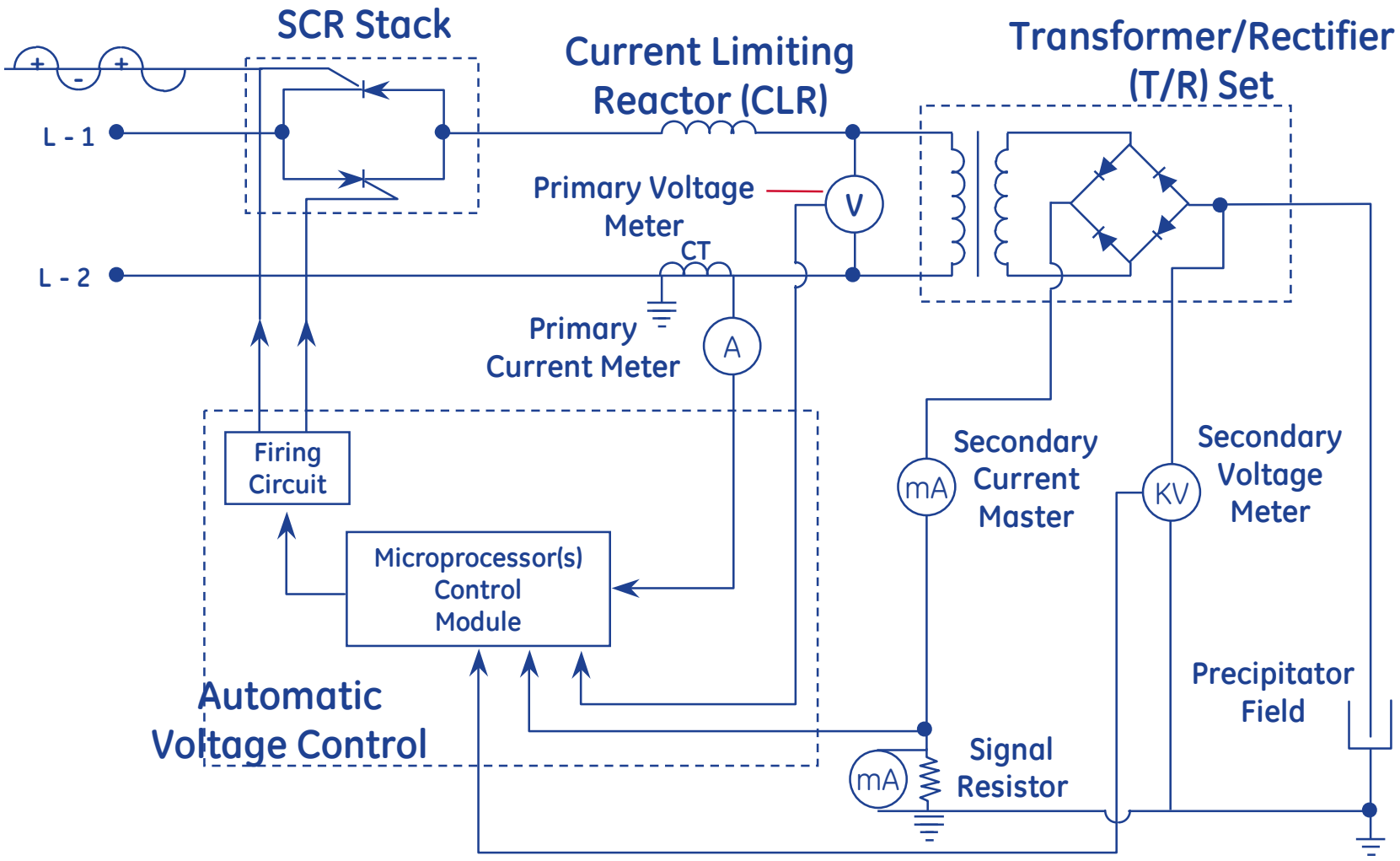
KNOW WHERE YOUR ESP RUNS ON THE CURVE



AVC Cabinet, CLR & T/R Set



Typical SCR-CLR Electrical System



Just Remember, the Primary of a T-R Set is Rated in Units of RMS, the Secondary is in Average

- 400 V AC RMS
- 120 A AC RMS
- 45 KV DC Average
- 750 mA DC Average

Therefore use an RMS Reading Meter to Calibrate the Primary Meters

Look closely, you can see the difference in the meters' scale.

Iron Vane Movement

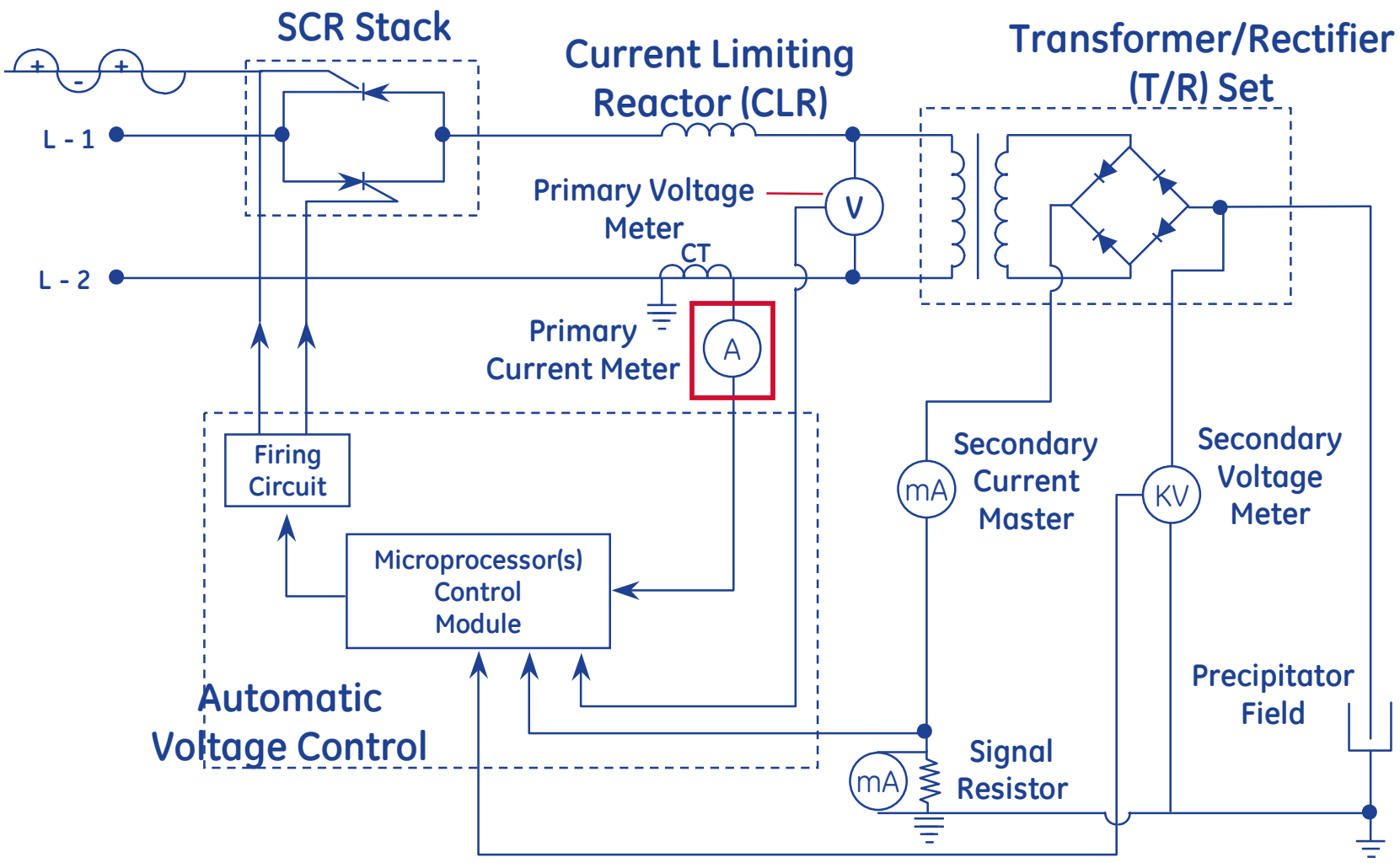
RMS

D'Arsonval

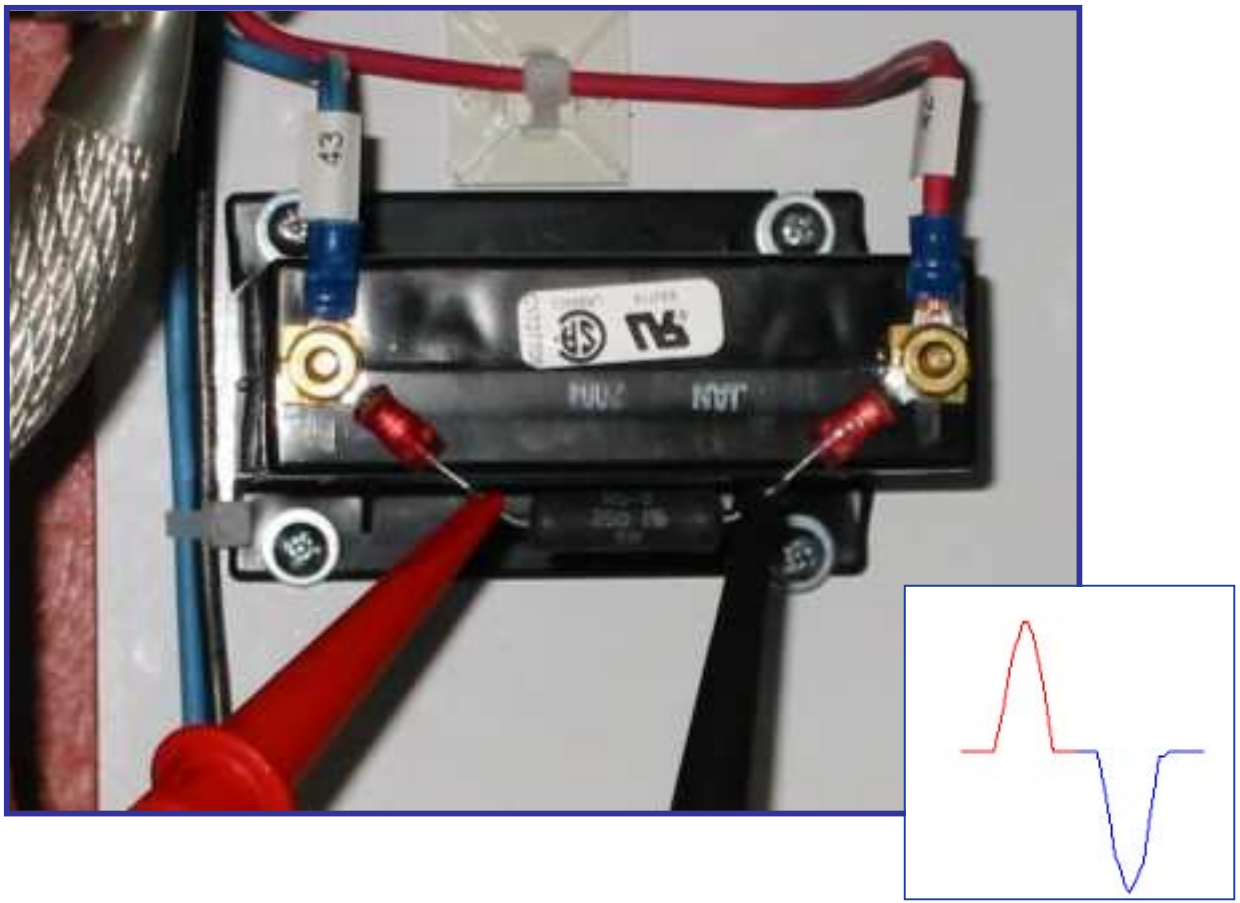
Average

The Meter Scale Distance is not the Same on the RMS Meter.

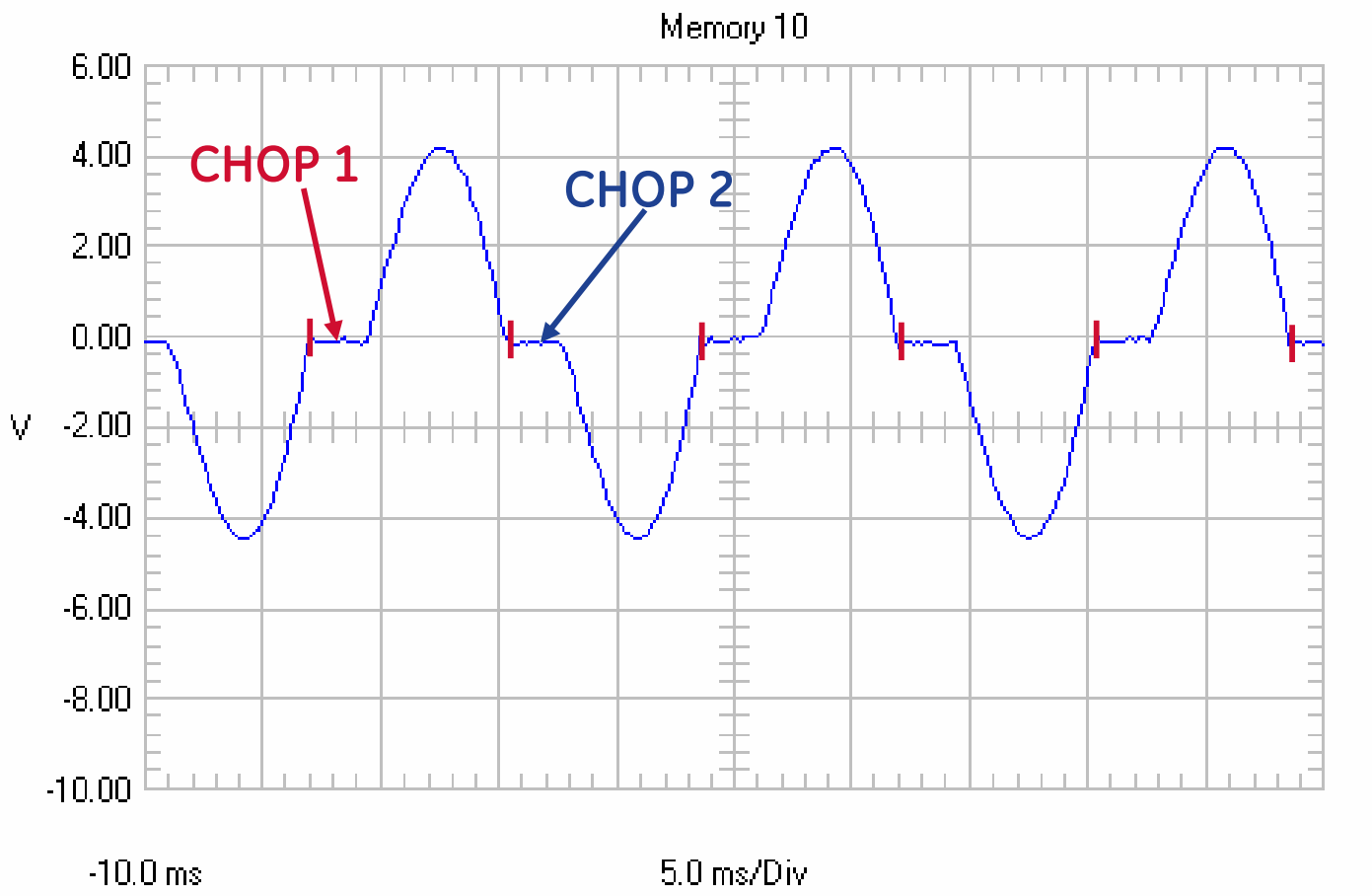
Primary Current Meter



Finding the Primary Current Waveform

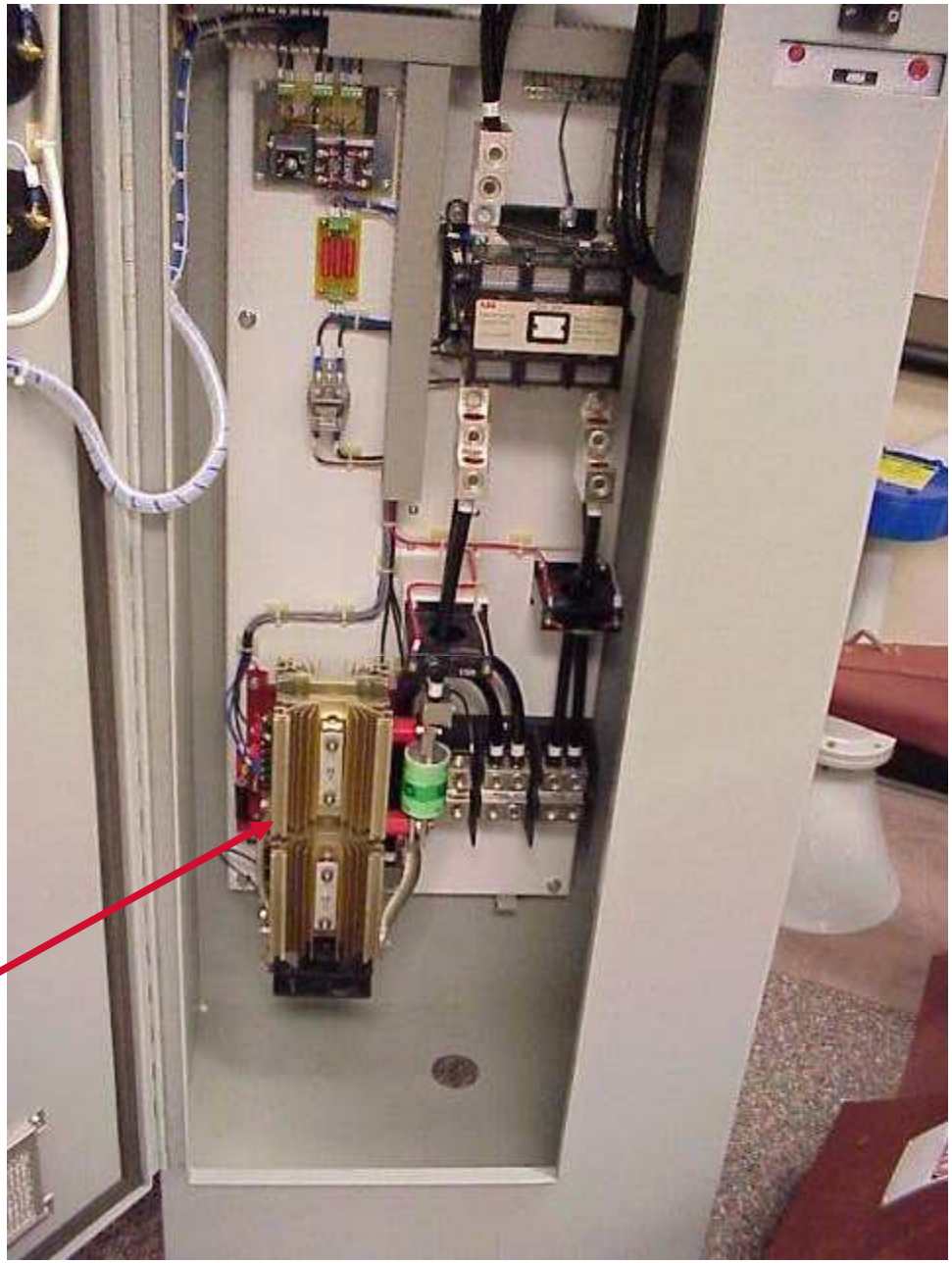


Primary Current – A Chopped Sine Wave

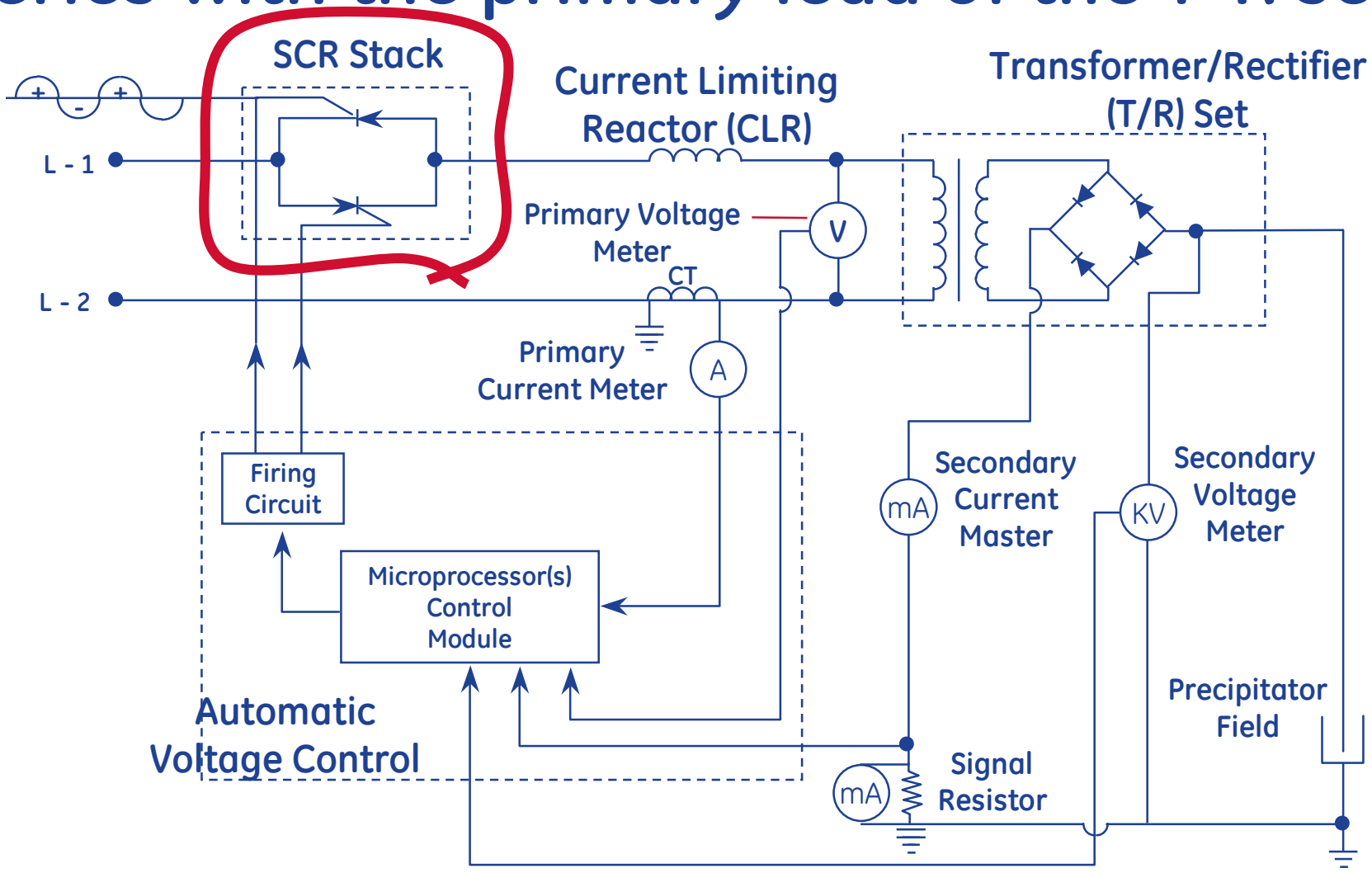


Not the nice sine wave we had coming into the AVC cabinet. WHY?

