Power Supply and automatic Voltage Control

12-09-13

Understanding ESP Controls

Power Supply System

- The power supply system is designed to provide voltage to the electrical field (or bus section) at the highest possible level.
- The voltage must be controlled to avoid causing sustained arcing or sparking between the electrodes and the collecting plates.
- Precipitator power system animated schematic showing representative components.

- When electrical fields are in series, the power supply for each field can be adjusted to optimize operation of that field.
- Likewise, having more than one electrical bus section in parallel allows adjustments to compensate for their differences, so that power input can be optimized.

Components

The power supply system has four basic components:

- Automatic voltage control
- Step-up transformer
- High-voltage rectifier
- Sensing device
- Voltage control

AVC

Automatic voltage control

a. varies the power to the transformer-rectifier
b. in response to signals received from sensors in the precipitator and the transformer-rectifier itself.
c. monitors the electrical conditions inside the precipitator,
d. protects the internal components from arc-over damages, and
e. protects the transformer-rectifier and other components in the primary circuit.

AVC Contd….

The ideal automatic voltage control would produce

a. maximum collecting efficiency by holding the operating voltage of the precipitator at a level just below the spark-over voltage.
b. this level cannot be achieved given that conditions change from moment to moment.
c. Instead, the automatic voltage control increases output from the transformer-rectifier until a spark occurs.
d. Then the control resets to a lower power level, and the power increases again until the next spark occurs.

Automatic Voltage Controllers (for Electrostatic Precipitators)
An electronic device used to control the application of D.C. power into a field of an electrostatic precipitator.

Functions:

- *Optimize power application*:- to deliver as much useful electrical power to the corresponding field(s) as possible.
- *Spark reaction* – When the voltage applied to the field is too high for the conditions at the time, a spark over (or corona discharge) will occur.

Detrimentally high amounts of current can occur during a spark over if not properly controlled, which could damage the fields.

A voltage controller will monitor the primary and secondary voltage and current of the circuit, and detect a spark over condition.

Once detected, the power applied to the field will be immediately cut off or reduced, which will stop the spark.

After a short amount of time the power will be ramped back up, and the process will start over.

• *Protect system components by adhering to component limitations* – The Transformer Rectifier set (TR set) can be damaged by excessive amounts of current or voltage flowing through it.

• Each TR set has voltage and current limits established by the manufacturer, which are labeled on an attached nameplate.

• These nameplate limit values (typically primary and secondary current, and voltage) are programmed into the voltage controller.

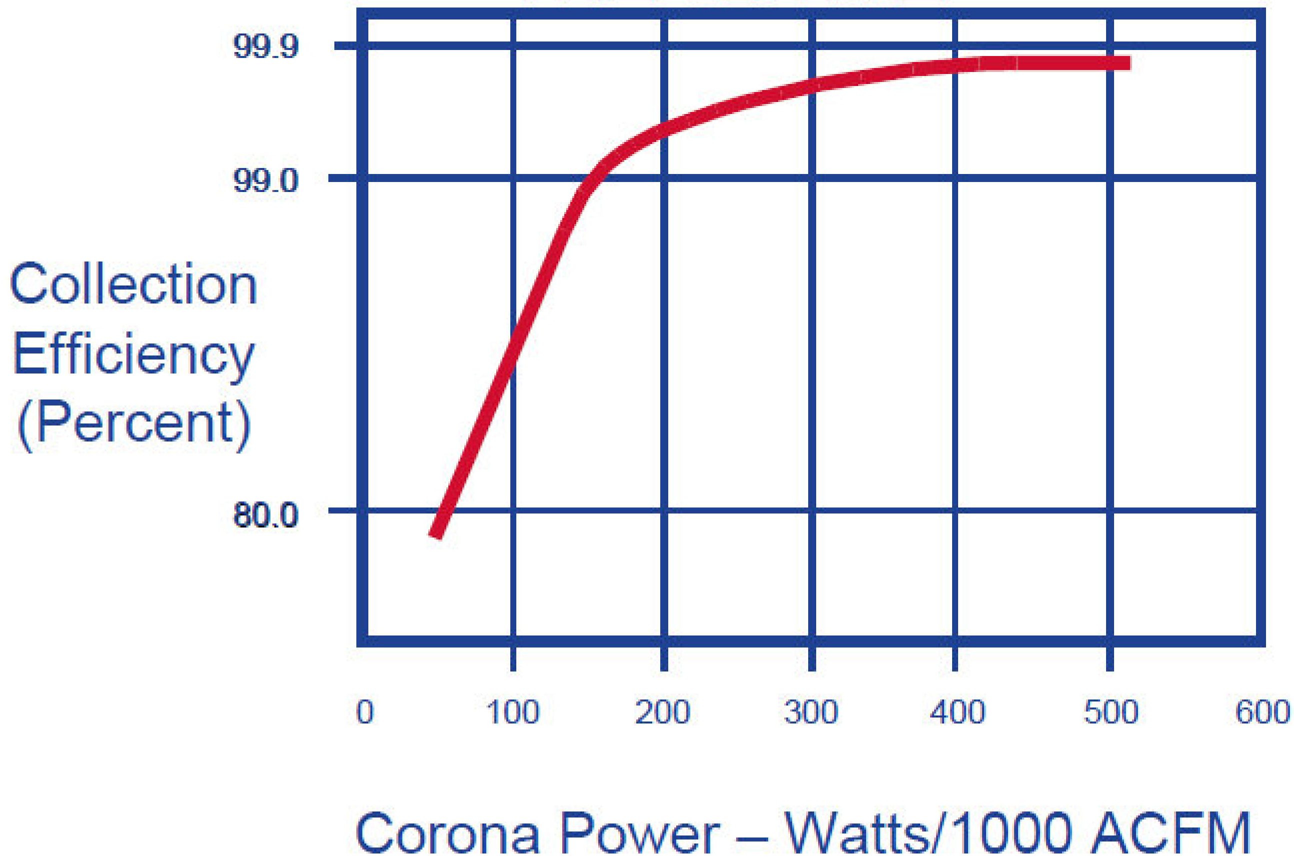
• *Tripping* – When a condition occurs that the voltage controller cannot control, often times the voltage controller will trip.

• A trip means the voltage controller (by way of the contactor) will shut off the individual precipitator power circuit.

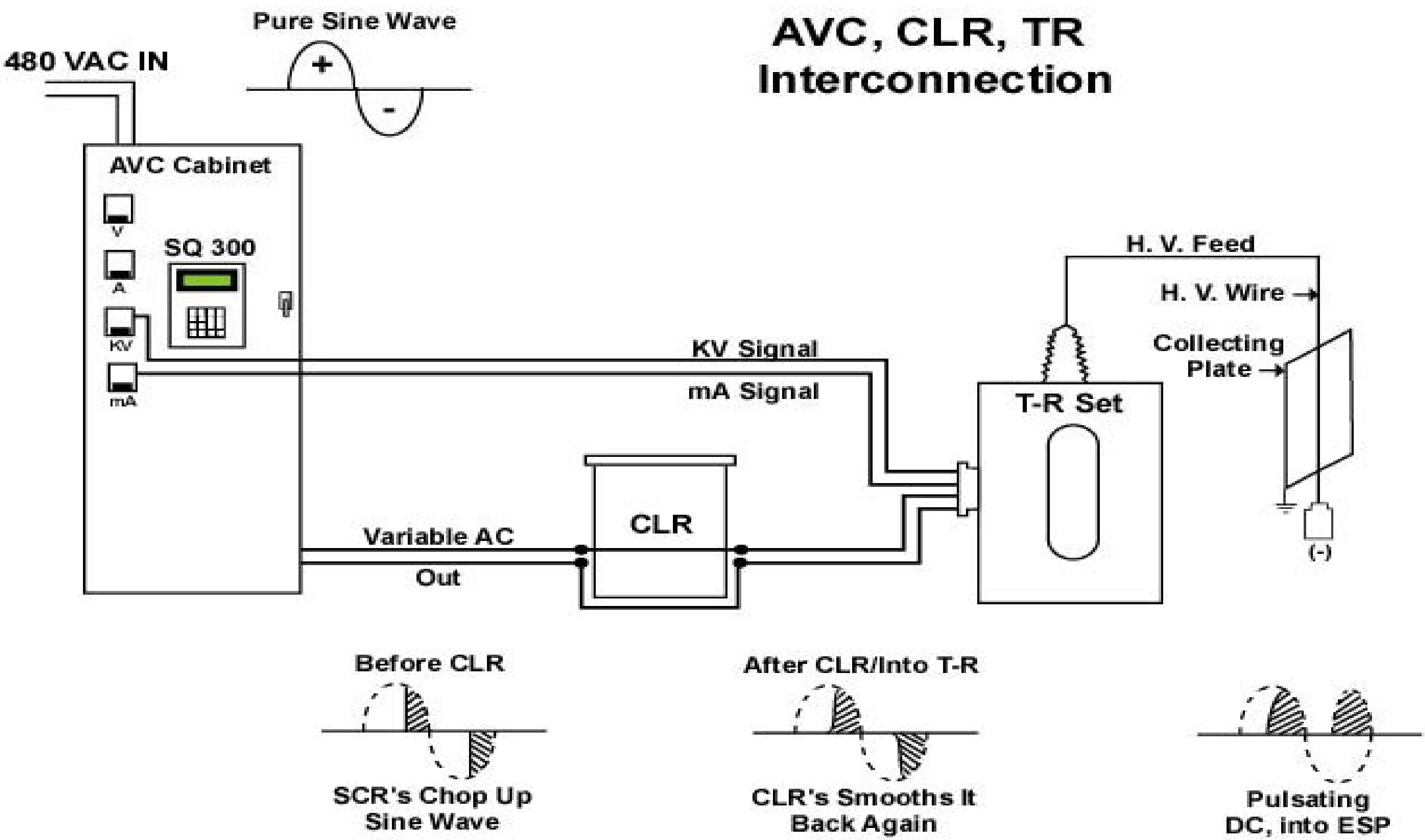
•A short inside the electrostatic precipitator field caused by a fallen discharge electrode (wire), or a shorted out Silicone Controlled Rectifier are examples of conditions that a voltage controller cannot control.

Efficiency vs. Specific Corona Power

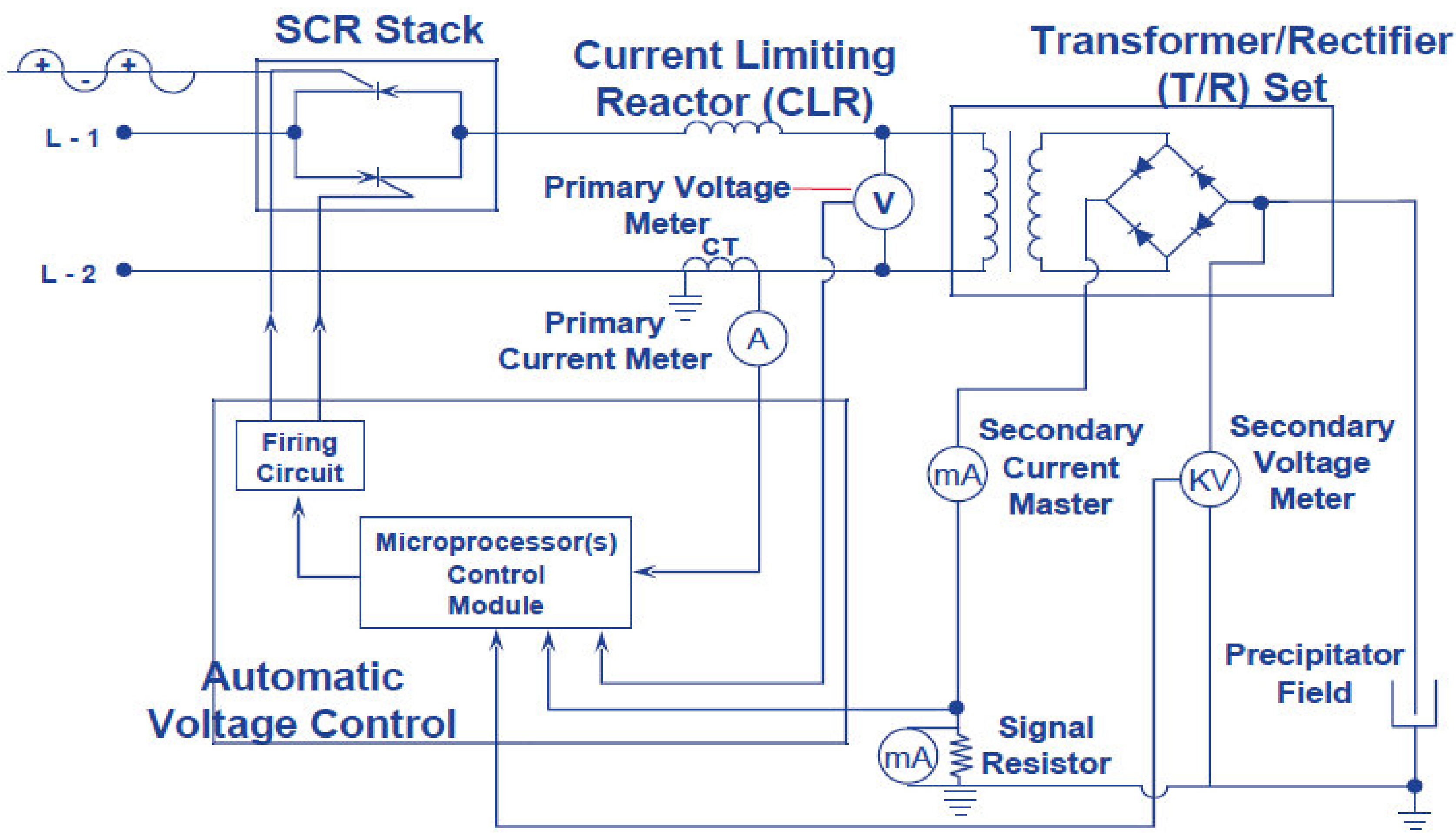
KNOW WHERE YOUR ESP RUNS ON THE CURVE



AVC Cabinet, CLR & T/R Set



Typical SCR-CLR Electrical System



Typical SCR-CLR Electrical System

steag

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

How to Tell The Difference?

