Welcome

Amusement & Music Operators Association

LCD Power Supply Troubleshooting Tech Seminar

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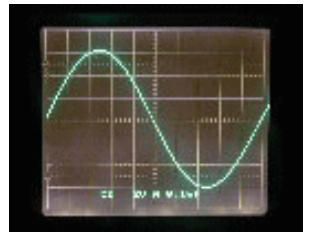
11-Golden Rules of Safety



1. Anything with a AC plug must go into an isolation transformer.

2. Remove all jewelry (rings,watches,chains, hanging I.D. Cards) when working on anything electrical or electronic.

3. Always hook instrument *ground* (Black) connection up first.

4. Only one hand touching chassis or circuit components; preferably right hand; with fingers pointing up.

5. *Never* place one hand on one piece of electronic equipment then one hand on a separate piece of electronic equipment.

6. Always use Safety Ground Strap when working the Bench or on site.

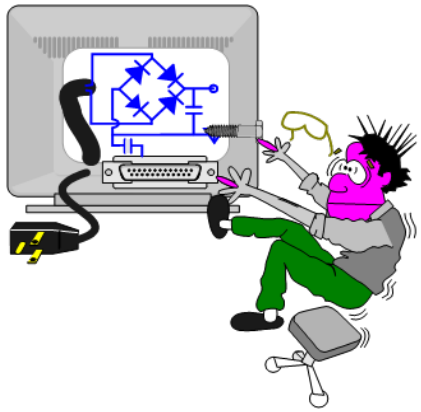
7. When working with an Electronic Trainer with Trouble Switches, turn power to Trainer off, switch in Trouble Switch, turn Trainer on.

8. Electronics and liquids do not mix. (no drinks on working benches pleas

9. Use *all* senses *all* the time. See, hear, feel, smell or sense something not right, power down Bench or product under test.

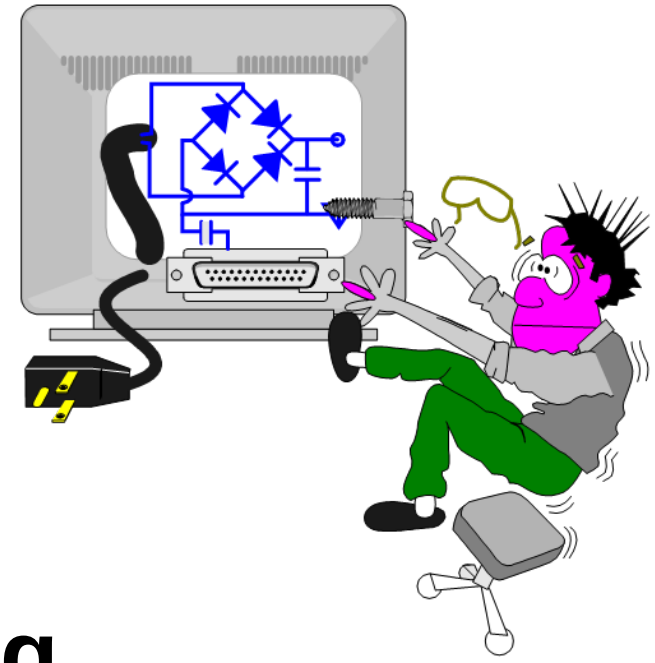
10. Power Down Bench when leaving for any period of time.
(preferably with one Bench Master Power Switch)

11. Don't Feel Well? Take a Break or Go Home!



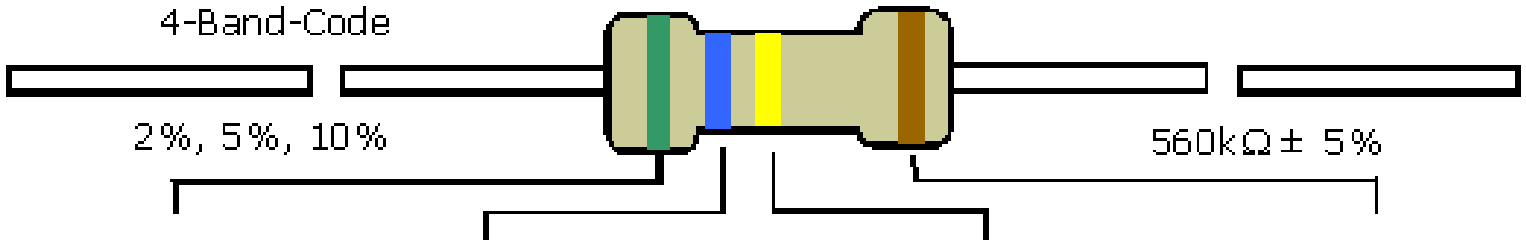
Monitor Safety Guidelines

- ☑ **Use an Isolation Transformer!**
- ☑ **Remove power first!**
- ☑ **Read each procedure carefully!**
- ☑ **Use common sense!**
- ☑ **Take precautions working around and handling CRTs!**
- ☑ **Ask for help!**

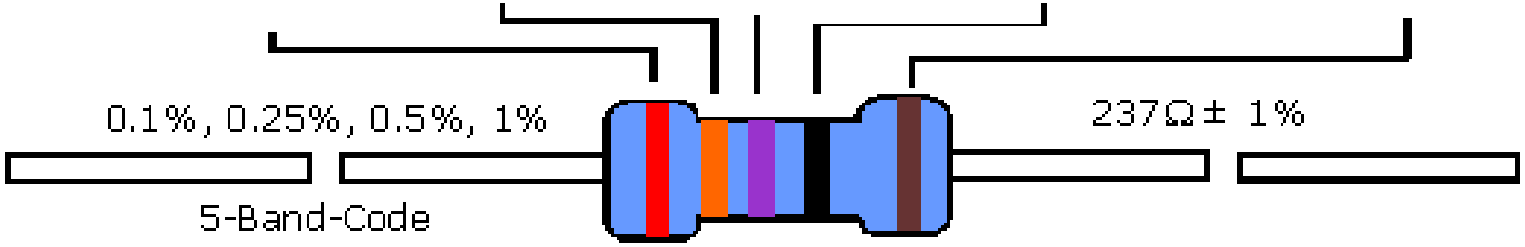


CRT Handling Dangers

- **CRTs are constructed with a near-perfect vacuum**
  - **Implosion risk**
- **CRTs operate at high voltages up to 30kV (30,000 volts)**
- **Be careful when chassis is running**
  - **shock (HV won't kill you but your reaction might)**
  - **arcing will damage components**
- **Be careful when chassis is off**
  - **CRTs rebuild charge after being discharged**



COLOR	1st BAND	2nd BAND	3rd BAND	MULTIPLIER	TOLERANCE	
Black	0	0	0	1Ω		
Brown	1	1	1	10Ω	± 1%	(F)
Red	2	2	2	100Ω	± 2%	(G)
Orange	3	3	3	1KΩ		
Yellow	4	4	4	10KΩ		
Green	5	5	5	100KΩ	±0.5%	(D)
Blue	6	6	6	1MΩ	±0.25%	(C)
Violet	7	7	7	10MΩ	±0.10%	(B)
Grey	8	8	8		±0.05%	
White	9	9	9			
Gold				0.1	± 5%	(J)
Silver				0.01	± 10%	(K)



Oscilloscope Operation Tips

- Select correct CRT MODE
  - CH A, CH B, CH A&B
- Use AC input coupling
- Set timebase (TIME/DIV) to match signal
  - 2mS - 5mS for low frequency waveforms
  - 2μS - 10μ S for high frequency waveforms
- Set vertical sensitivity (VOLTS/DIV) to match signal level
  - use digital VPP meter as guide
- Set Horizontal & Vertical position controls
- Set trigger source to the channel being used (A or B)
- Set TRIGGER MODE to the AUTO position
- Adjust TRIGGER LEVEL until a stable waveform is displayed

Agenda

Reference TS400 Book

And now:

Switch Mode Power Supplies

- **Power Supply Theory of Operation**
  - Power Supply Basics
  - Safety Concerns
  - Common Switch Mode Power Supply (SPMS) Types
  - Functional Block Diagram
- **Pulse Width Modulation (PWM) SMPS Familiarization**
- **Hands-On PWM SMPS Troubleshooting**
- **Pulse Rate Modulation (PRM) SMPS Familiarization**
- **Hands-On PRM SMPS Troubleshooting**
- **Component Analyzing**
- **Review**

Direct Off-Line Supply

All electronic systems require a power supply

Focus on two common switching power supplies

- Pulse Width Modulated (PWM)
- Pulse Rate Modulated (PRM)