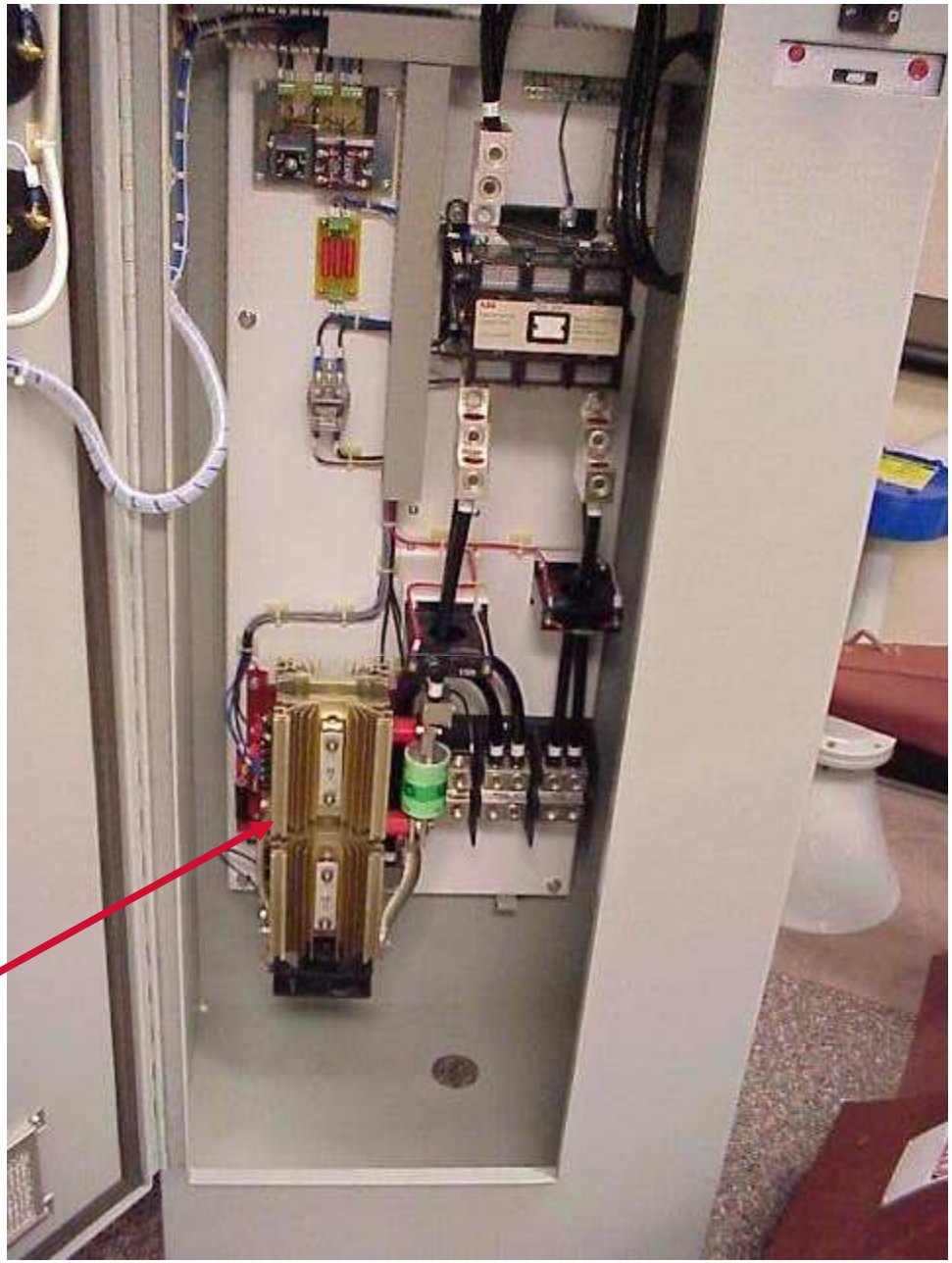
The SCR's are the Reason



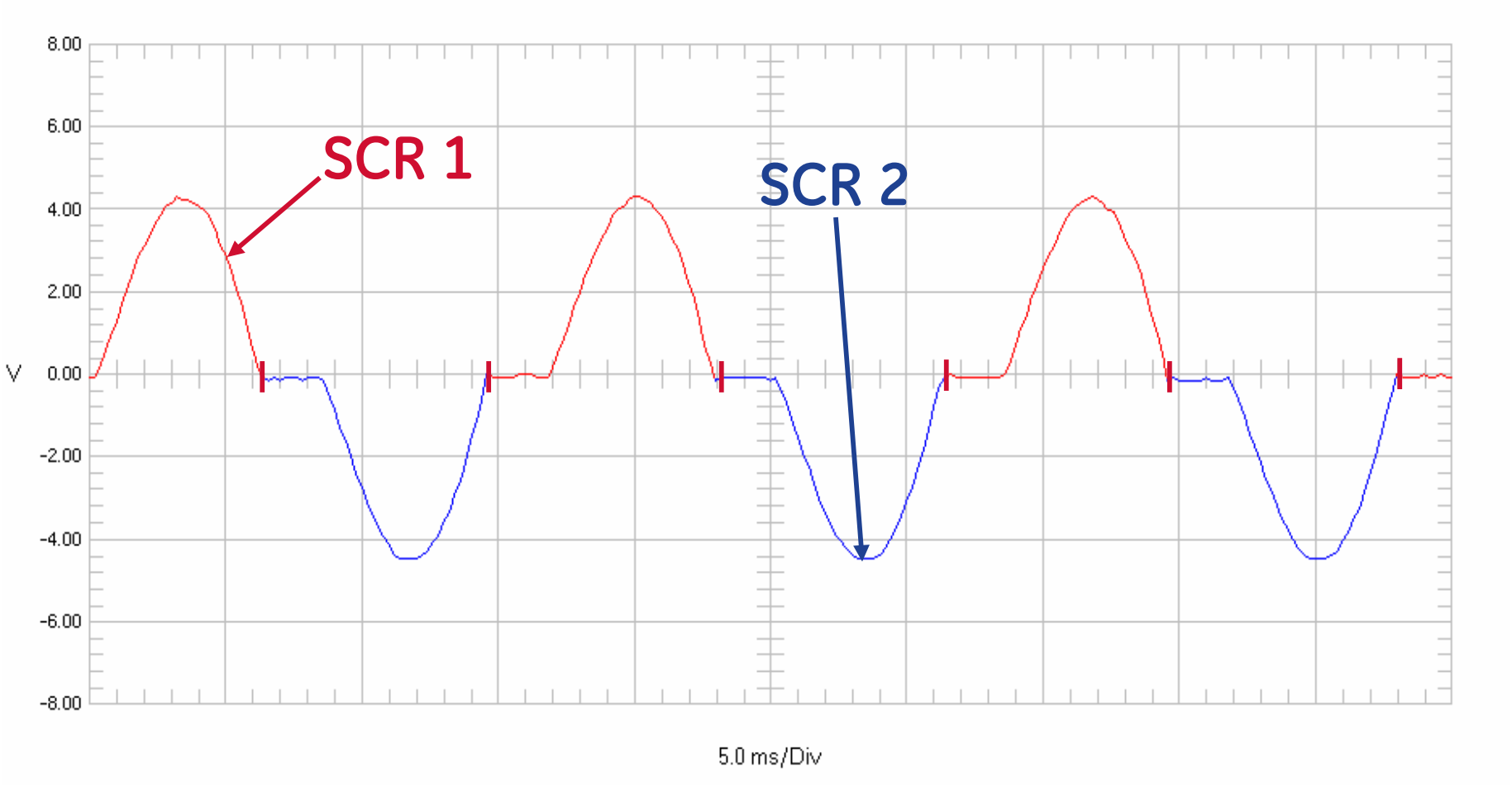
Two parallel, opposed SCR's are used in series with the primary lead of the T-R set



The SCR functions as a synchronous switch to control the flow of current to the ESP



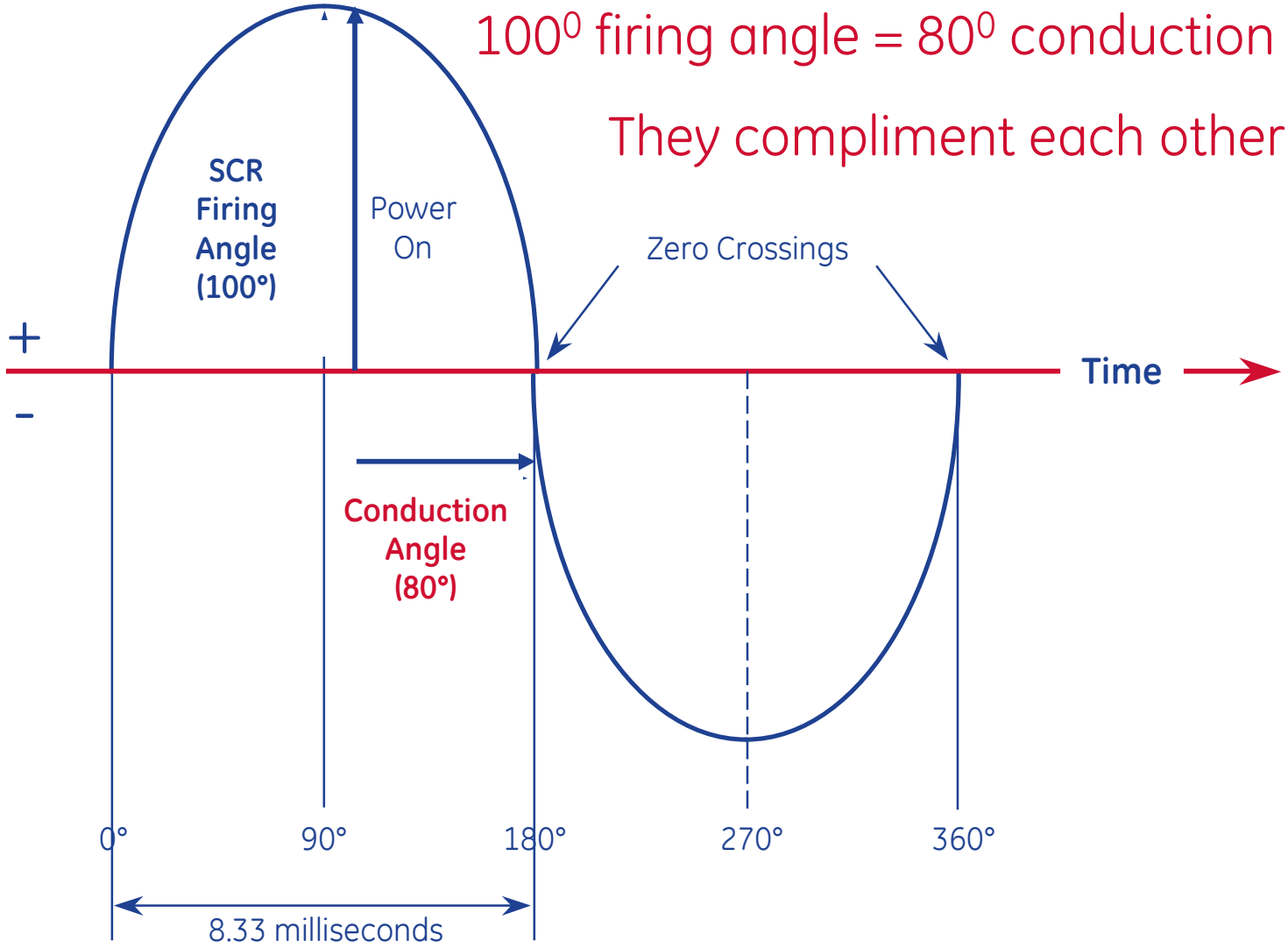
Looking again at the primary current waveform, SCR 1 and SCR 2's contribution to controlling current can be better seen



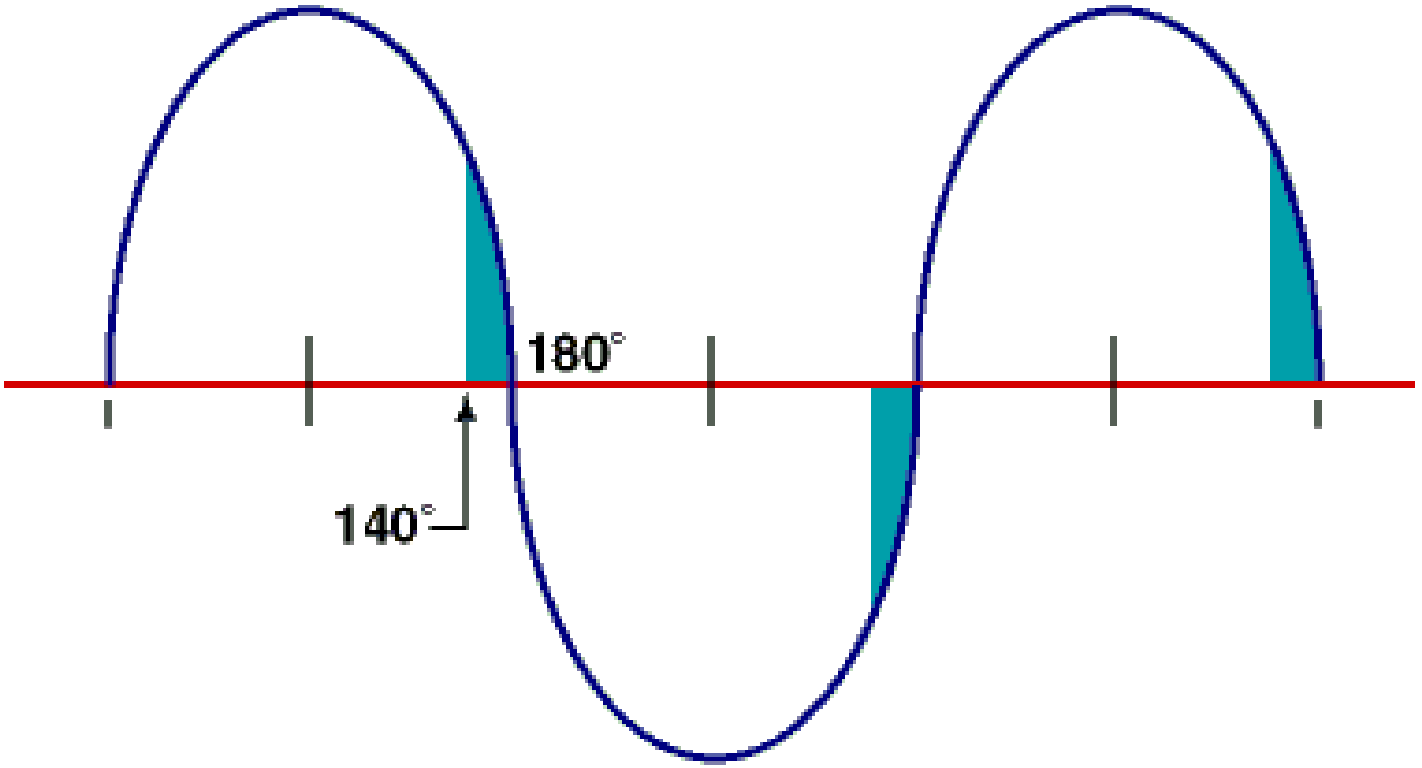
Typical Sine Wave and SCR Terms

100^0 firing angle = 80^0 conduction angle

They compliment each other

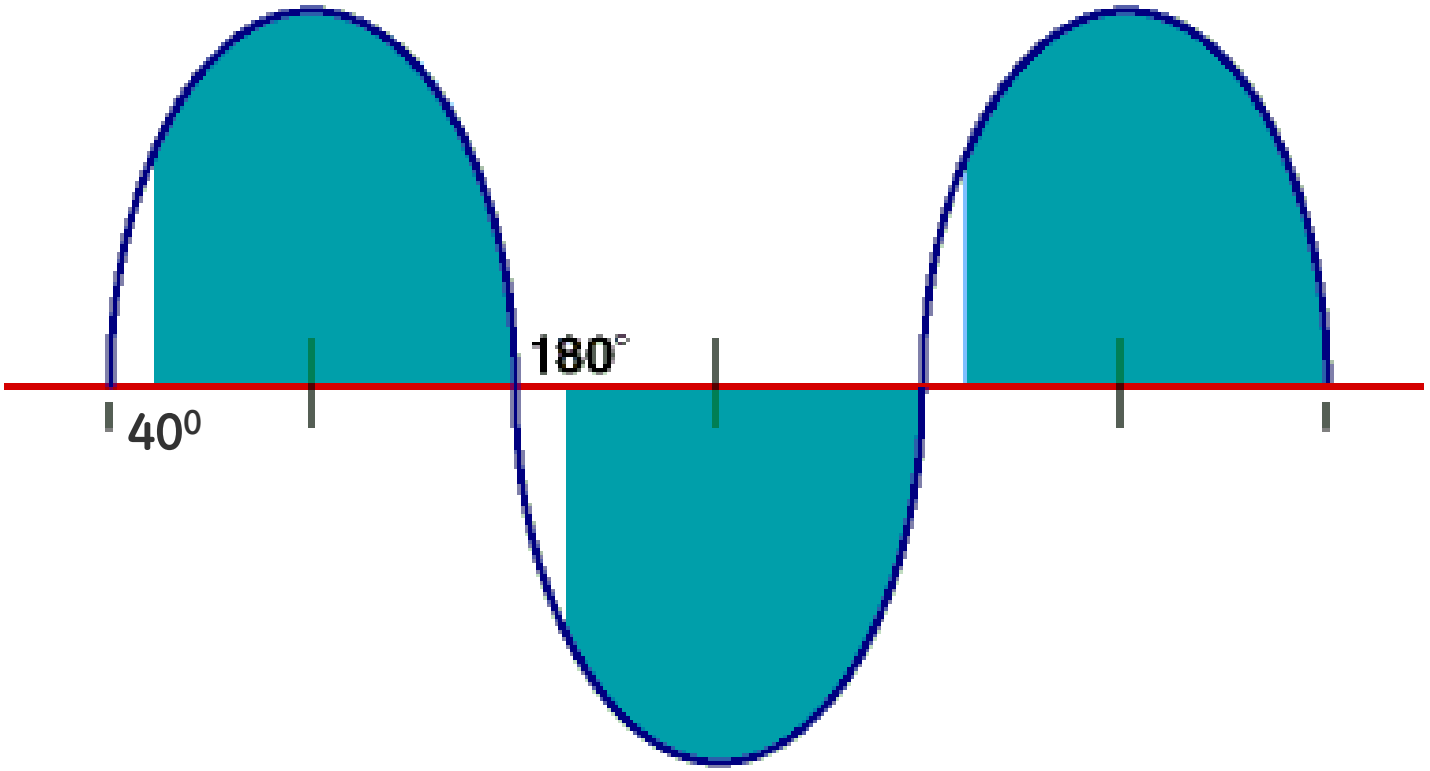


SCR: Low Current Flow to T-R Set



Firing Angle 140°
Conduction angle 40°

SCR: High Current Flow to T-R Set



Firing Angle 40°
Conduction angle 140°

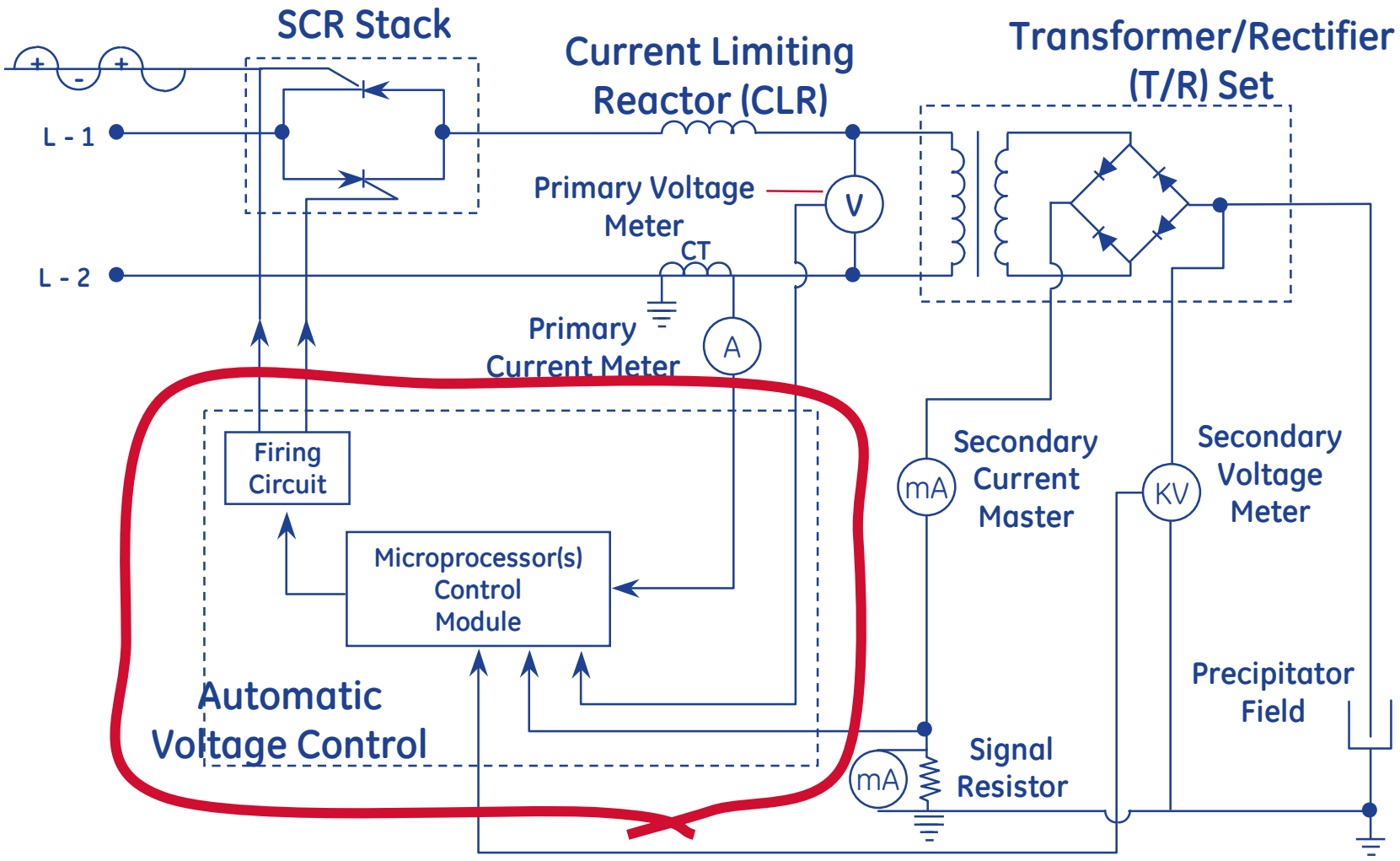
But What Controls the SCR'S?