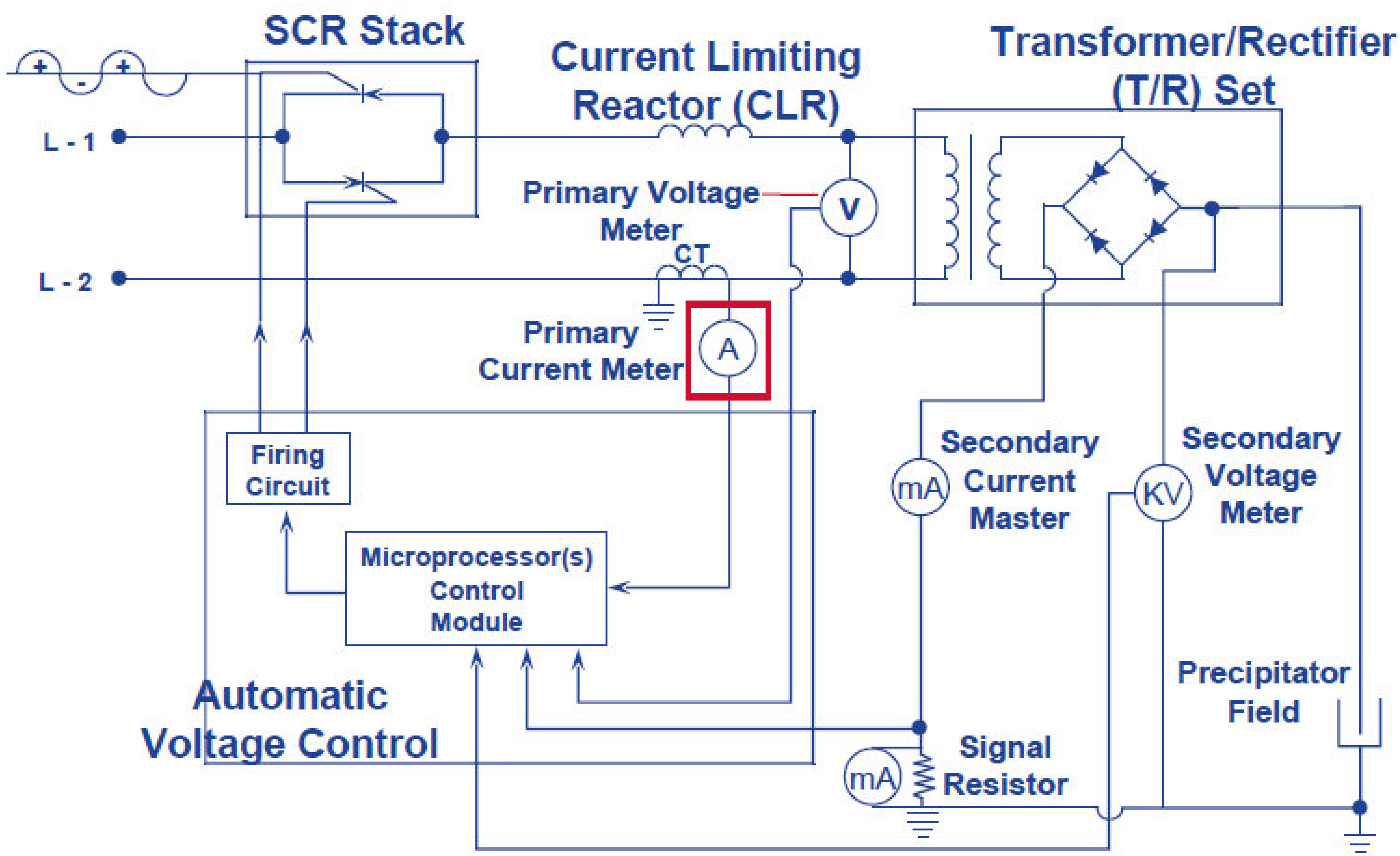
Iron Vane
Movement

D'Arsonval
Average

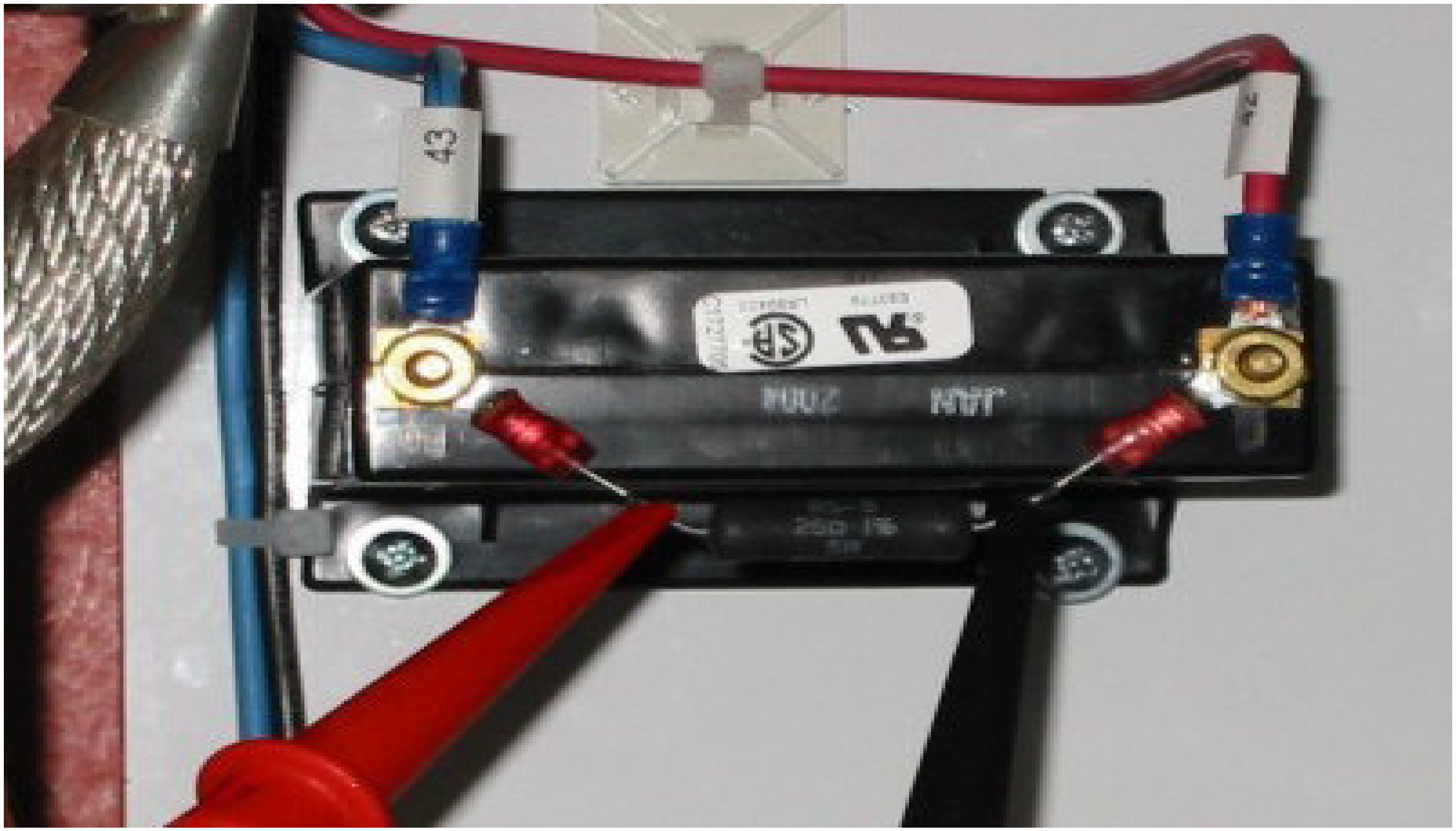
RMS

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

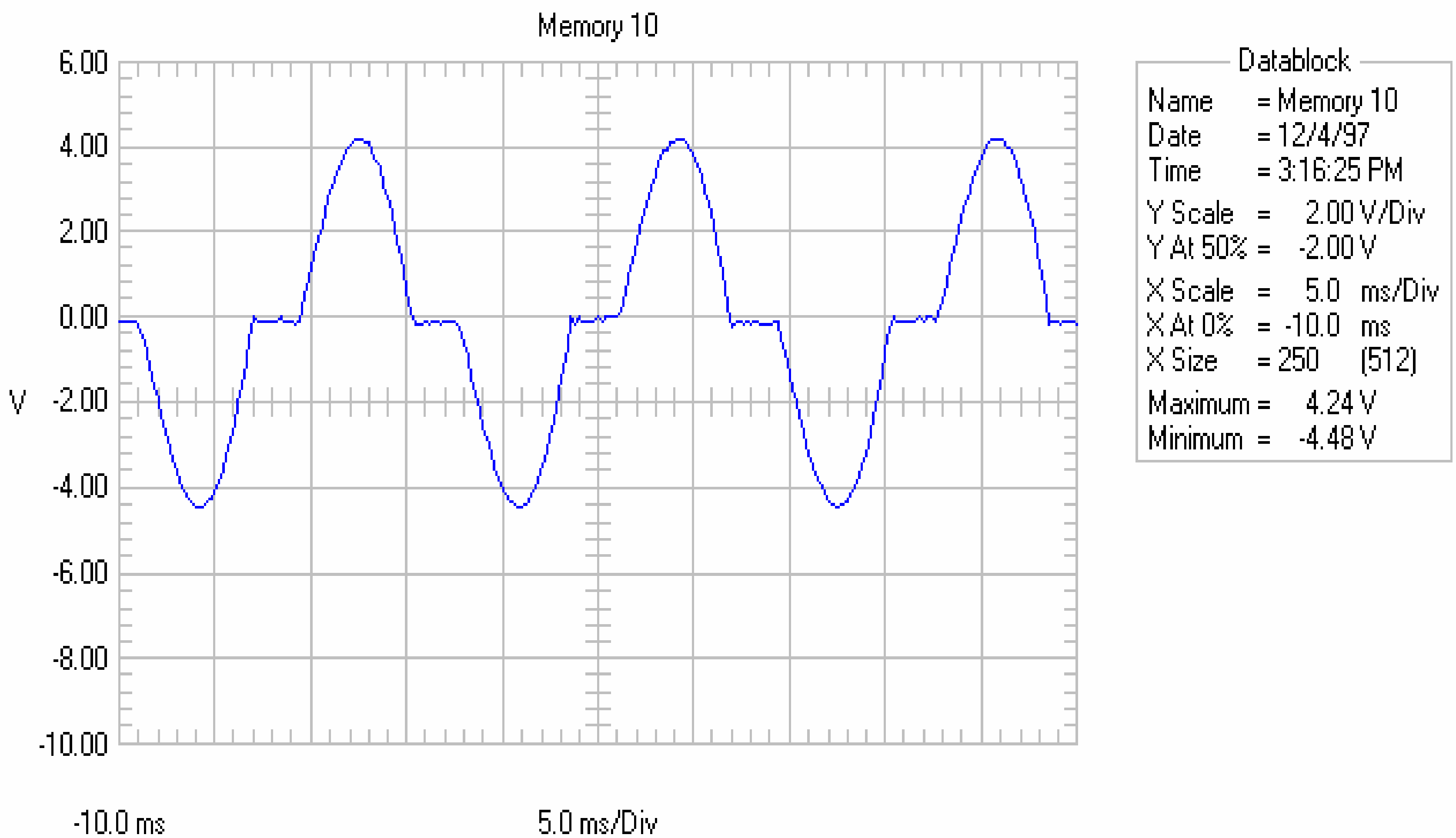
Primary Current Meter



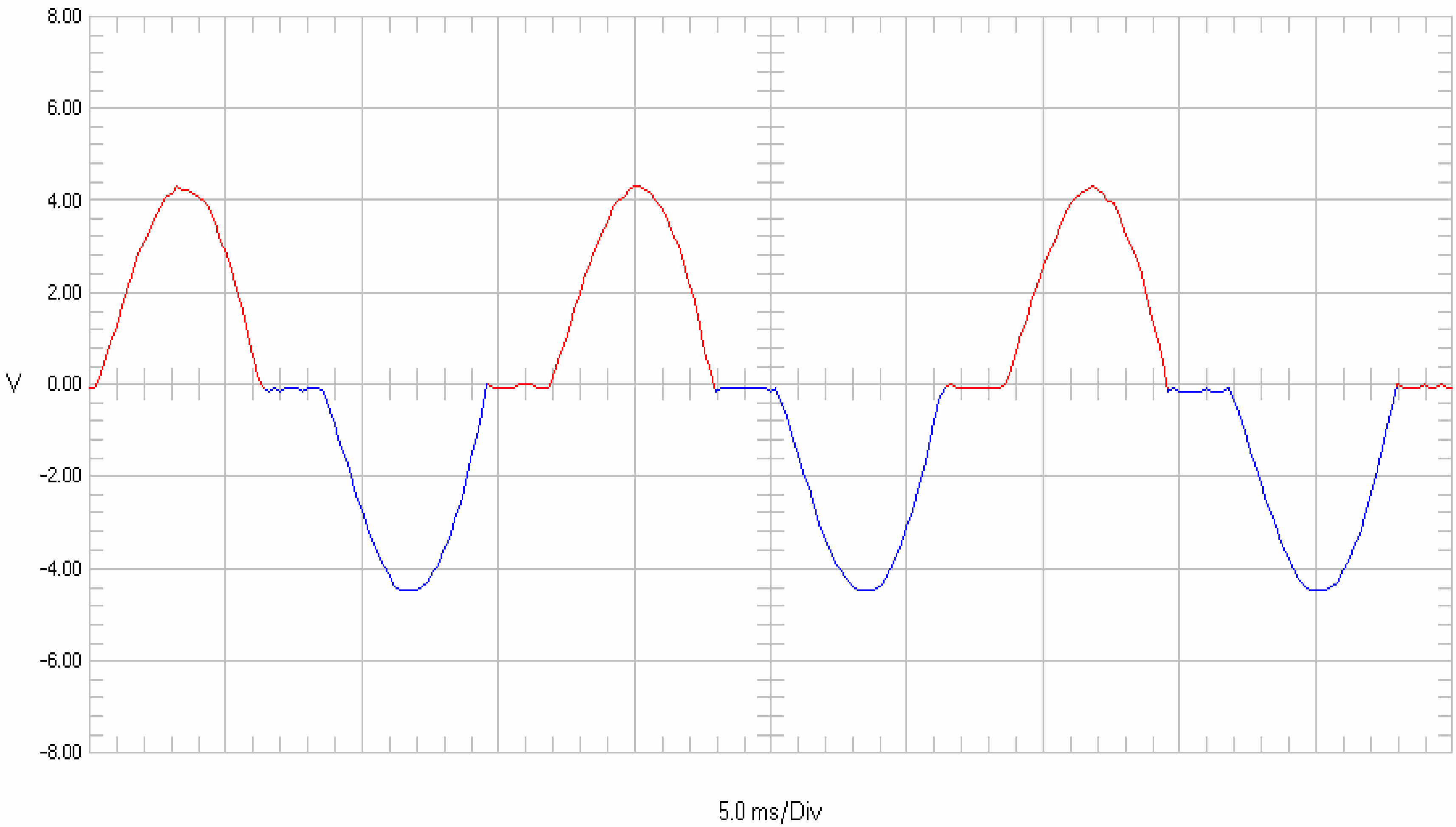
Finding the Primary Current Waveform



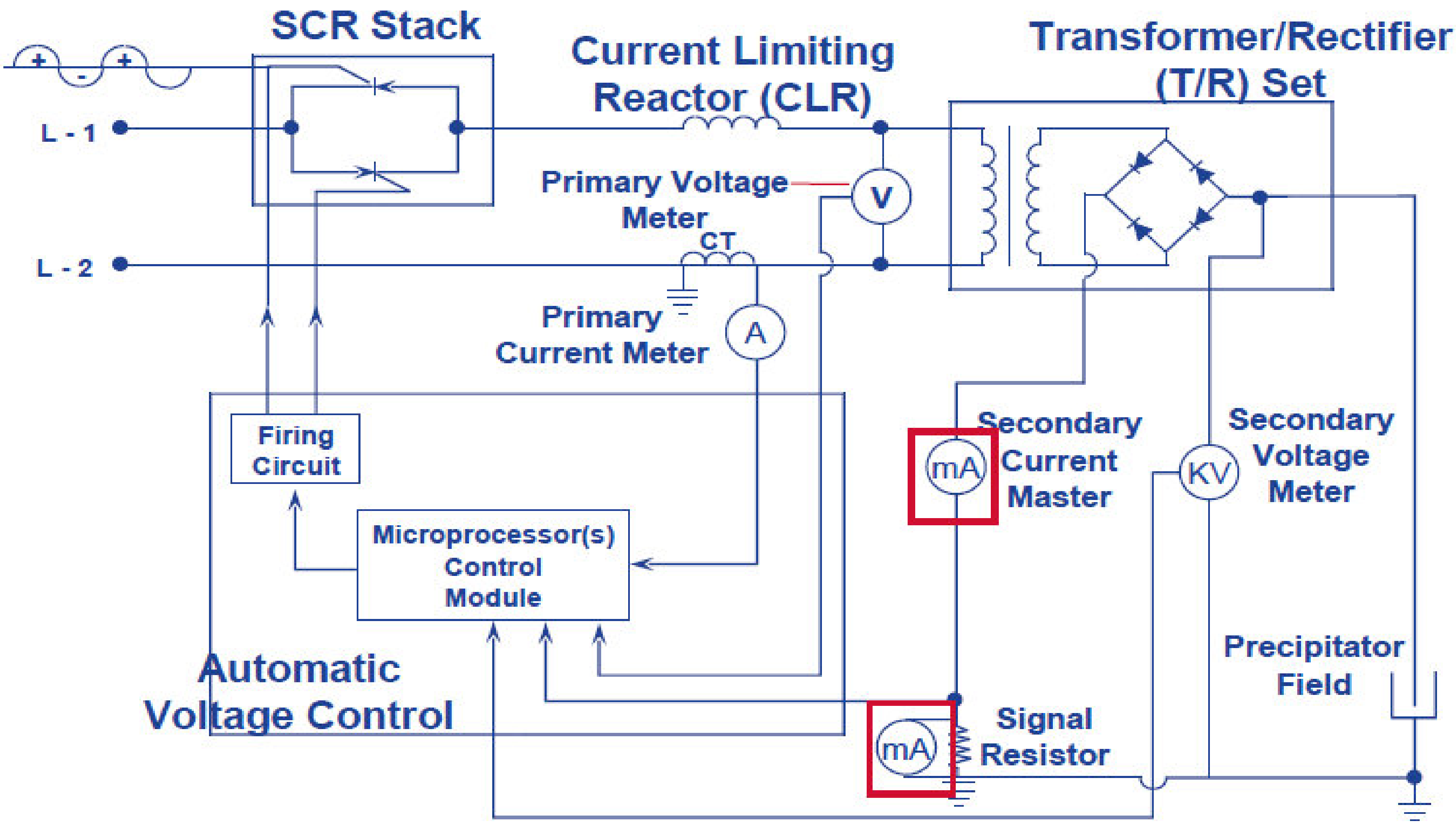
Primary Current – A Chopped Sine Wave



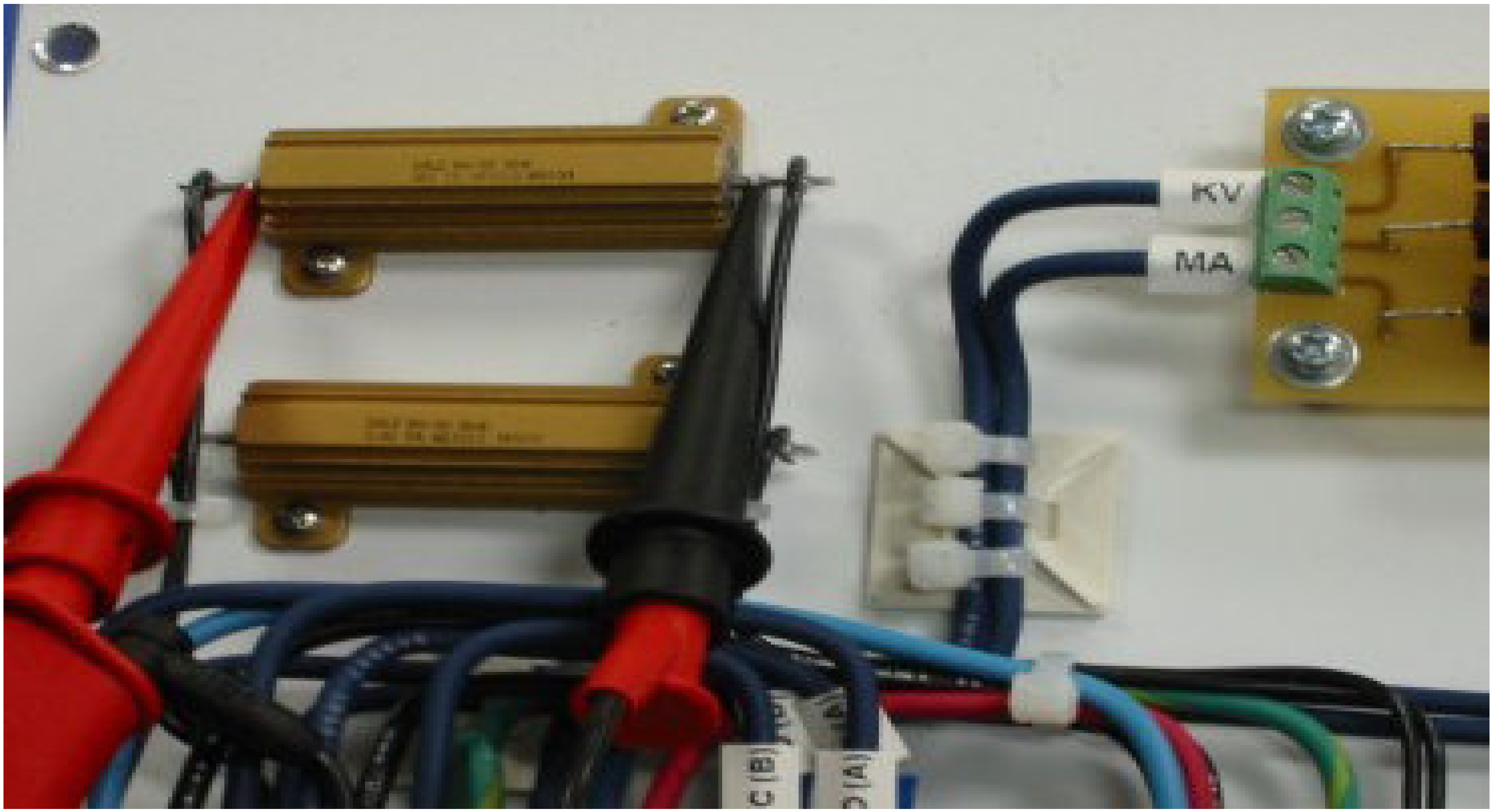
Primary Current Waveform - Positive and Negative Half-Cycles = SCR 1 and SCR 2