These supplies utilize AC line derived DC supplies

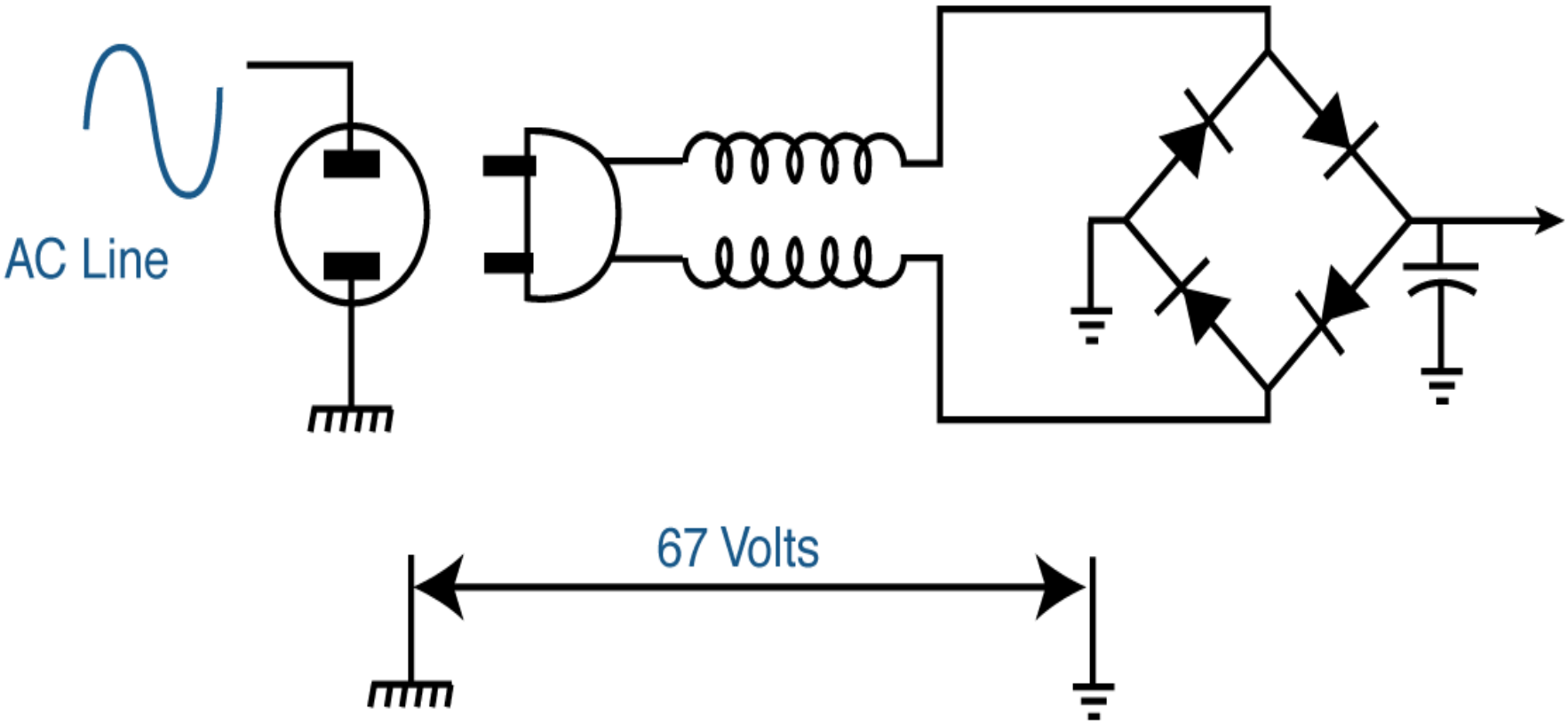
- Raw B+ supply

Two common Raw B+ supplies

- Half-Wave Rectifier
- Full-Wave Bridge Rectifier

Hot Ground - Full wave supply

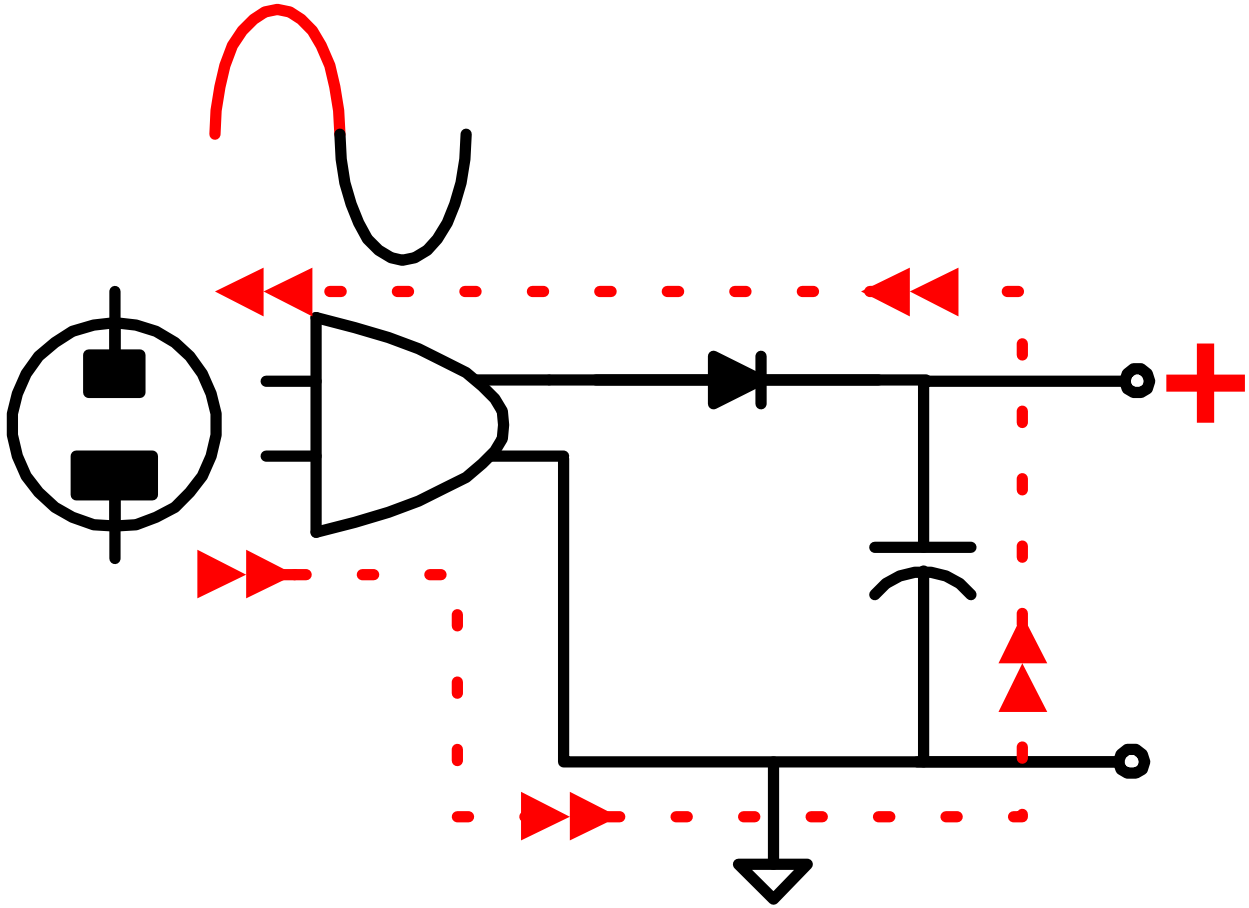
- **Full-Wave Bridge Rectifier & Filter**
- **Commonly used to provide SMPS raw B+**