The **AVC**

is the **BRAINS**

of the ESP

Next – The Automatic Voltage Control



Older Analog AVC

Microprocessor Based AVC

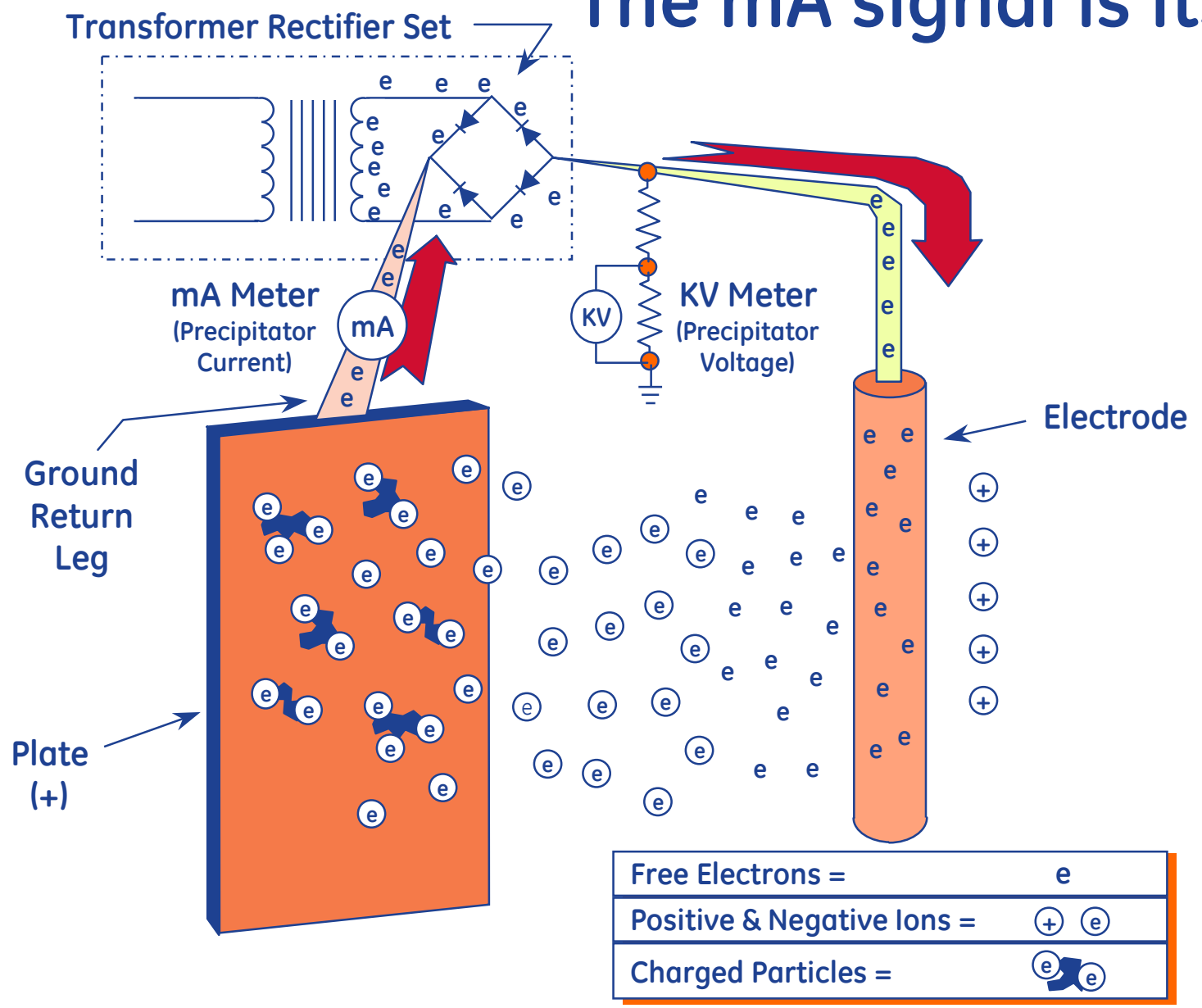
The AVC has 2 Jobs to Execute

- Control the amount of sparking in the ESP.
- If a T/R set is not sparking, then its AVC should be pushing that T/R set to one of its pre-set, healthy limits (volts, amps, KV, ma, or firing angle).
- I'll explain what is meant by "healthy" in a minute

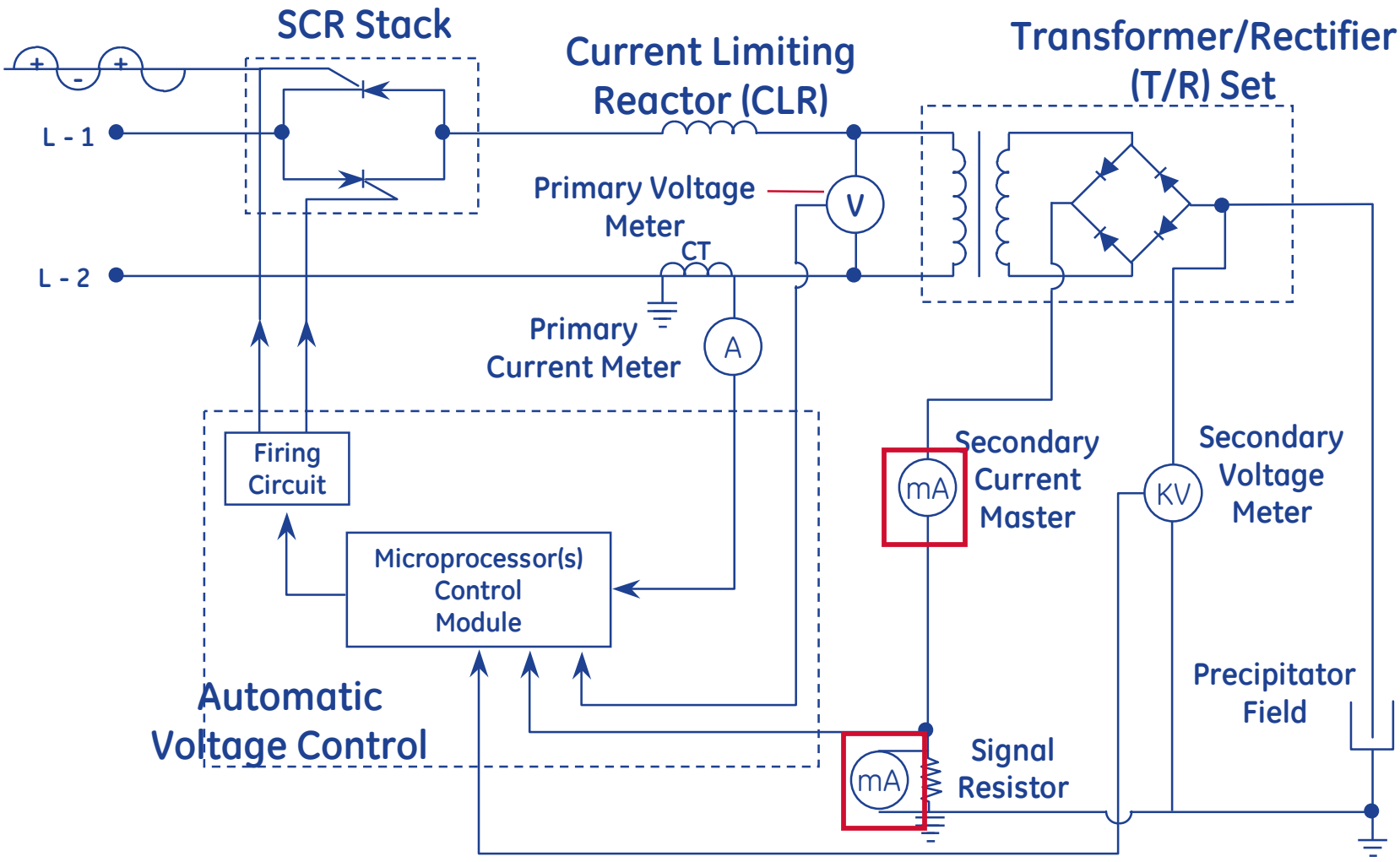
The AVC has 2 Jobs to Execute…

But how does the AVC know what's happening in the ESP?

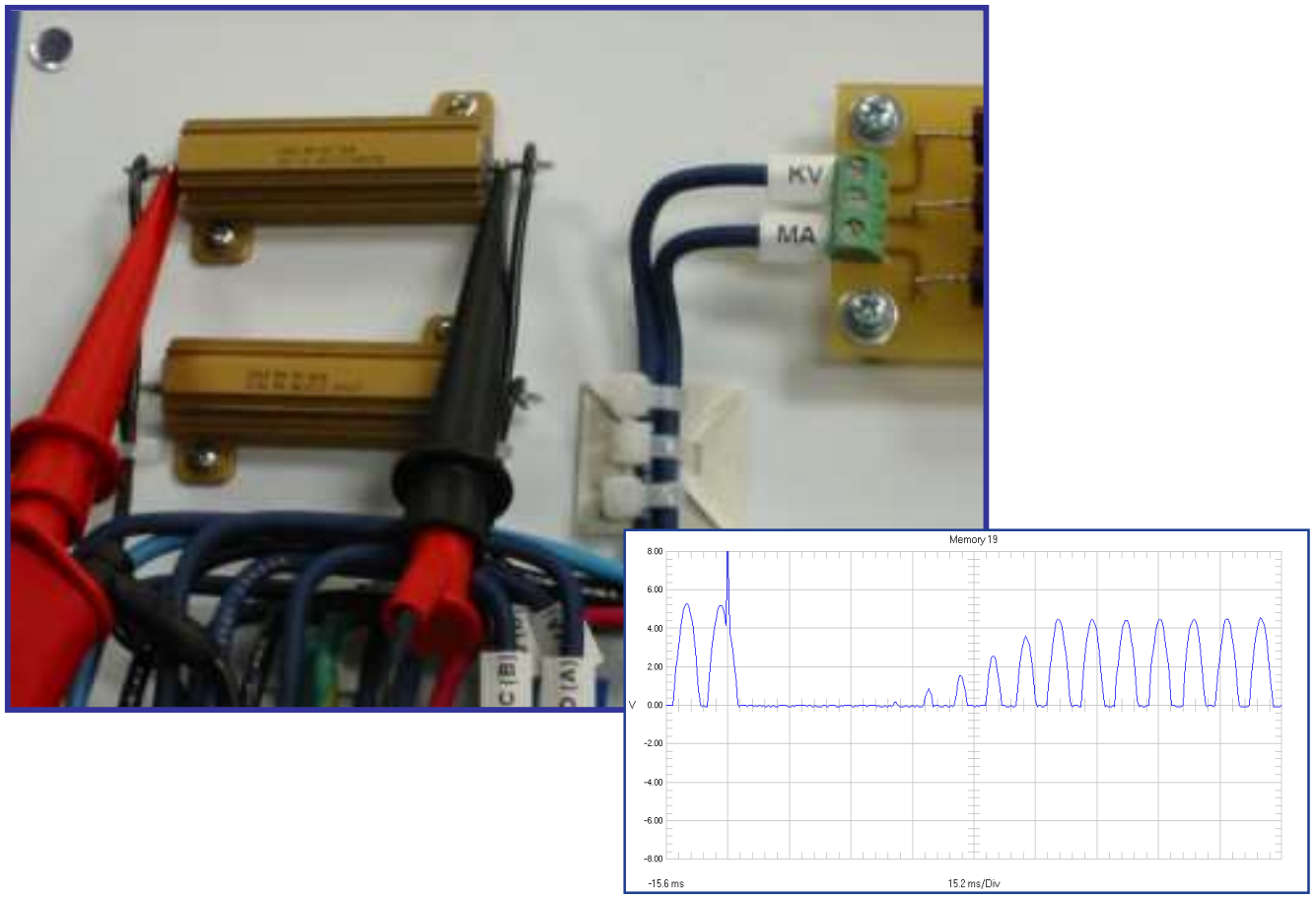
The mA signal is its eyes!