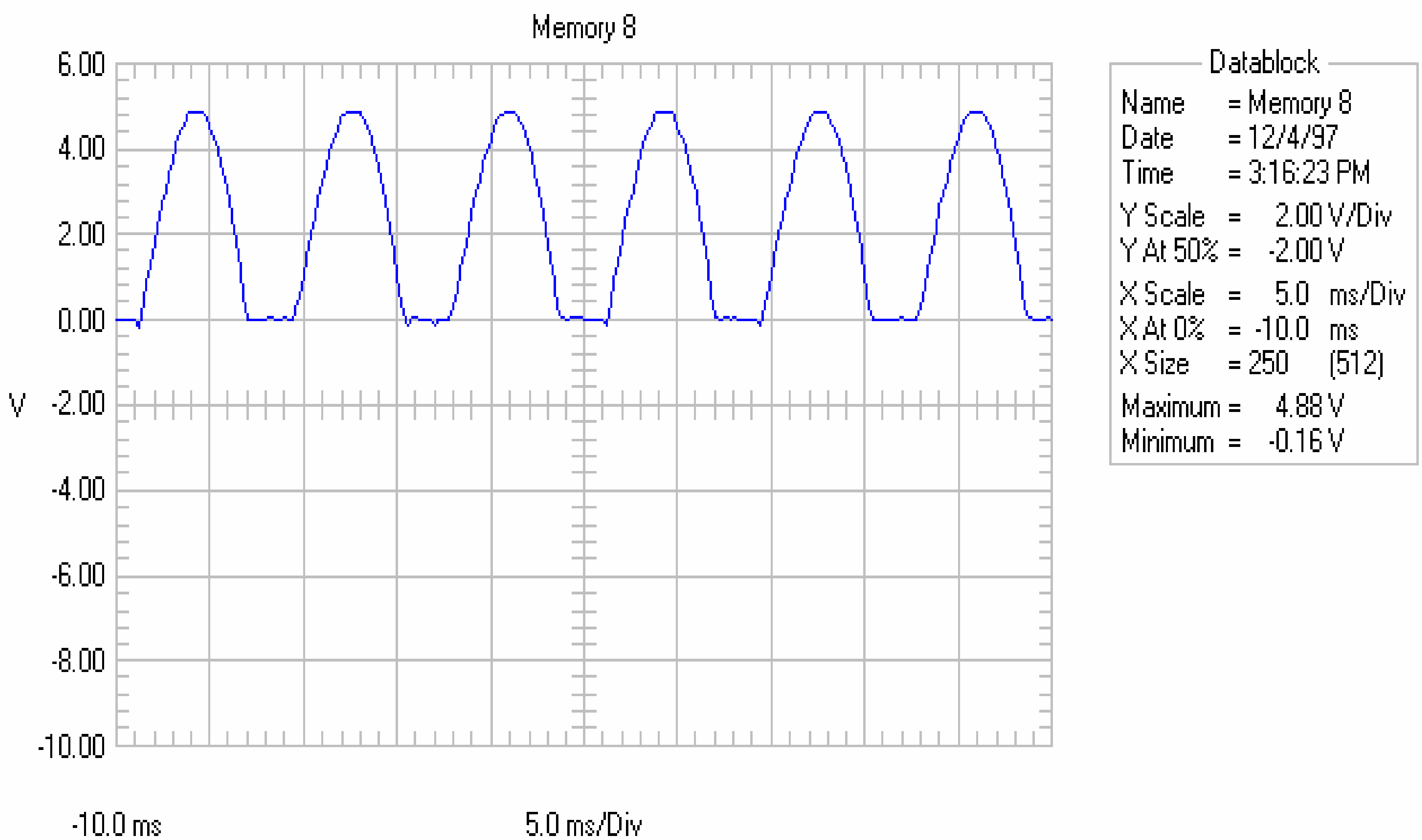
Secondary Current Meter



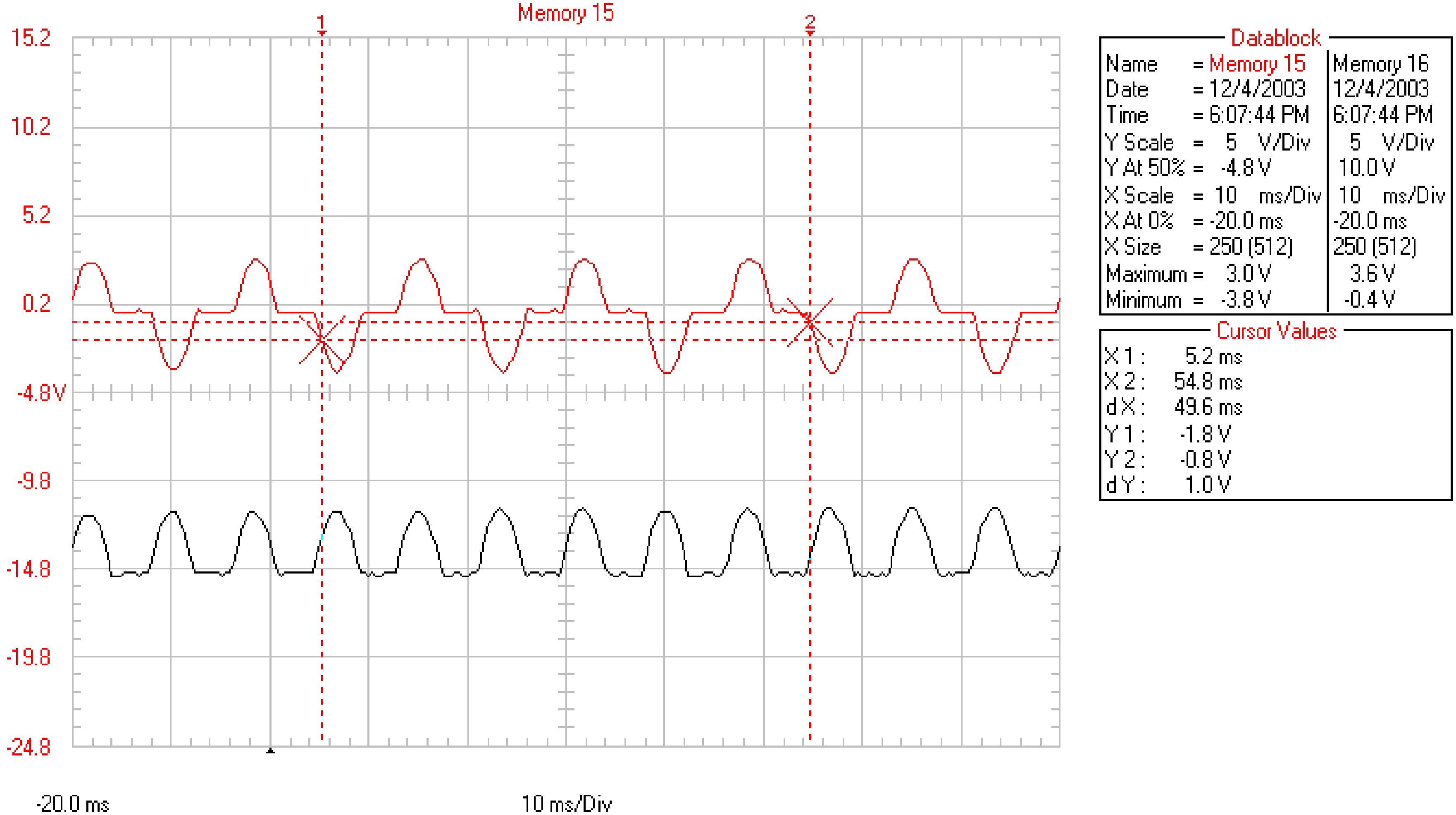
Finding the mA Signal



Secondary Current – Pulsating DC

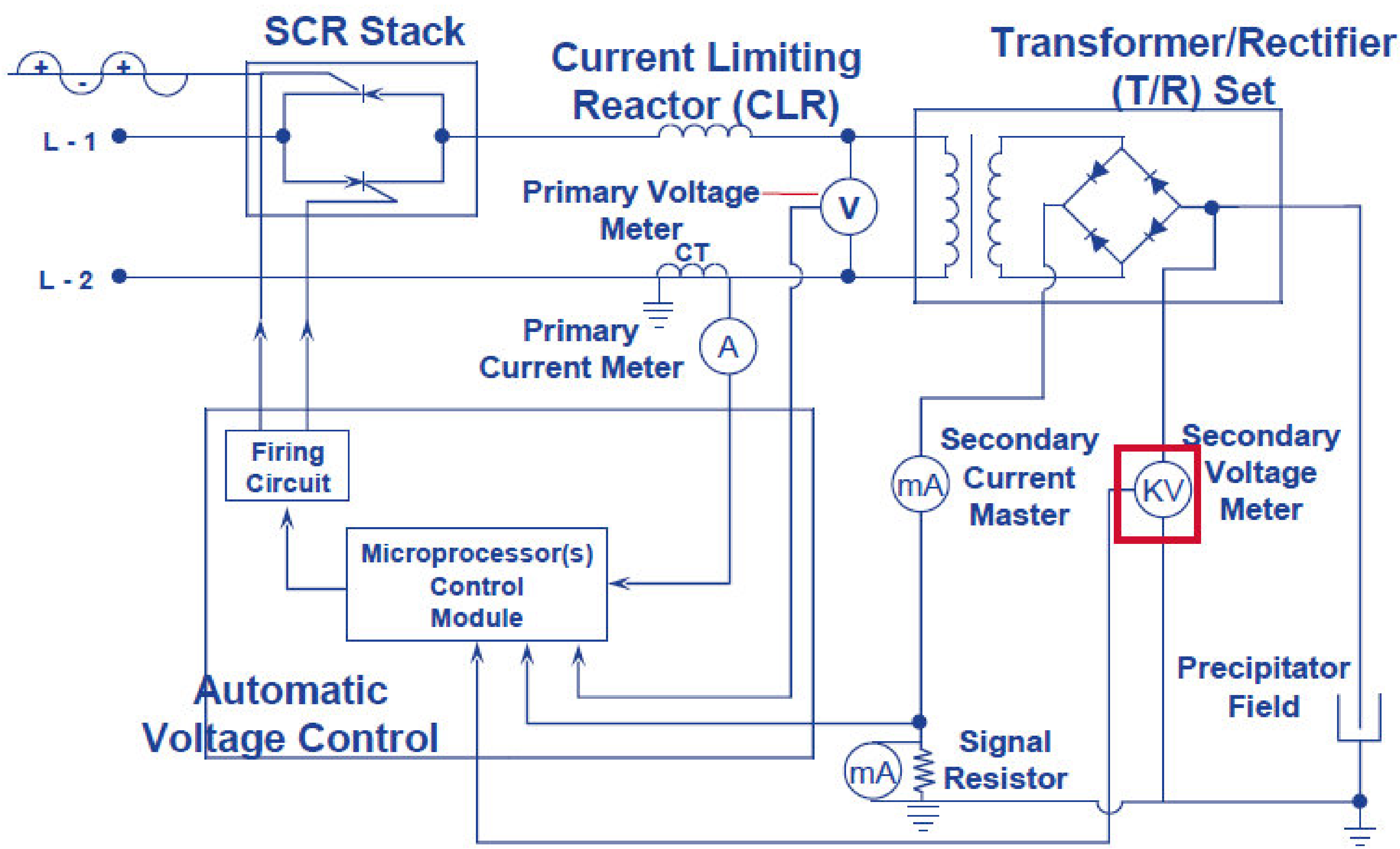


Typical Primary and Secondary current

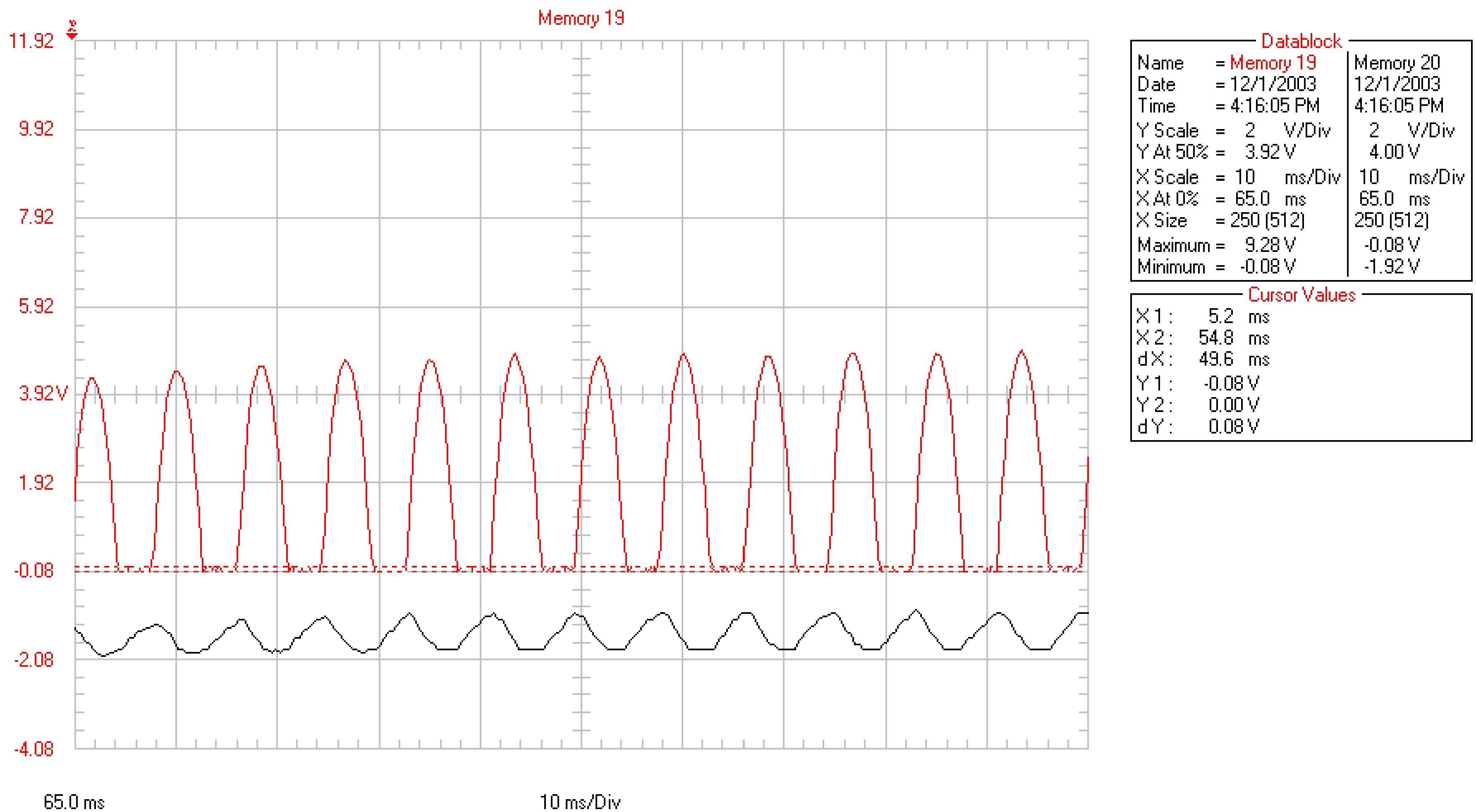


11&12C Pri/Sec

Secondary Voltage Meter

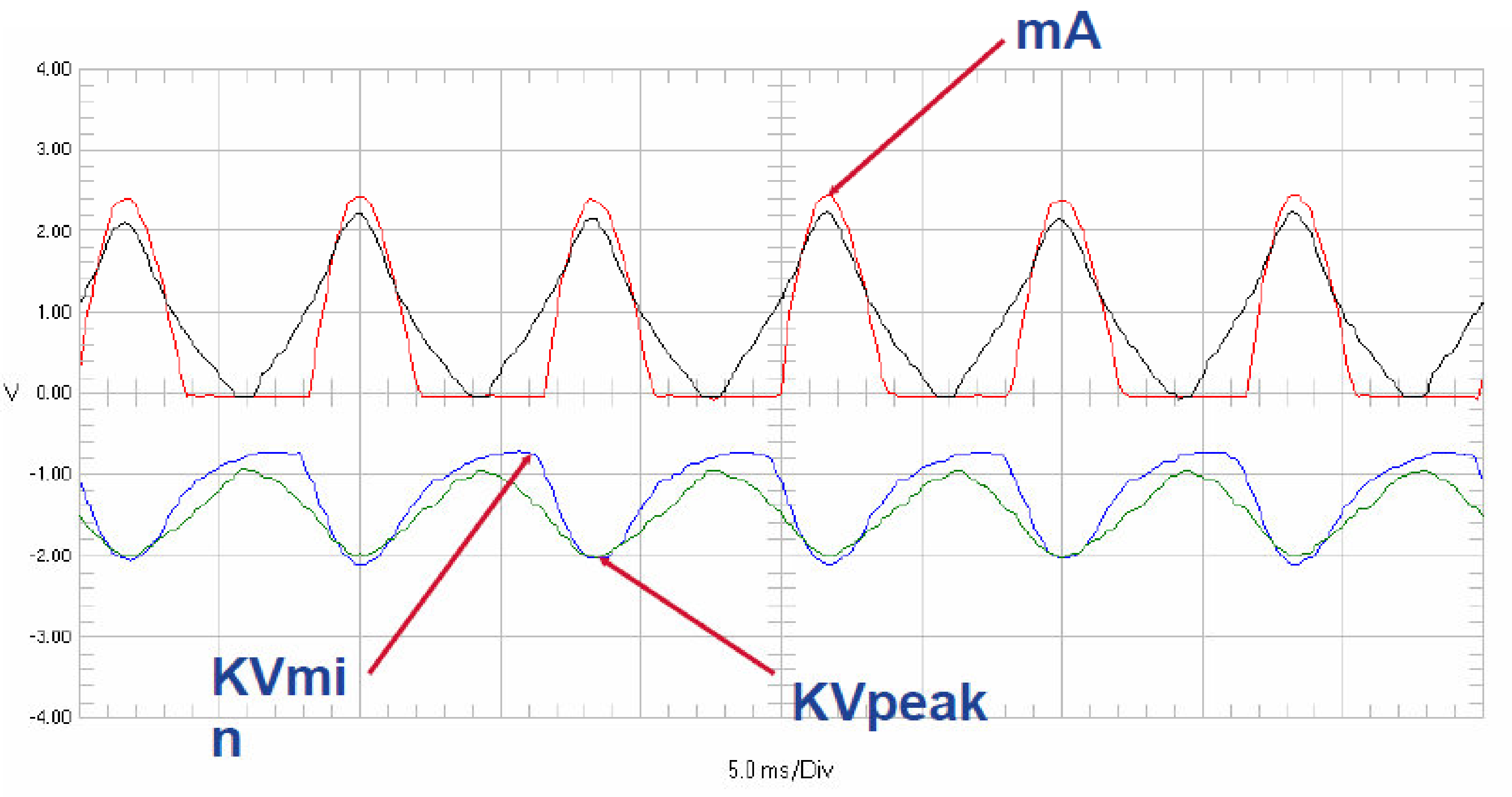


Current Limit - mA & KV

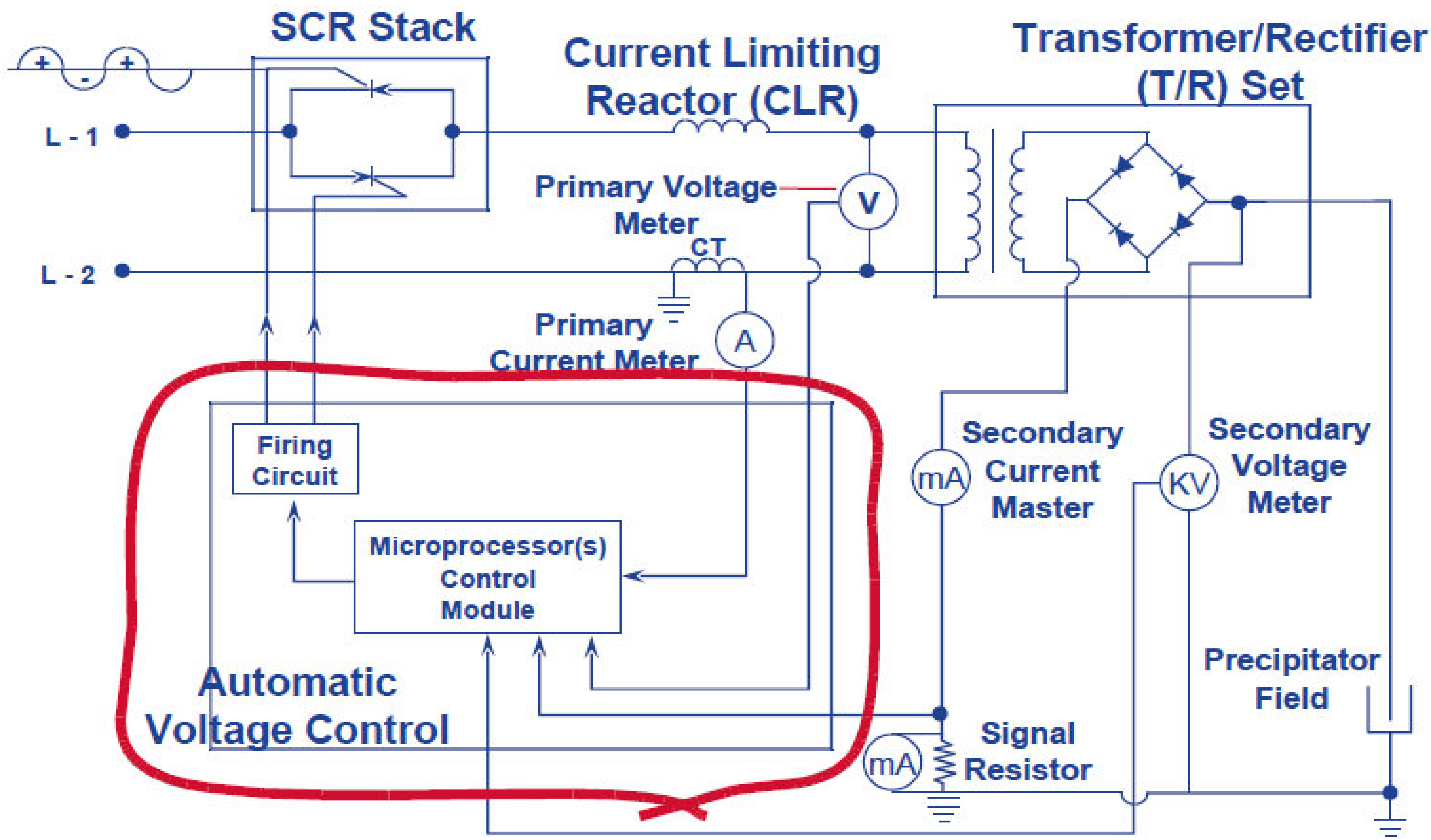


9&10F mA/KV

Secondary Voltage Waveforms – True Negative

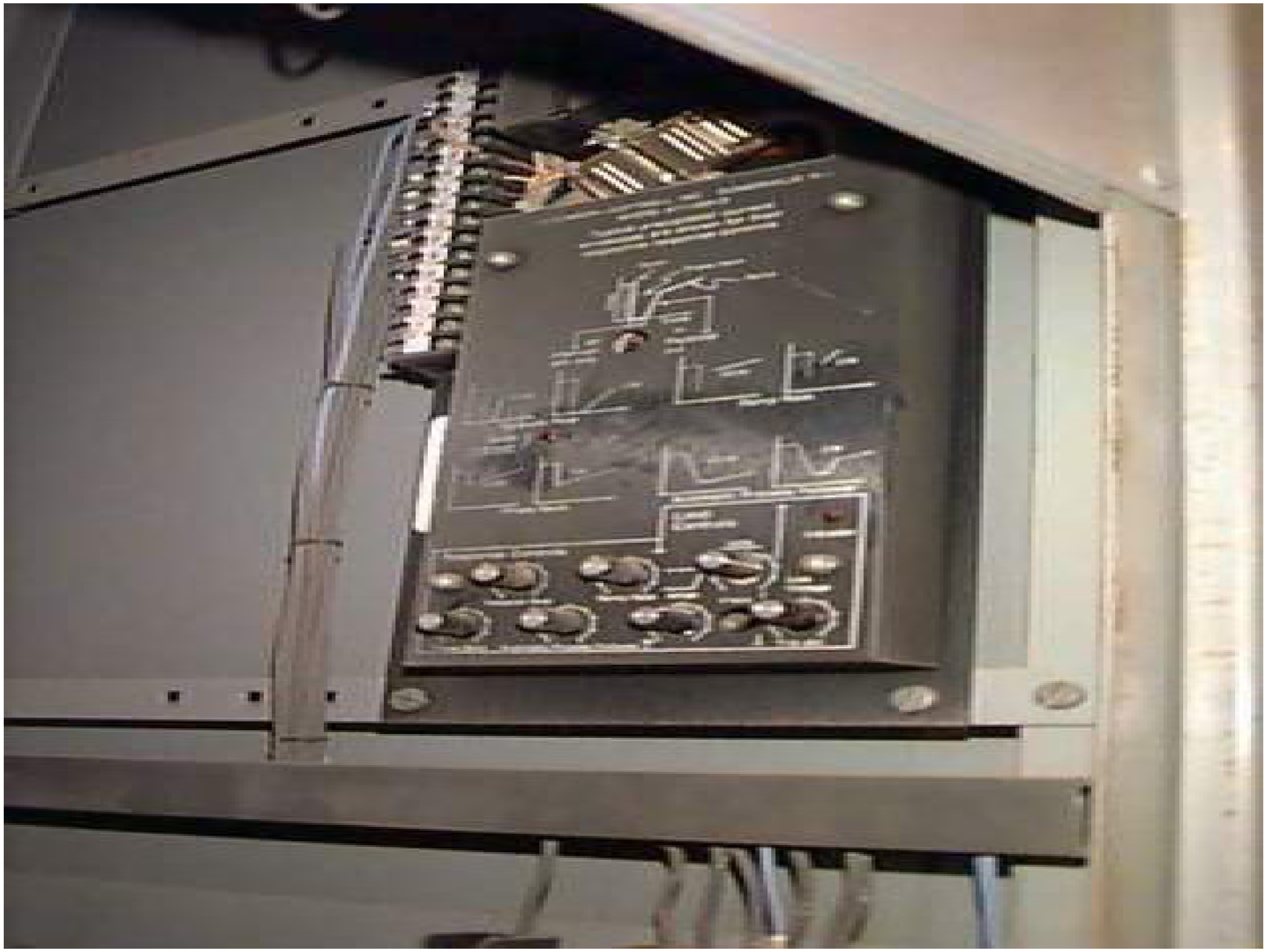


Next – The Automatic Voltage Control



The AVC
is the BRAIN
of the ESP

Older Analog AVC



Microprocessor Based AVC

The AVC has 2 Jobs to Execute

- Control the amount of sparking in the ESP.