Direct Off-Line Supply

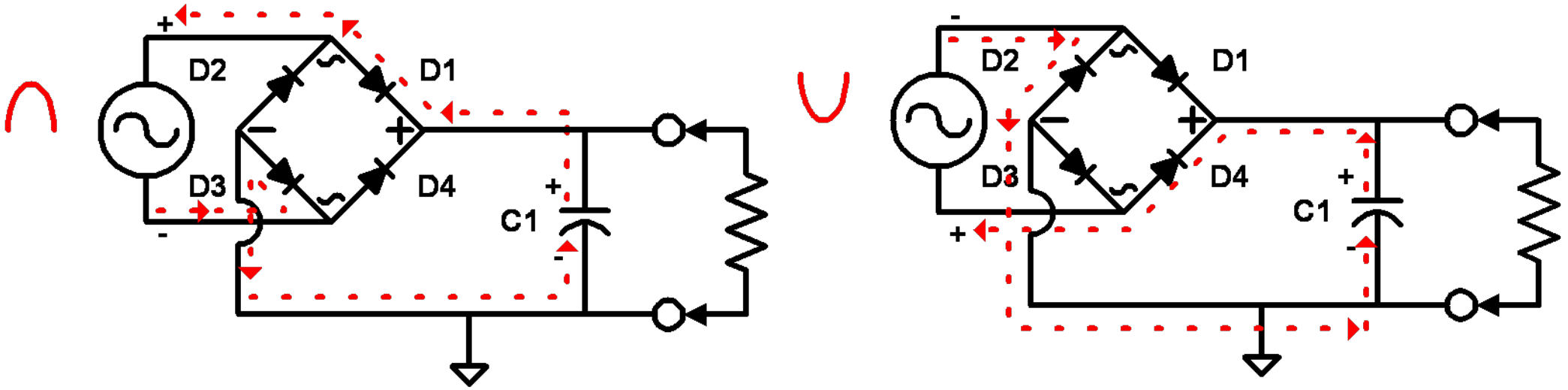
Half-Wave AC Rectifier & Filter

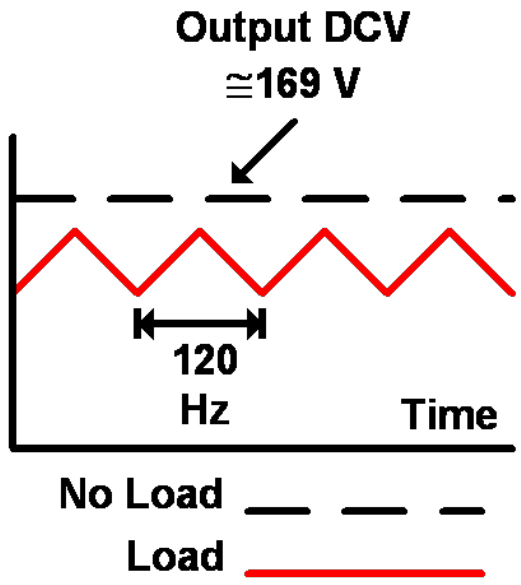
- low power application



Full Wave Rectification

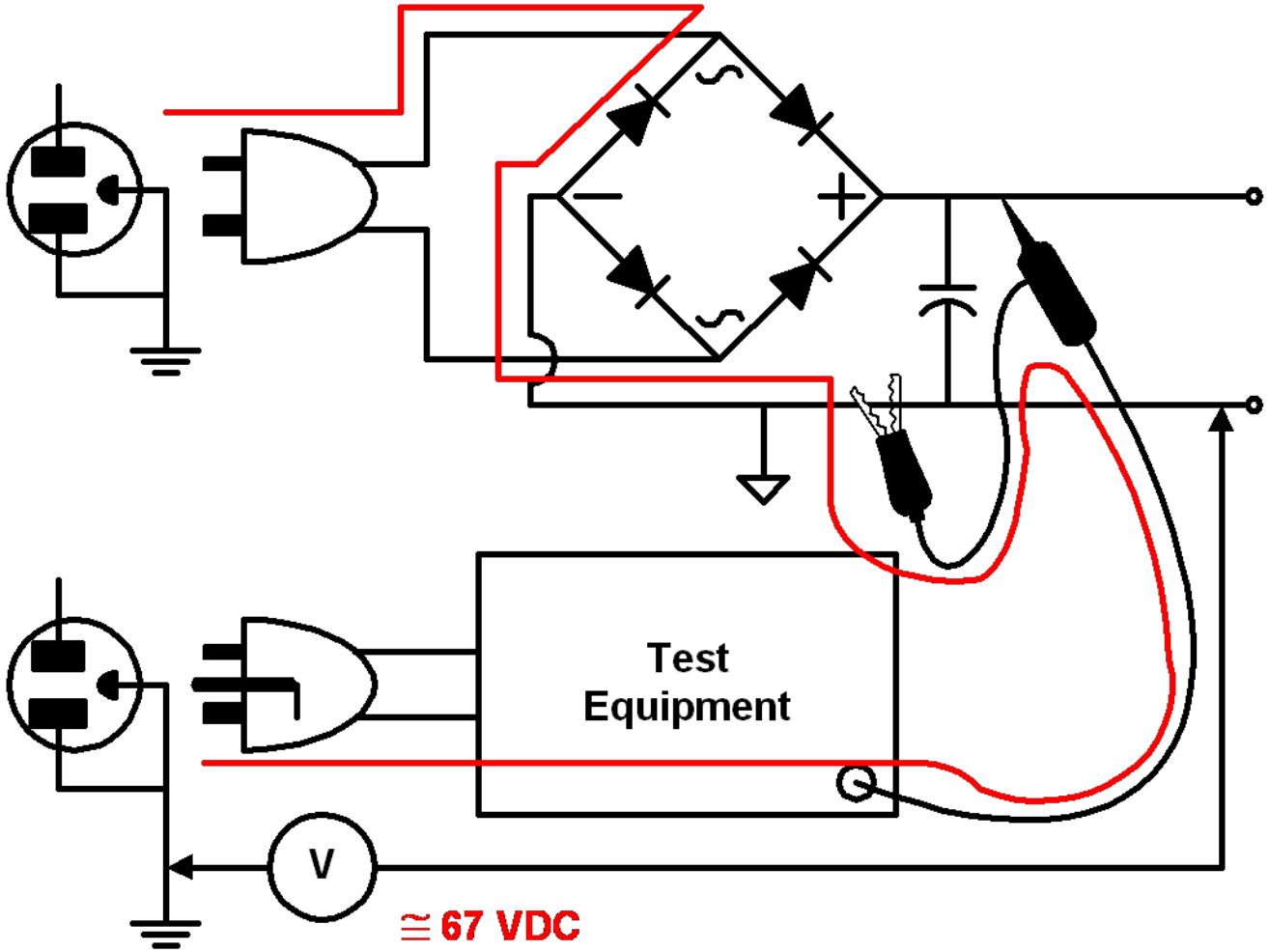
Each half cycle of the 60Hz AC input voltage turns on different diodes in the bridge rectifier





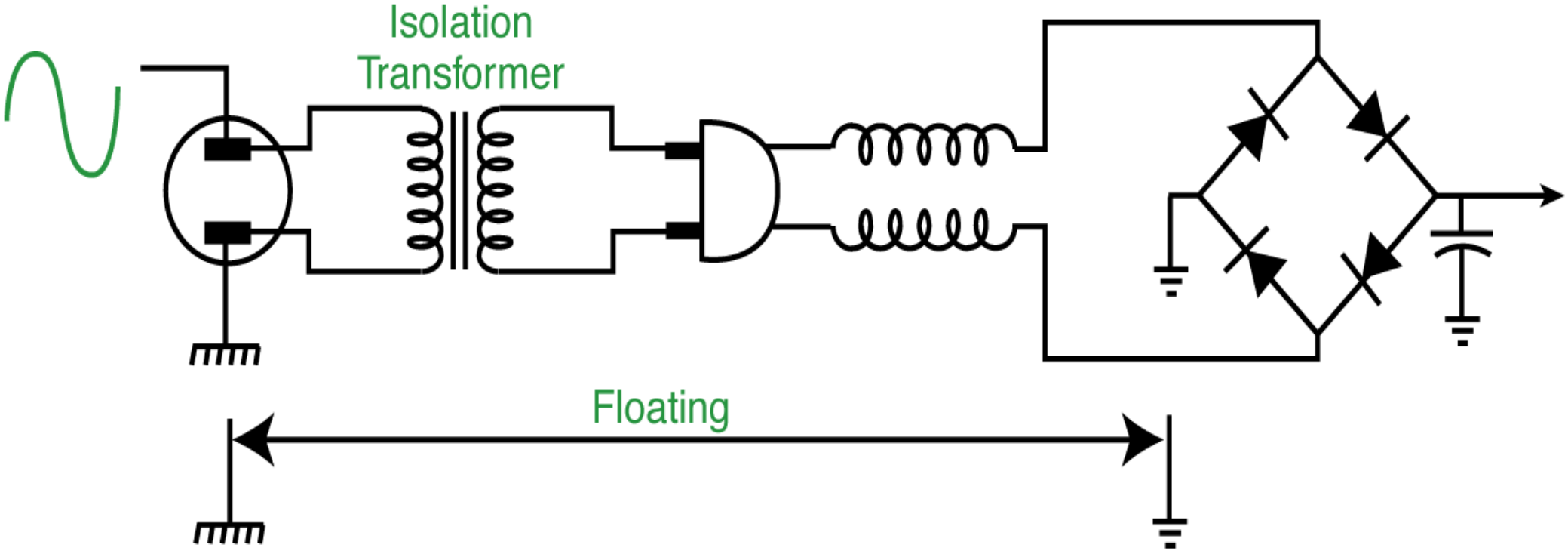
Hot Ground - Full wave supply

- **Full wave supplies are *ALWAYS* hot ground**
- ***Damage to Test Equipment and to the monitor can occur!***



Hot Ground - Isolation

Servicing Safety



- **Isolation transformer breaks DC electrical connection**
- **Allows chassis to float to earth ground potential**
- **Safe to connect the ground of oscilloscope**

AC Power Safety Guidelines

Servicing Safety

1. ***ALWAYS*** **plug the monitor into an isolation transformer.**
2. **Never connect test equipment to the isolation transformer.**
3. **Do not defeat the 3rd wire safety ground.**
4. **Connect only one monitor at a time to the isolation transformer.**

What Is AC Leakage?