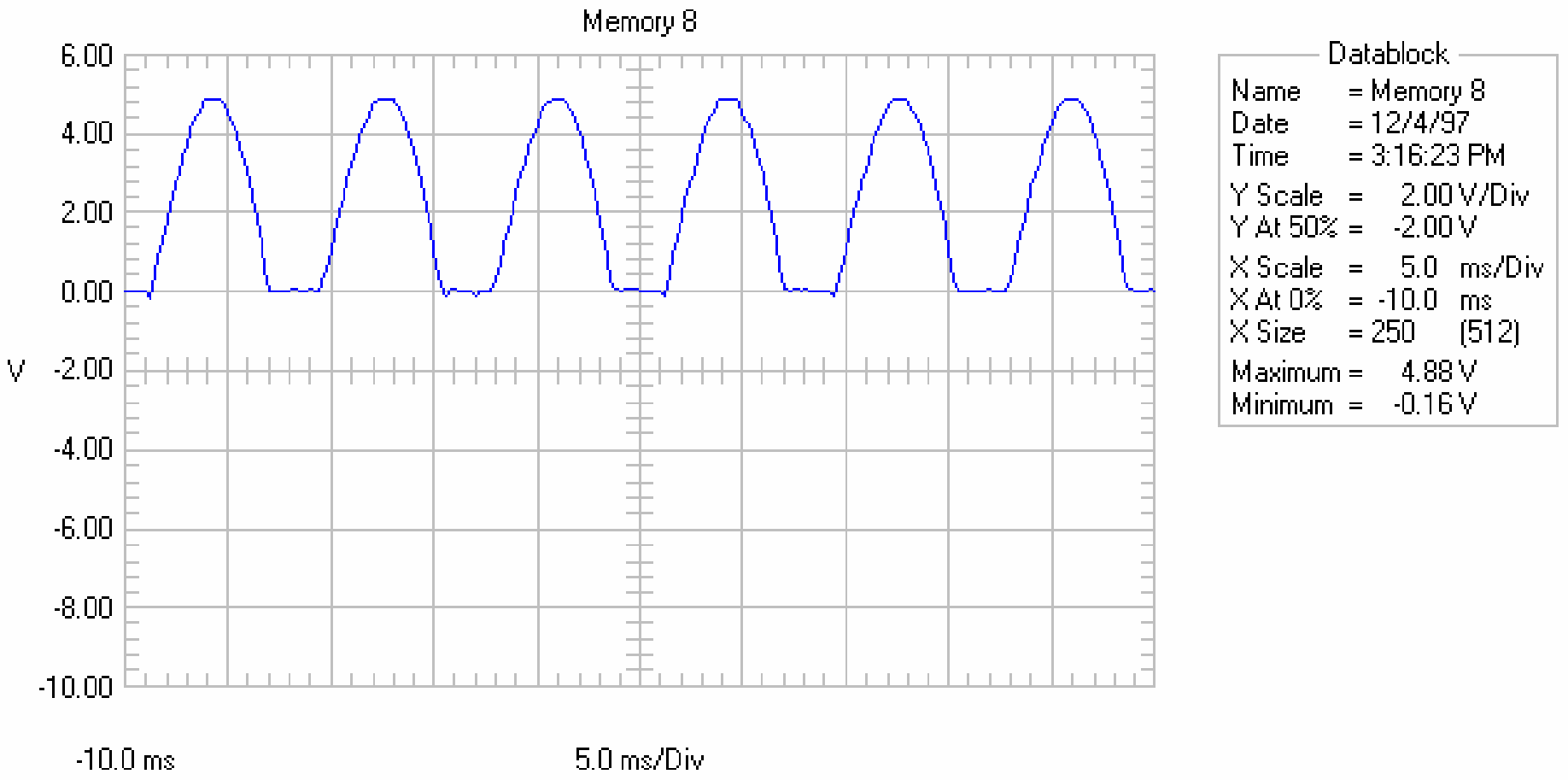
Secondary Current Meter



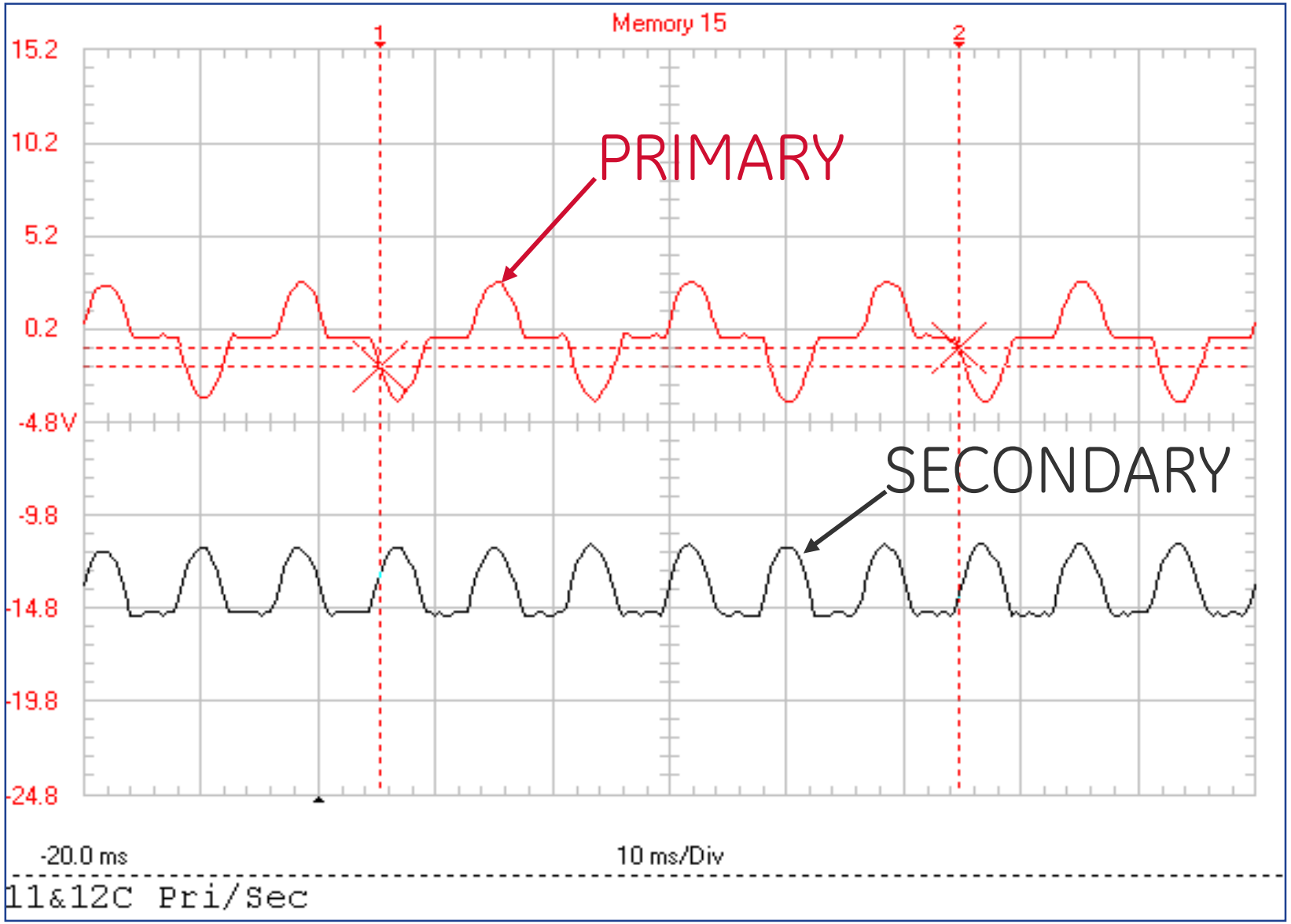
Finding the mA Signal



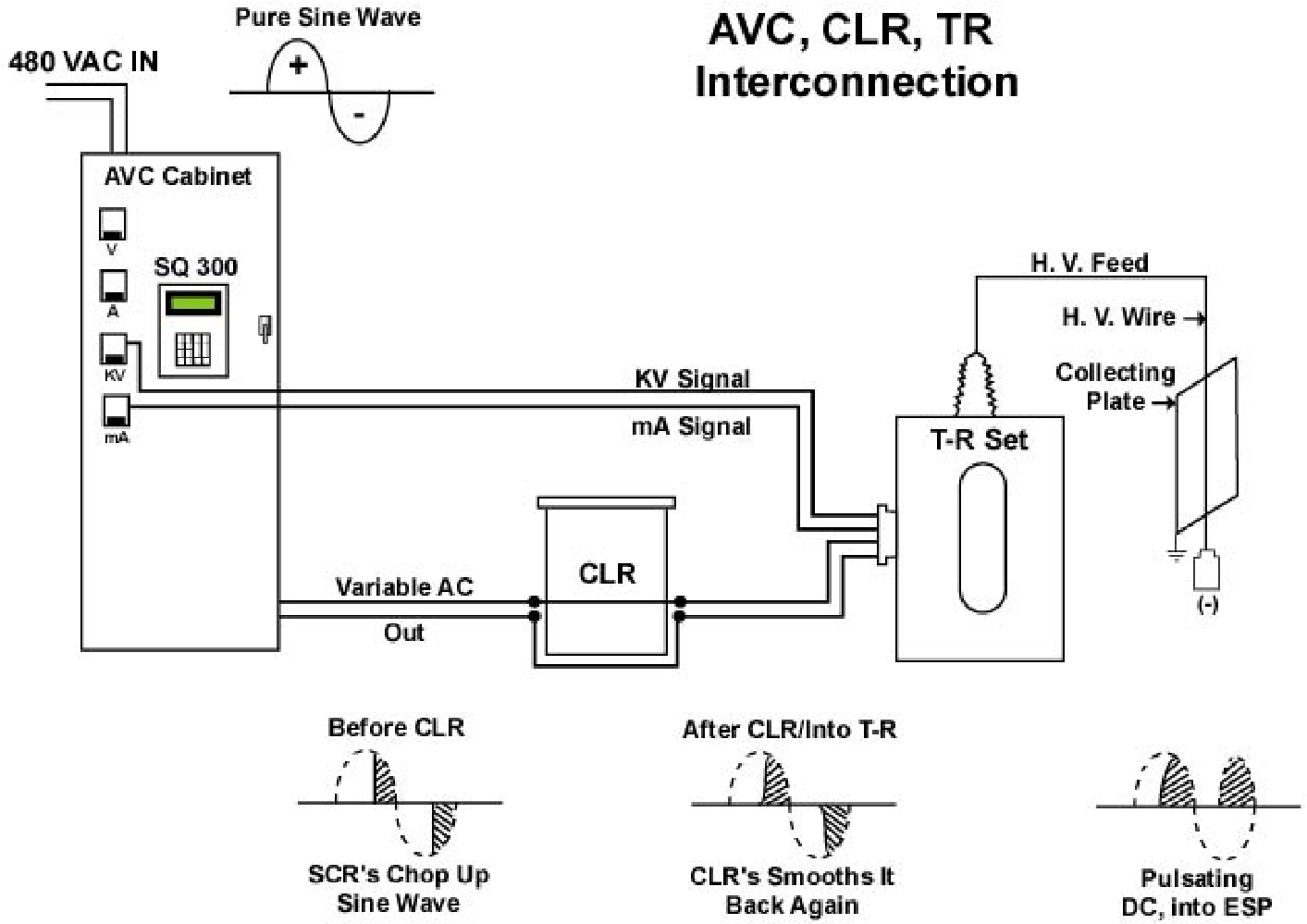
Secondary Current – Pulsating DC



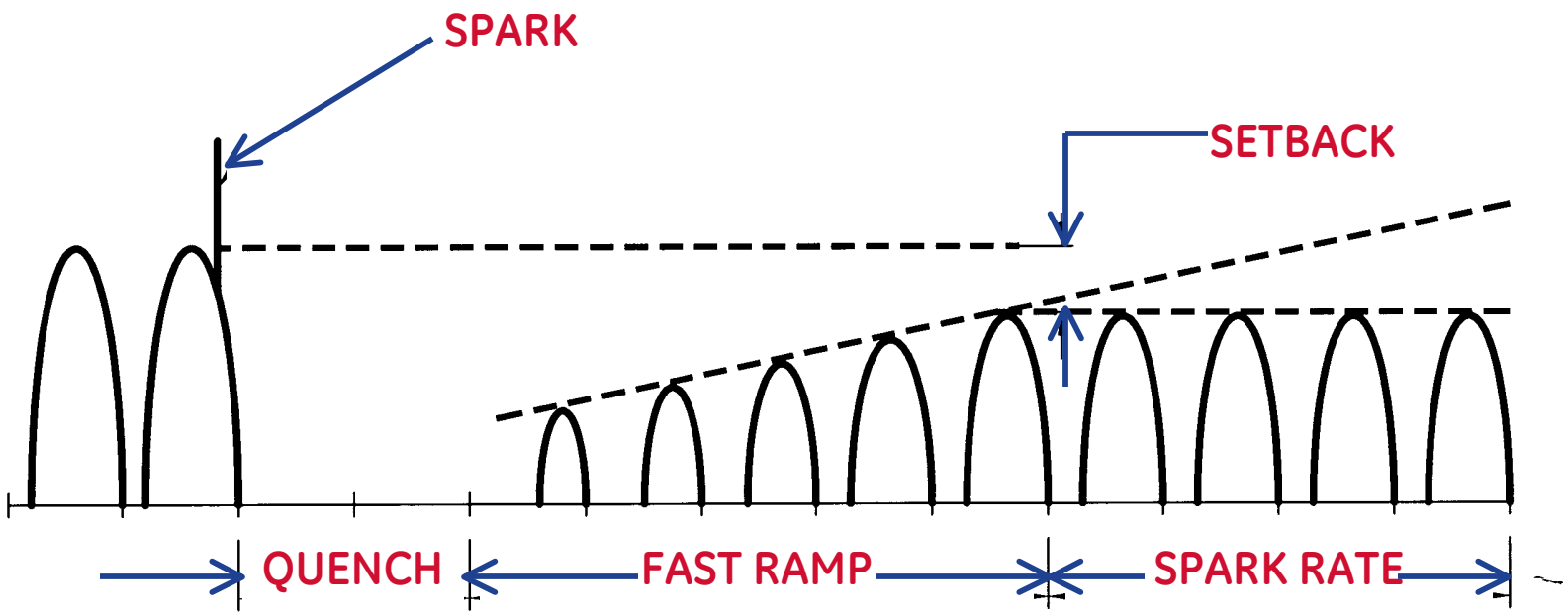
Typical Primary and Secondary Current



AVC Cabinet, CLR & T/R Set



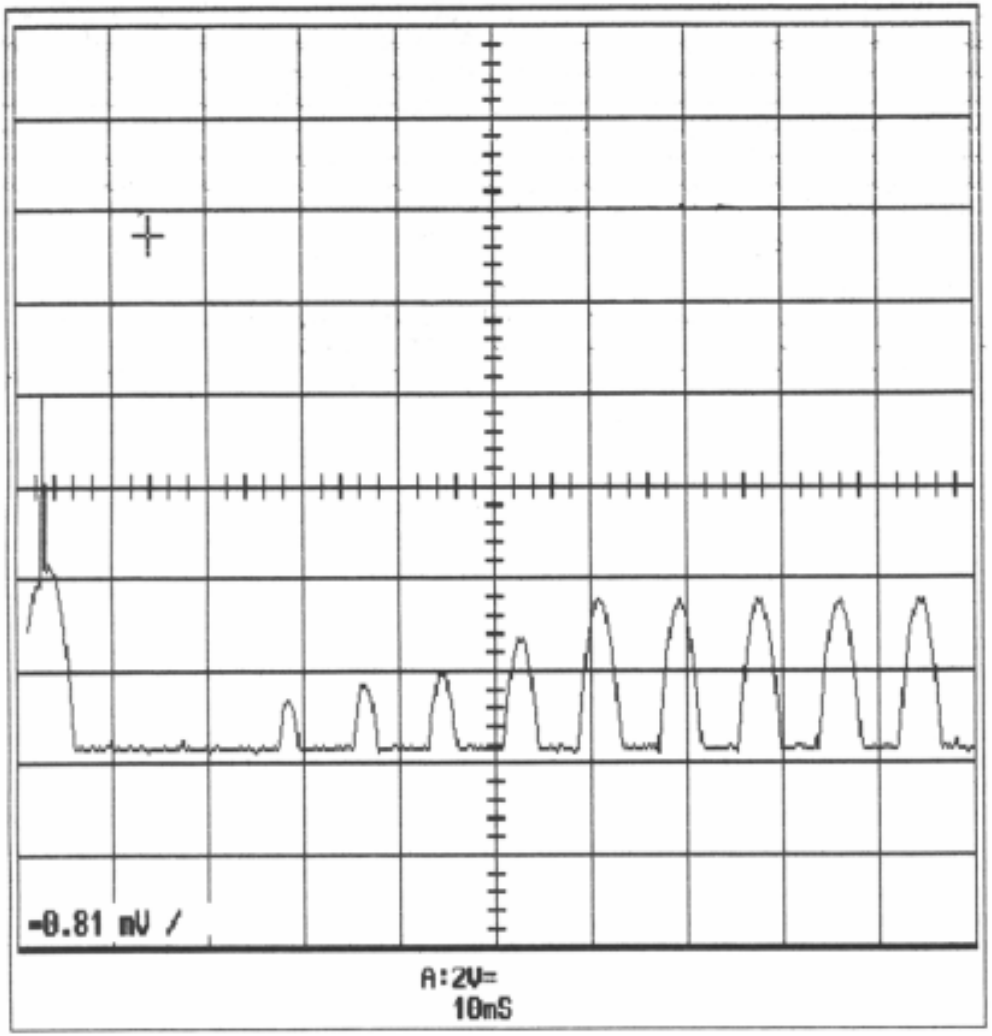
AVC Spark Response



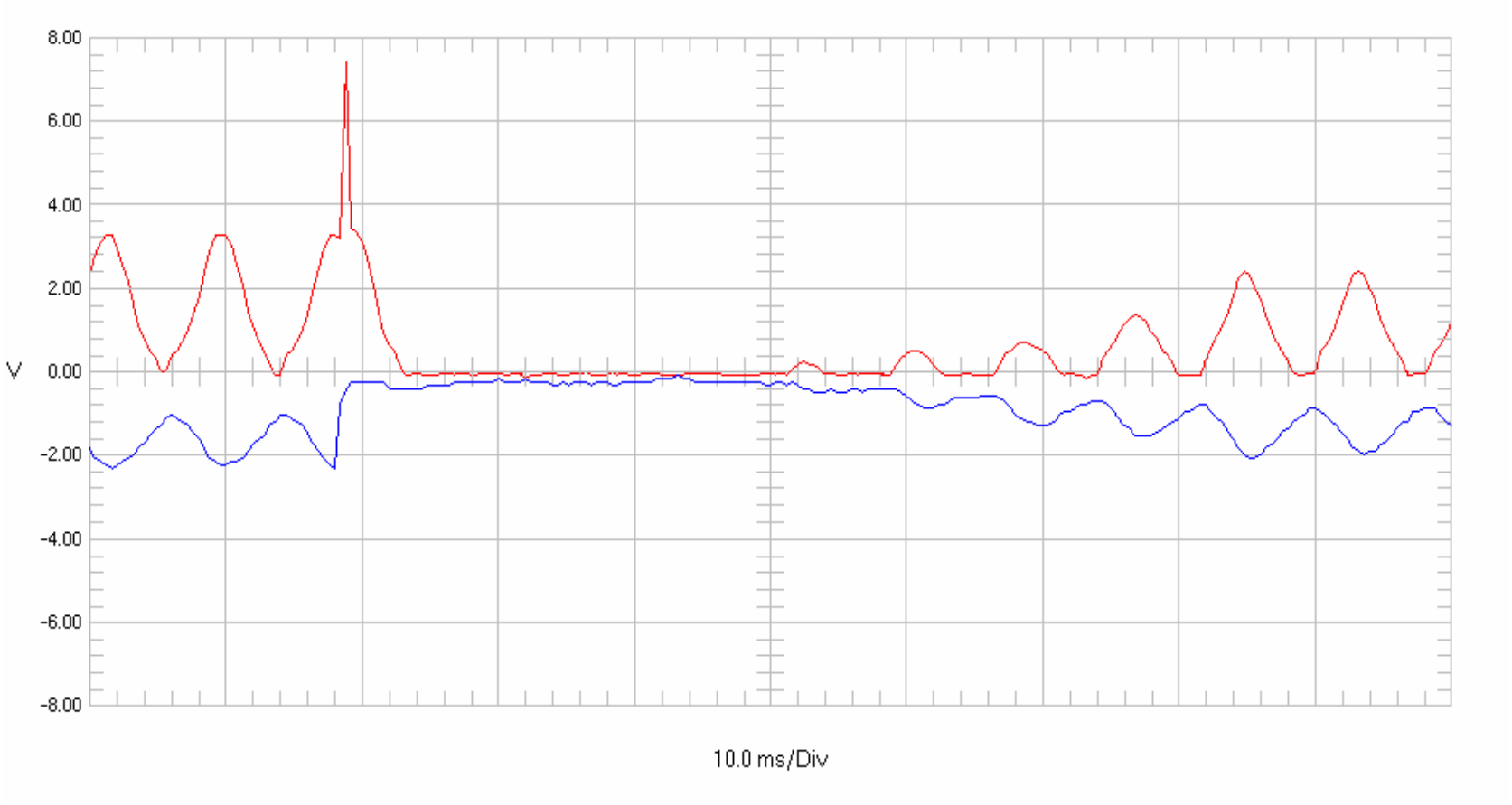
Good Initial Settings for an AVC

1. Quench = 1 Full Cycle
2. Fast Ramp = 5 or 6 Half Cycles
3. Setback = 15 to 20%
4. Spark Rate = 30SPM

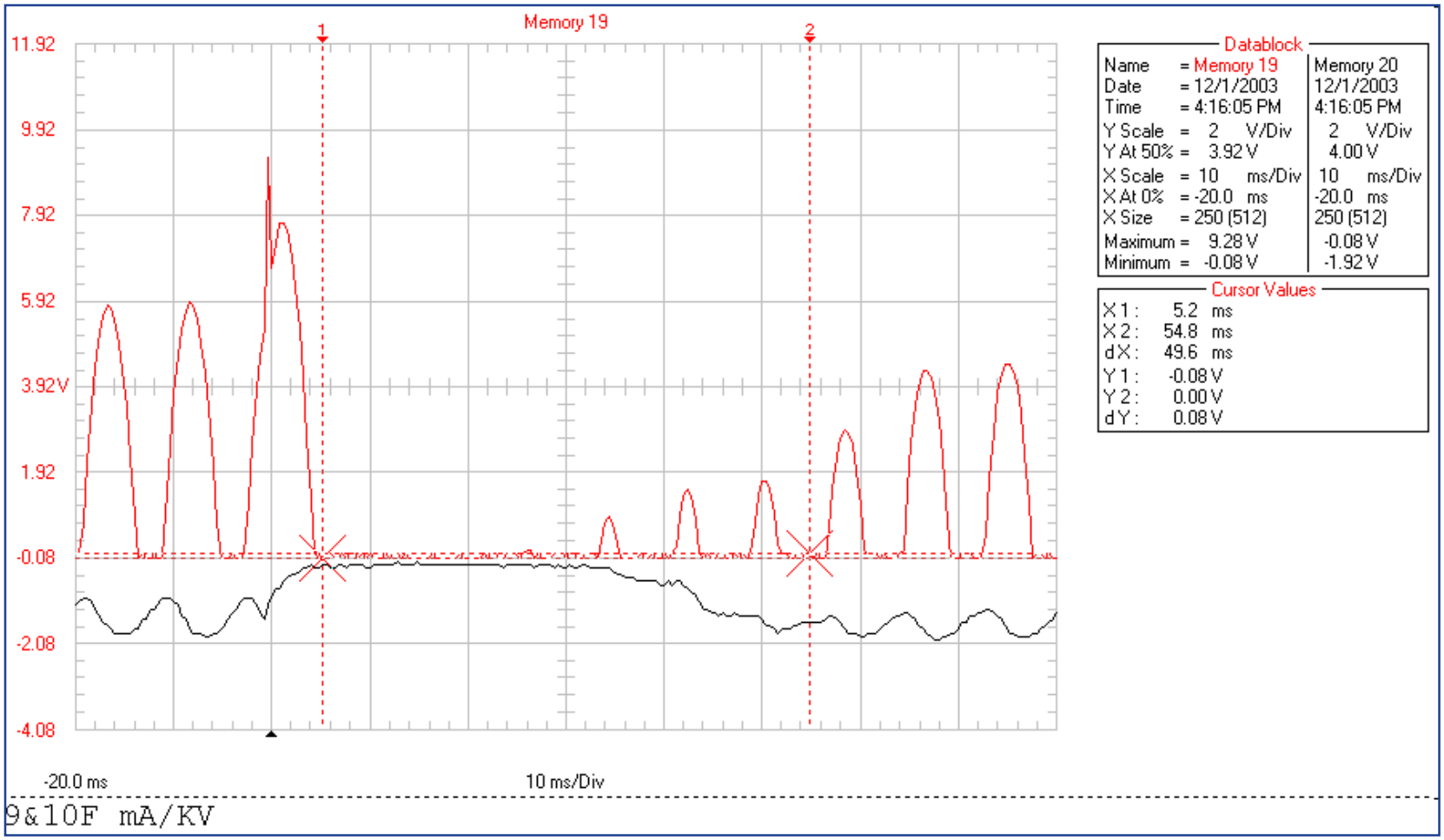
Proper AVC Response to Sparking



Spark Response - Secondary Current and Voltage Waveforms



Typical Spark Response - mA & KV

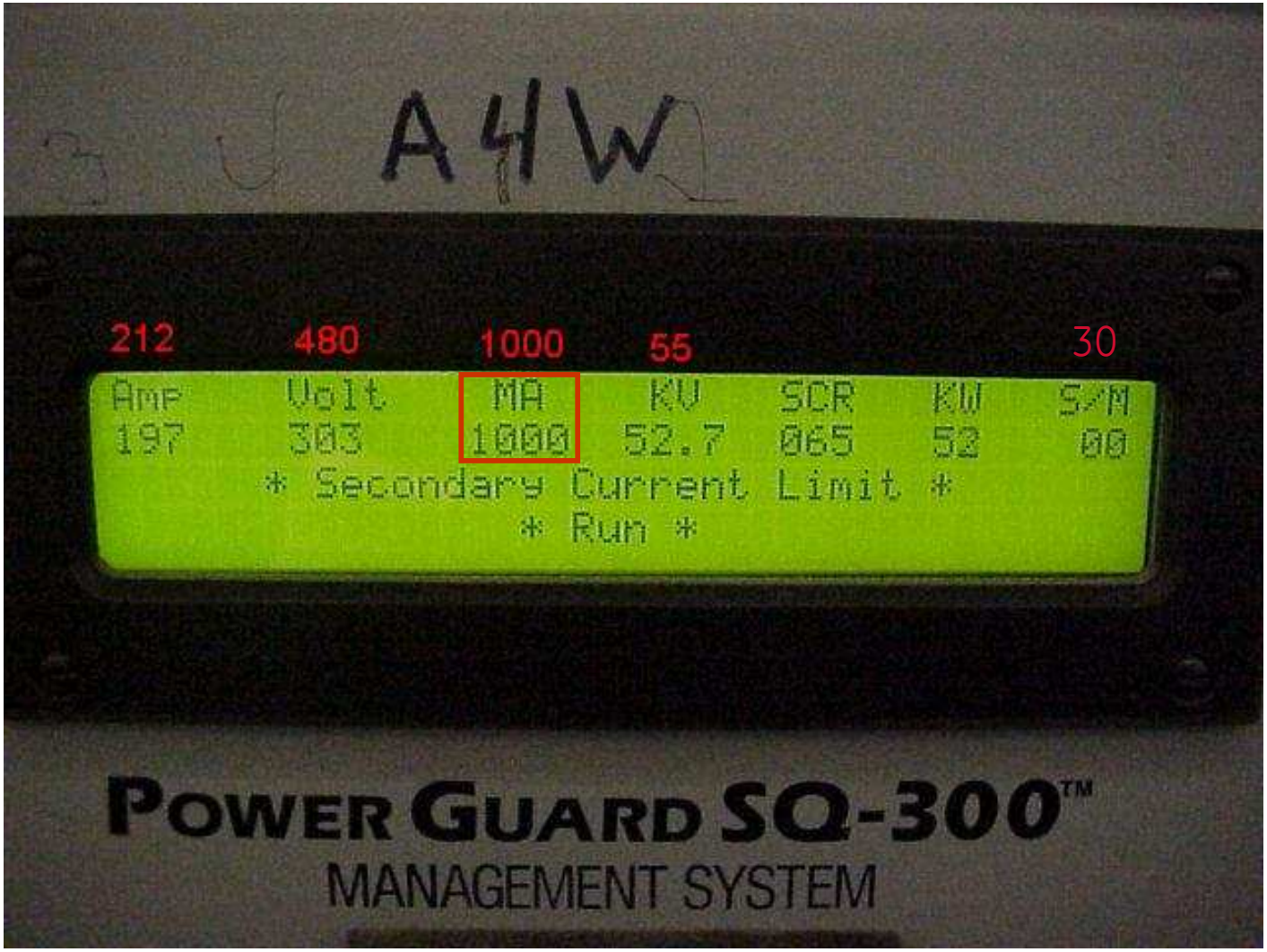


Examples of AVC ‘s at a Limit

AVC SPARK LIMITED – DOING IT'S JOB

T/R Current Limited with Sparking

T-R CURRENT LIMITED WITHOUT SPARKING

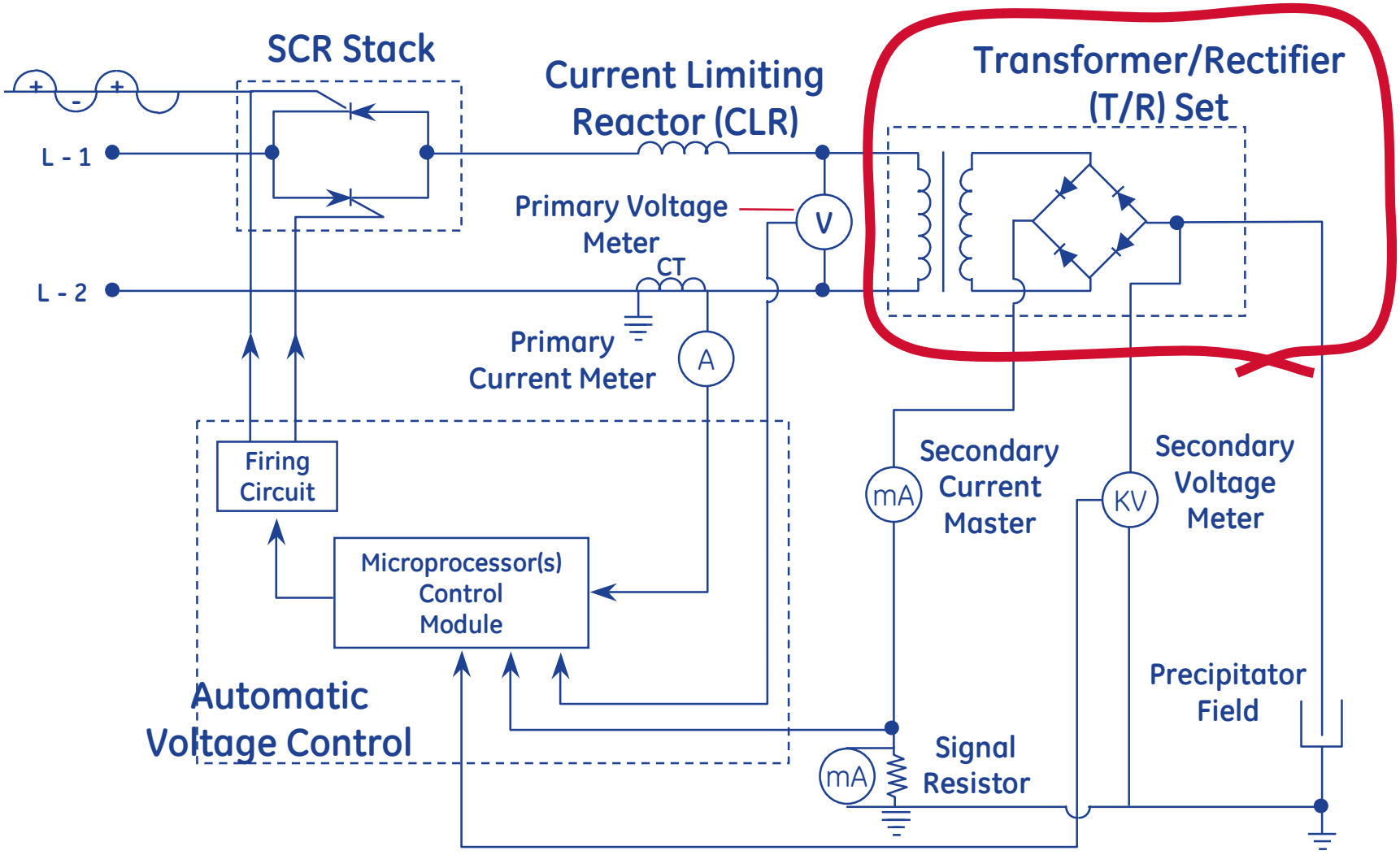


T-R VOLTAGE LIMITED WITH SPARKING

What is meant by “Healthy Limits?”