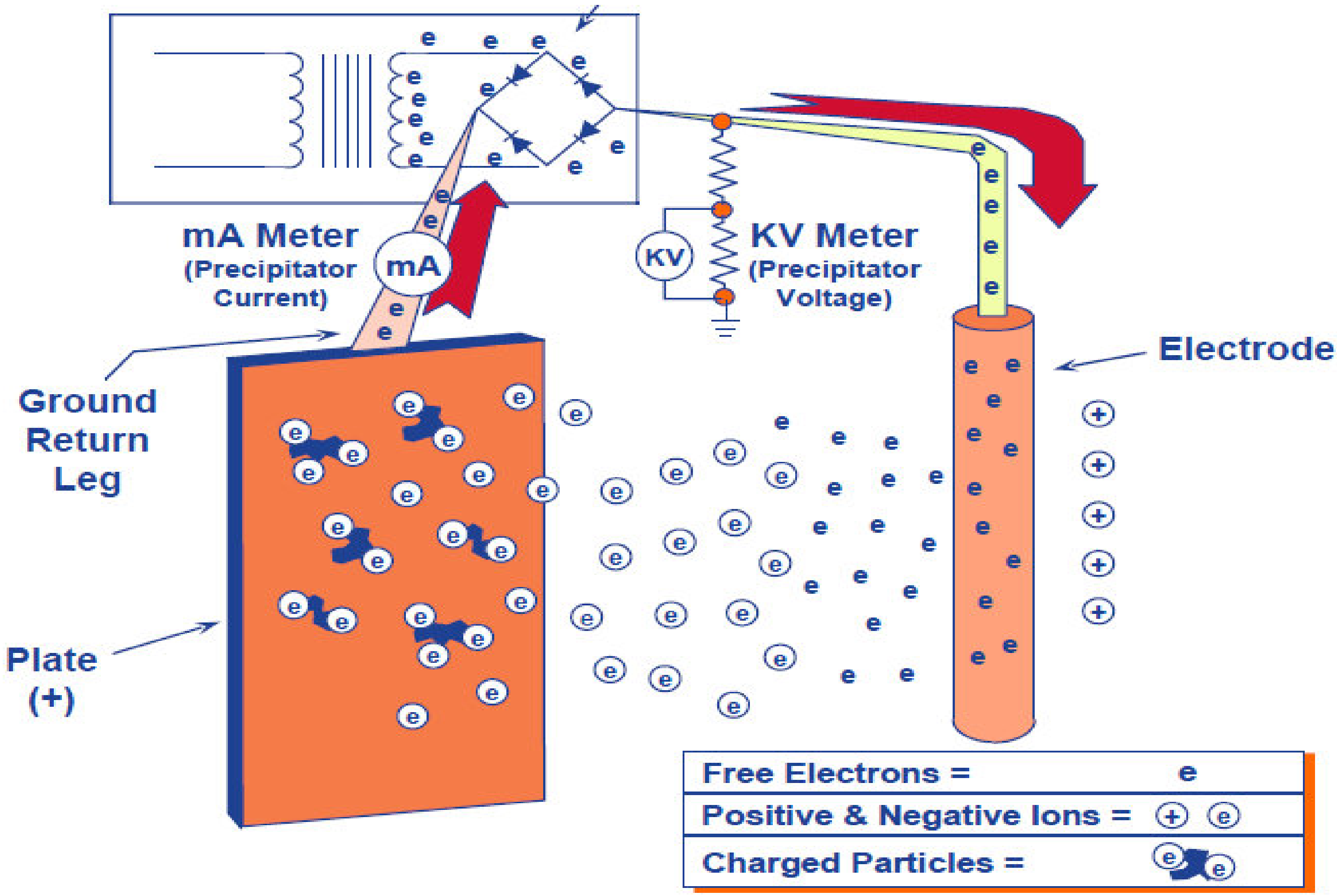
- If a T/R set is not sparking, then its AVC should be pushing that T/R set to one of its pre-set, healthy limits (volts, amps, KV, mA, or firing angle).

The AVC feedback?

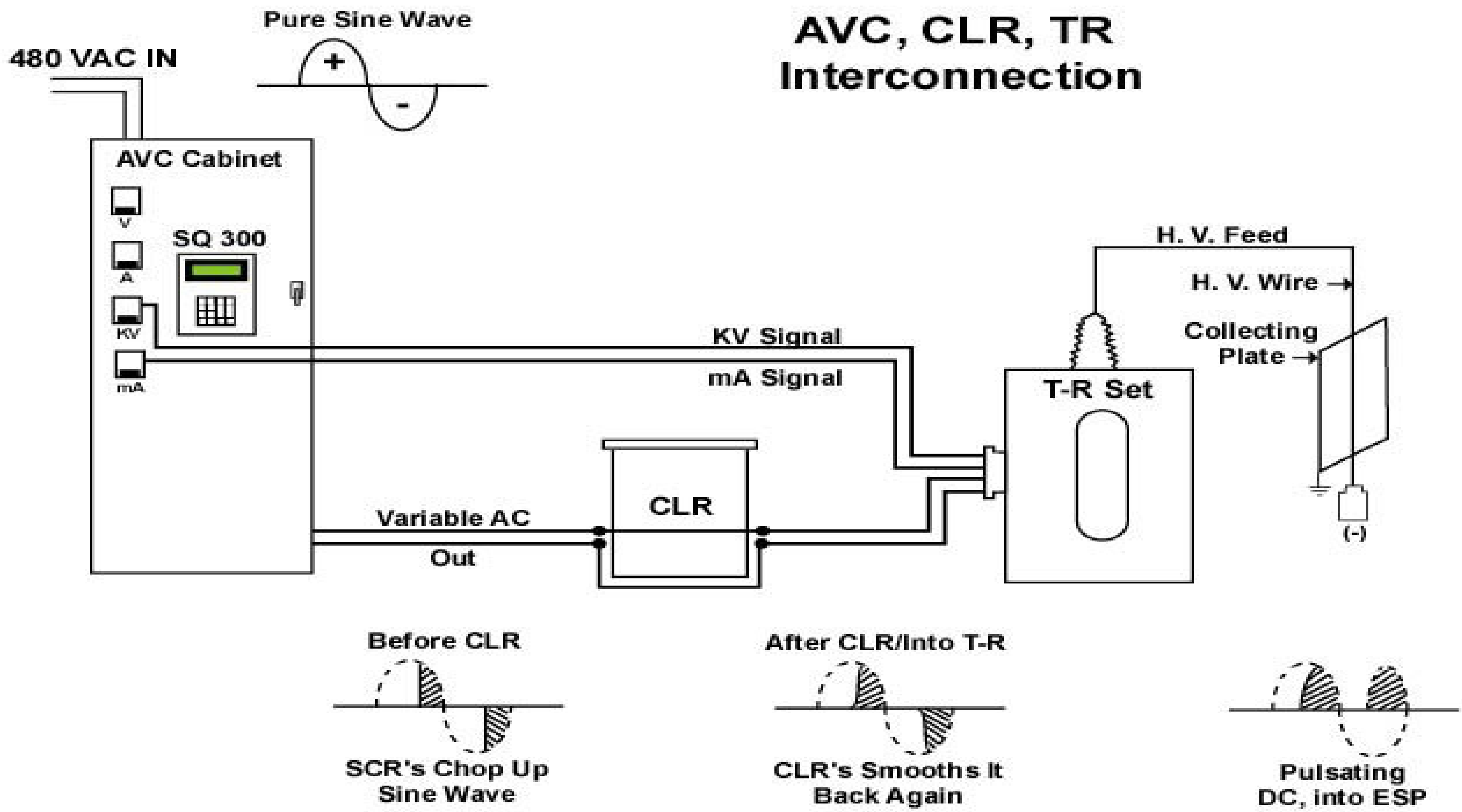
But how does the AVC know what's happening in the ESP?

The mA signal is its eyes!