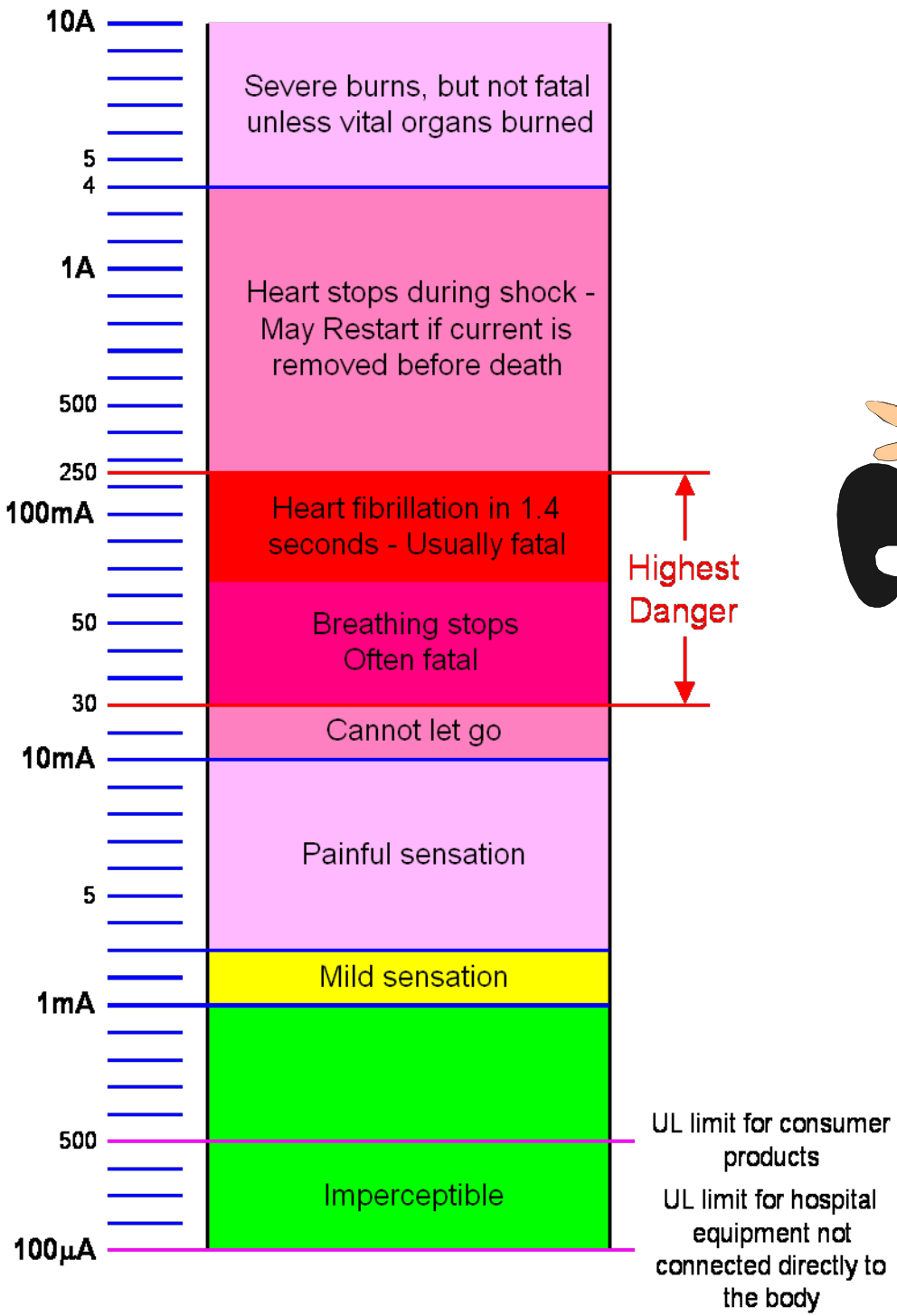
- Any current path that develops to what is normally an insulated part
- Any path which places the user in direct or indirect contact with the AC line

What Causes AC Leakage?

- Defective AC line or switching supply isolation transformer
- AC bypass capacitors
- Improper parts installation
- Foreign objects
- Improper case and mounting screws

AC Safety Leakage - Effects

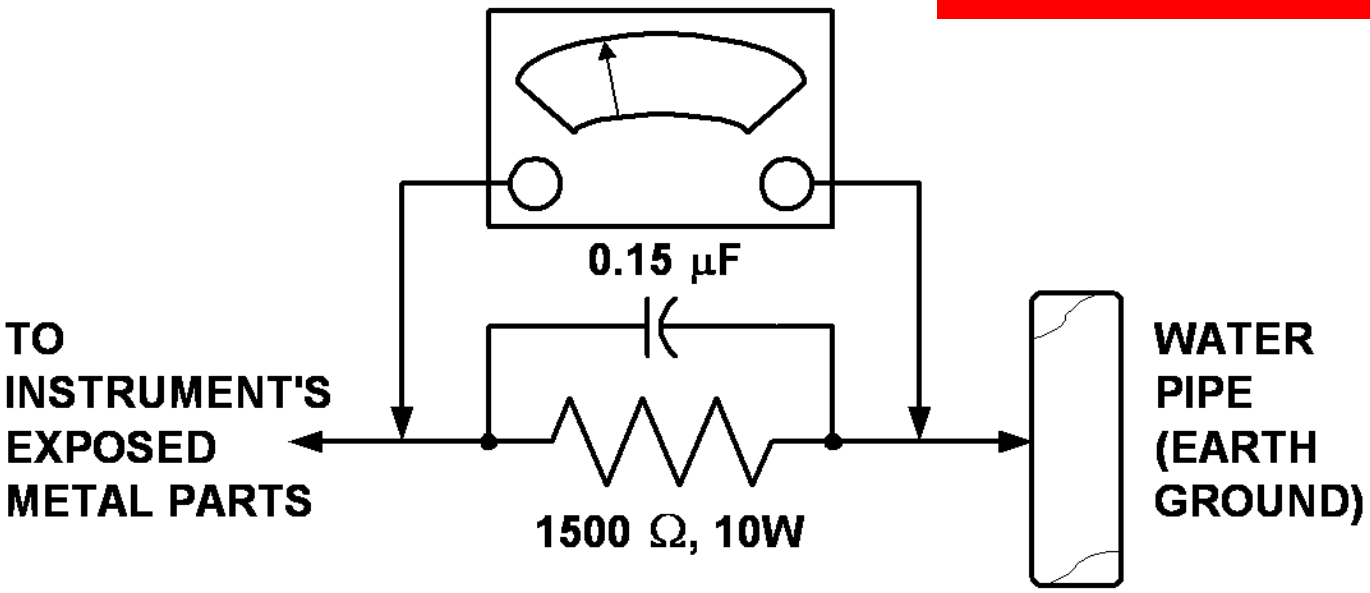
Servicing Safety



AC Safety Leakage - Testing

- Safety leakage test ensures that monitor doesn't have AC leakage to exposed metal parts
- Service literature specifies that a safety leakage test be performed at the completion of all repairs
- Safety leakage testing applies to all consumer electronic devices powered from the AC line, whether or not they have a 3-wire power cord
- Underwriter's Laboratory (UL) standard is 500 ma
- Other standards may apply
- International Electrotechnical Commission (IEC) standard is 700 μa

Typical Safety Leakage Test



1 **Do not use an isolation transformer for this test. Plug the completely reassembled unit directly into the ac outlet.**

2 **Connect a 1.5K, 10W resistor paralleled by an .015uF capacitor between each exposed metal cabinet part and a good earth ground such as a water pipe, as shown above.**

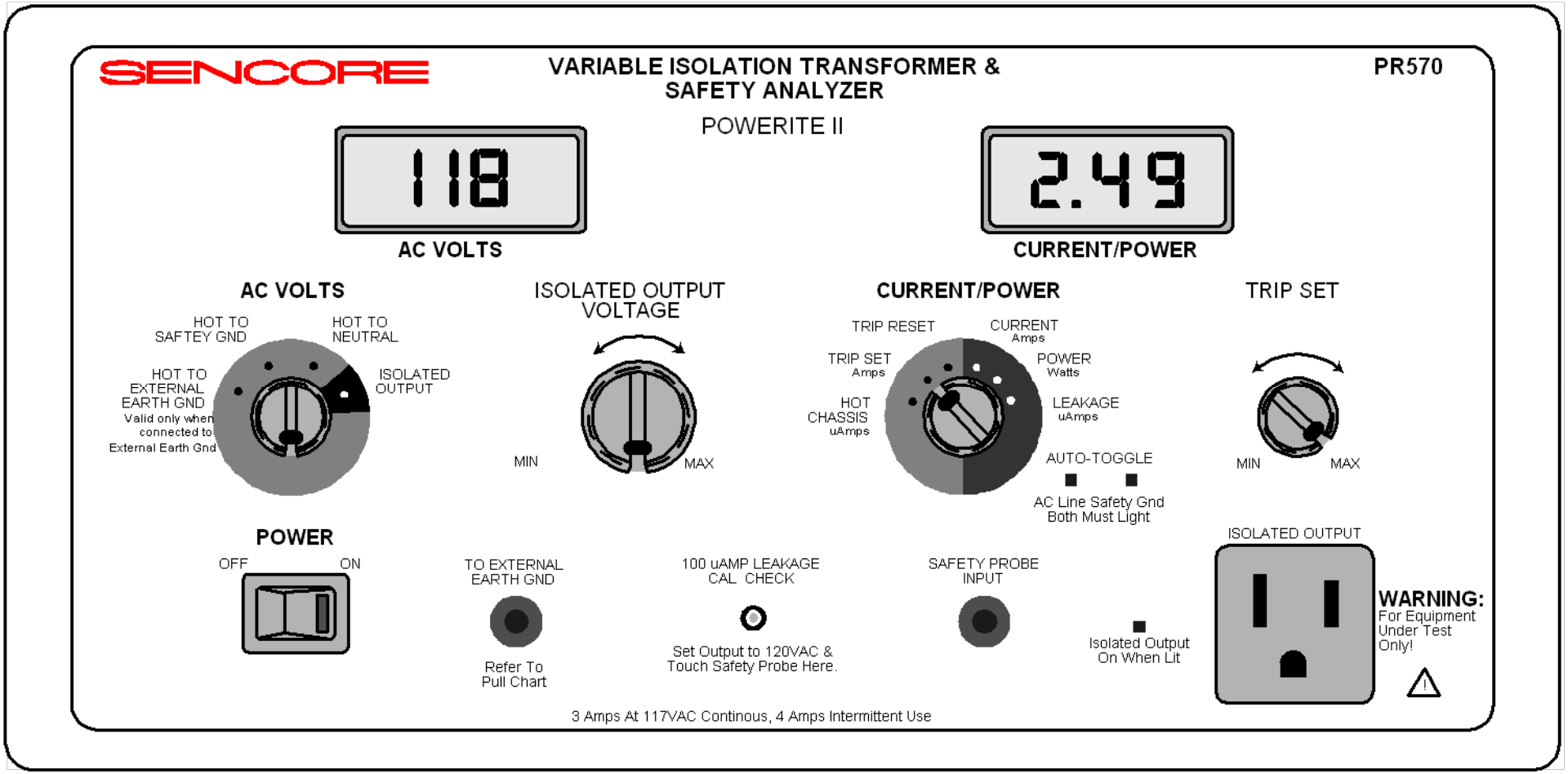
3 **Use an ac voltmeter with at least 5000 ohms/volt sensitivity to measure the potential across the resistor.**