- Primary or Secondary Limit is not healthy when accompanied by a Primary Voltage level < 90 VAC or a Secondary level < 12KV. It usually indicates a short circuit.
- Secondary Voltage Limit is not healthy when there is very little Secondary Current. It usually indicates an open circuit.
- Neither condition is aiding in particle capture

The T-R Set


SCR Stack
Current Limiting Reactor (CLR)
Transformer/Rectifier (T/R) Set
L - 1
L - 2
Primary Voltage Meter
V
CT
Primary Current Meter
A
Firing Circuit
Microprocessor(s) Control Module
Automatic Voltage Control
mA
Secondary Current Master
KV
Secondary Voltage Meter
Precipitator Field
mA
Signal Resistor

Transformer Rectifier (T/R) Set

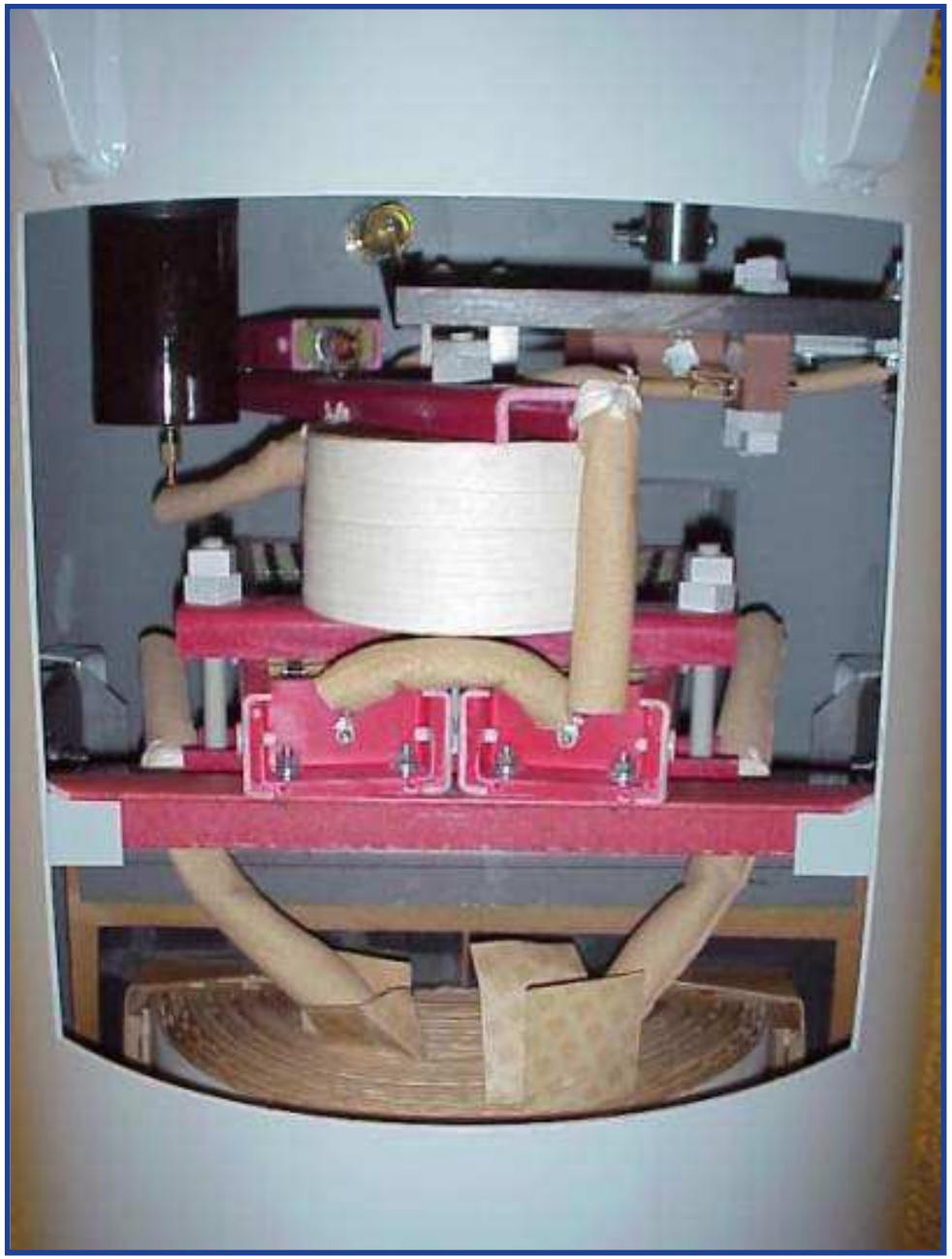
Typical Sizes from 100–2000mA and 45-80 KVDC Avg.

T-R Set Size (Rating) depends on:

1. Type of Electrode
2. Gas Density
3. Field Position on ESP
4. Process
5. Sectionalization
6. Gas Passage Width

Looking Inside the T/R Tank

Drain the Oil, First!



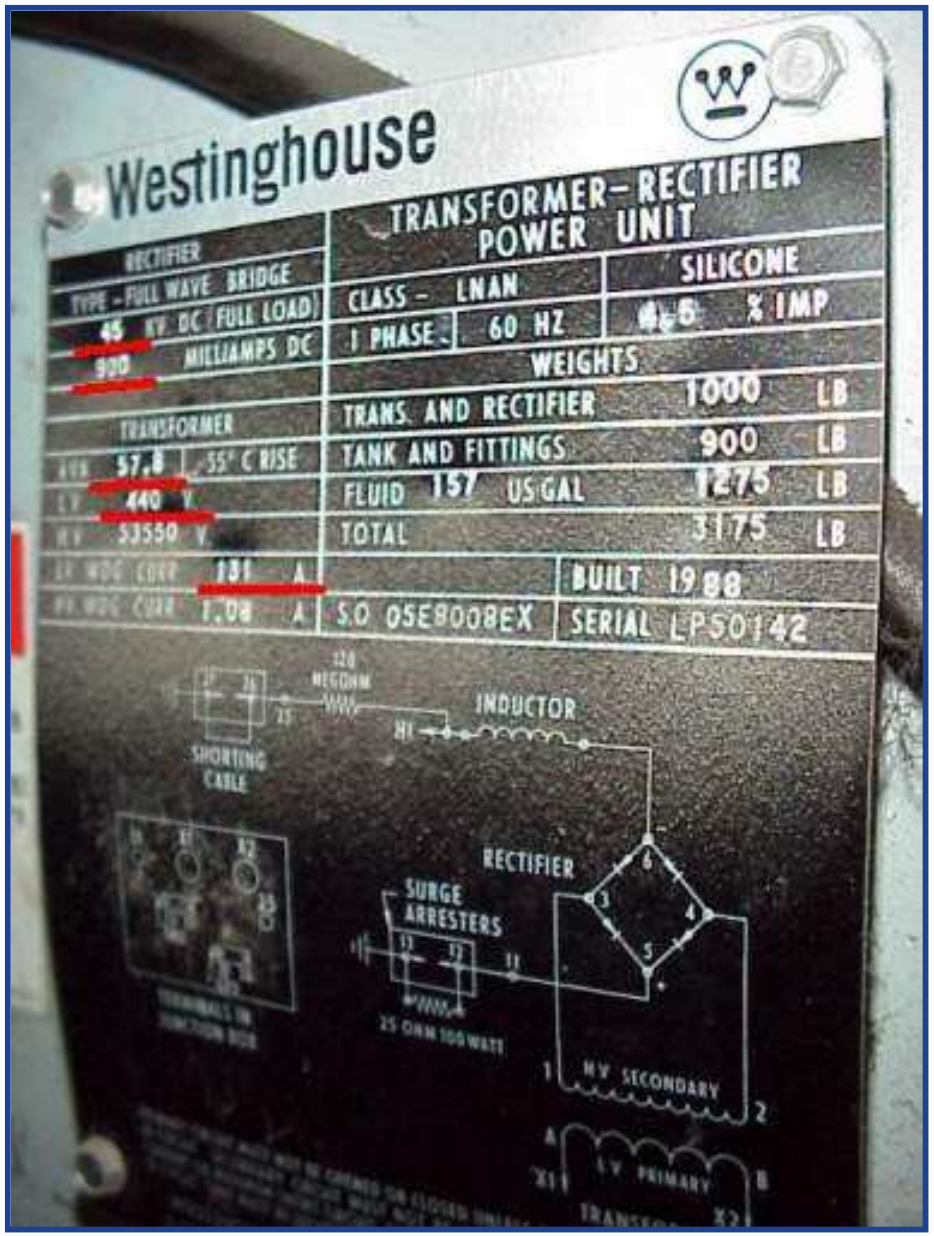
High Voltage Transformer

High Voltage is needed to get current to flow through flue gas

Diode Stack – Converts the AC from the HV Transformer to pulsating DC which is required by the ESP

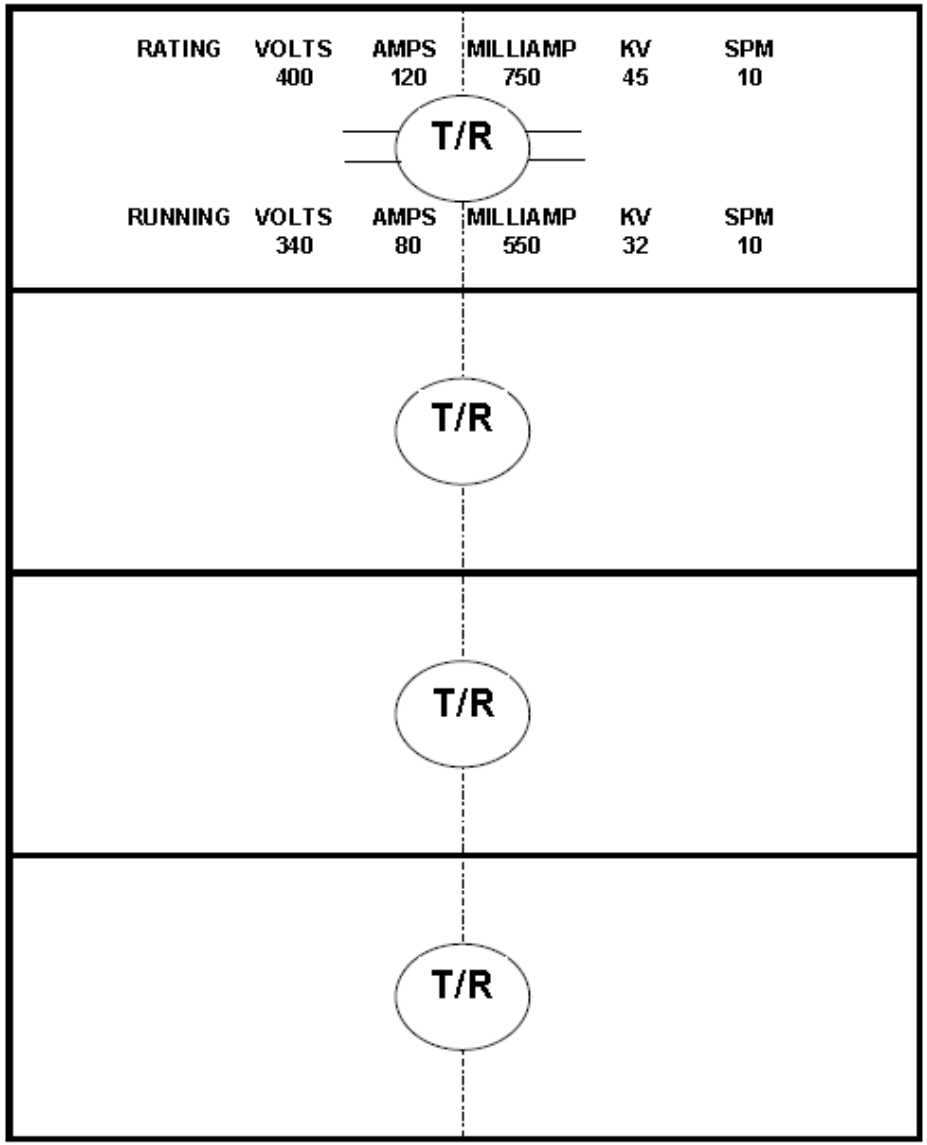
Low Voltage Junction Box

T/R Nameplate



T-R Sets

Could the efficiency of this ESP be increased by replacing this T-R with a bigger one?



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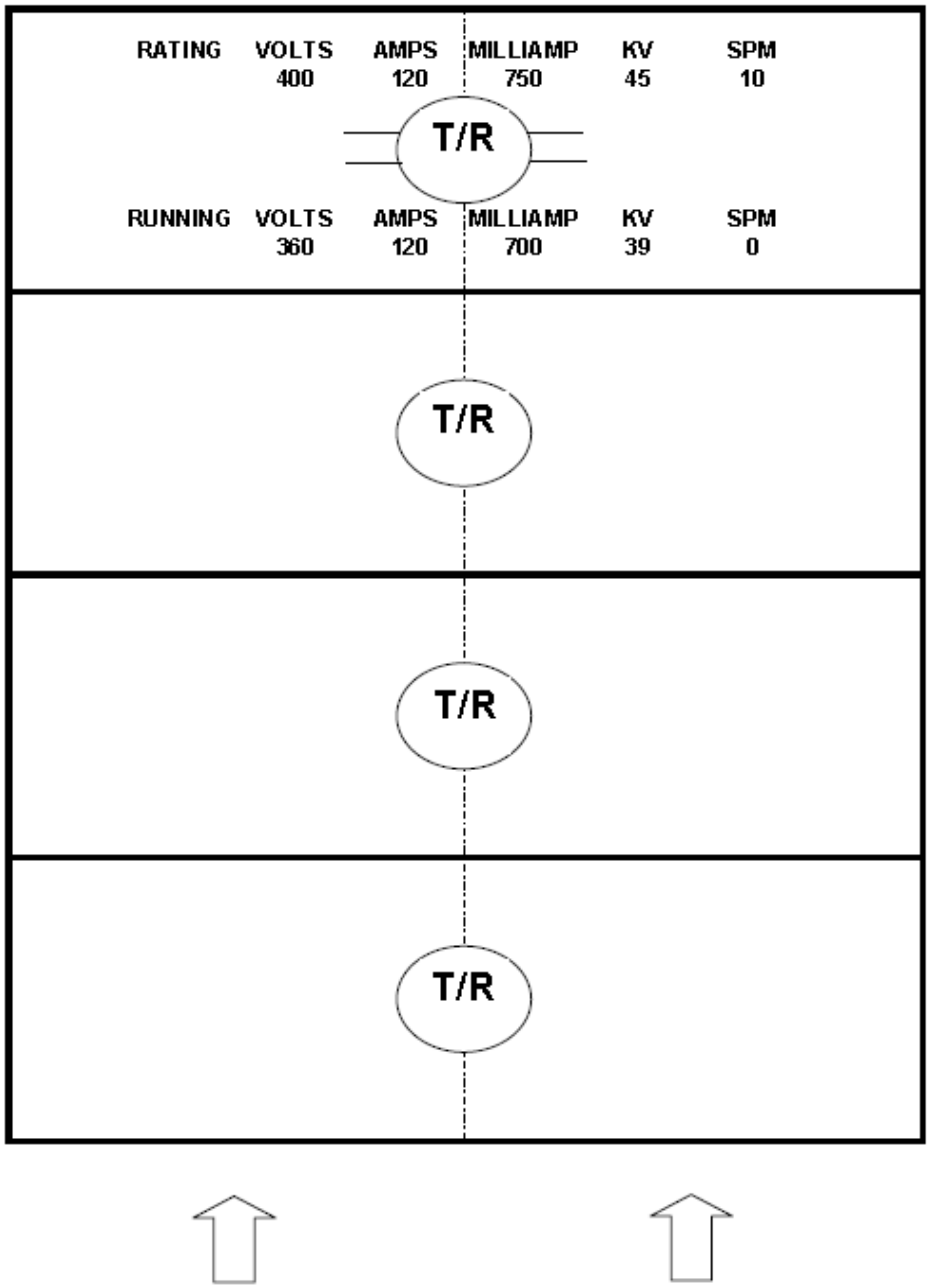
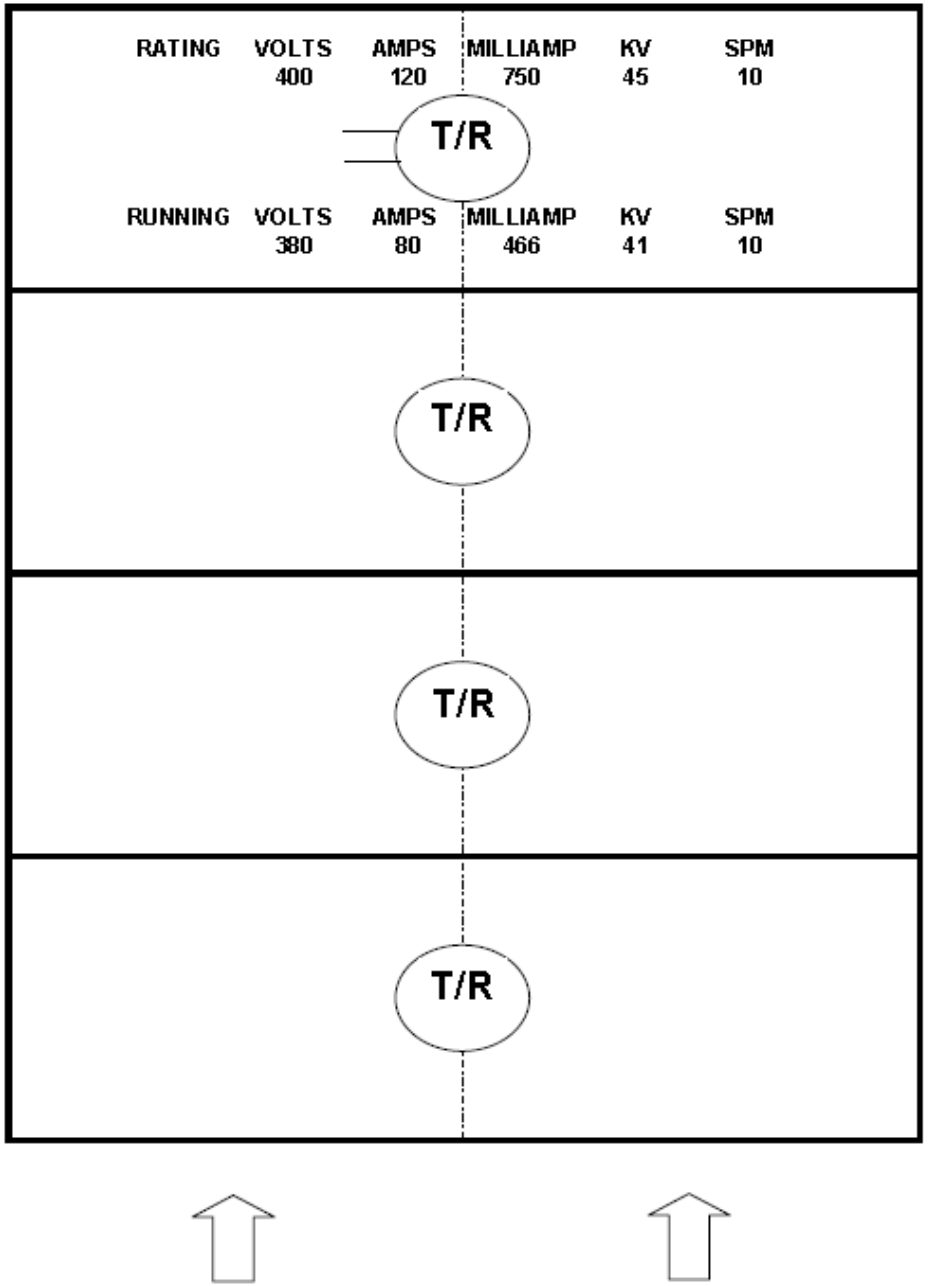
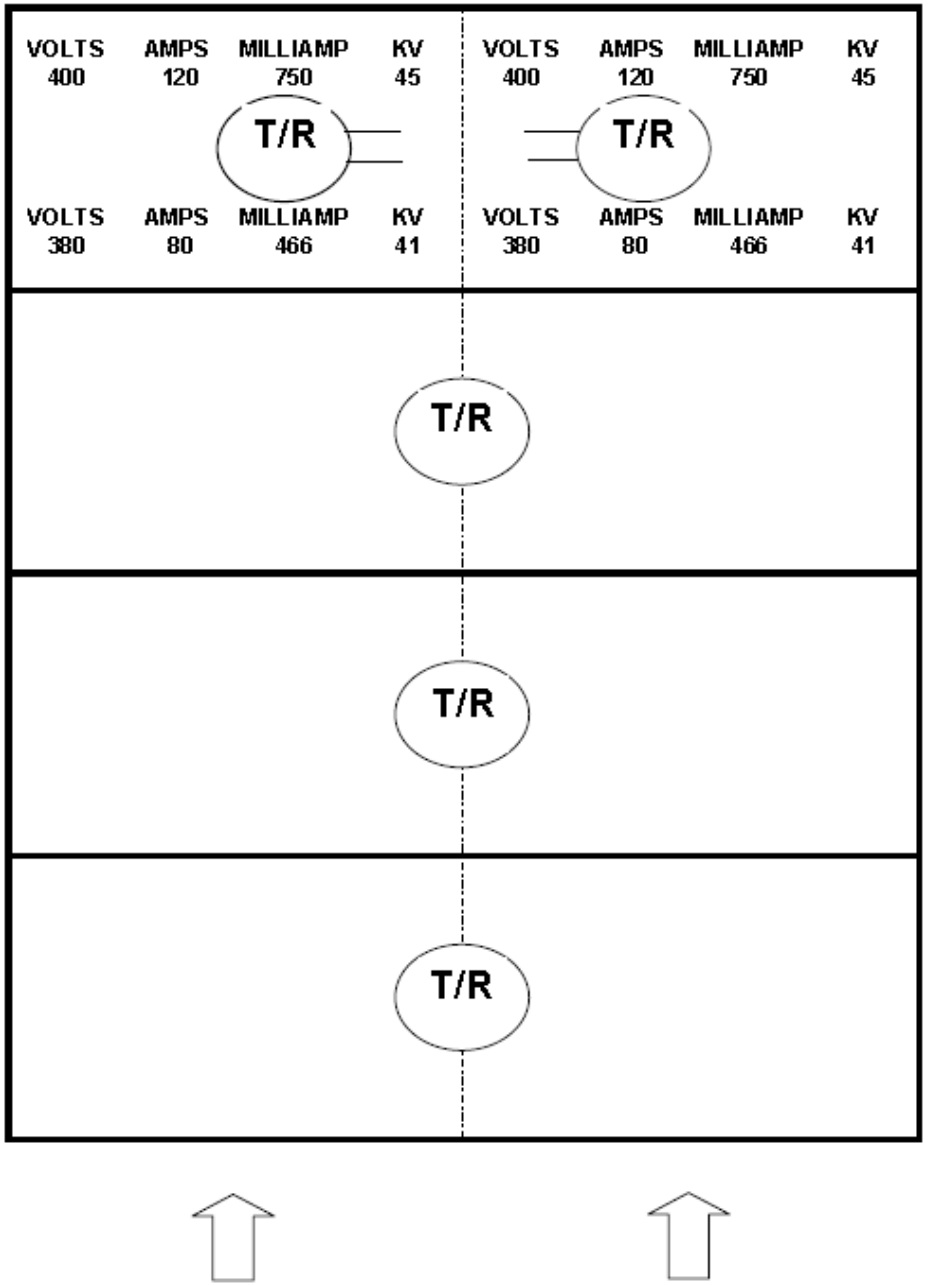


Possibly.
Experiment by energizing one bushing at a time and see what the results are.