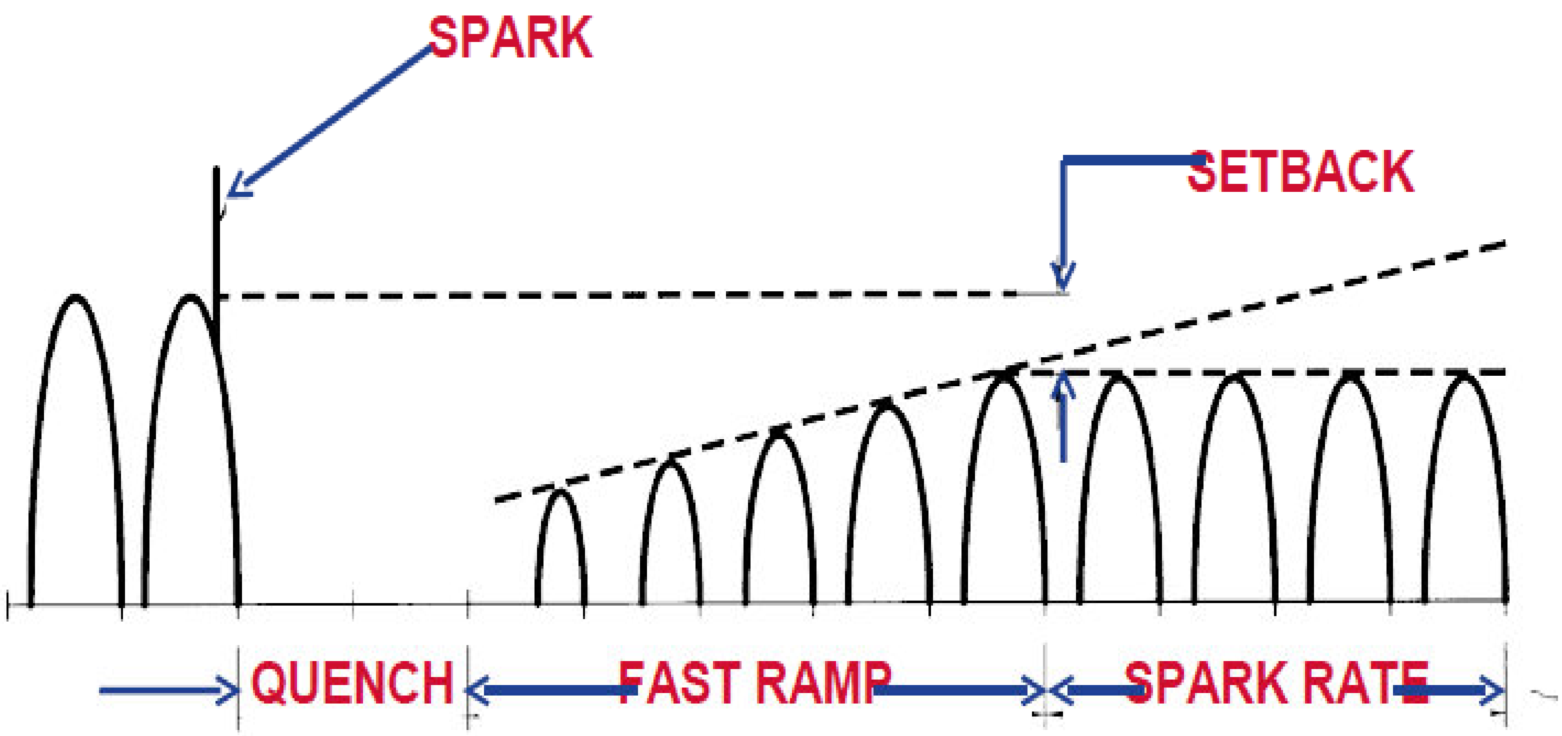
Transformer Rectifier Set



AVC Cabinet, CLR & T/R Set



AVC Spark Response



Good Initial Settings for an AVC

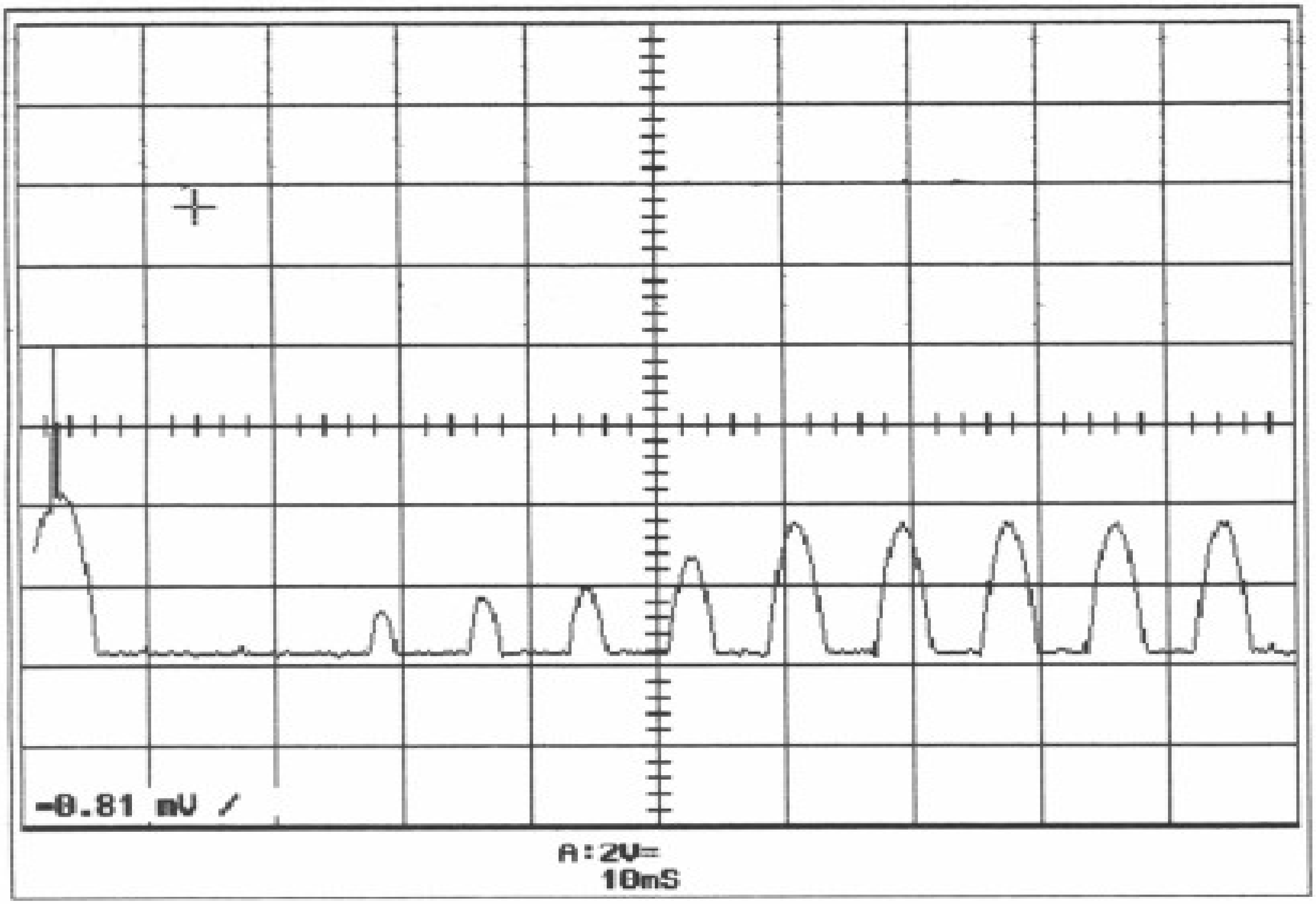
1. Quench = 1 Full Cycle

2. Fast Ramp = 5 or 6 Half Cycles

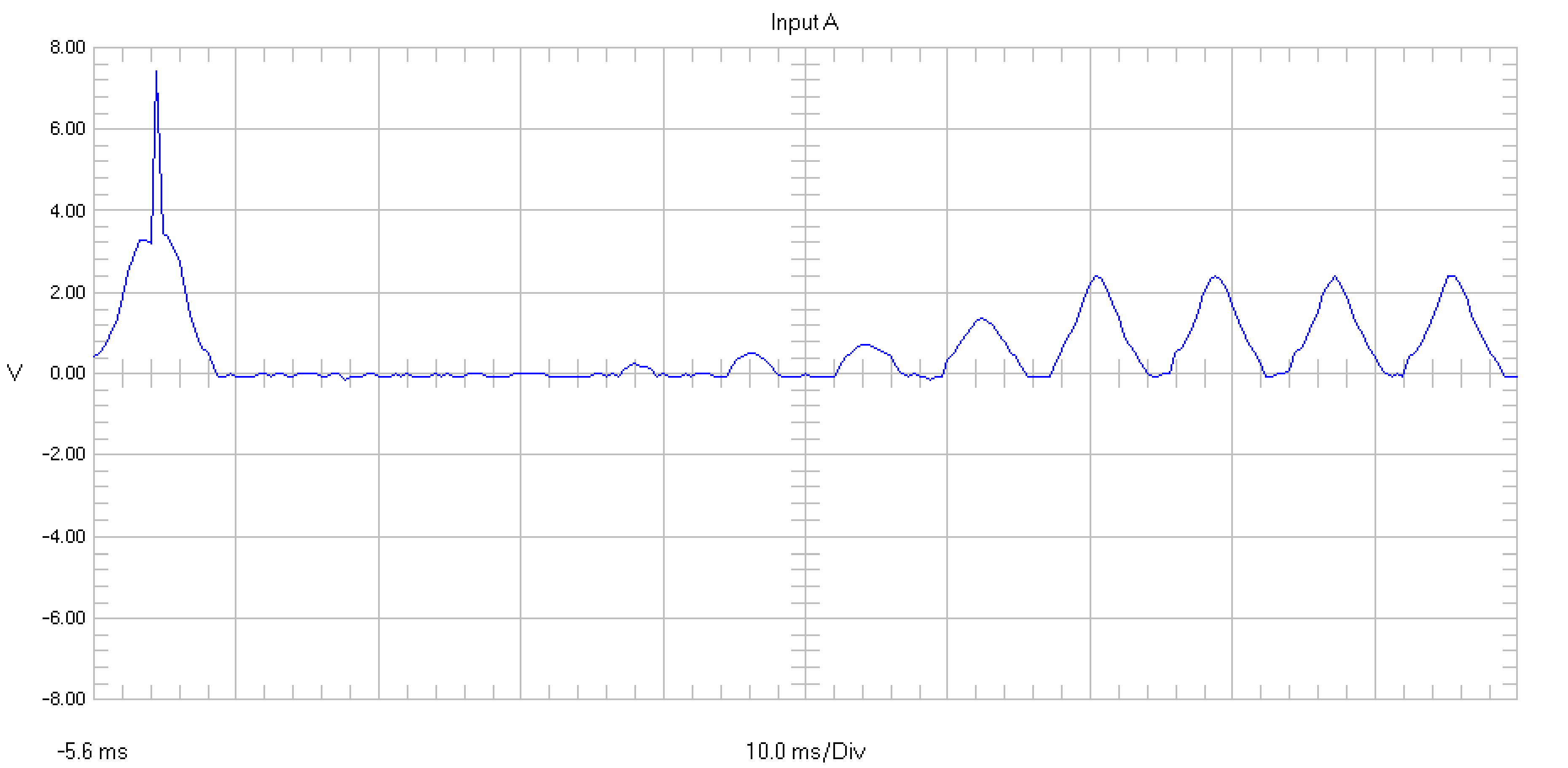
3. Setback = 15 to 20%

4. Spark Rate = 30SPM

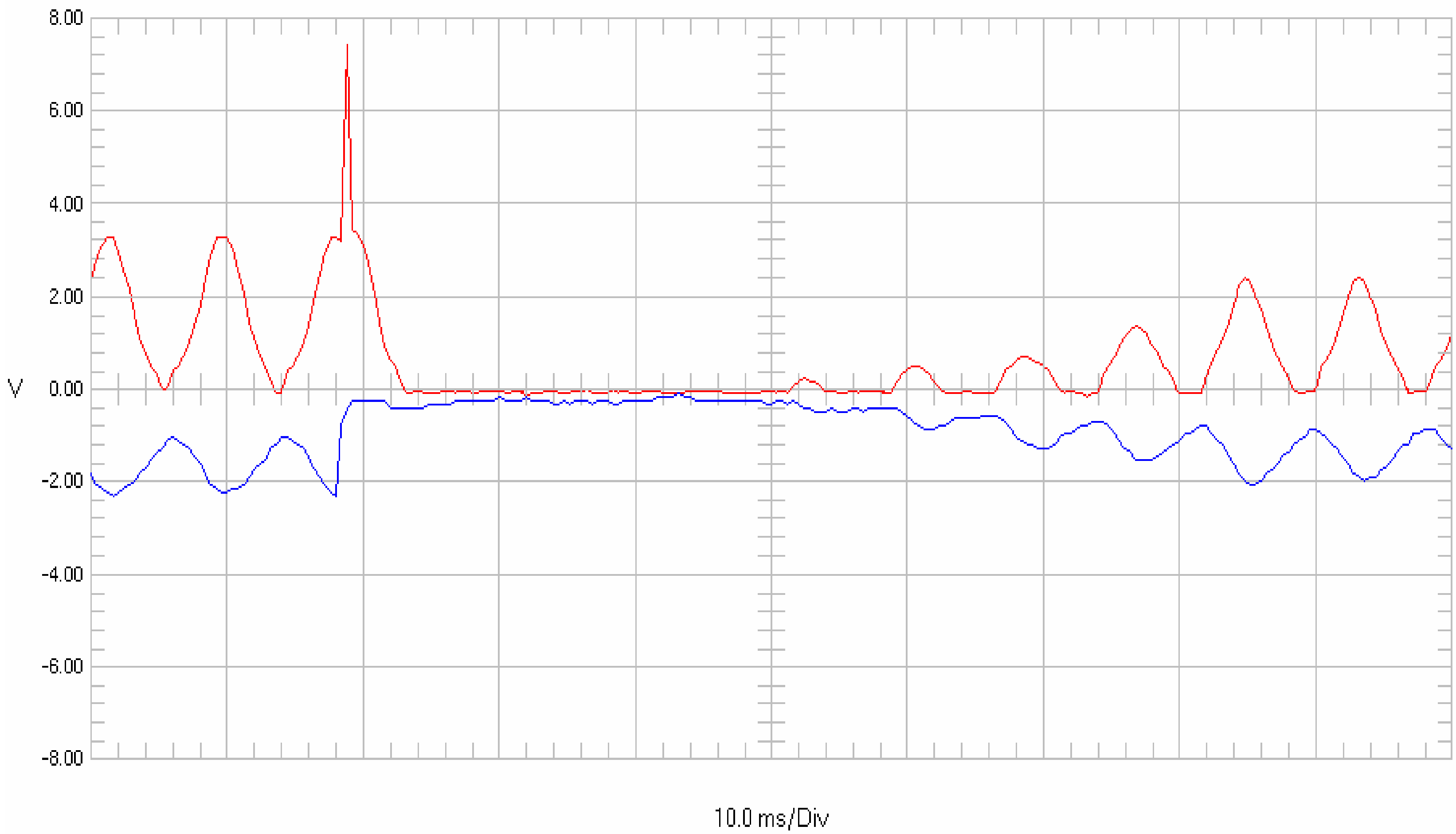
Proper AVC Response to Sparking



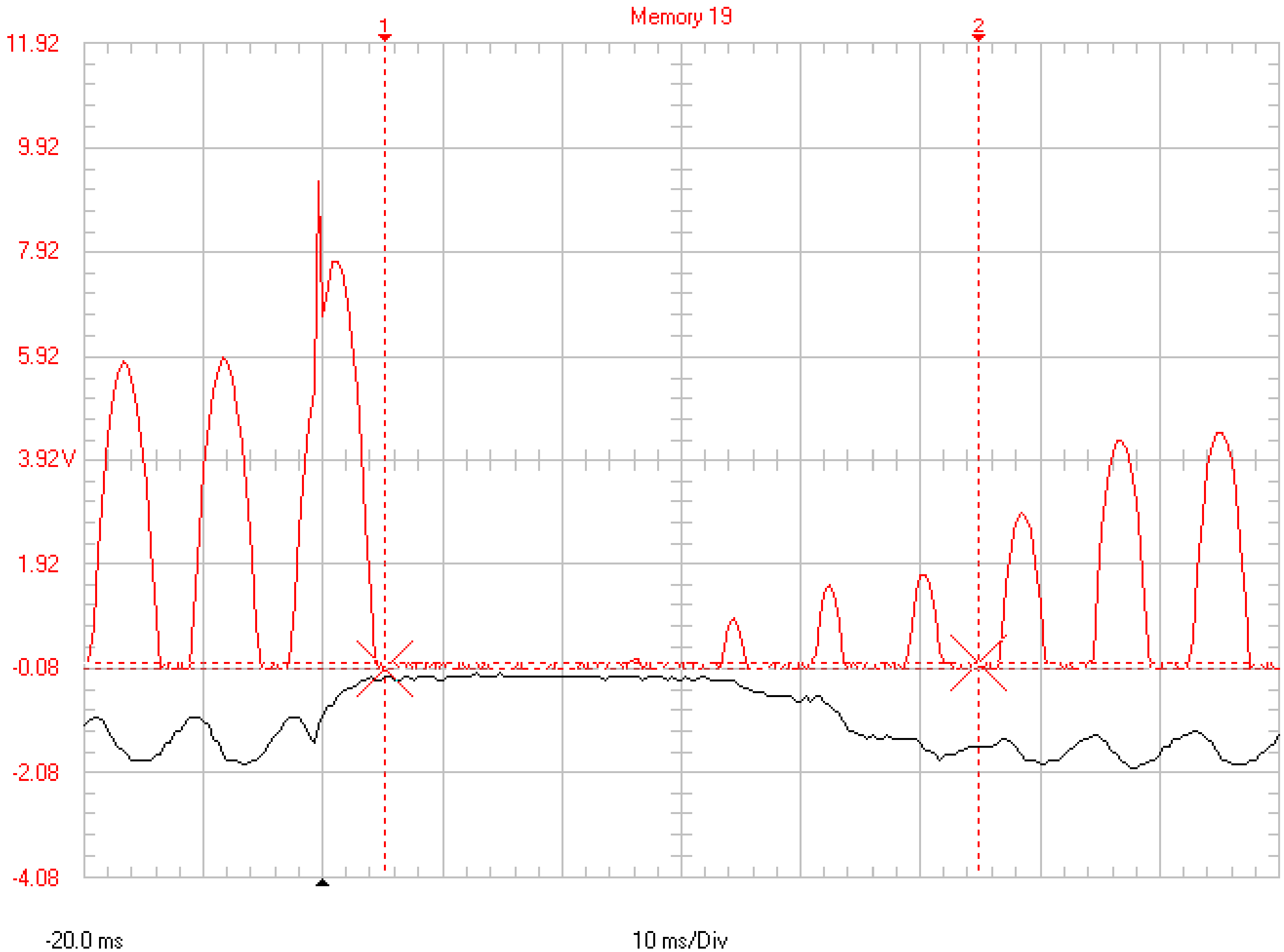
Spark Response - Secondary Current Waveform



Spark Response - Secondary Current and Voltage Waveforms



Typical Spark Response - mA & KV

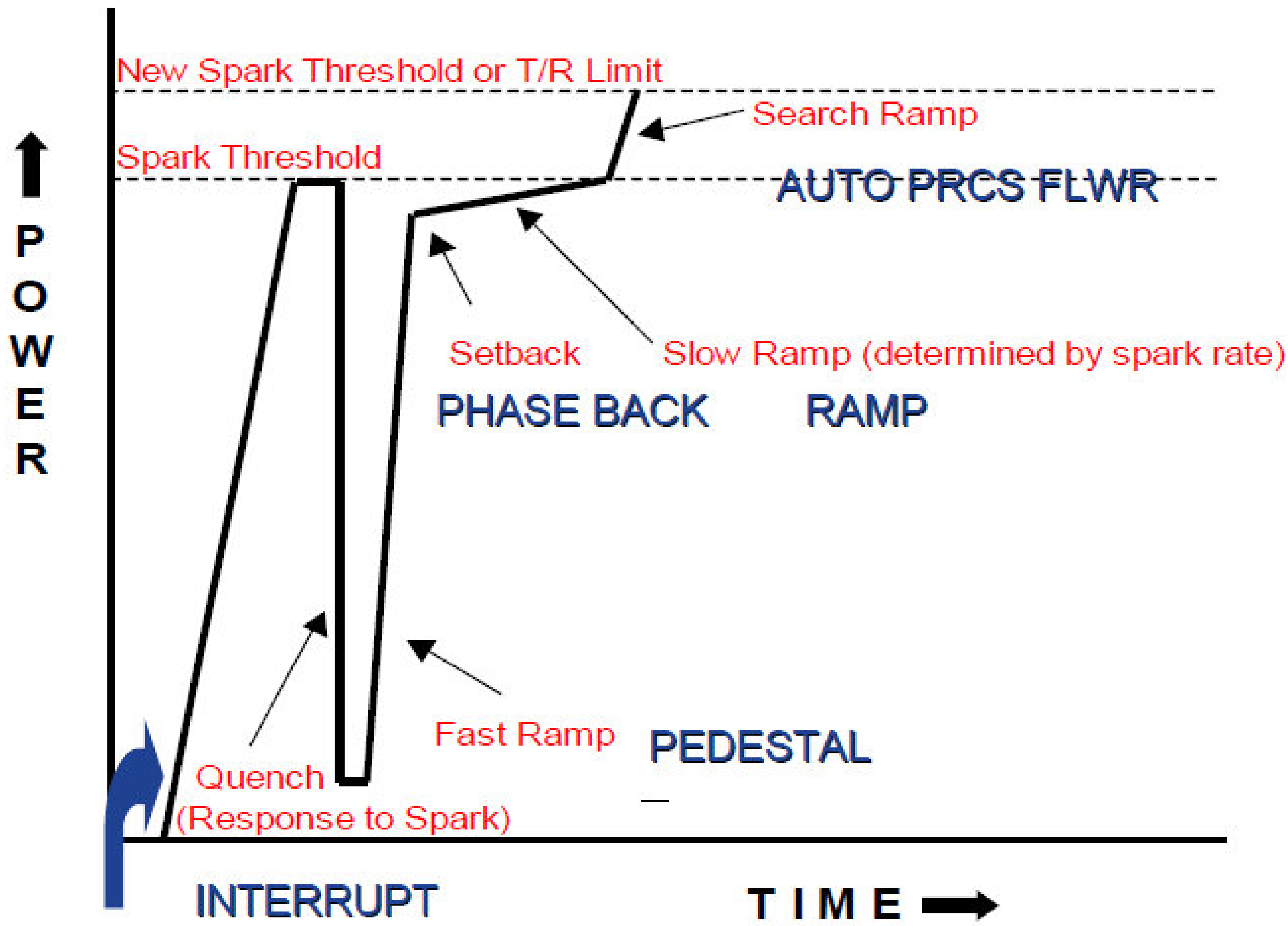


Datablock		
Name	= Memory 19	Memory 20
Date	= 12/1/2003	12/1/2003
Time	= 4:16:05 PM	4:16:05 PM
Y Scale	= 2 V/Div	2 V/Div
Y At 50%	= 3.92 V	4.00 V
X Scale	= 10 ms/Div	10 ms/Div
X At 0%	= -20.0 ms	-20.0 ms
X Size	= 250 (512)	250 (512)
Maximum	= 9.28 V	-0.08 V
Minimum	= -0.08 V	-1.92 V

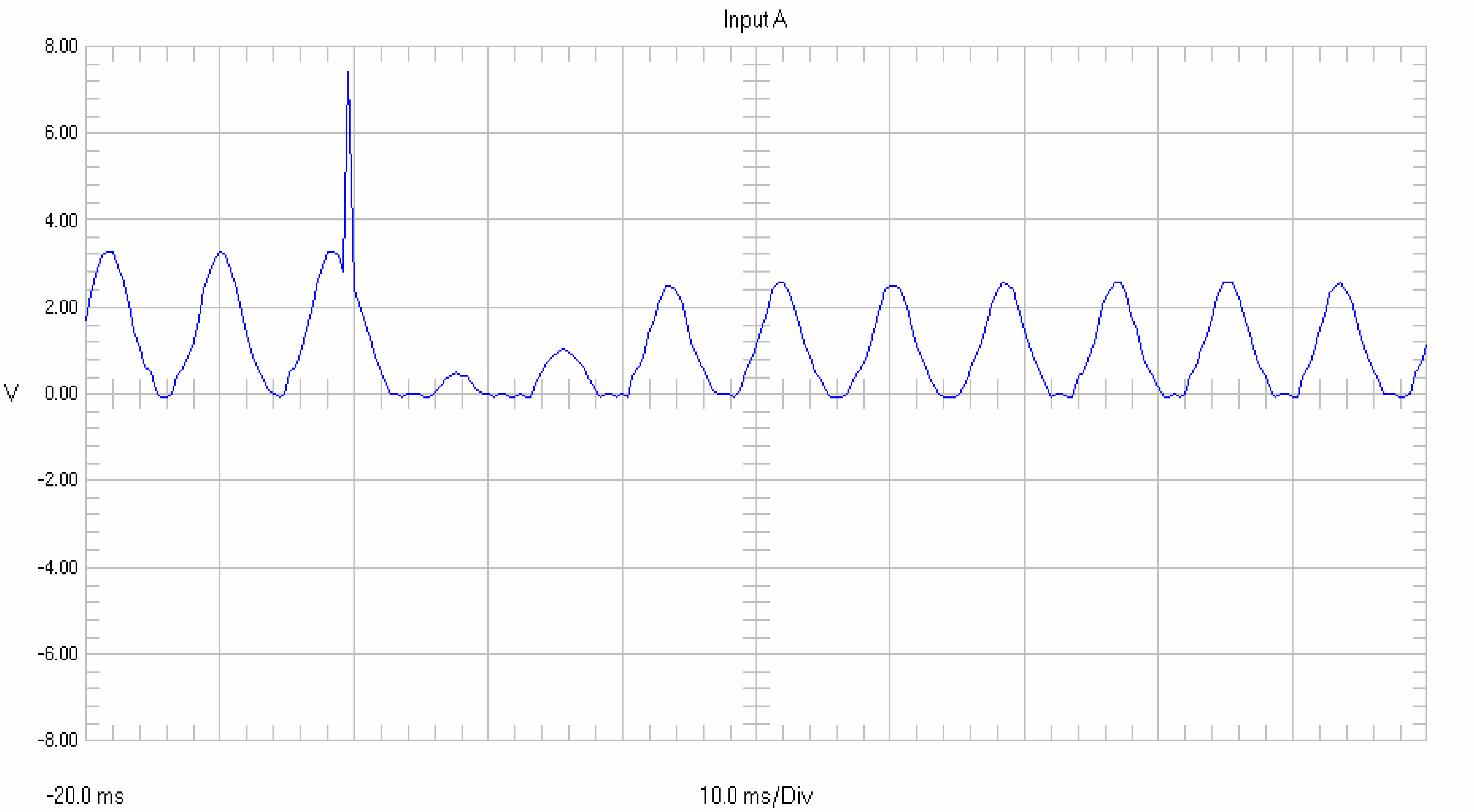
Cursor Values		
X 1 :	5.2	ms
X 2 :	54.8	ms
d X :	49.6	ms
Y 1 :	-0.08 V	
Y 2 :	0.00 V	
d Y :	0.08 V	