4 **The potential at any point should not exceed 0.75 volts. A leakage current tester may be used to make this test; leakage current must not exceed 0.5 milliamps. If a measurement is outside of the specified limits, there is a possibility of shock hazard. The chassis should be repaired and rechecked before returning it to the customer.**

5 **Repeat the above procedure with the ac plug reversed. (Note: An ac adapter is necessary when a polarized plug is used. Do not defeat the polarizing feature of the plug.)**

PR570

Equipment Familiarization

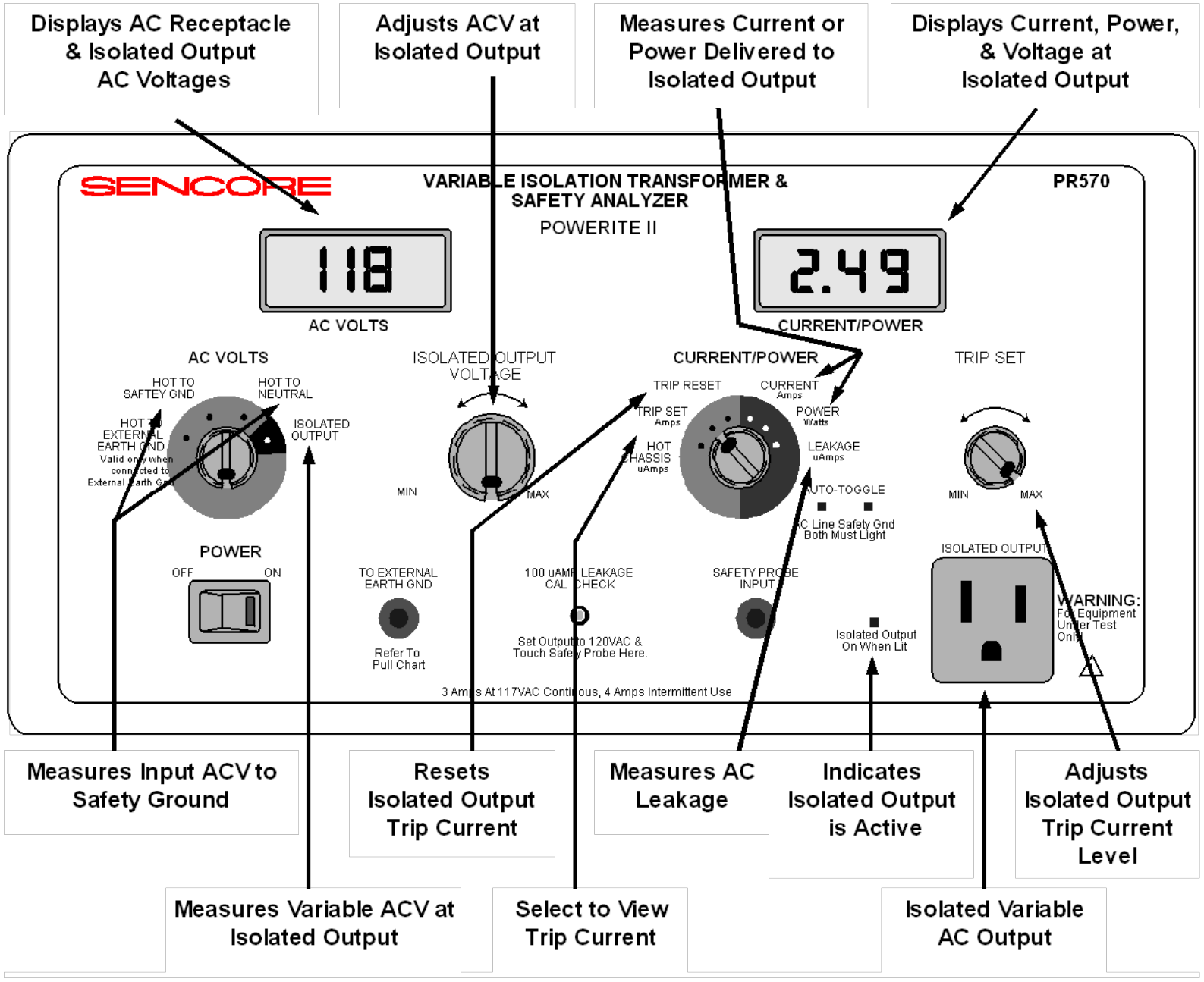


- **Variable Isolation Transformer**
- **Safety Analyzer**

PR570

Equipment Familiarization

TS400 Book - page 7



Regulation

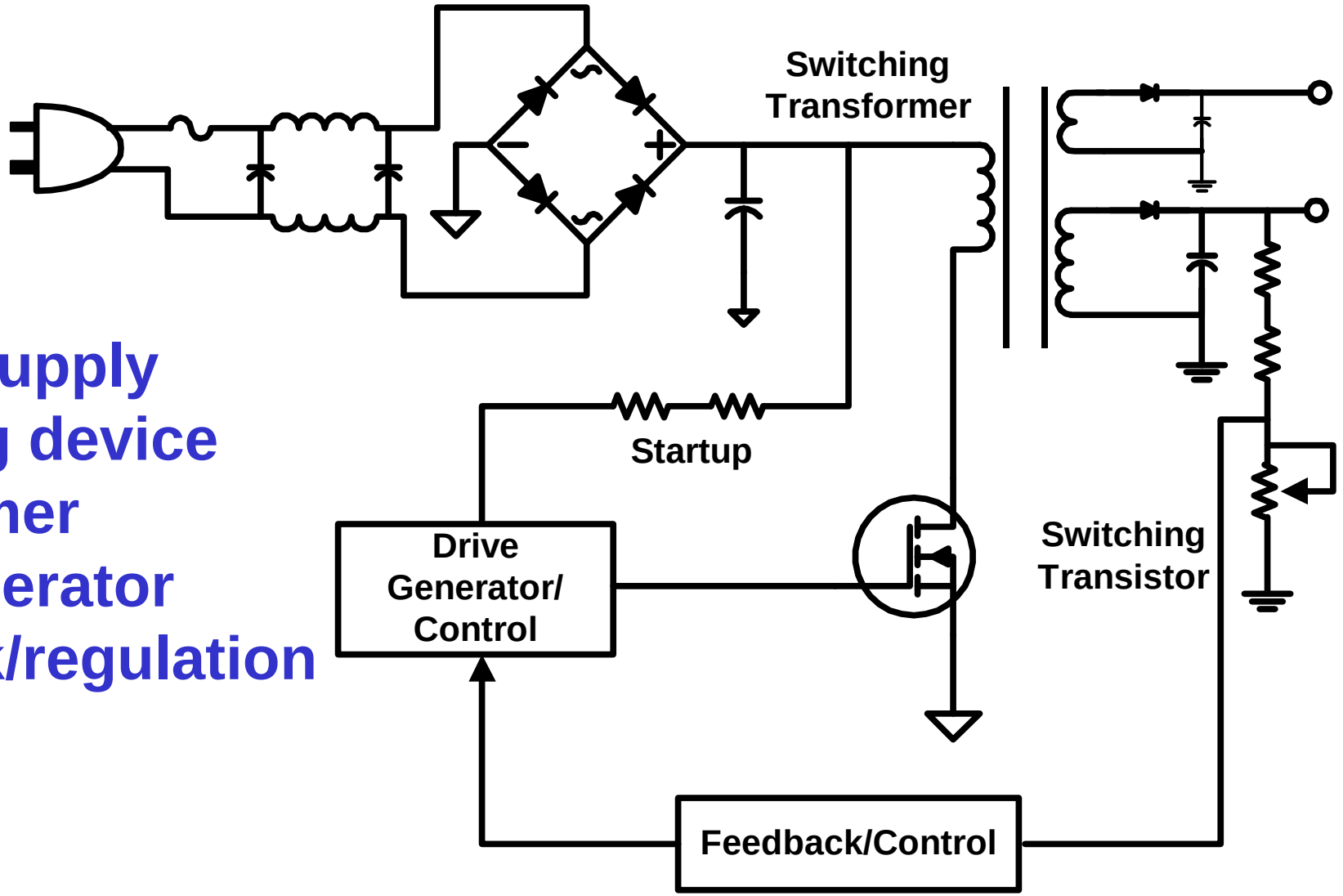
- Raw B+ power supply has only one output and no regulation
- Power supplies must maintain a constant output voltage
  - Must detect and compensate for AC line voltage variations and load changes
- Three ways to regulate power supply output voltages:
  - Series Linear Pass
  - PWM Switch Mode Power Supply
  - PRM Switch Mode Power Supply