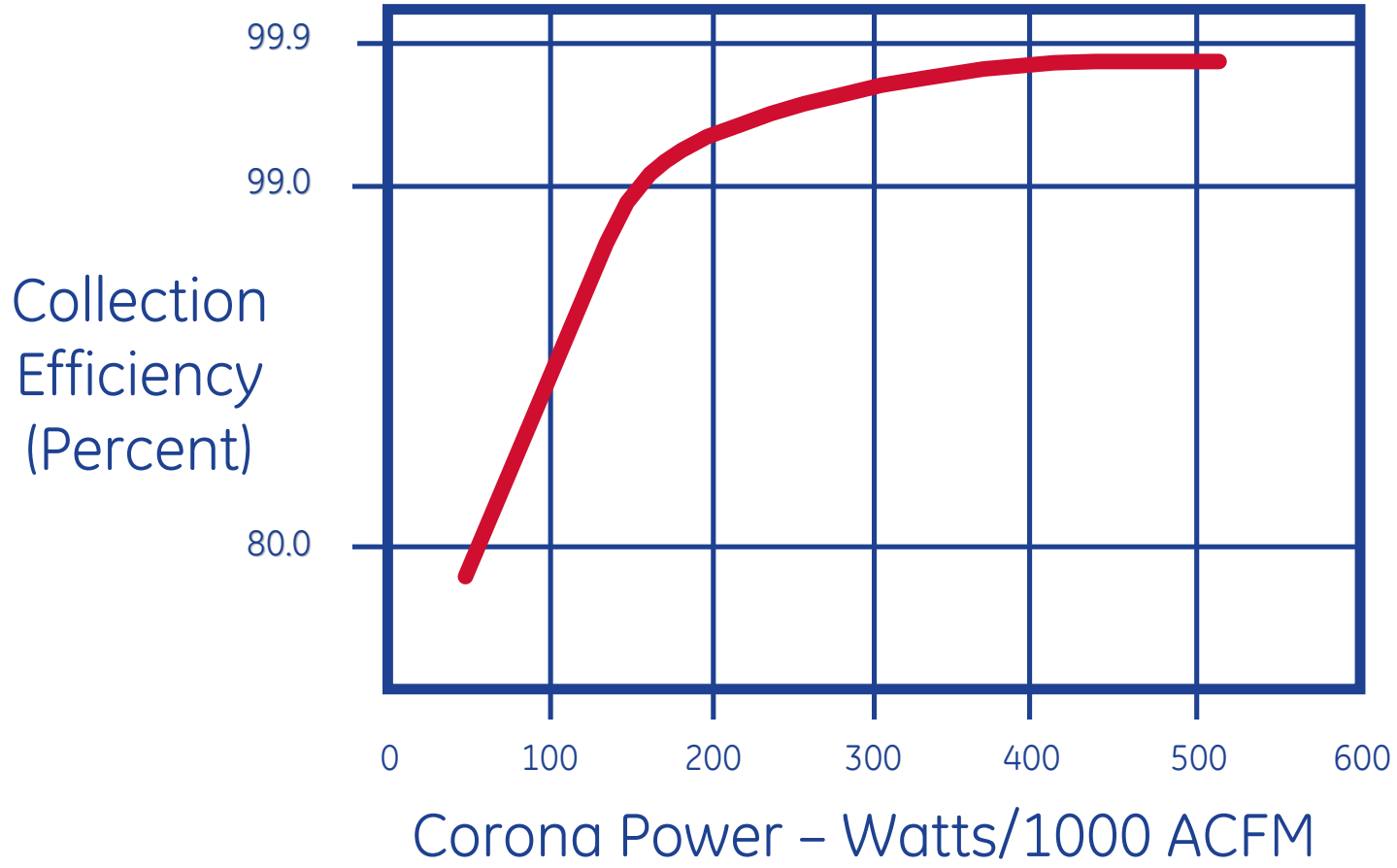


Your experiment shows that adding a second T-R would be the best way. More power means higher efficiency if you are on the straight part of the curve

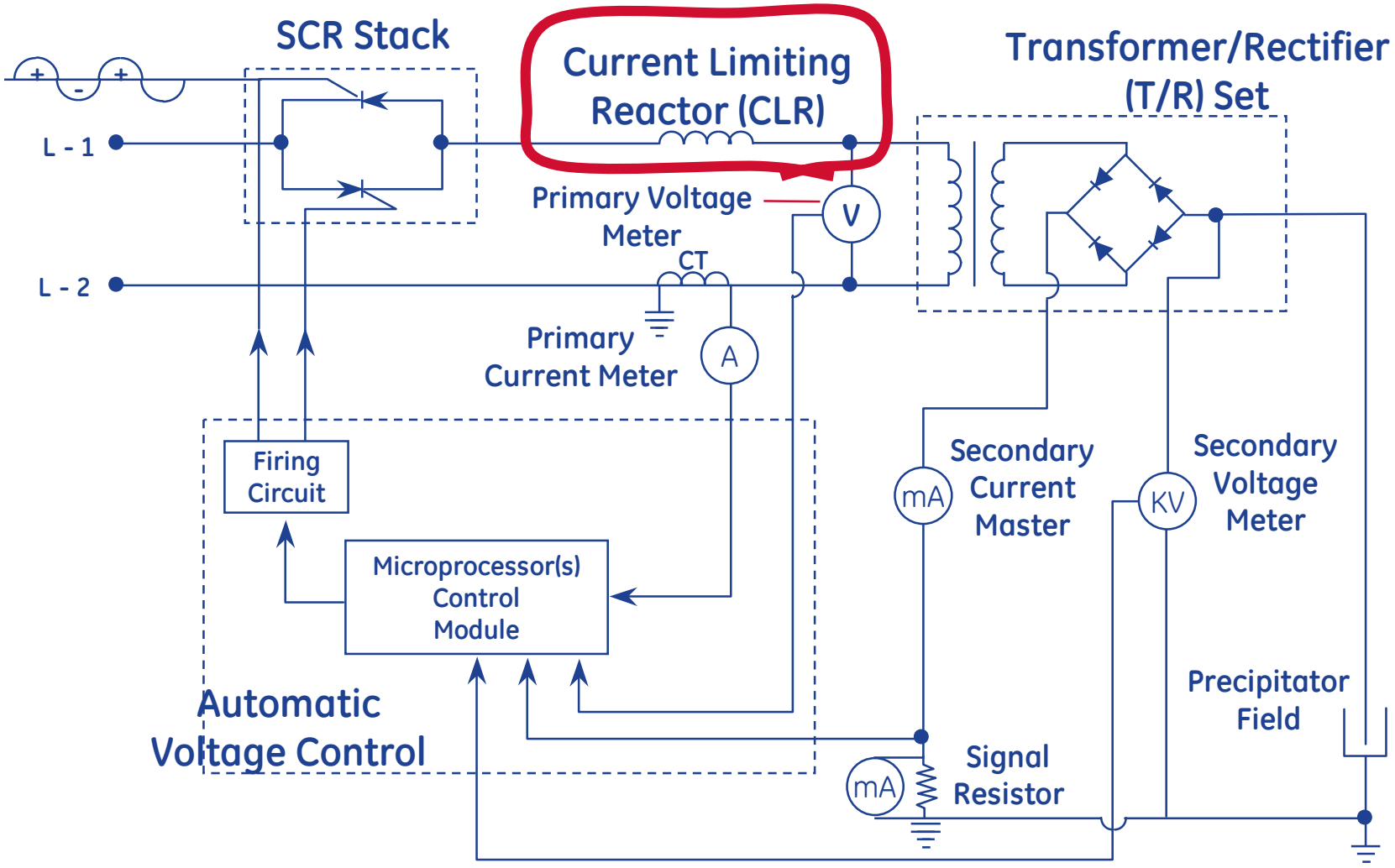


Efficiency vs. Specific Corona Power

KNOW WHERE YOUR ESP RUNS ON THE CURVE



The CLR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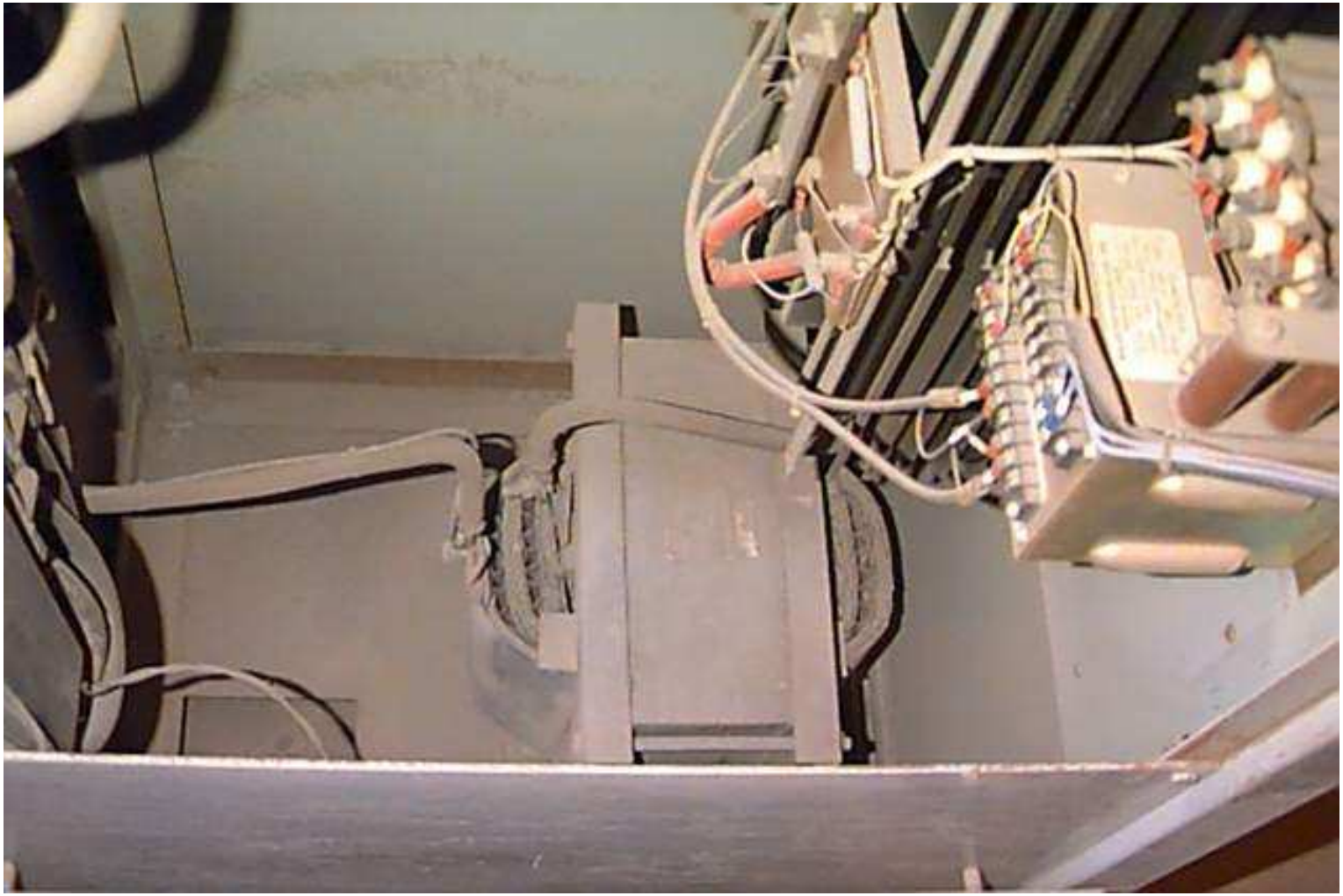
Current Limiting Reactor

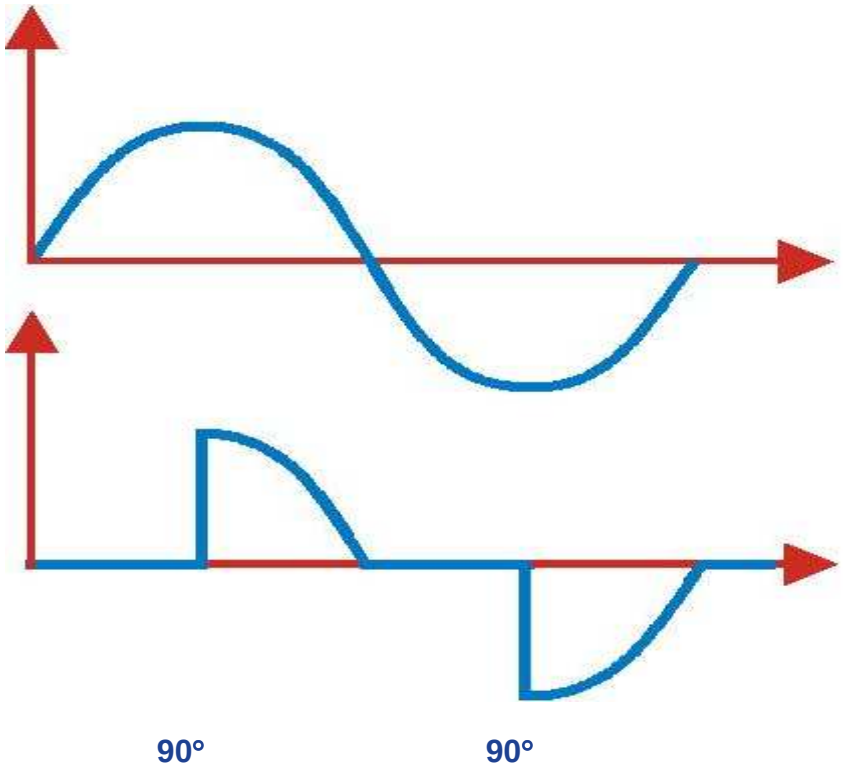


Current Limiting Reactor at T-R Set -

1. It's an inductor that limits current flow on the primary of the T-R under short circuit conditions (sparking)
2. Controls the current wave shape
3. Typical inductance ratings of 2 - 15 mH

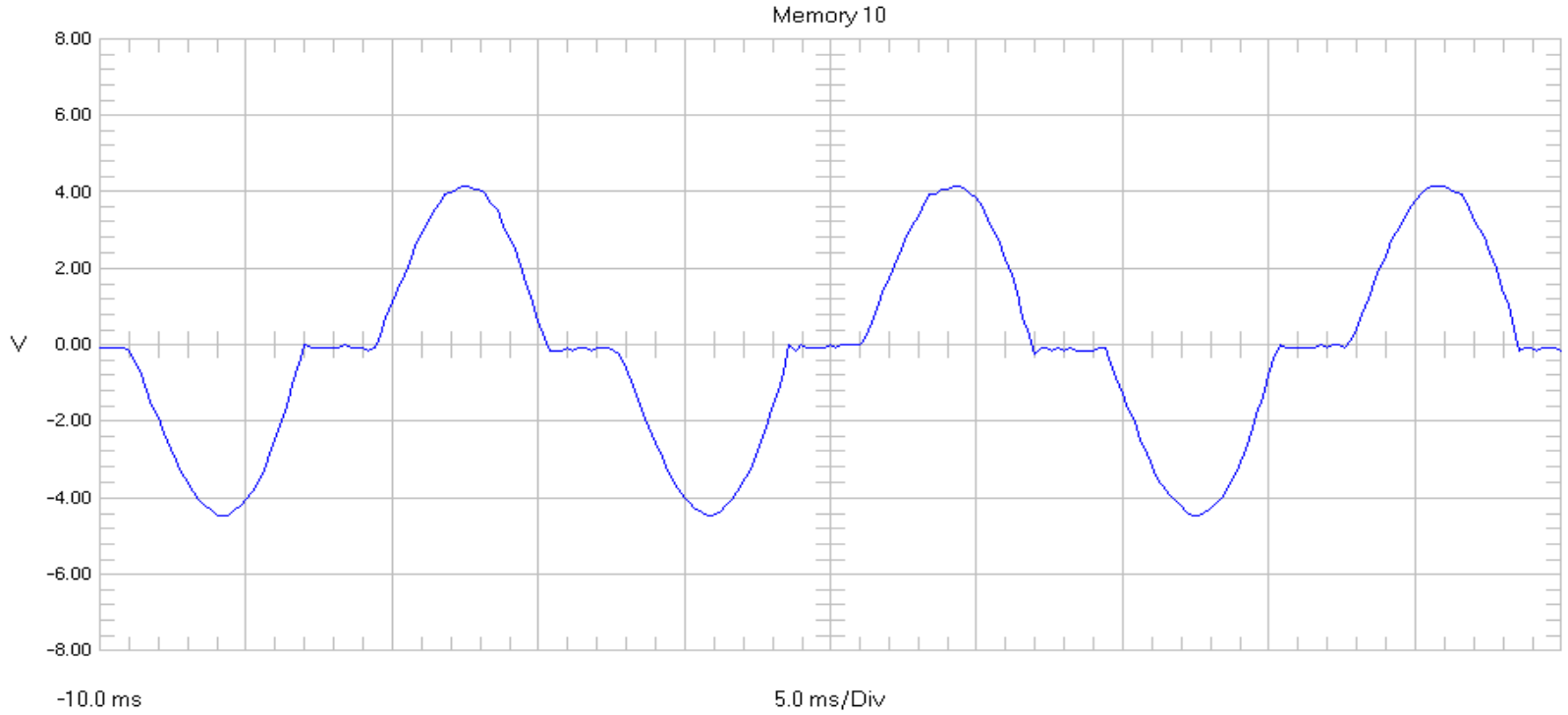
SCR's are why CLR's are Needed

- The diagram would represent the waveform with the SCRs turning on at 90°.
- If this waveform were applied to the T/R set, very inefficient operation would occur.
- Output power from the T/R set would be greatly reduced.



Electrical Basics: CLR

To increase the efficiency of the T/R set, a device called a CLR (current limiting reactor) is used. A CLR is an inductor. Recall that the property of an inductor is to oppose a change in current. Because of this property, the shape of the current waveform is changed and it starts looking more like a sine wave.