9&10F mA/KV

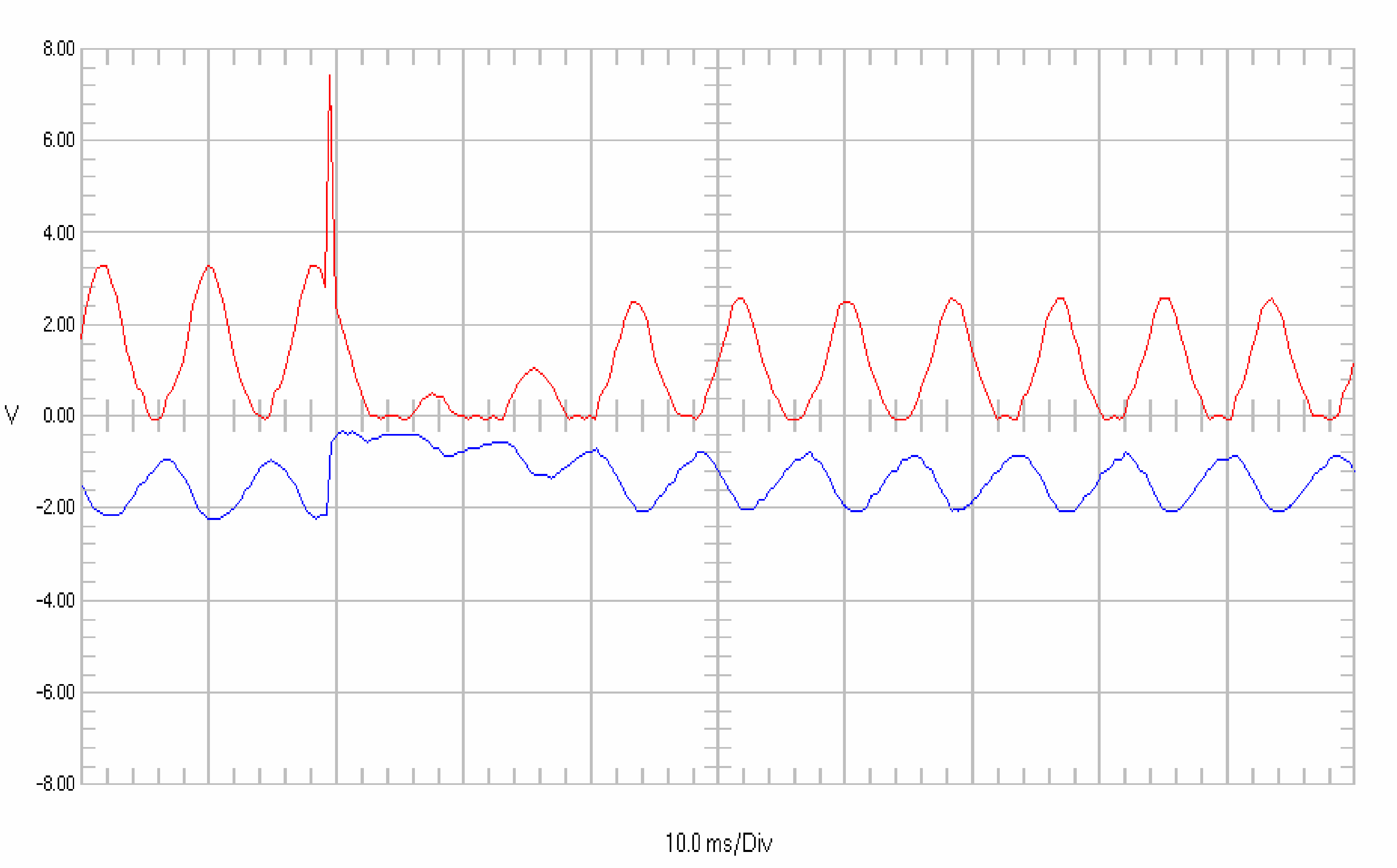
Further Control – A Search Ramp Rate



Spit Spark Response (mA)Ramp Rate



Spit Spark Response - Secondary Current and Voltage Waveforms

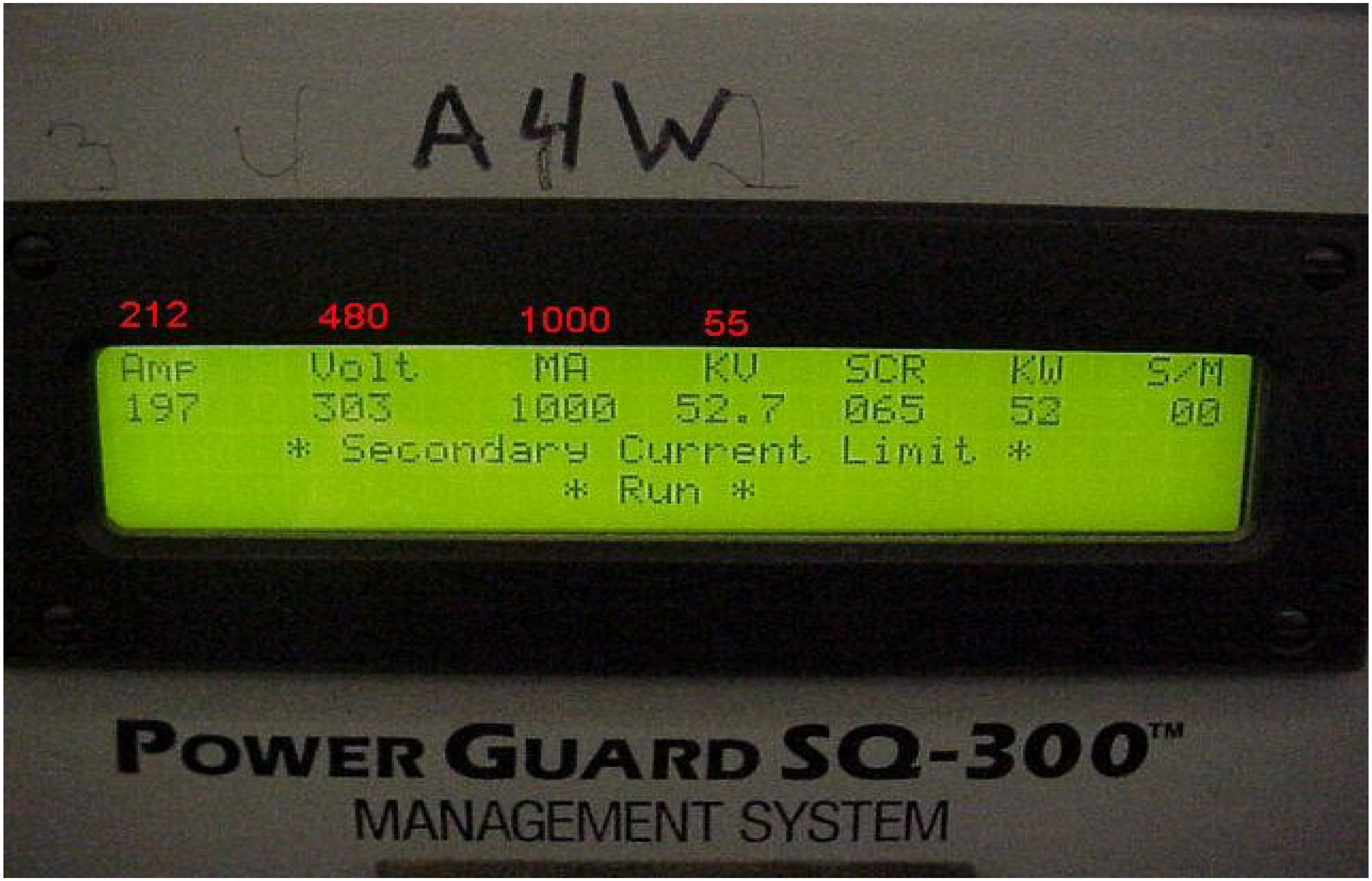


Examples of AVC ’s at a Limit

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

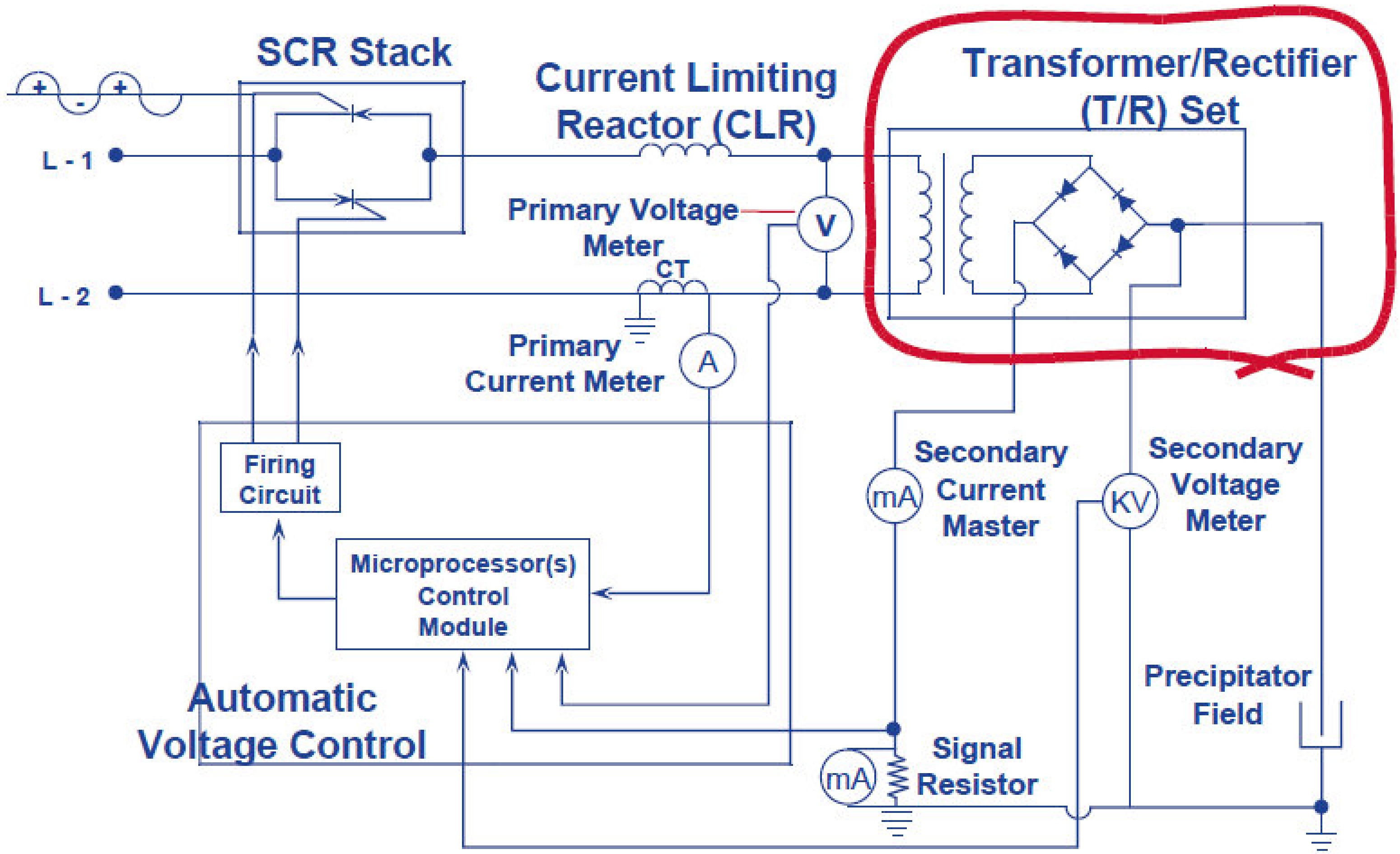
What is meant by “Healthy Limits?”

- 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

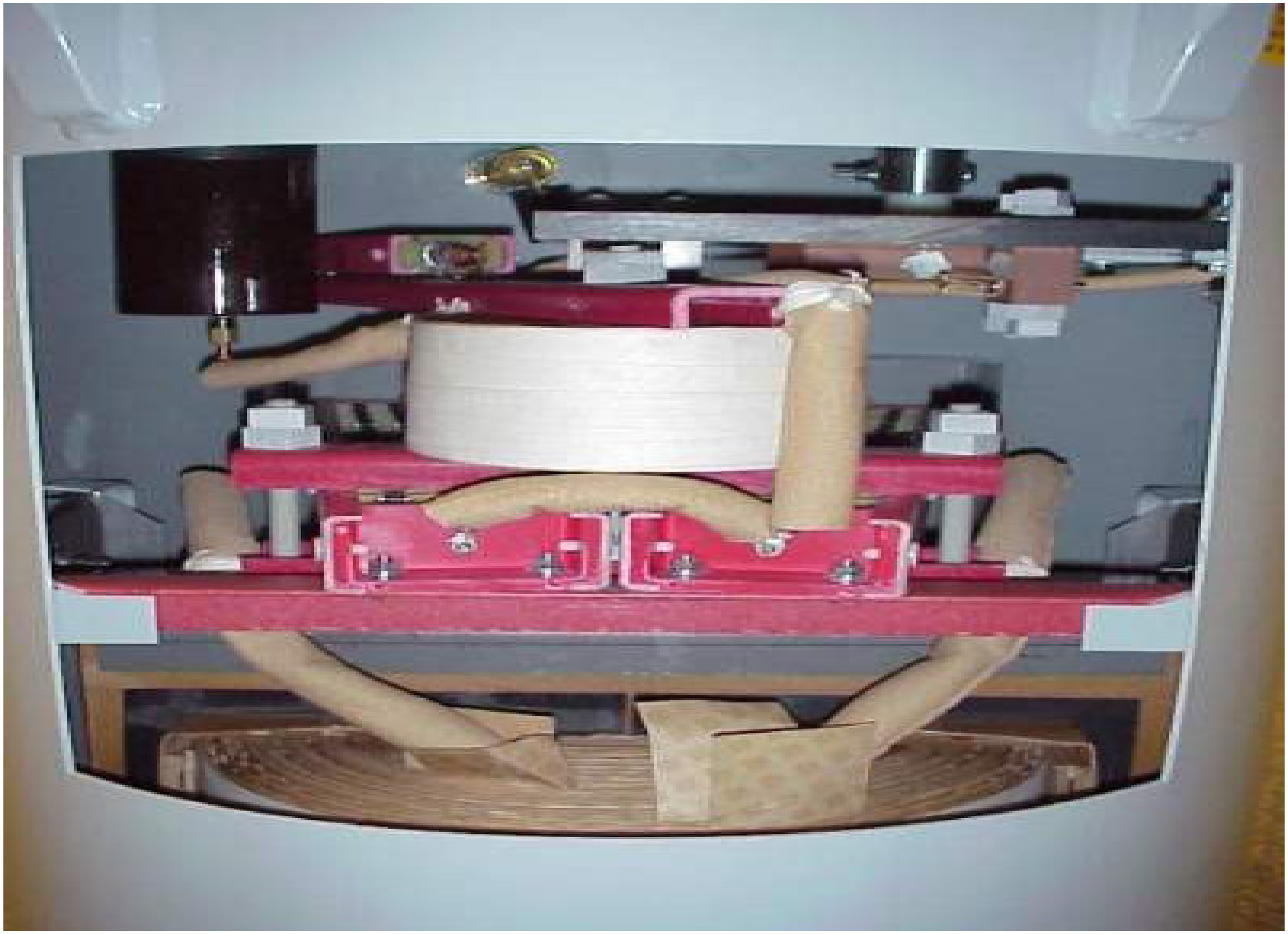
The T-R Set



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

Transformer Rectifier (T/R) Set

Inside T/R Tank



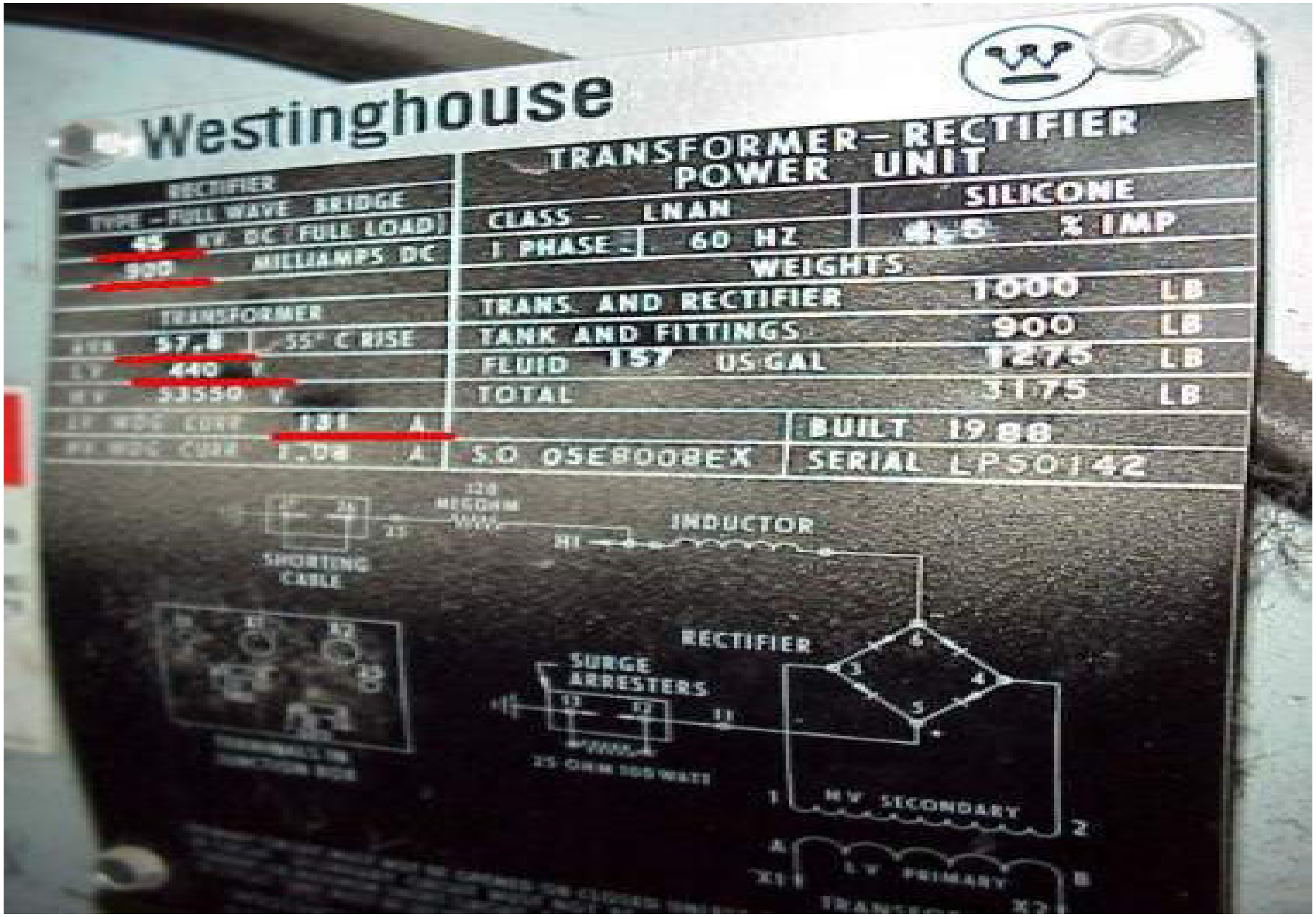
High Voltage Transformer

Diode Stack

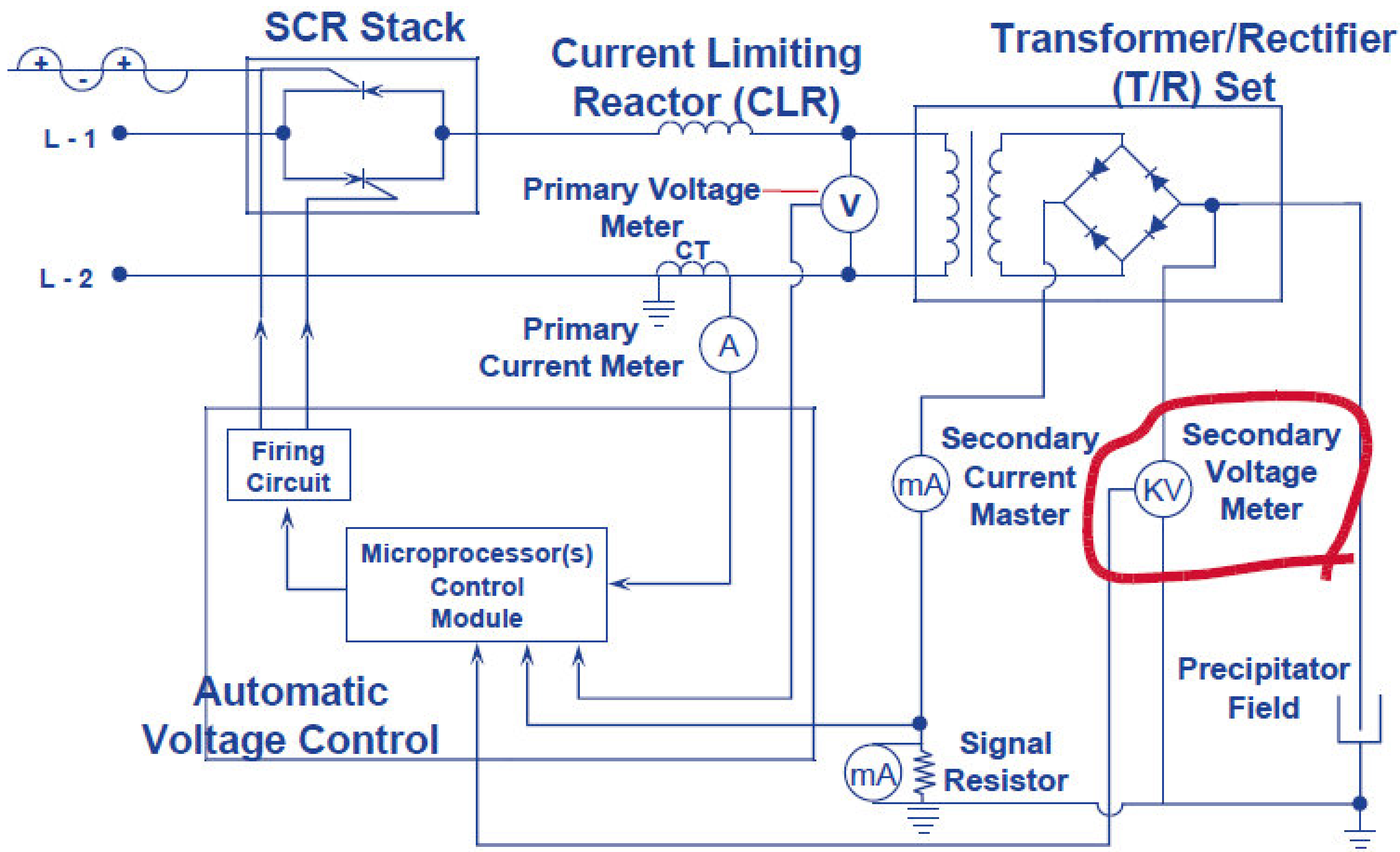
T/R Set -Low Voltage Junction Box

Low Voltage Junction Box

T/R Nameplate

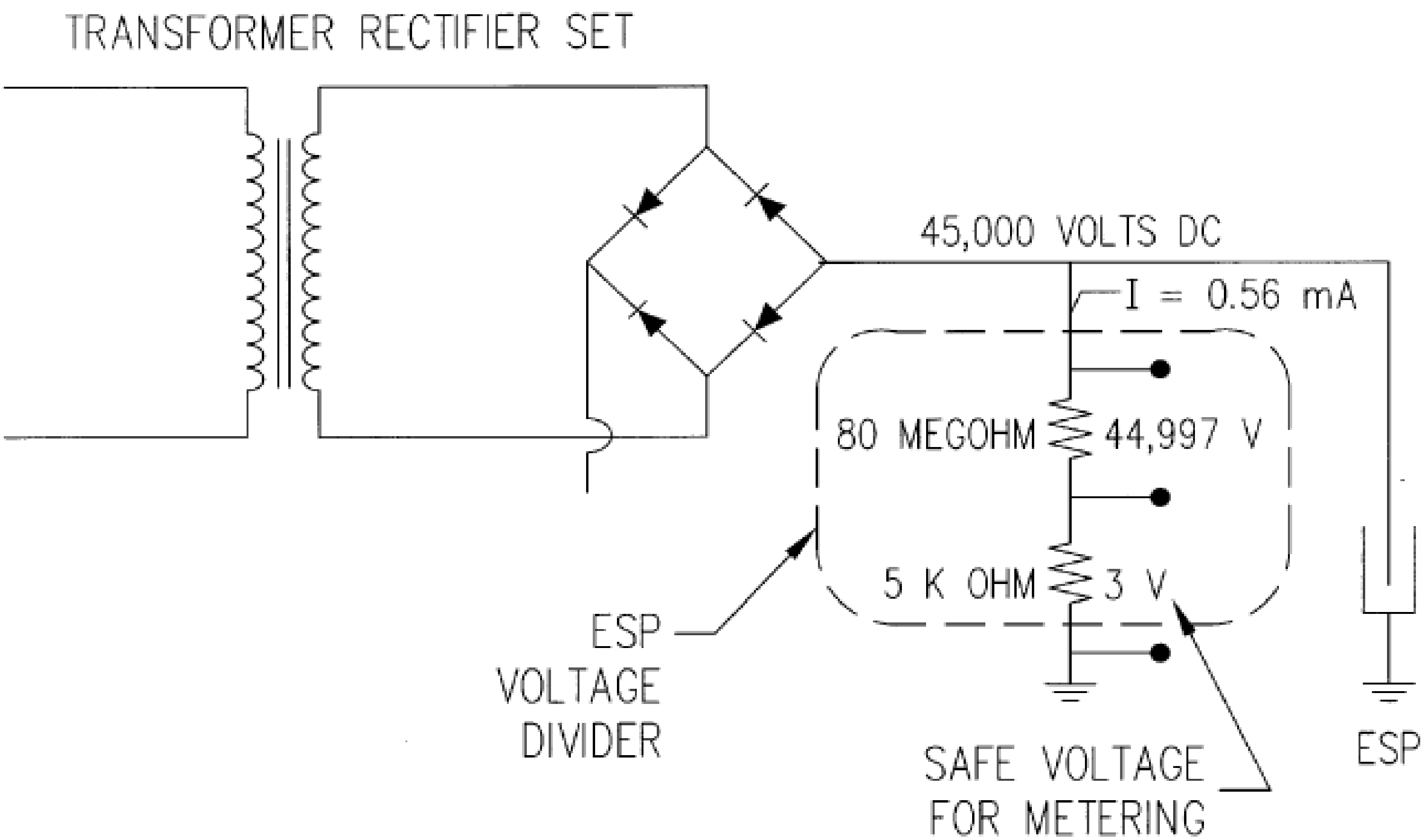


The KV Meter

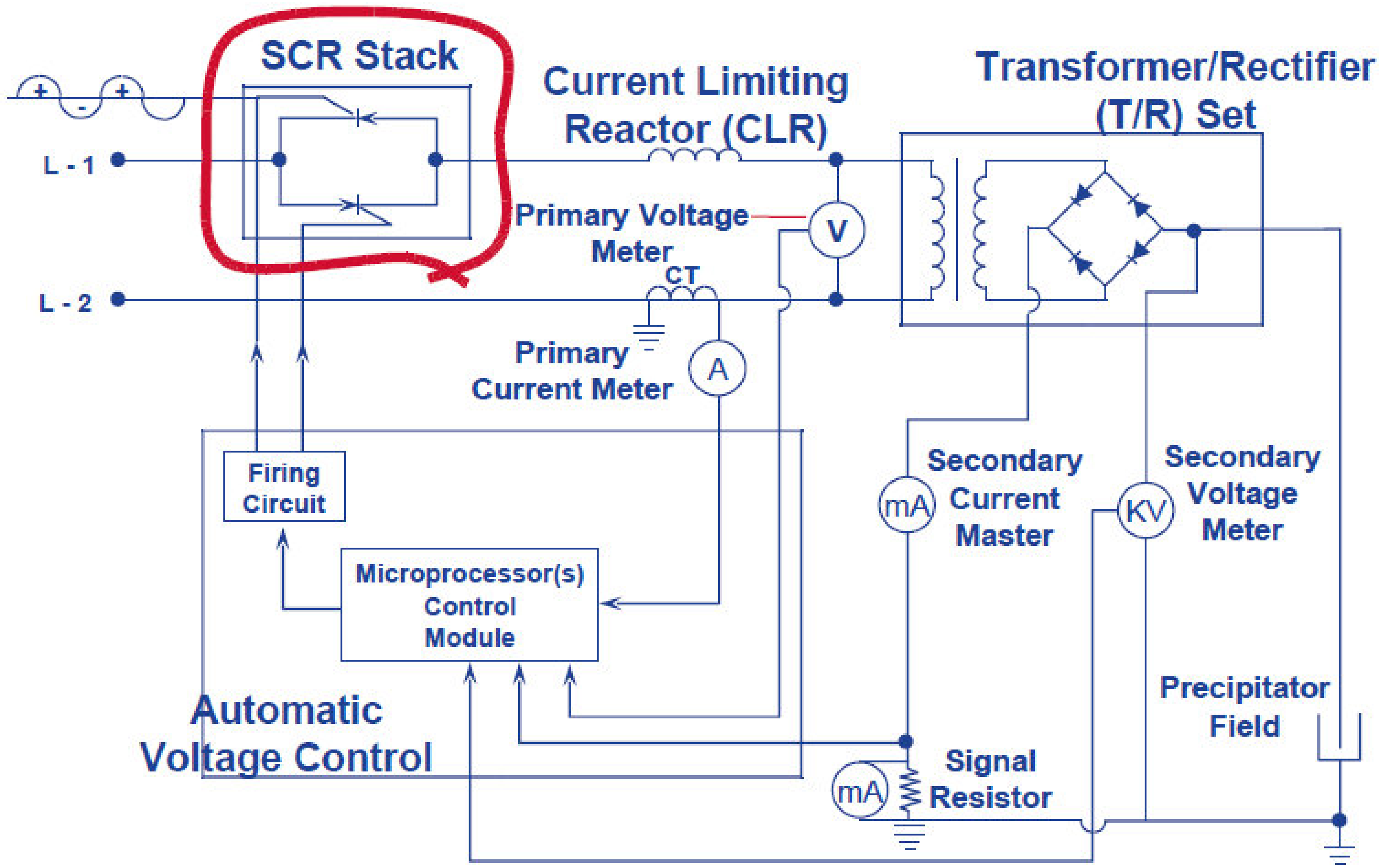


SCR Stack
Current Limiting Reactor (CLR)
Transformer/Rectifier (T/R) Set
L - 1
L - 2
Primary Voltage Meter
V
CT
Primary Current Meter
A
Firing Circuit
Microprocessor(s) Control Module
Automatic Voltage Control
Secondary Current Master
mA
Secondary Voltage Meter
KV
Precipitator Field
Signal Resistor
mA