Regulation

- SMPS advantages vs. linear supply
  - Higher efficiency
  - Tighter output voltage regulation
  - Smaller size and weight
- Early SMPS
  - Mechanical vibrator used in early automobiles
  - TV and monitor scan derived power supplies
- SMPS troubleshooting can be confusing, costly& frustrating without a logical and controlled troubleshooting procedure

All SMPs include these basic operational blocks:

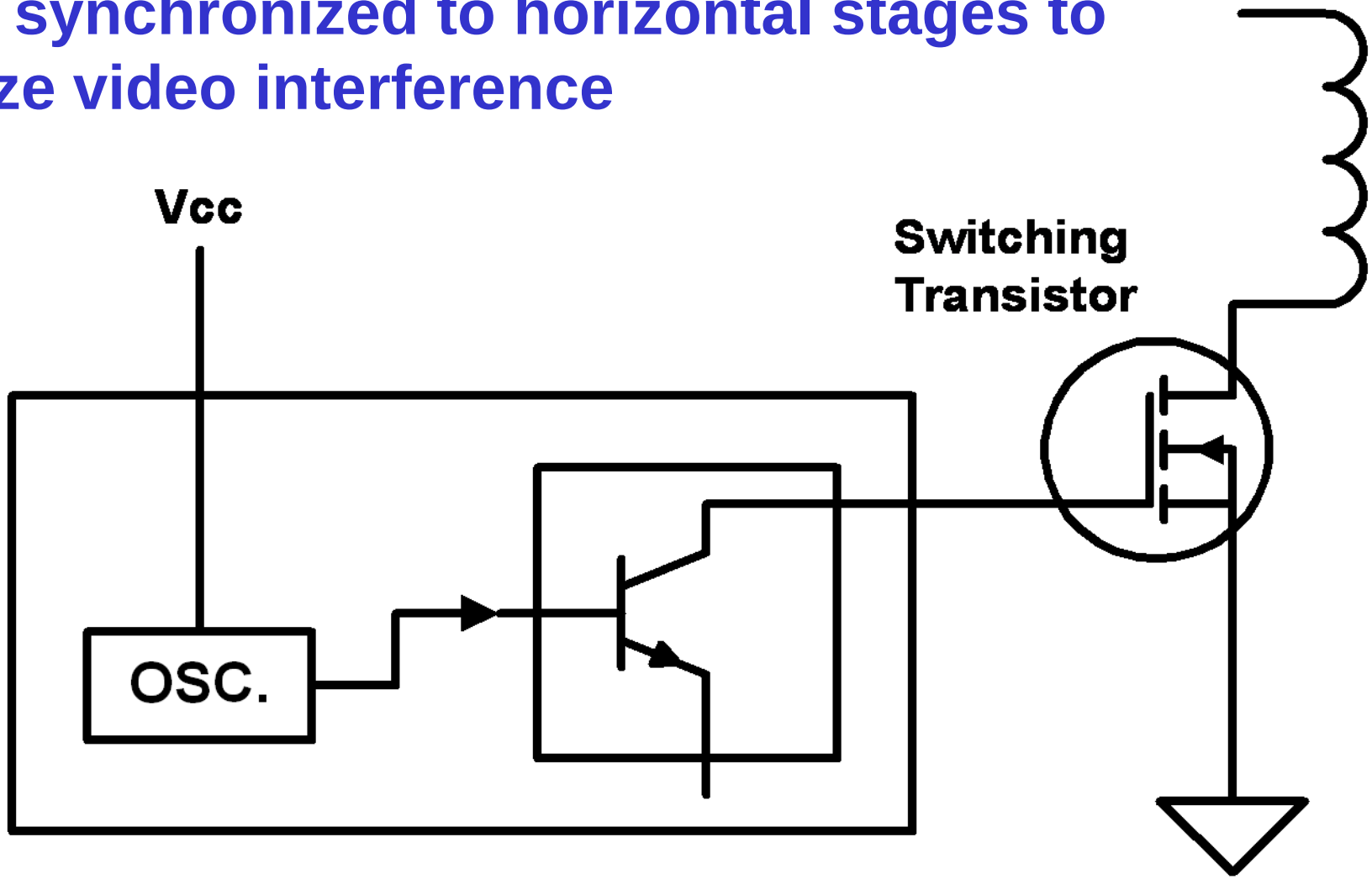
- Raw B+ supply
- Switching device
- Transformer
- Drive generator
- Feedback/regulation