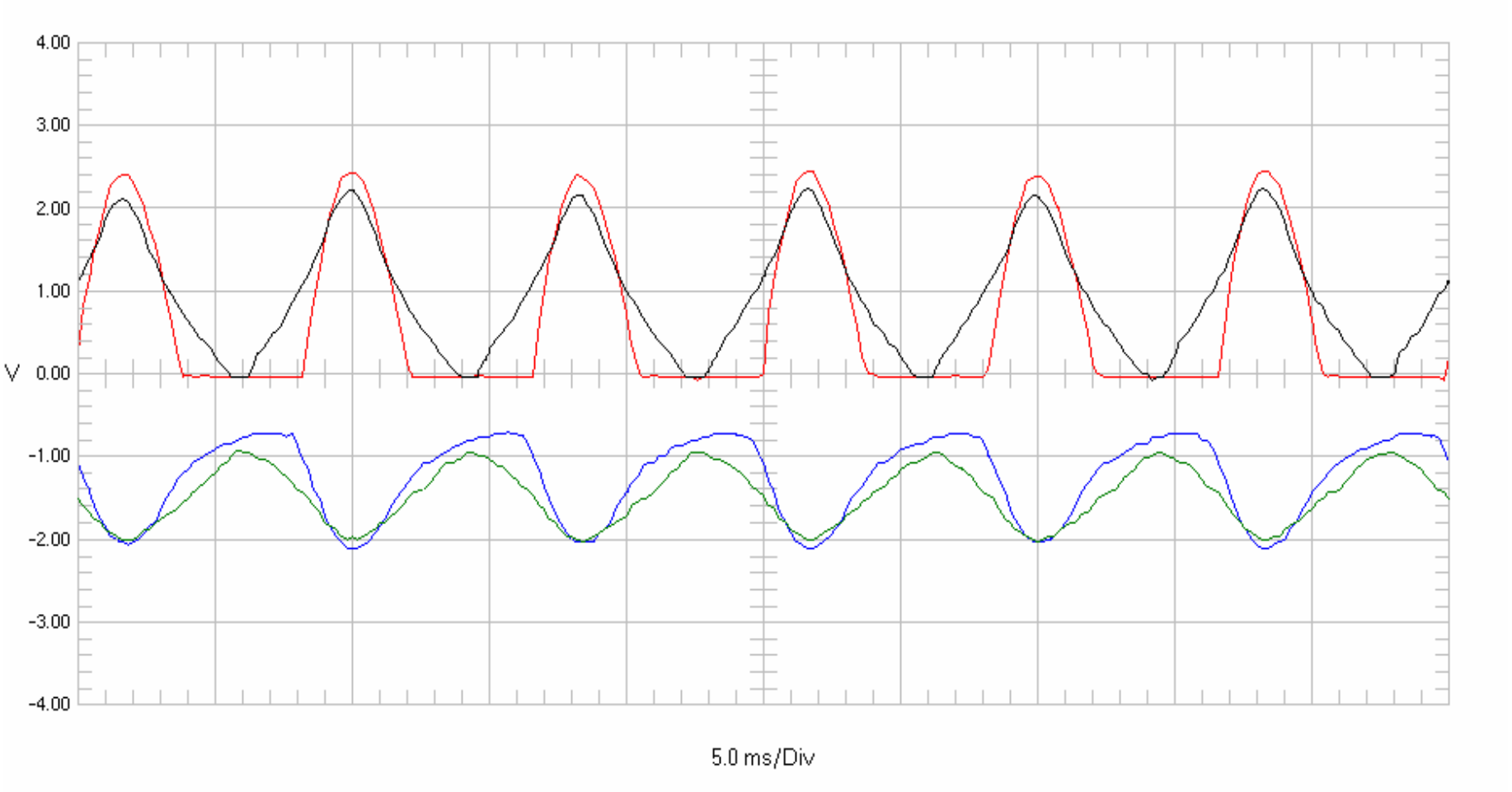


Proper CLR Sizes for Common T/R Sets

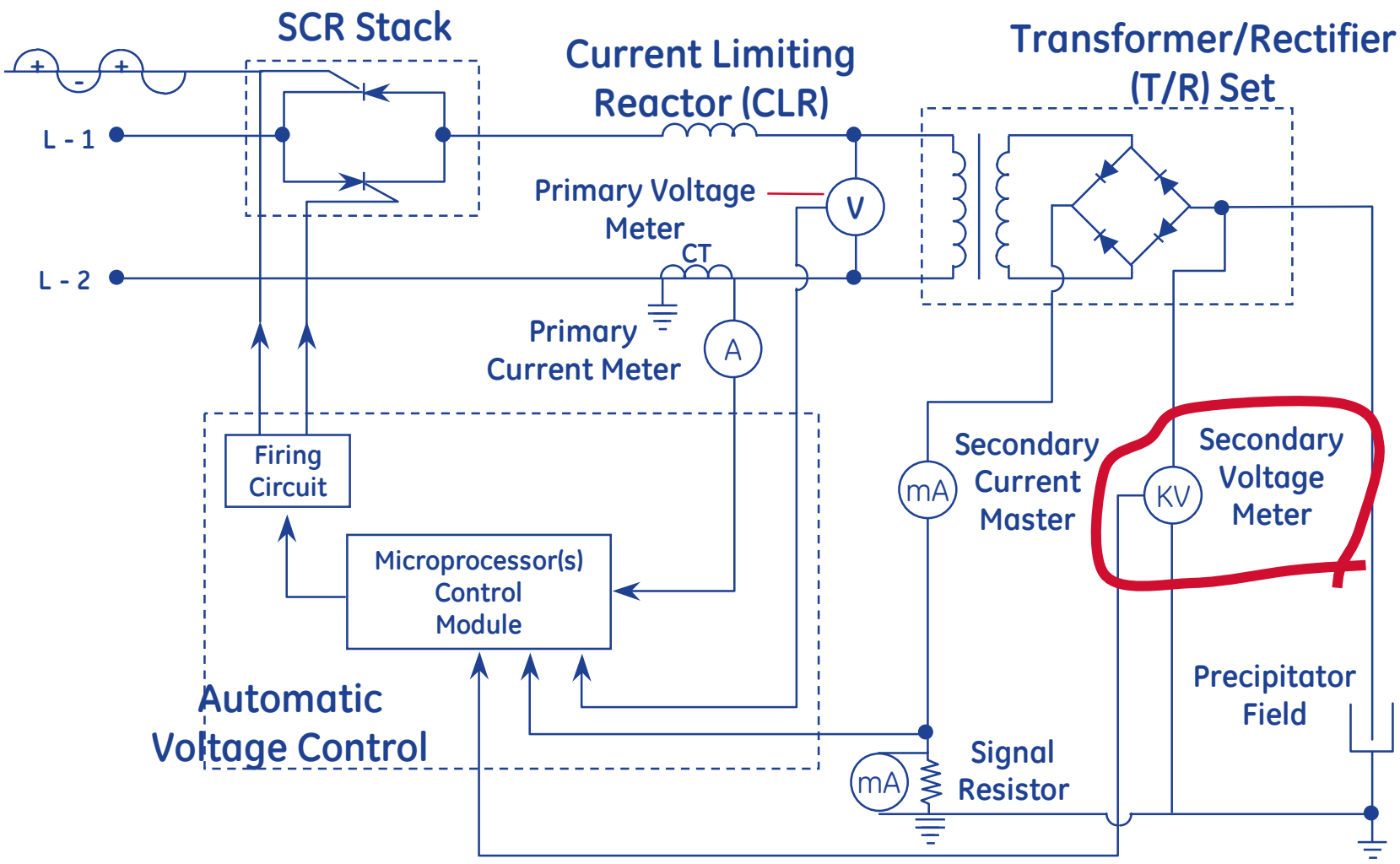
All T/R primaries are rated at 400V

PRI Current (Amps)	Sec. Current (mA)	Minimum (mH)
40	250	13.0
80	500	6.6
120	750	4.4
160	1000	3.3
200	1250	2.6
240	1500	2.2

CLR – Wave Shape Changes with Impedance



The KV Meter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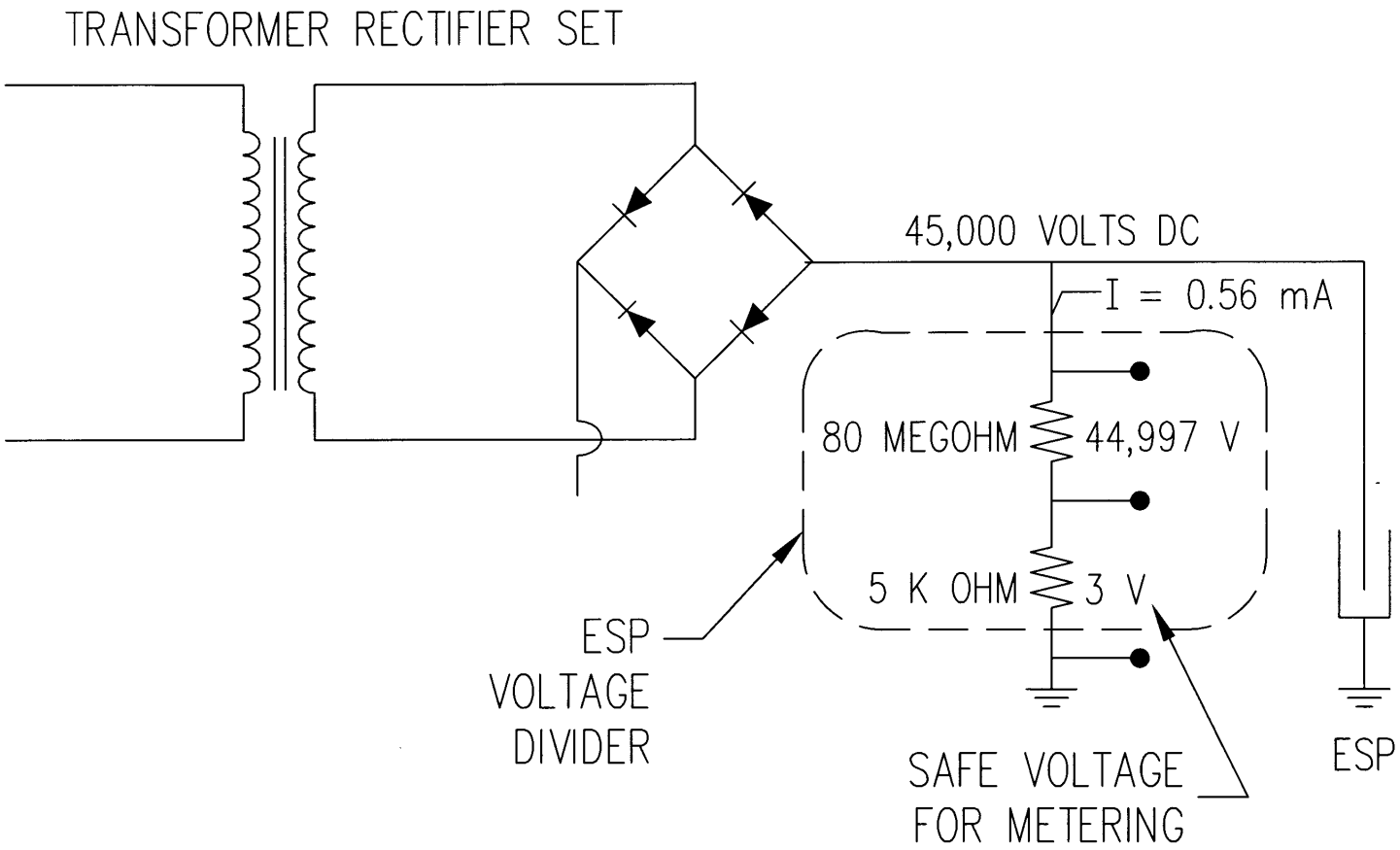
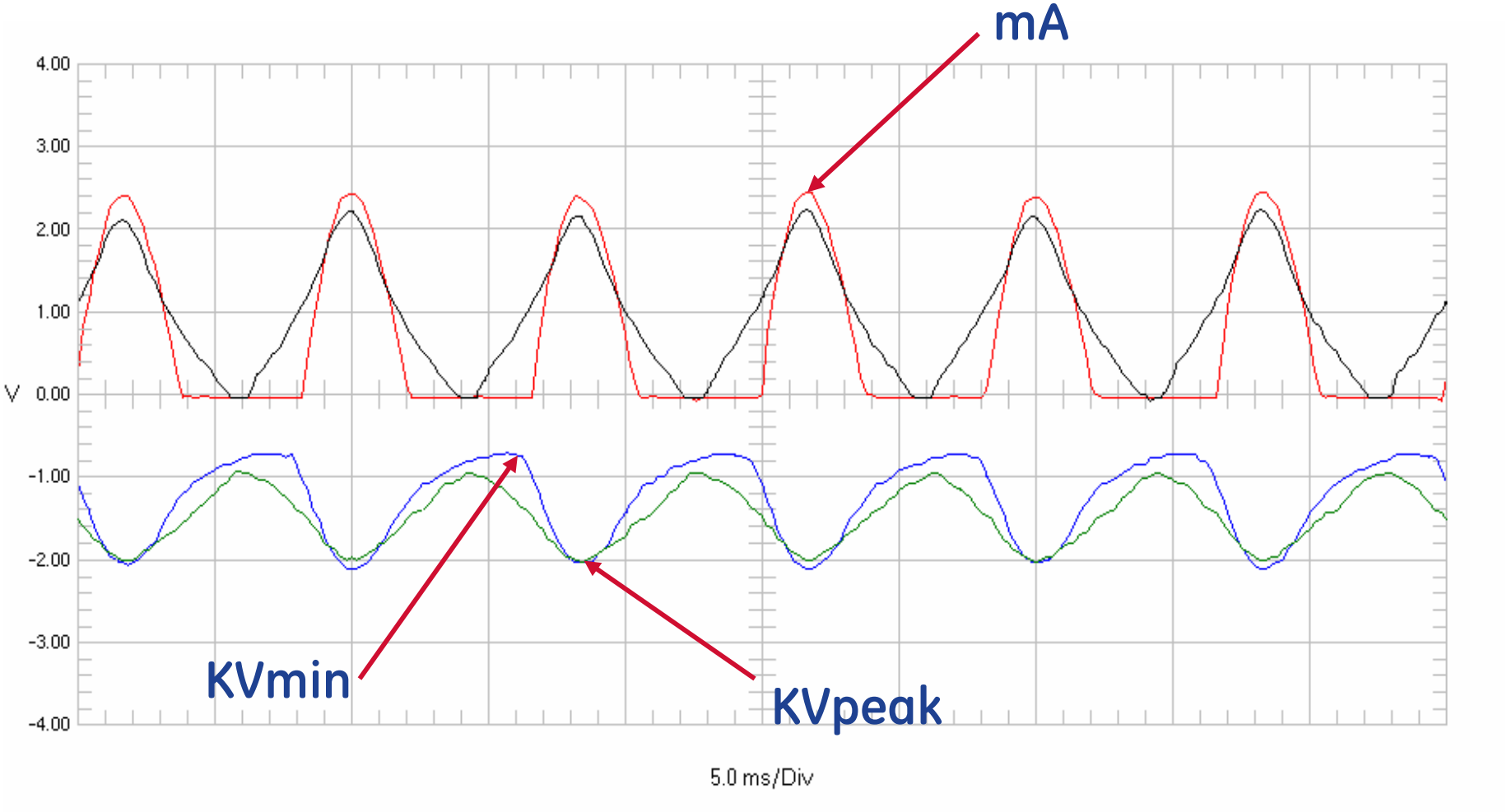
Voltage Divider



Secondary Voltage Waveforms – True Negative



GE Energy

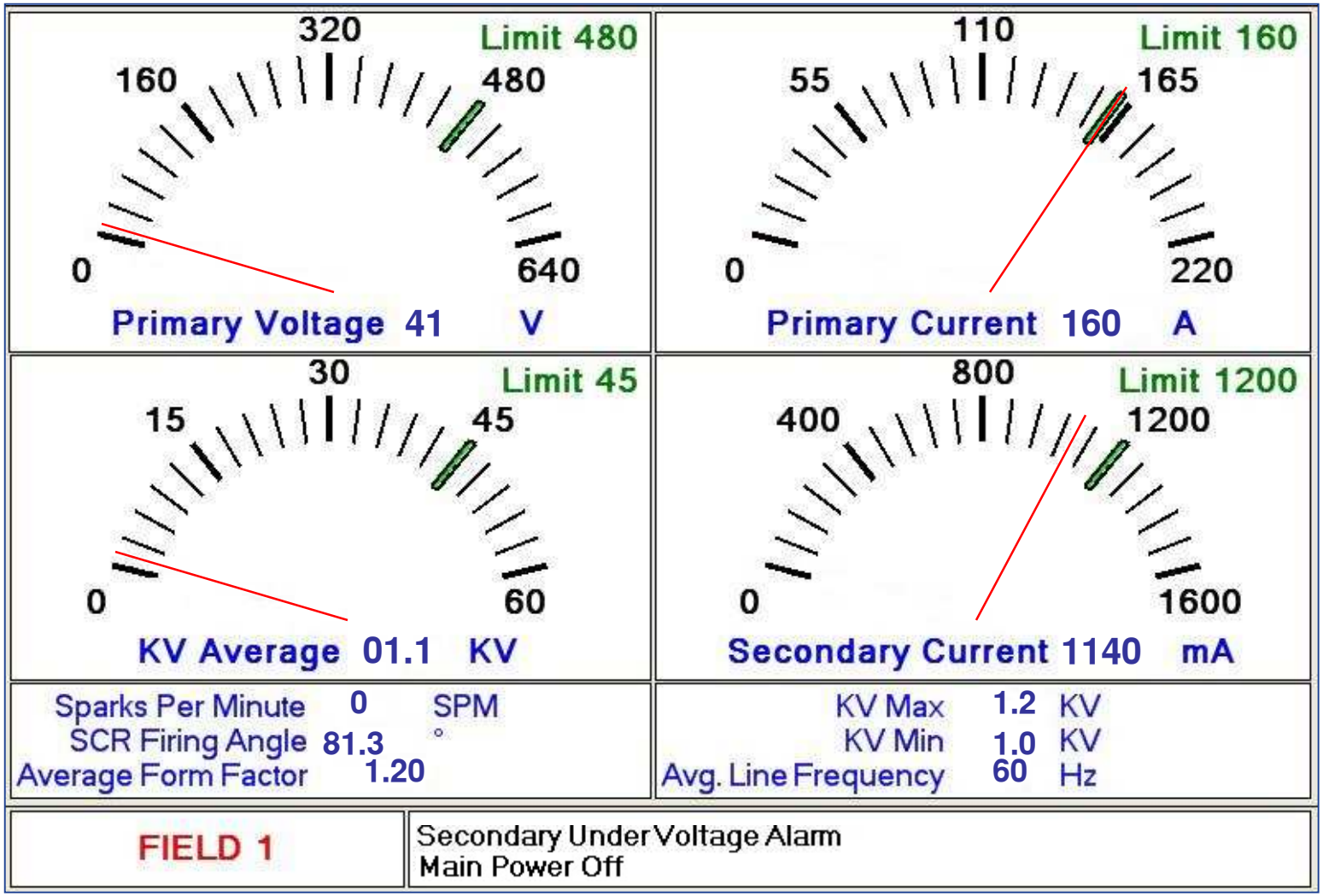
Basic ESP Electrical Troubleshooting

imagination at work

TR Set Namplate Ratings

Primary Current	- 160 AAC
Primary Voltage	- 480 VAC
Secondary Current	- 1200 mA
Secondary Voltage	- 45 KV

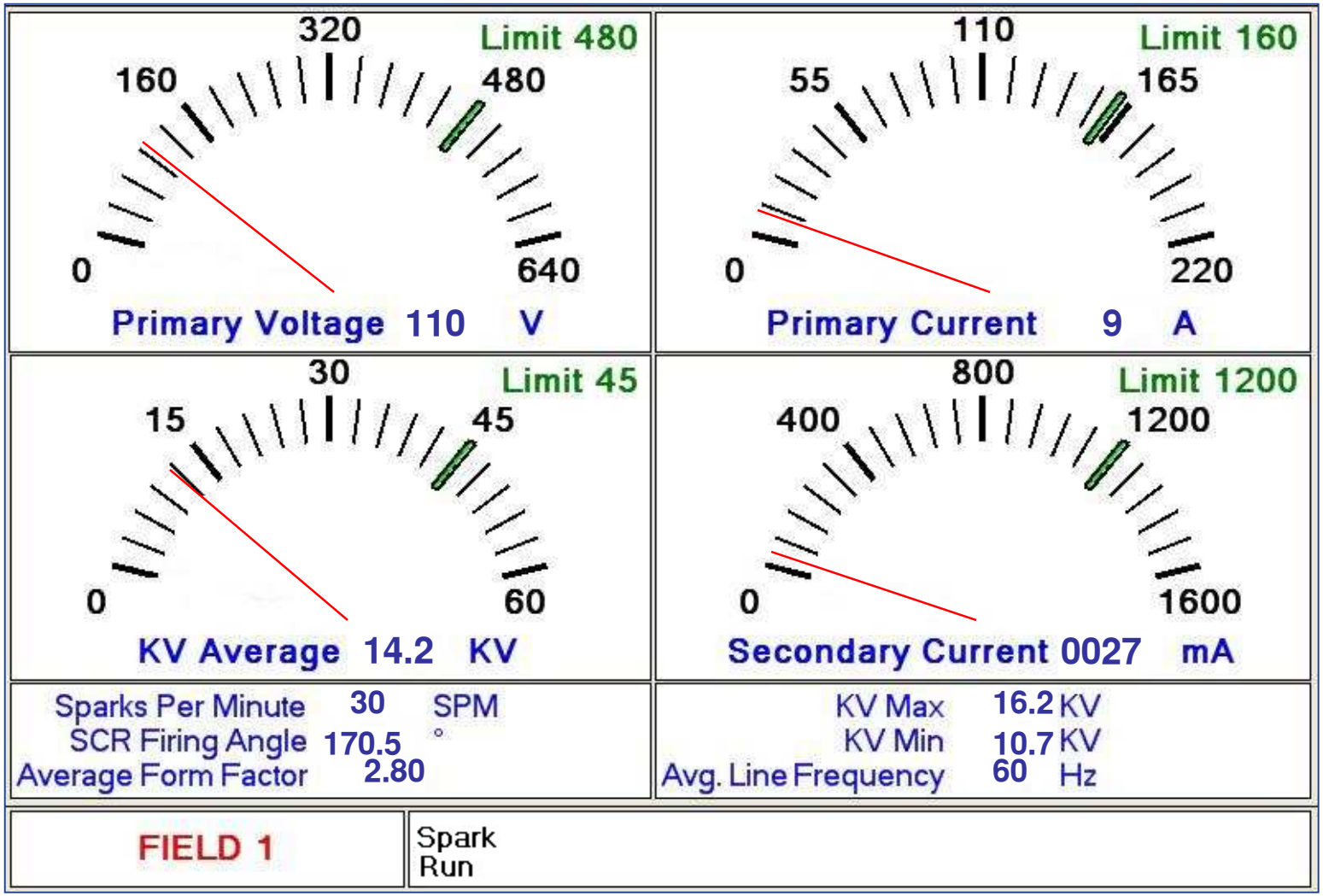
Short


320
160
480
0
640
Limit 480
Primary Voltage 41 V
110
55
165
0
220
Limit 160
Primary Current 160 A
30
15
45
0
60
Limit 45
KV Average 01.1 KV
800
400
1200
0
1600
Limit 1200
Secondary Current 1140 mA
Sparks Per Minute 0 SPM
SCR Firing Angle 81.3 °
Average Form Factor 1.20
KV Max 1.2 KV
KV Min 1.0 KV
Avg. Line Frequency 60 Hz
FIELD 1
Secondary Under Voltage Alarm
Main Power Off

Mechanical Checks for Shorts

- Insulators dirty, tracked or broken
  - Location of Insulators?
- Broken wire or RDE or adjacent field
- Construction/maintenance debris in field (welding rod, metal tools, temporary brackets, etc)
- Grounding strap left in place
- High Hopper