Voltage Divider

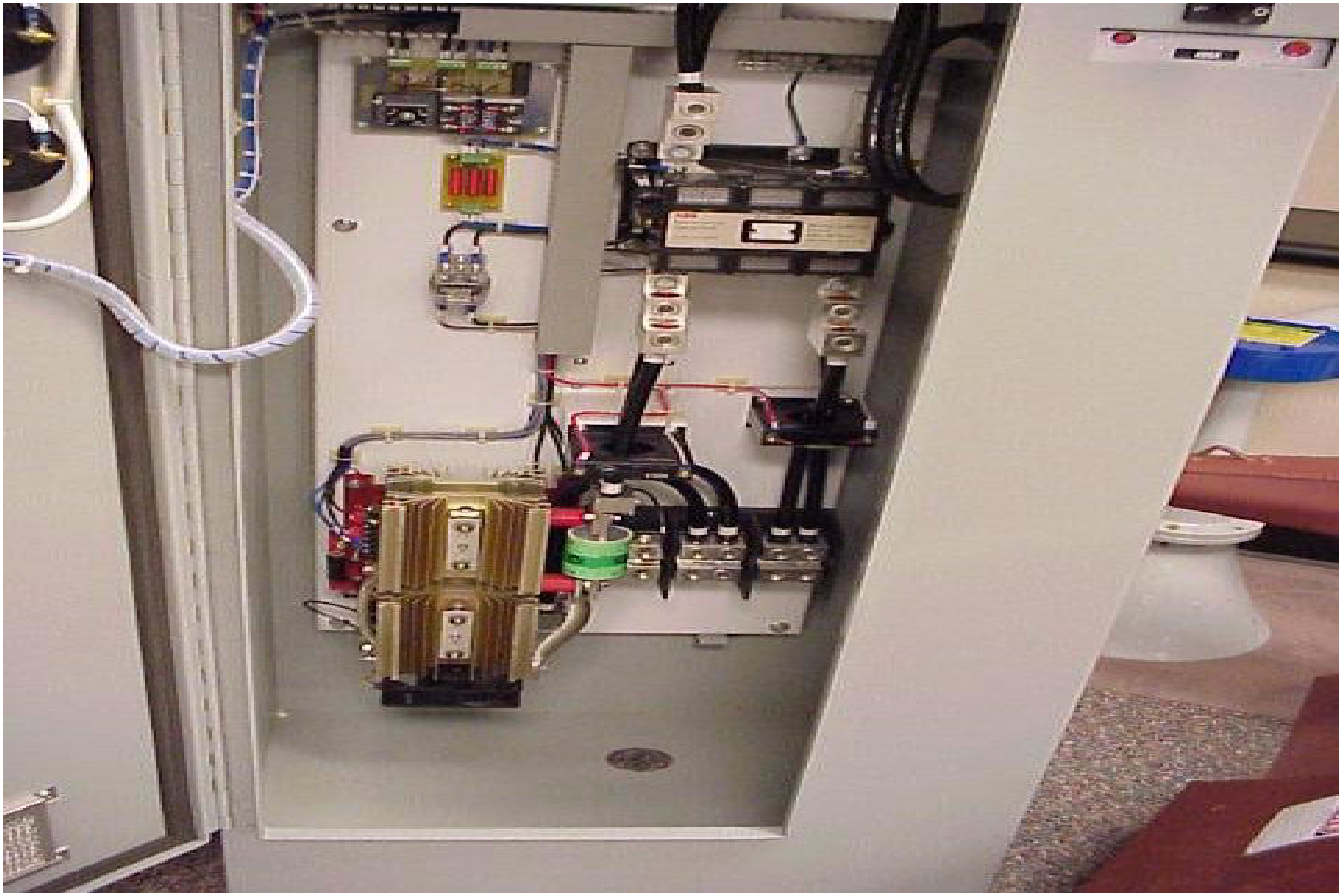


SCR'S

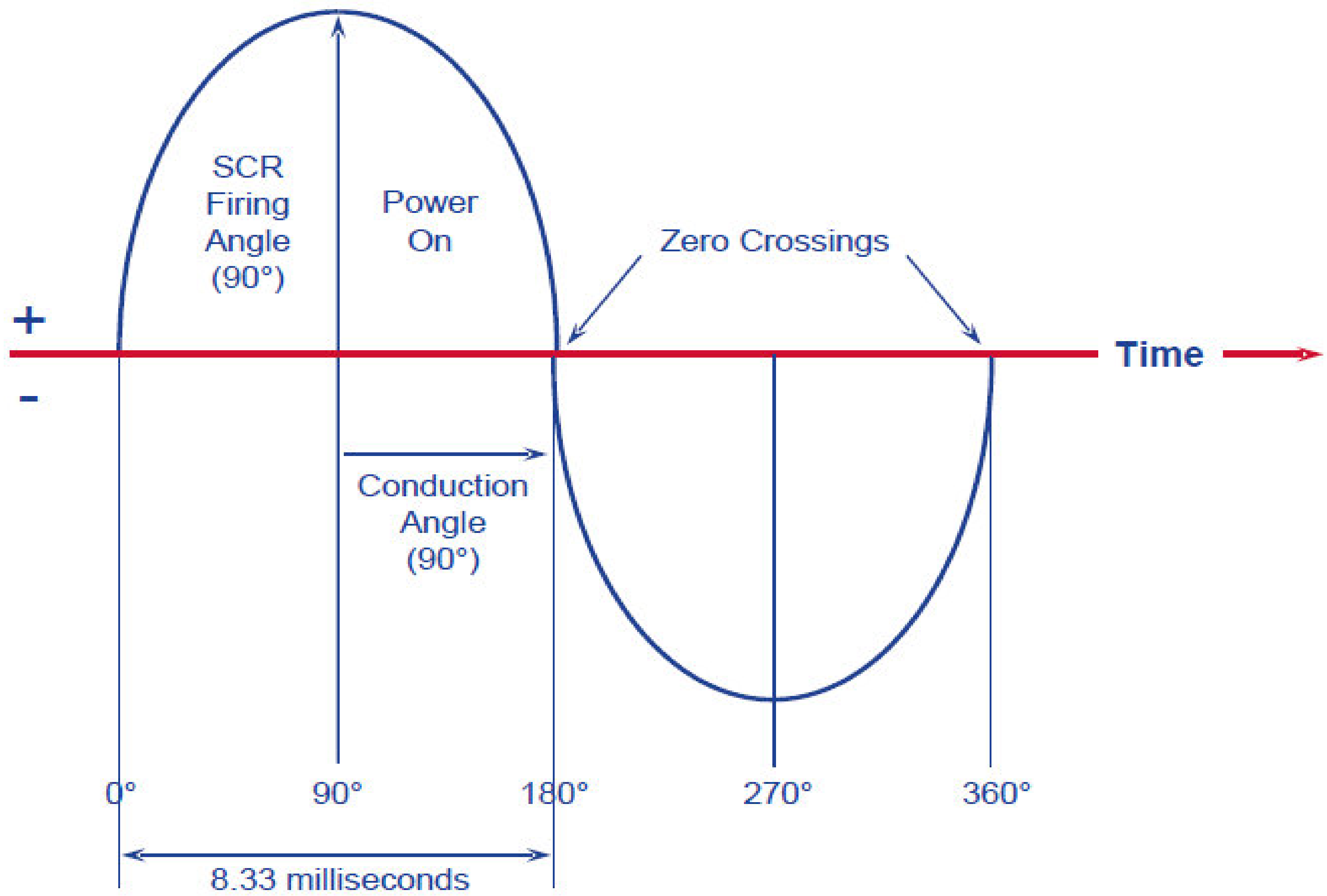


SCR Stack
Current Limiting
Reactor (CLR)
Transformer/Rectifier
(T/R) Set
+
-
+
L - 1
L - 2
Primary Voltage
Meter
V
CT
Primary
Current Meter
A
Firing
Circuit
Microprocessor(s)
Control
Module
Automatic
Voltage Control
Secondary
Current
Master
mA
Secondary
Voltage
Meter
KV
Precipitator
Field
Signal
Resistor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