Pulse Width Switching Supply

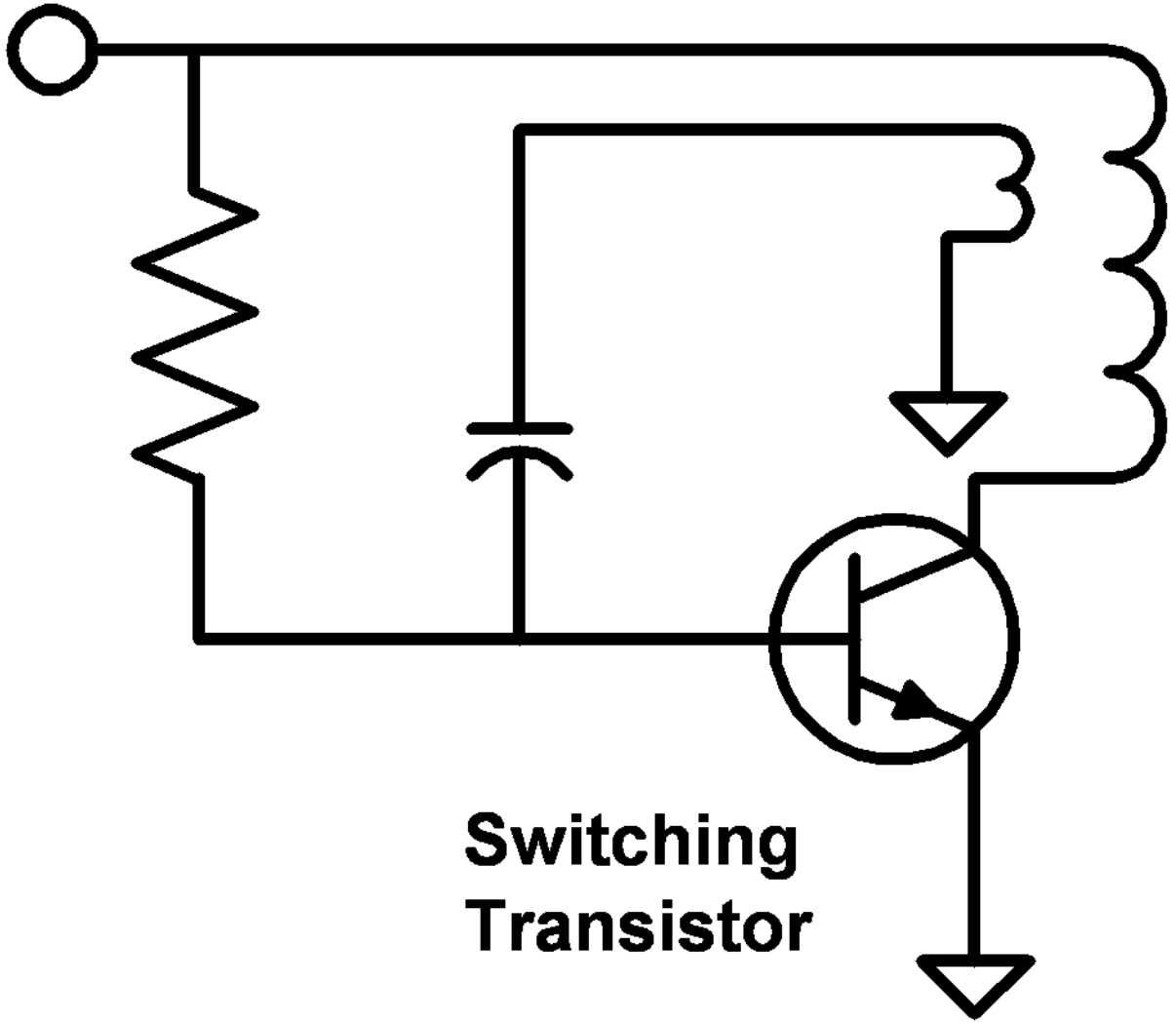
Drive = IC Oscillator

Can be synchronized to horizontal stages to minimize video interference



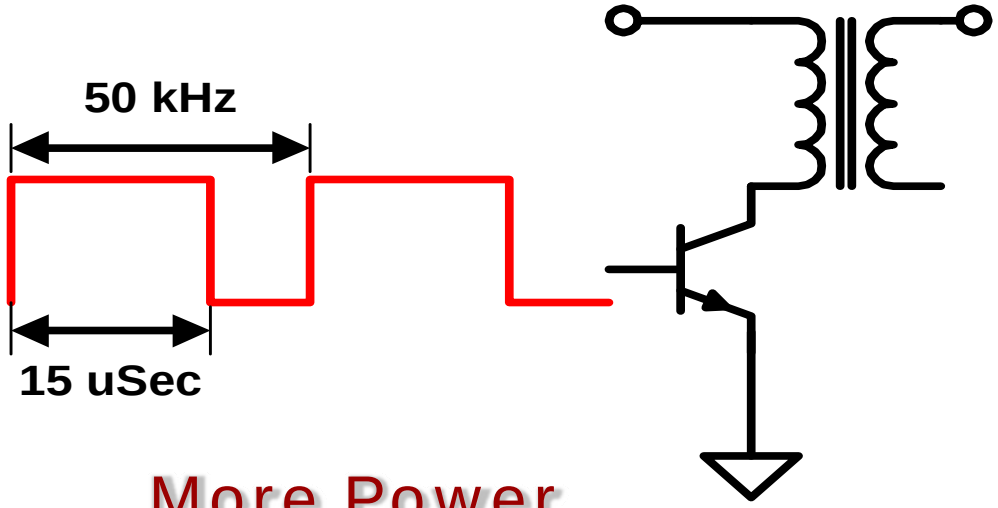
Pulse Rate Switching Supply

Drive = Self-Oscillation

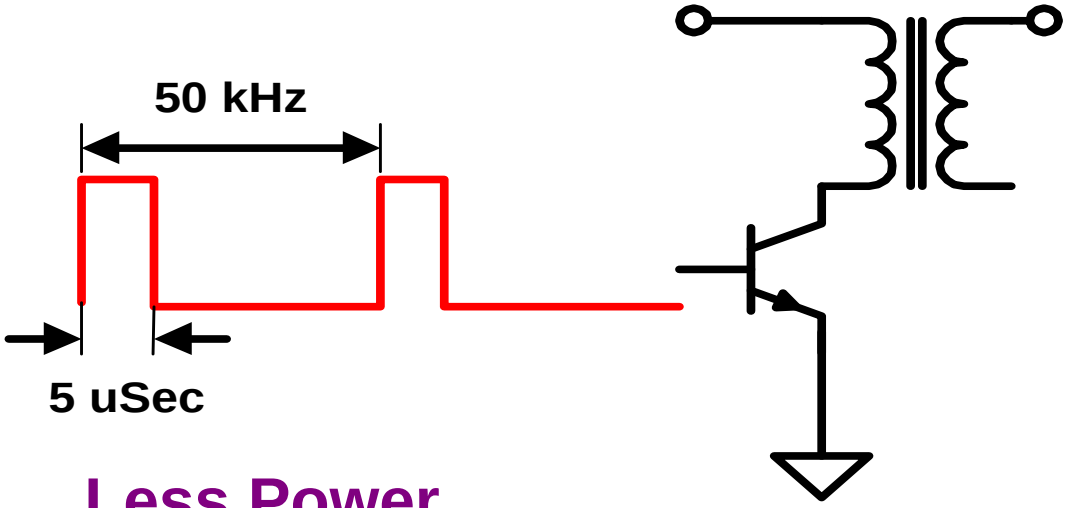


Regulation

Pulse Width

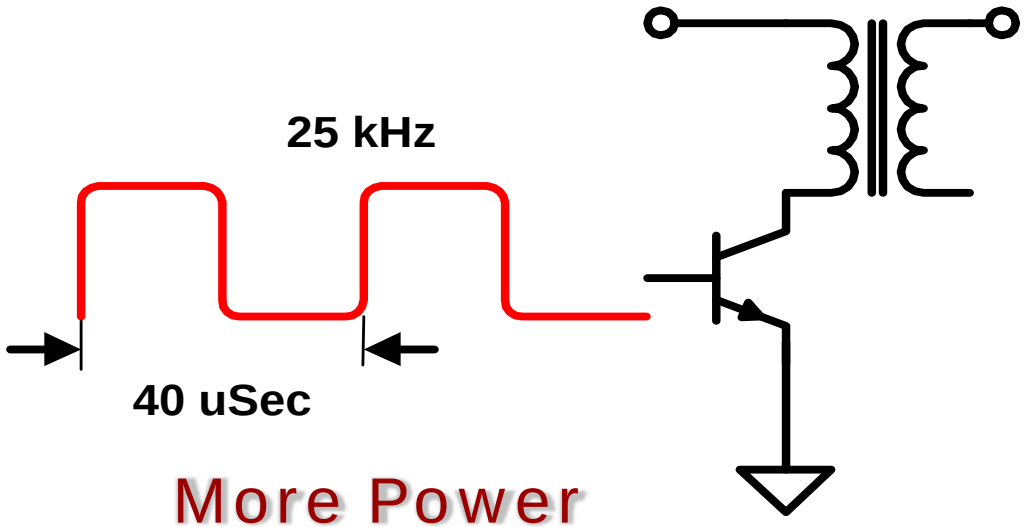


More Power

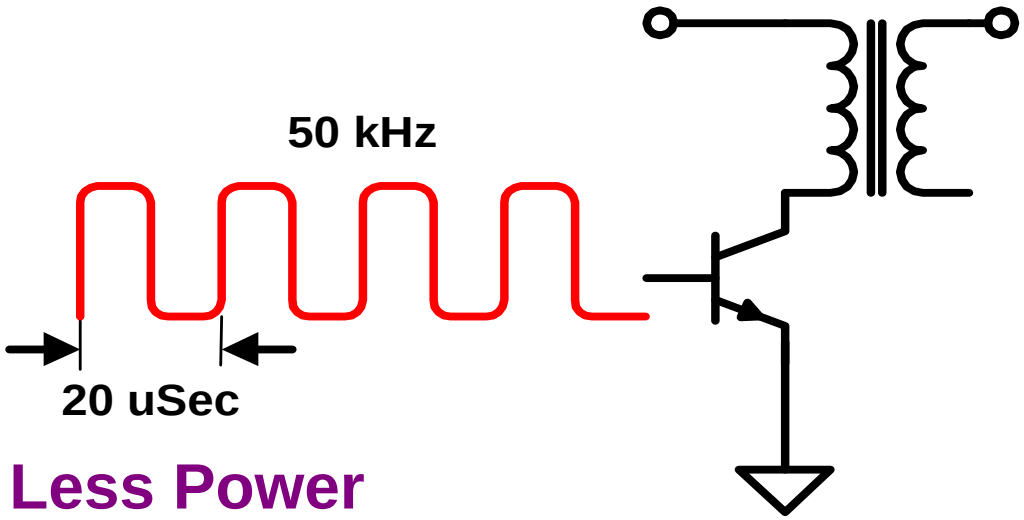


Less Power

Pulse Rate $X_L = 2\pi fL$ > f = > X_L = < power induced



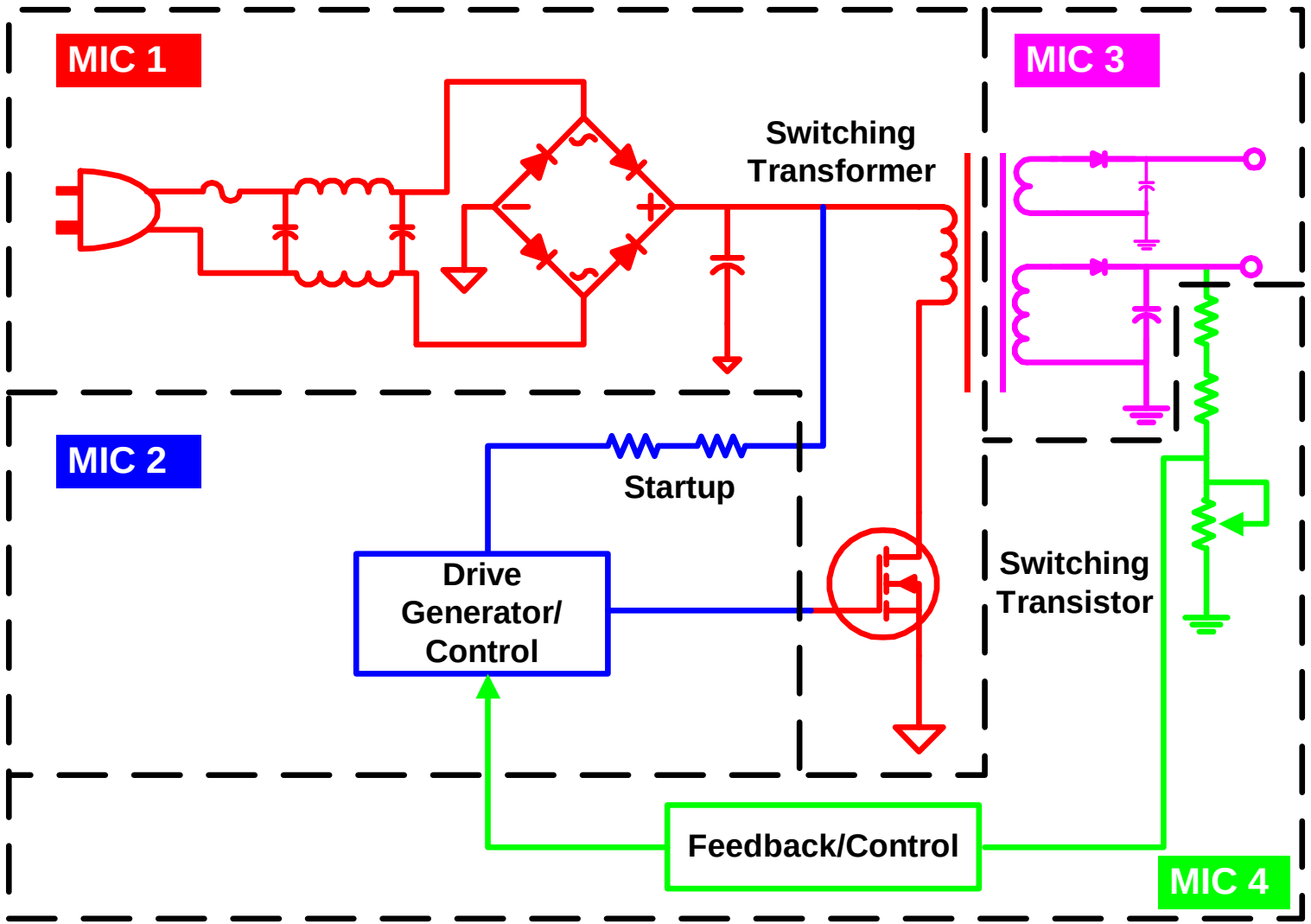
More Power



Less Power

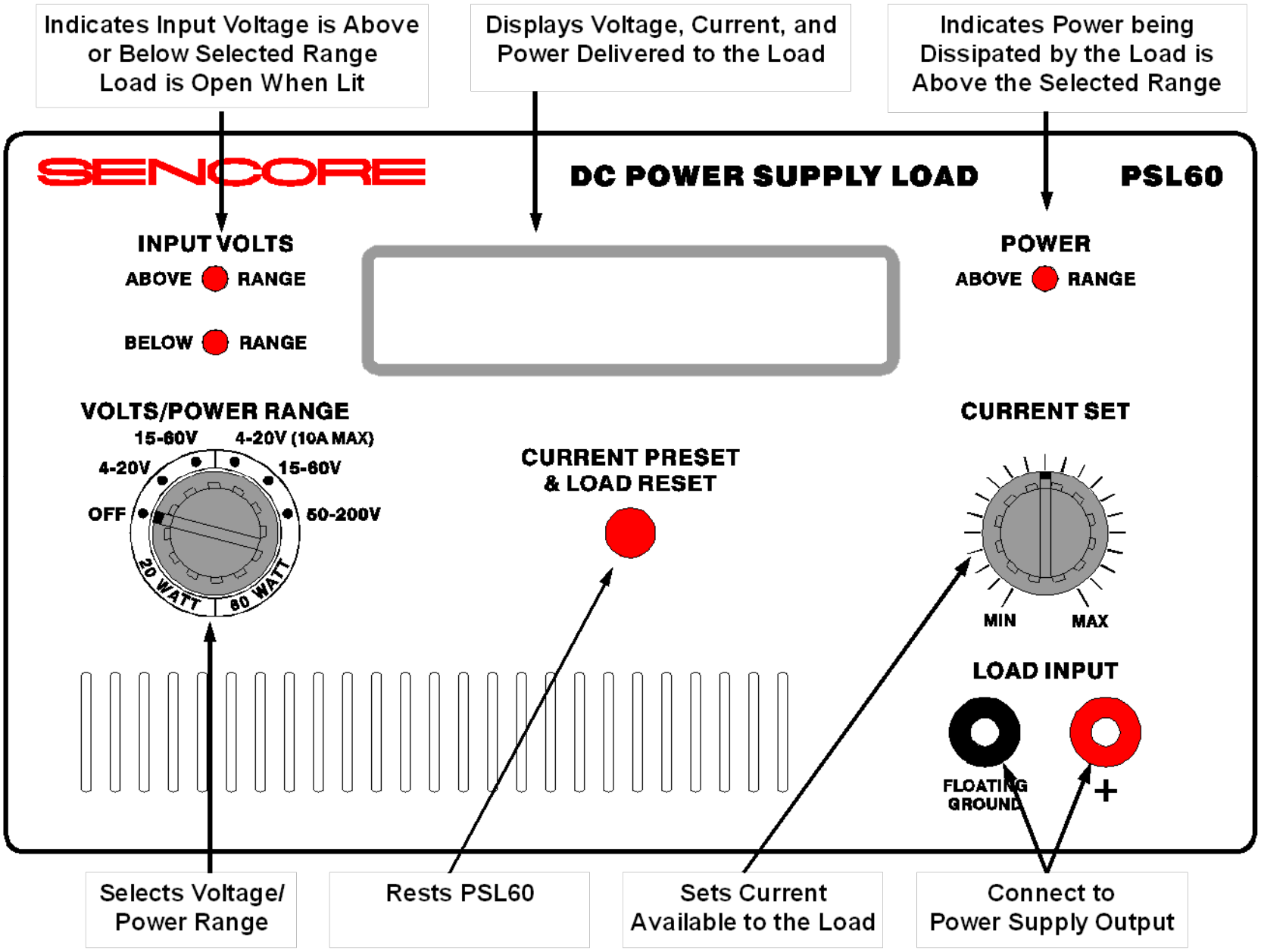
Most Important Circuits