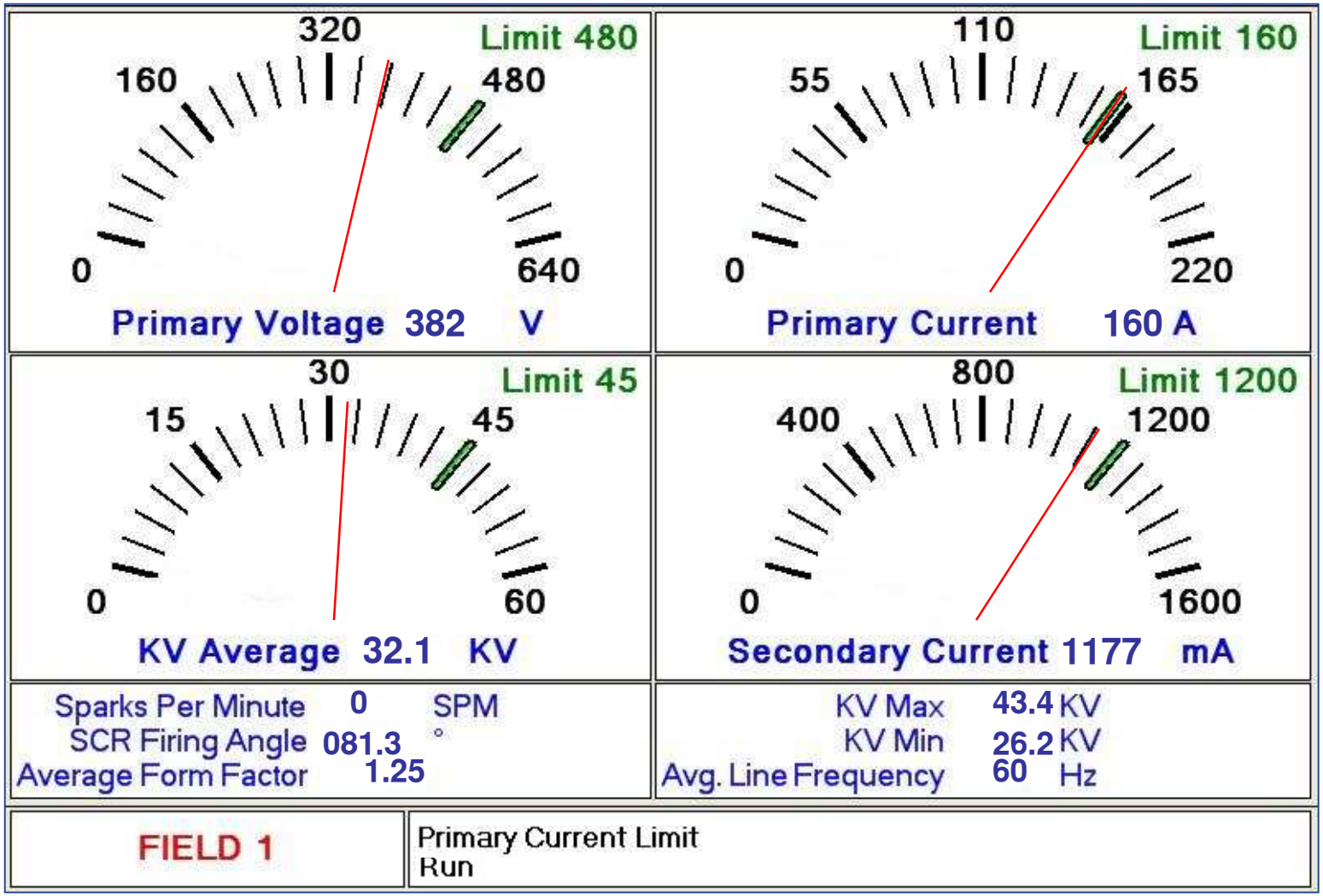
Close Clearance



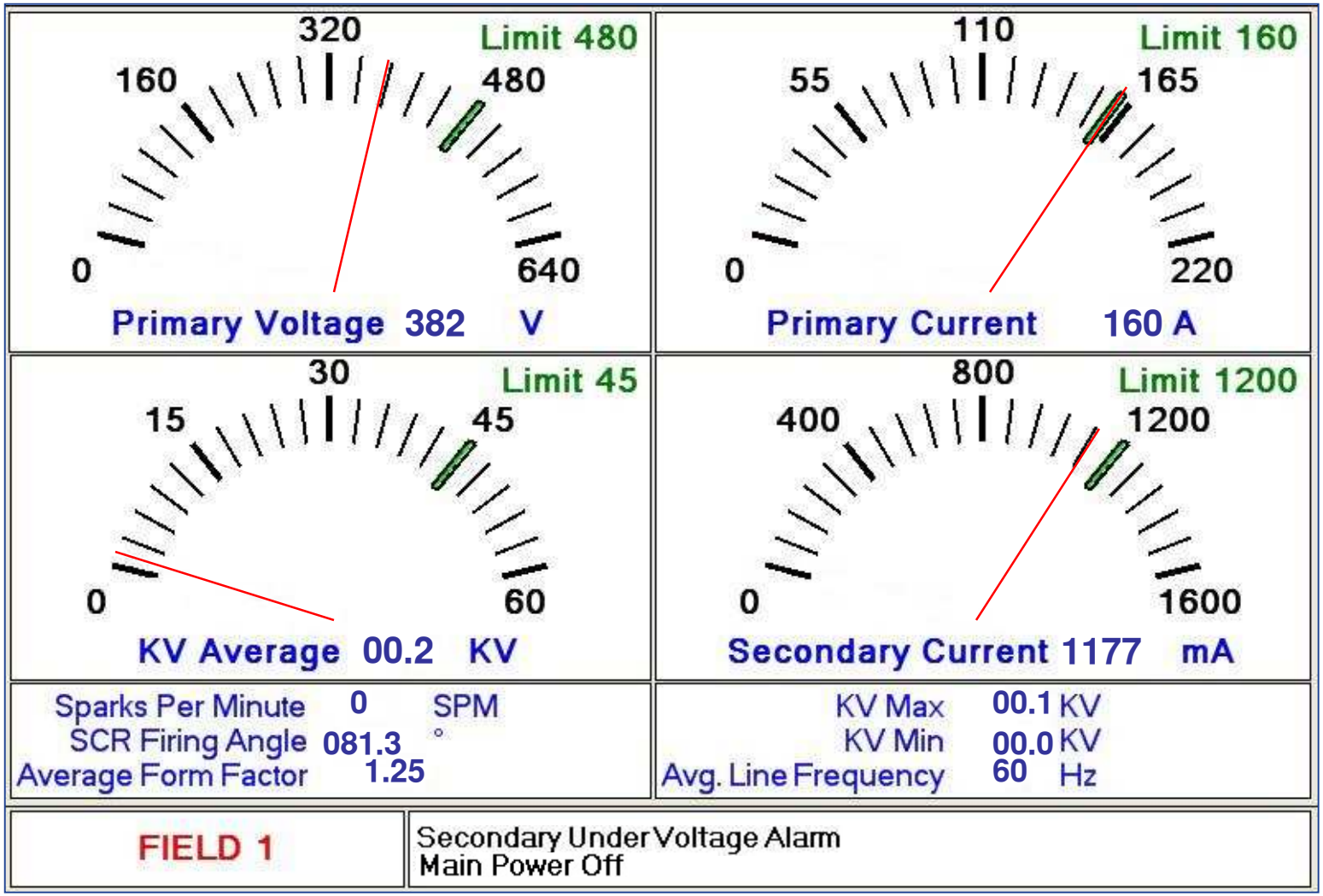
Mechanical Checks for Close Clearances

- HV hanger rod at roof penetration/corona shield
- Misaligned HV frame to collecting system. Wires or RDEs too close to plates.
- Lower HV frames swinging (anti-sways broken).
- Broken wire (intermittent as it swings about). SCR firing angle will usually swing wildly in this case
- Construction/maintenance debris in field
- Buildup

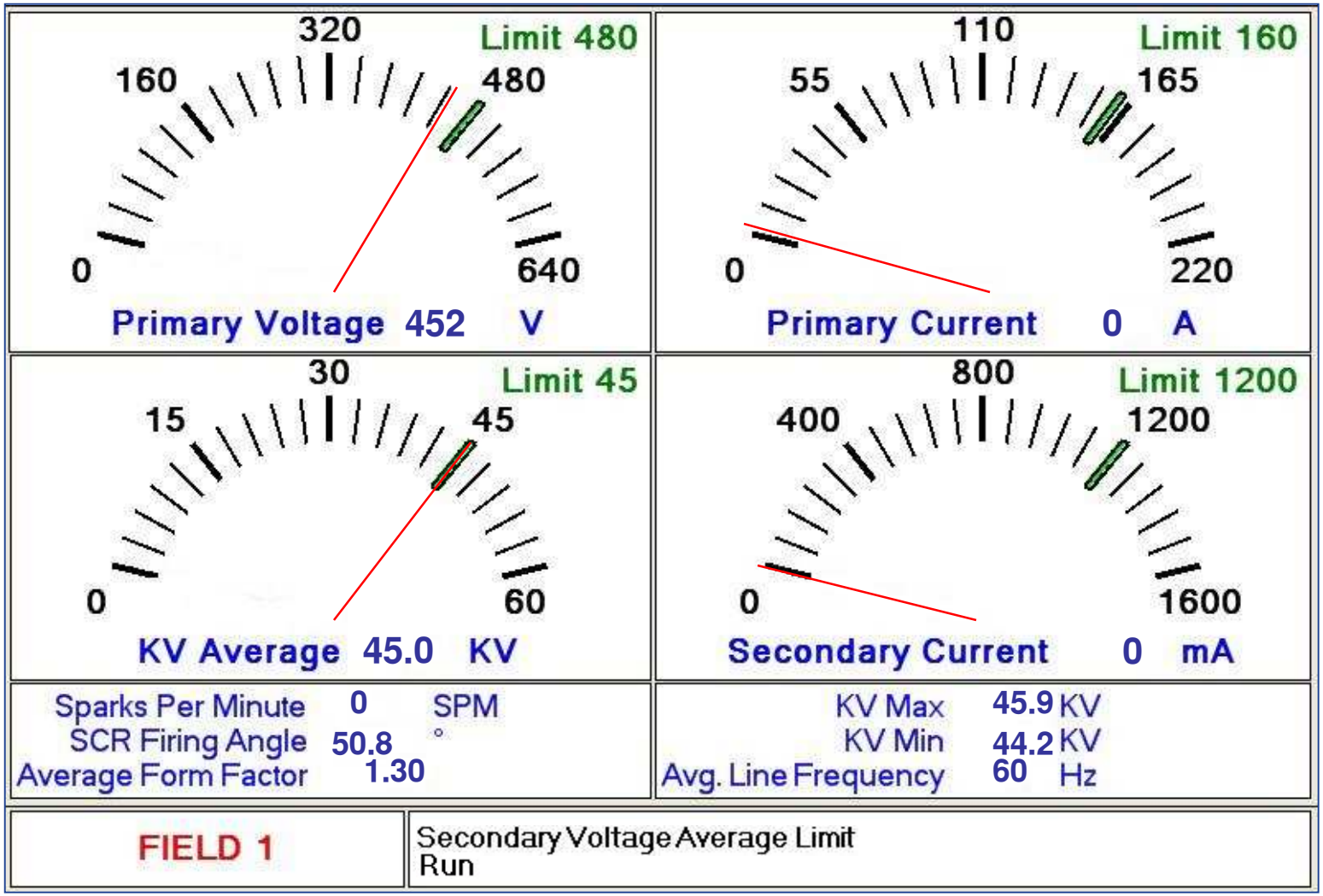
Outlet Field, Conductive Dust



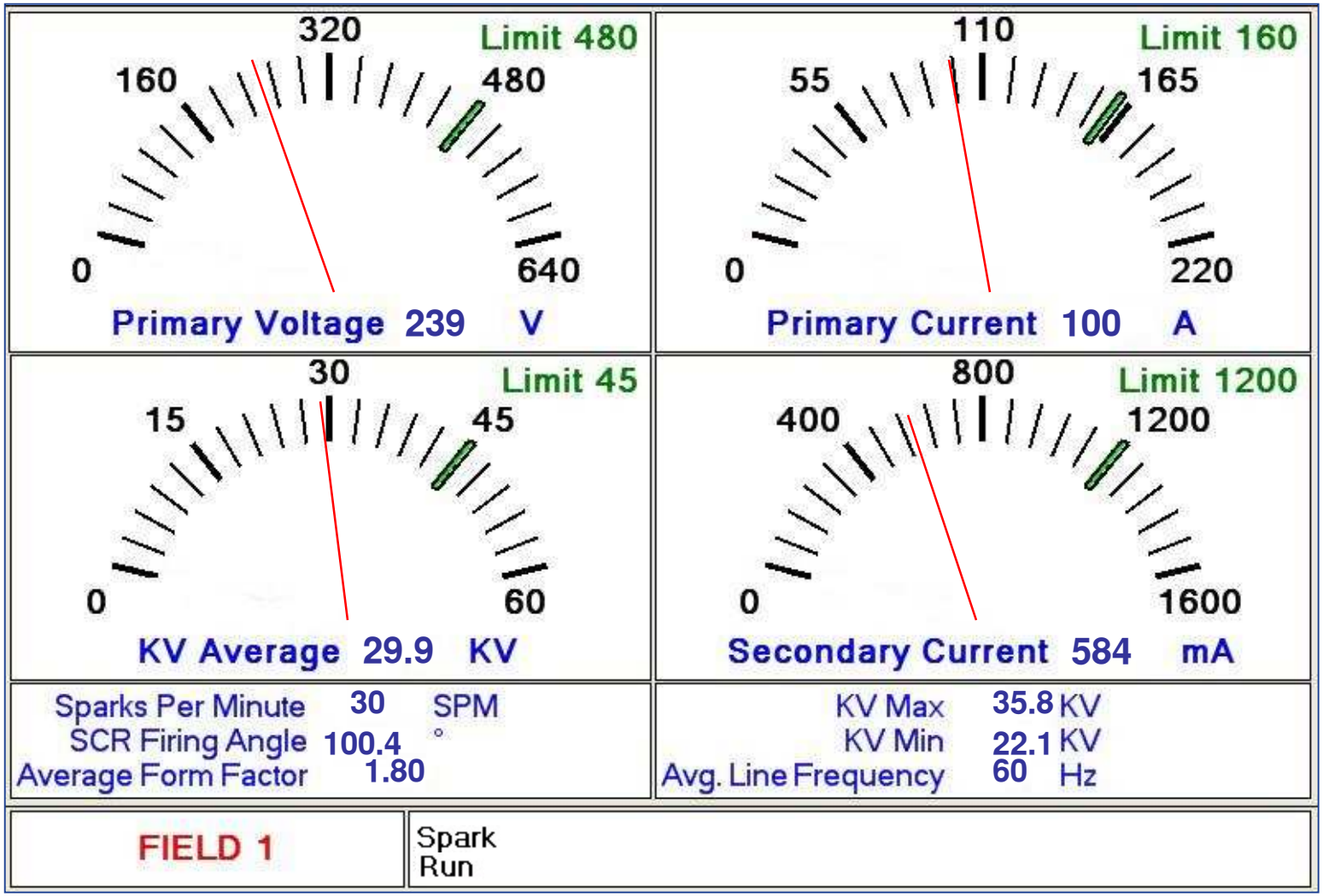
Bad KV Return



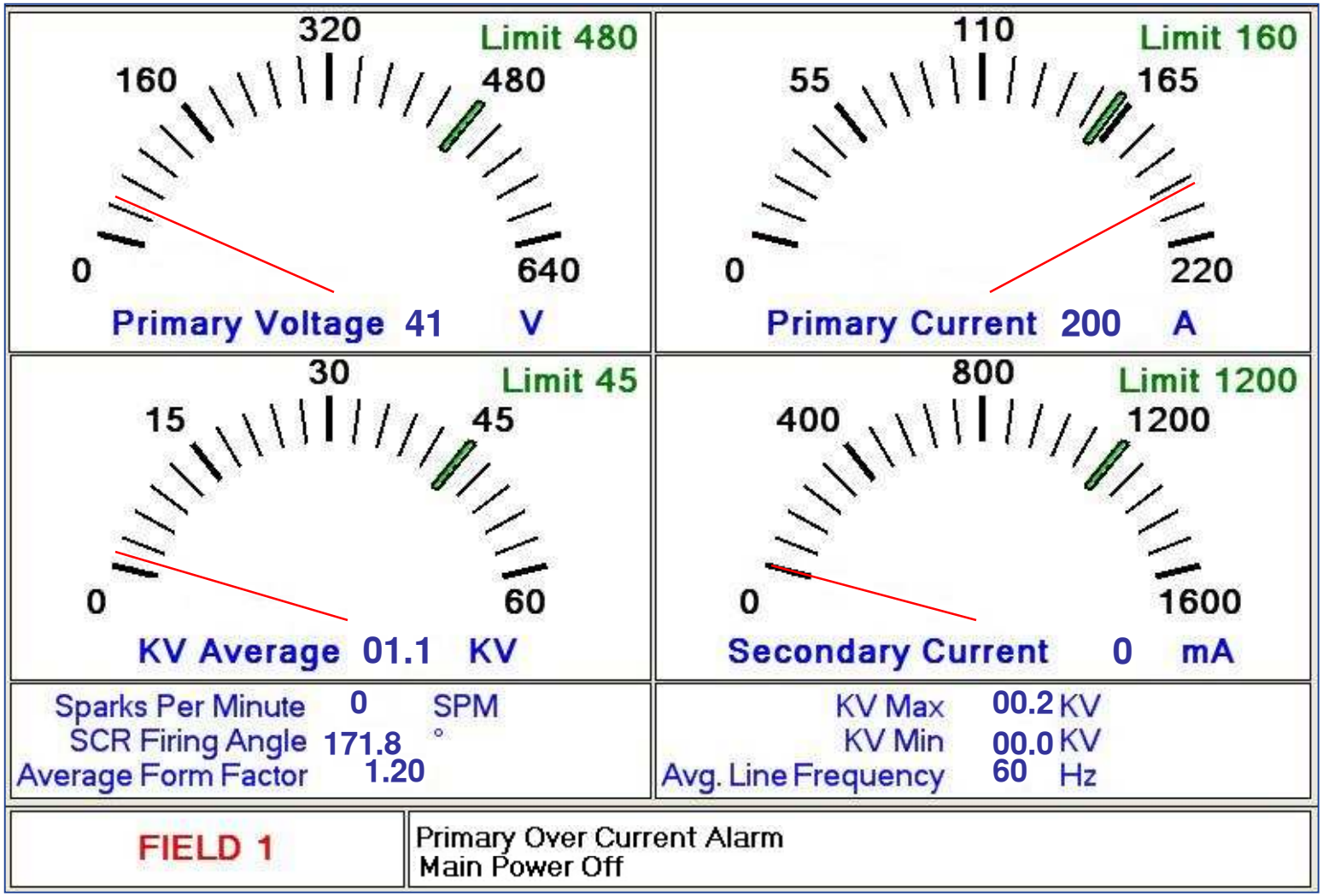
Open


320
160
480
0
640
Limit 480
Primary Voltage 452 V
110
55
165
0
220
Limit 160
Primary Current 0 A
30
15
45
0
60
Limit 45
KV Average 45.0 KV
800
400
1200
0
1600
Limit 1200
Secondary Current 0 mA
Sparks Per Minute 0 SPM
SCR Firing Angle 50.8 °
Average Form Factor 1.30
KV Max 45.9 KV
KV Min 44.2 KV
Avg. Line Frequency 60 Hz
FIELD 1
Secondary Voltage Average Limit
Run

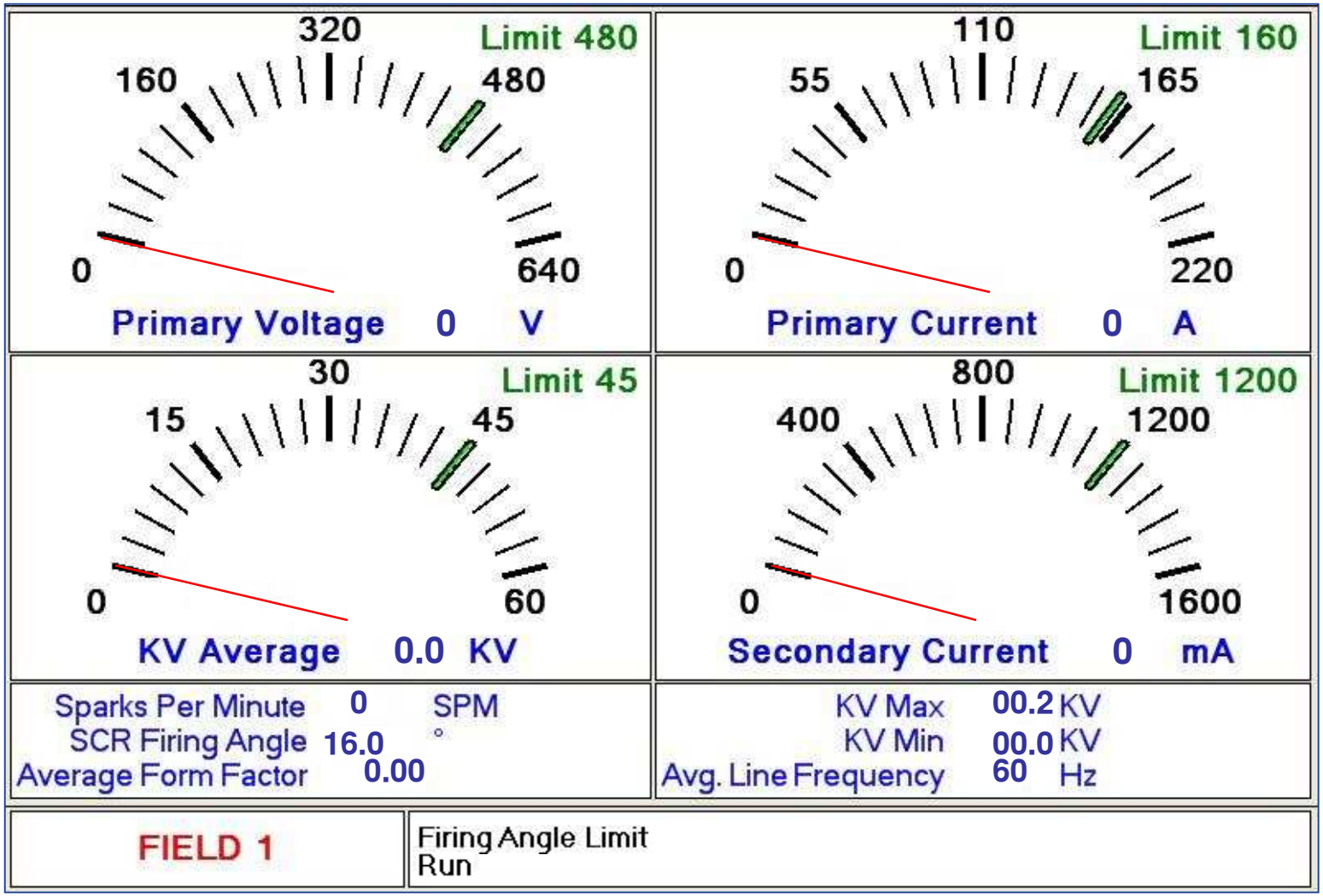
Normal Running Condition



Bad Secondary ma Return



SCR's not Firing



Questions?

Thank You.