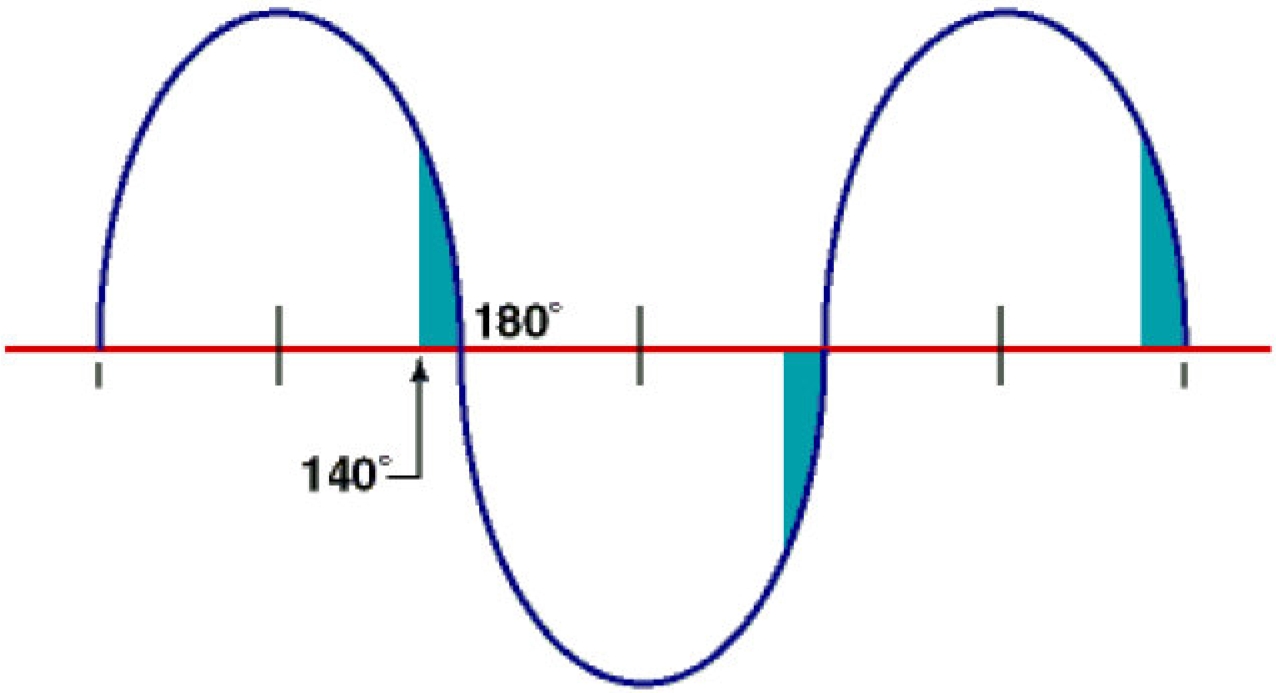
SCR



Typical Sine Wave

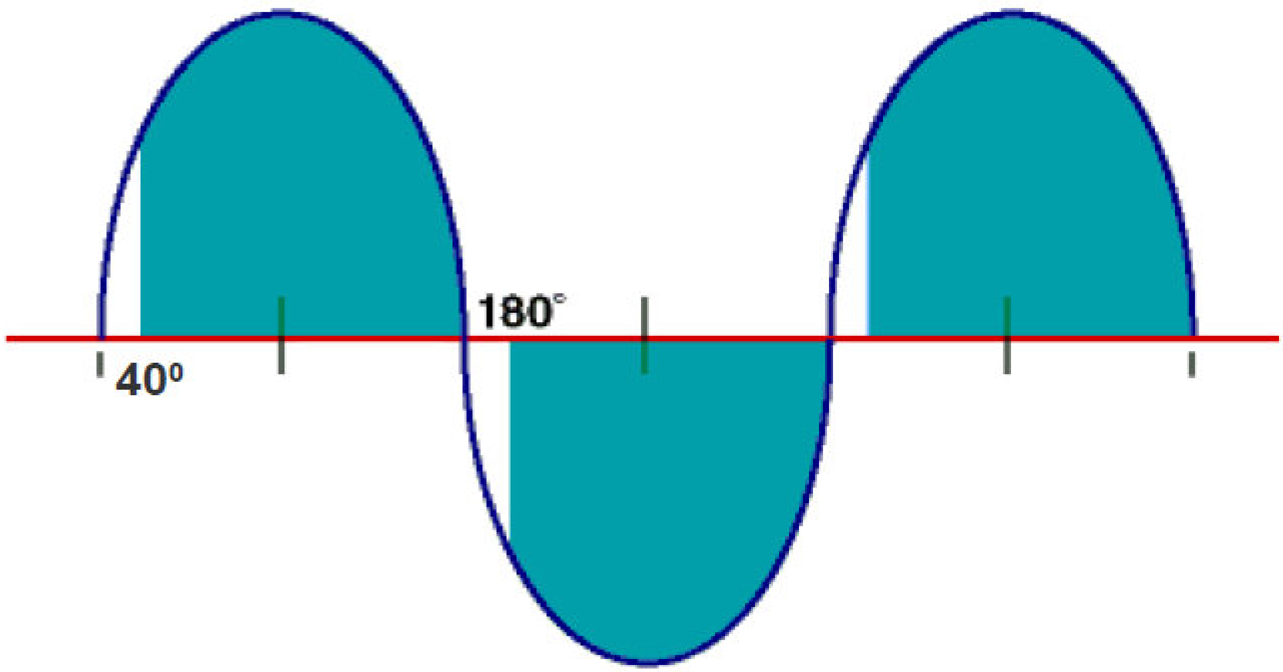


SCR: Low Voltage to T-R Set



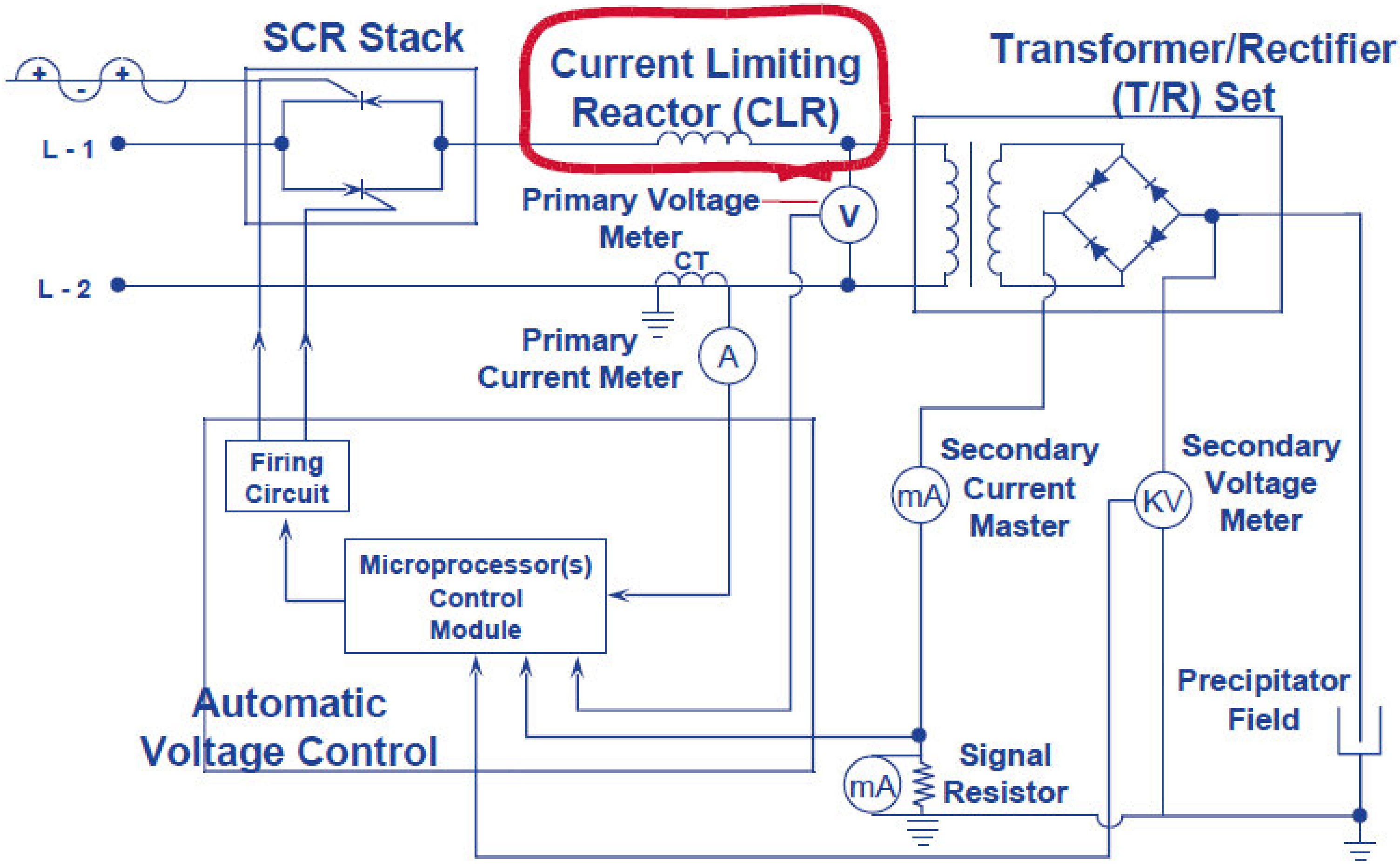
Firing Angle 140°
Conduction angle 40°

SCR: High Power to T-R Set



Firing Angle 40°
Conduction angle 140°

The CLR


SCR Stack
Current Limiting
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Primary Voltage
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Firing
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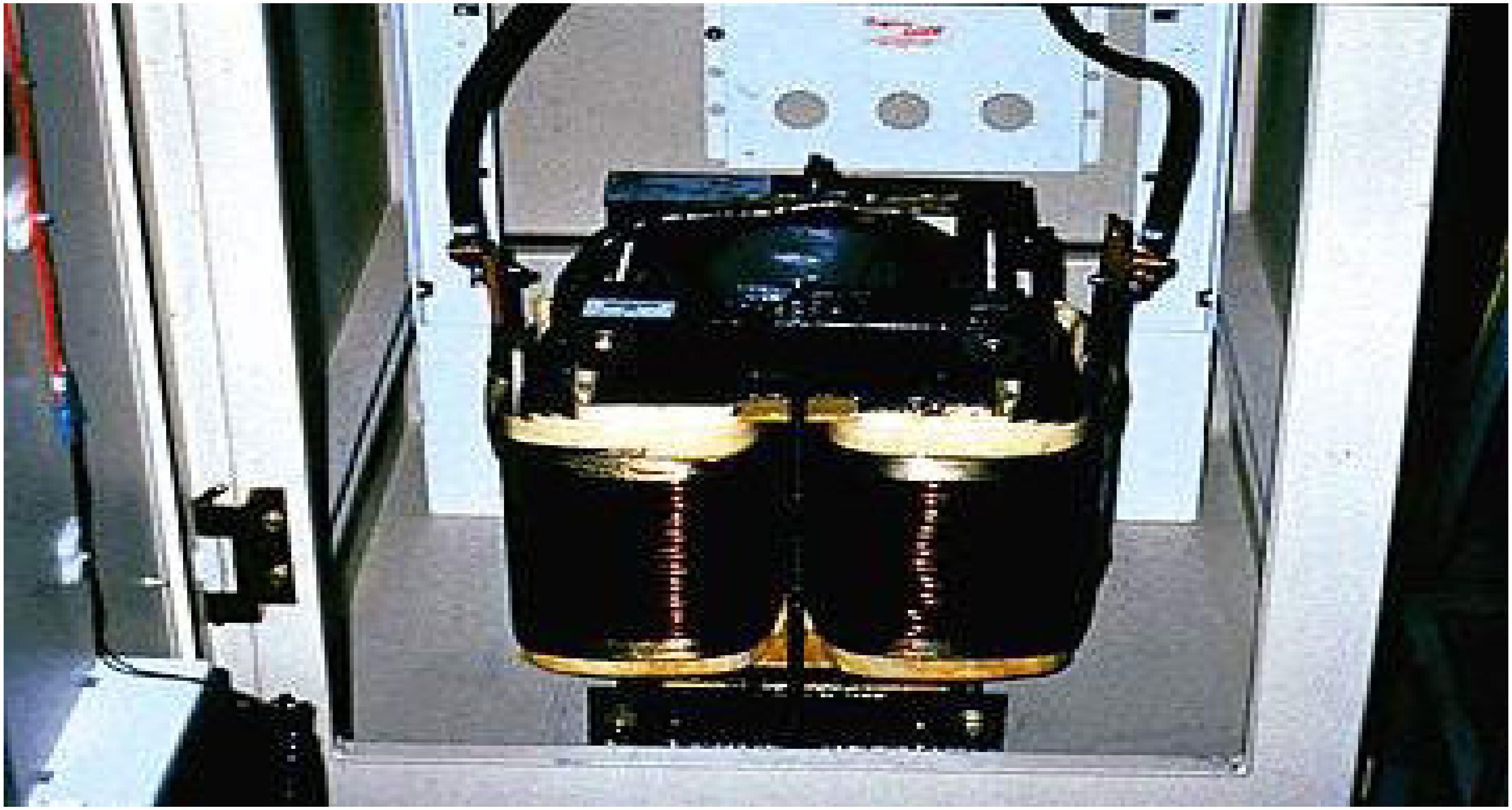
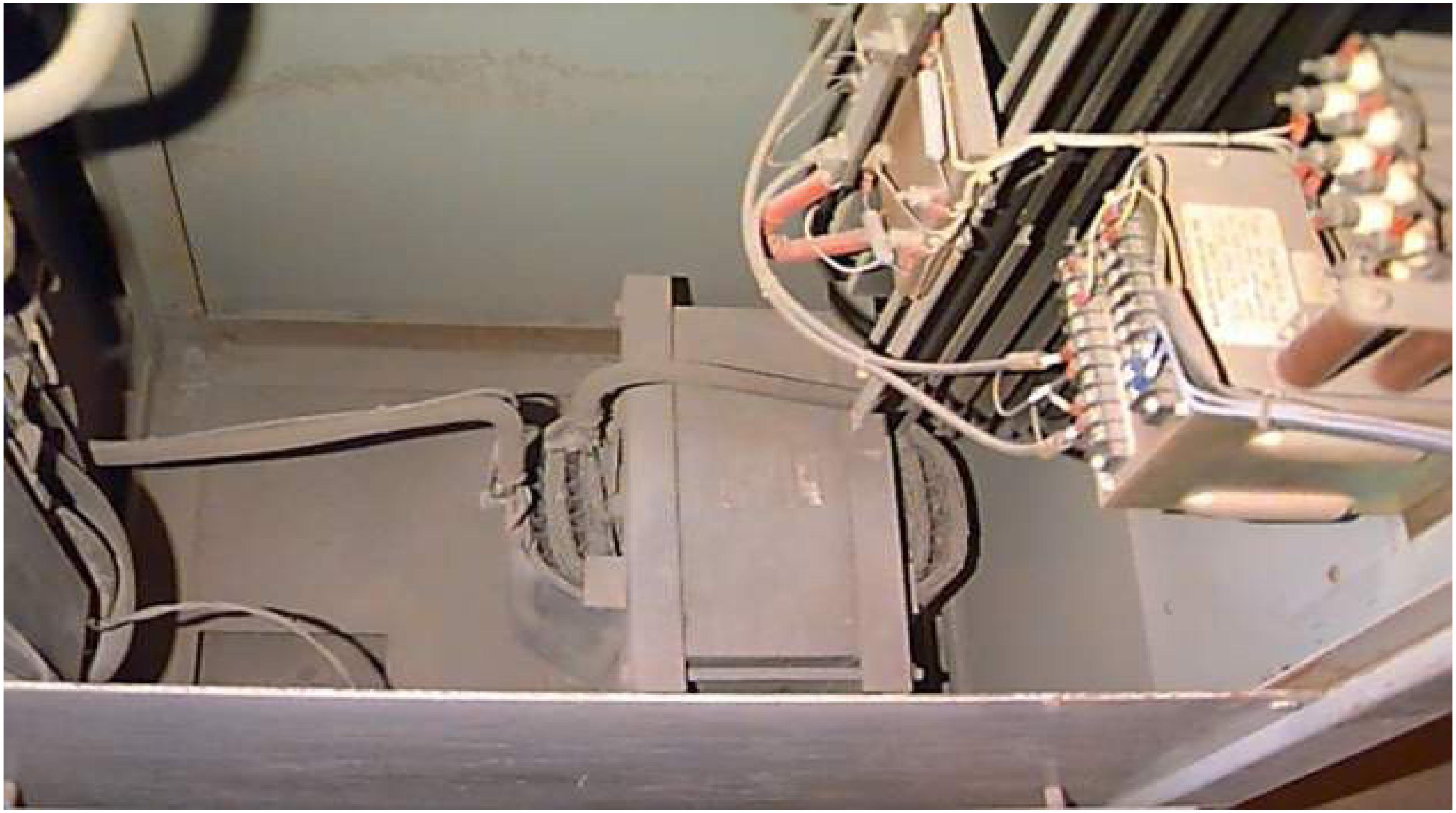
Microprocessor(s)
Control
Module
Automatic
Voltage Control
Secondary
Current
Master
mA
Secondary
Voltage
Meter
KV
Precipitator
Field
Signal
Resistor
mA

Current Limiting Reactor (CLR)



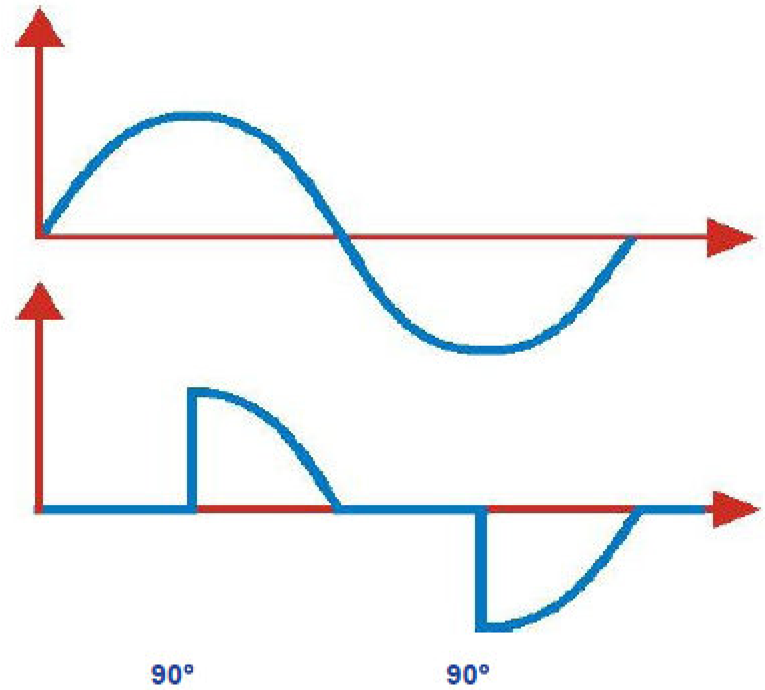
Current Limiting Reactor



Current Limiting Reactor at T-R Set

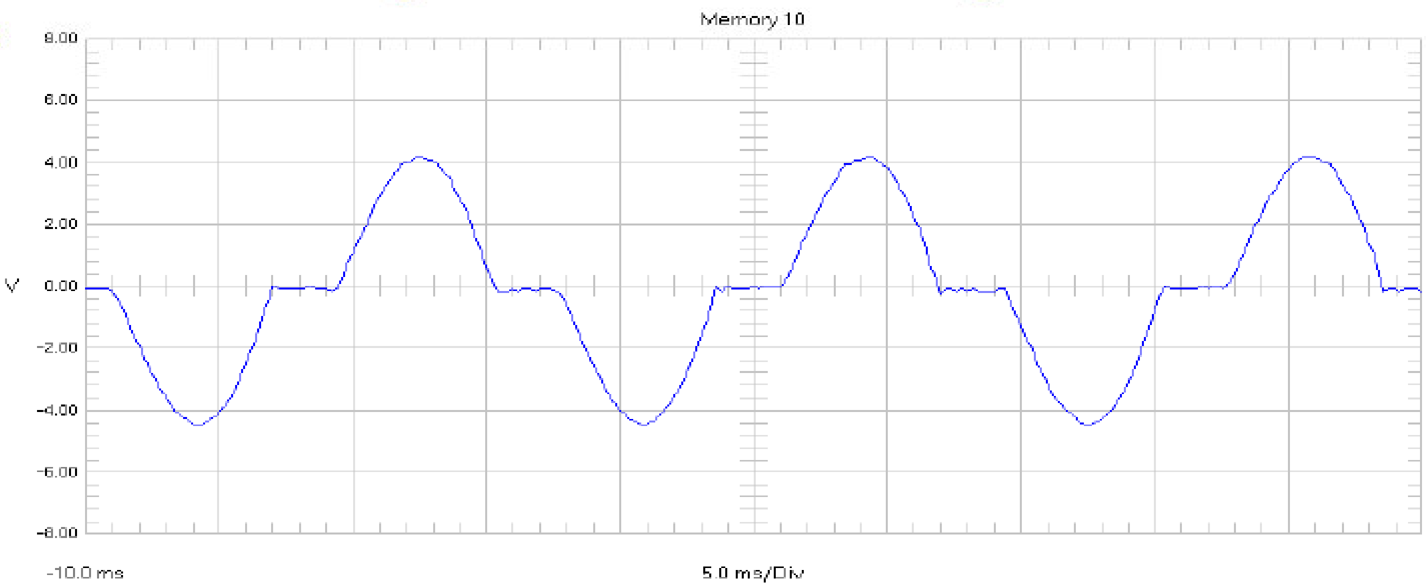
SCR's are why CLR's are Needed

- 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

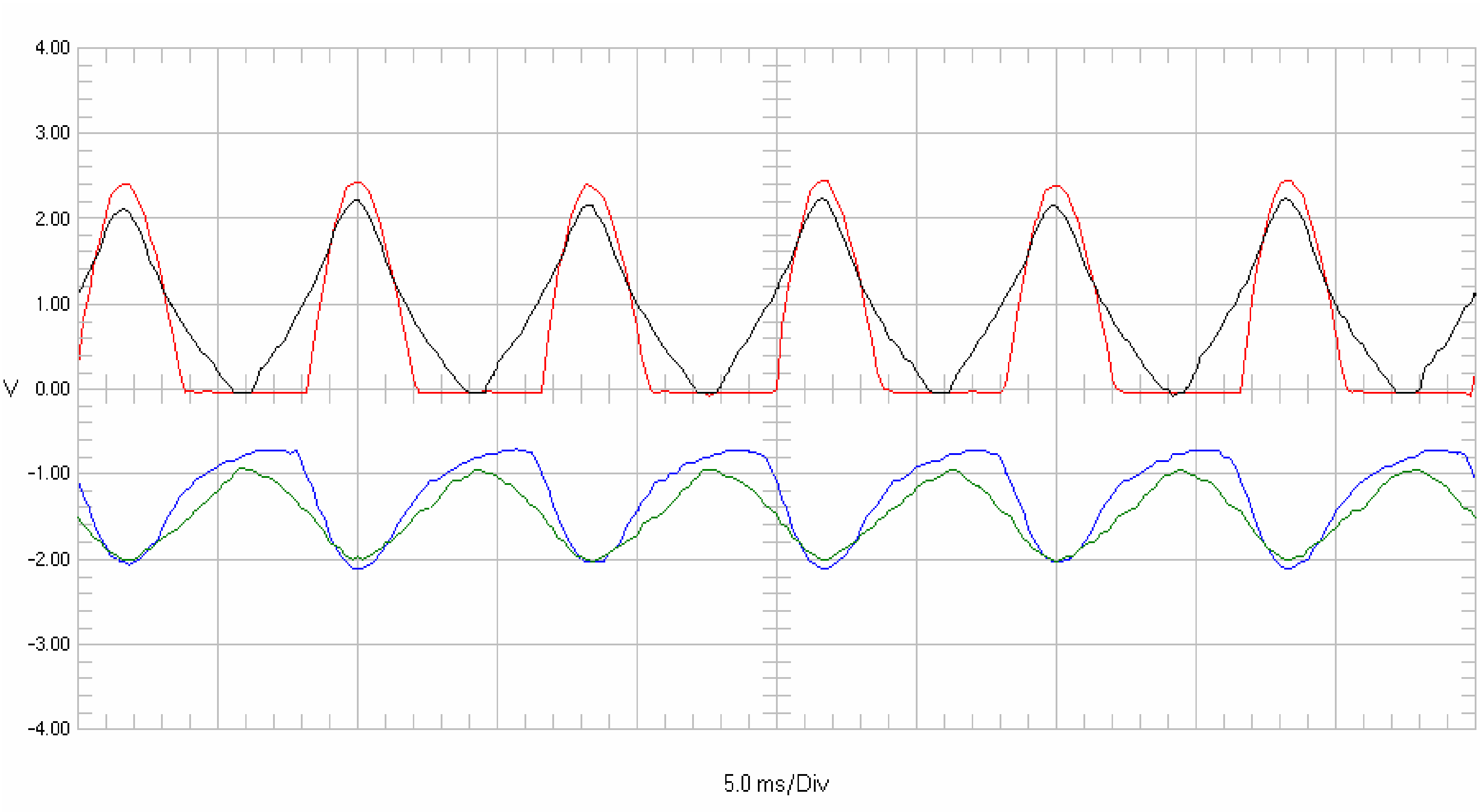
To increase the efficiency of the T/R set, a device called a CLR (current limiting reactor) is used. A CLR is an inductor. Recall that the property of an inductor is to oppose a change in current. Because of this property, the shape of the current waveform is changed and it starts looking more like a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



CLR Function

- Limit short circuit current
- Shape T/R secondary wave to be more Sinusoidal
- Provide proper form factor
- Protect SCRs and T/R diodes from steep current rise
- Increase precipitator voltage and current
- Not to be confused with air core reactor

CLR – Waveform Changes with Impedance



Proper CLR Sizes for Common T/R Sets

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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

Basic Troubleshooting

TR Nameplate Values
(For this exercise)

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Primary Current	160 Amps
Primary Voltage	480 Volts
Secondary Current	1200 mA
Secondary Voltage	45 kV

First Indication

160	480	1200	45			
Amp	Volt	MA	KV	SCR	KW	S/M
160	045	1067	00.9	081	00	00

* Primary Current Limit *

* Run *

Second Indication

Amp	Volt	MA	KV	SCR	KW	S/M
160	045	1067	00.9	081	00	00

* Primary Under Voltage Alarm *

* Main Power Off *

Short

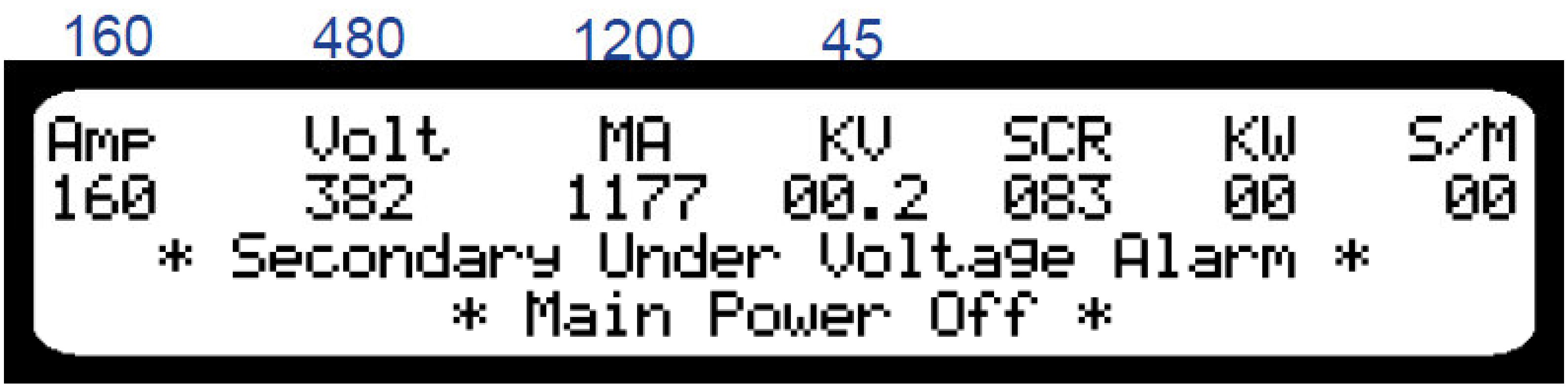
Close Clearance

160 480 1200 45

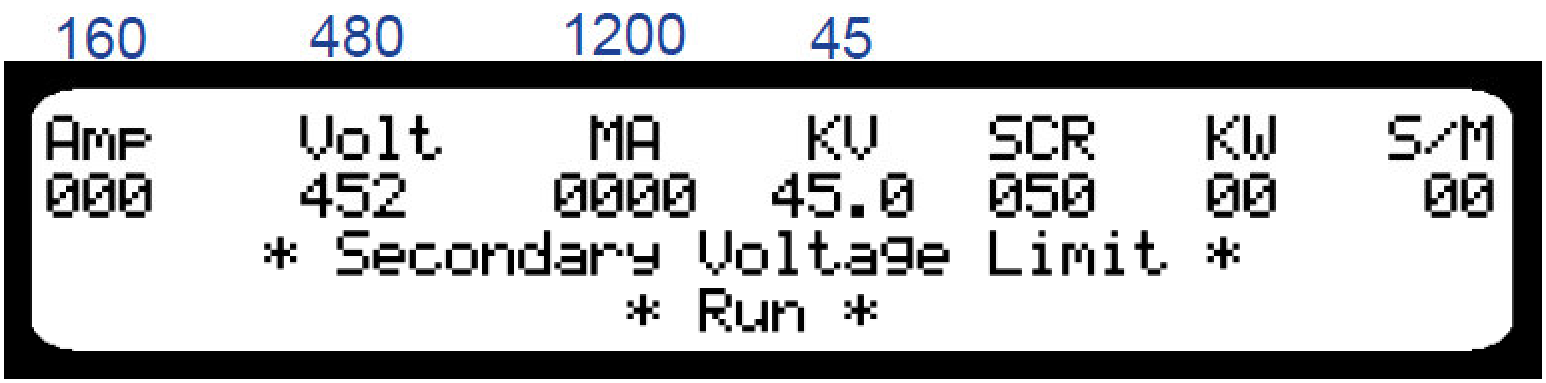
Conductive Dust, Outlet Field

160 480 1200 45

Bad KV Return



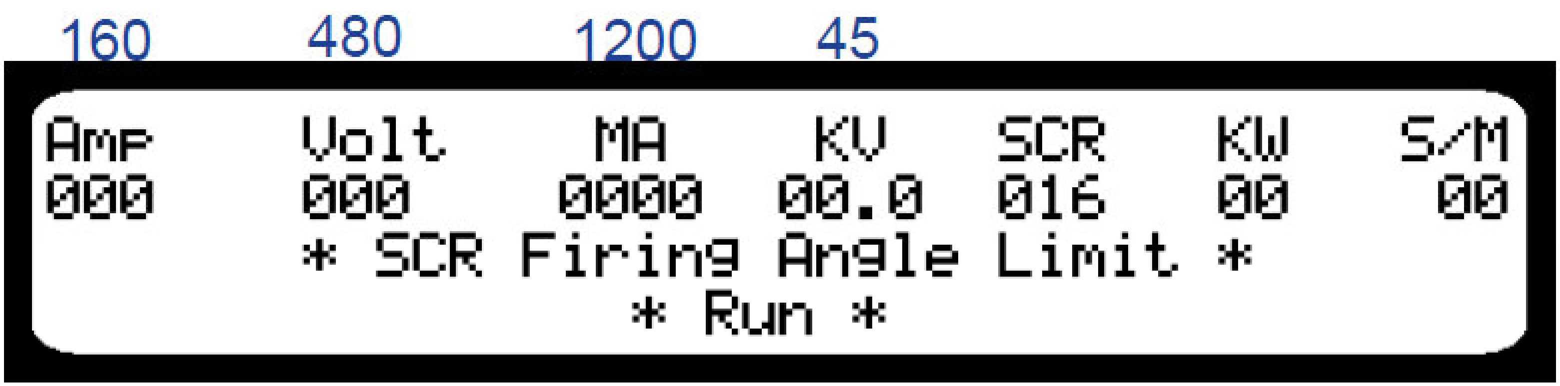
Open


160
480
1200
45
Amp Volt MA KV SCR KW S/M
000 452 0000 45.0 050 00 00
* Secondary Voltage Limit *
* Run *

Normal Running Condition

160 480 1200 45

SCRs Not Firing



Thank You.

steag