- **Simplified switch mode power supply block diagram with Most Important Circuits (MIC) identified**



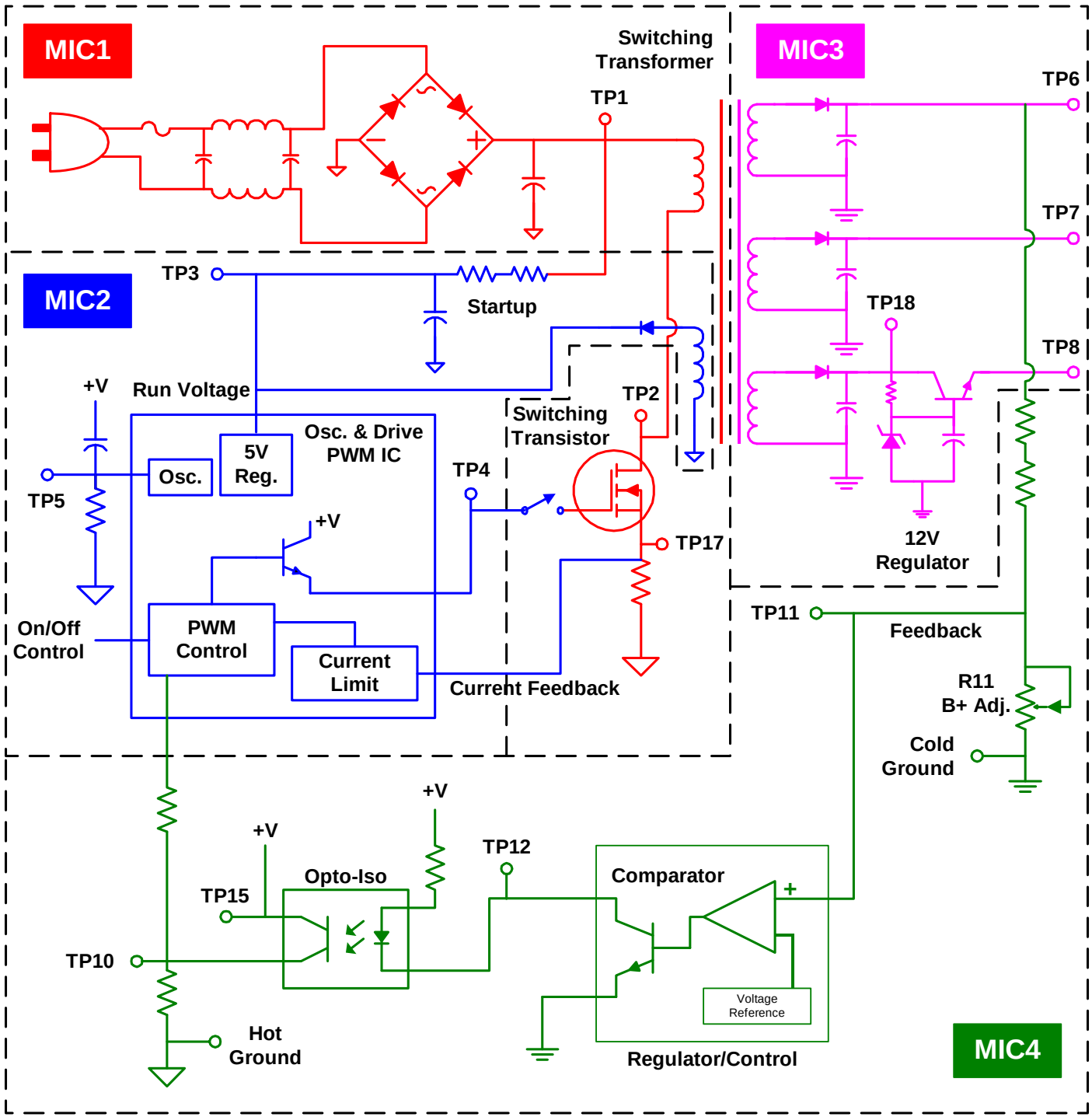
PSL60

Equipment Familiarization



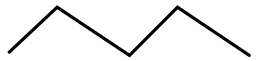
Simplified Schematic

Pulse Width SMPS
pg. 26



Pulse Width SMPS

Trainer Familiarization

Test Point	Ground	DCV	VPP	Frequency	Timebase	Waveform
TP1	HOT	157.3	5.3	120Hz	2ms	
TP2	HOT	157.3	331	25.5KHz	10µS	
TP3	HOT	15.3	N/A	None	None	None
TP4	HOT	2.0	14.7	25.5KHz	10µS	
TP5	HOT	1.9	1.76	25.5KHz	10µS	
TP10	HOT	2.28	.67	None	None	None
TP17	HOT	.06	2.5	25.5KHz	10µS	
TP6	COLD	150.0	.9	None	None	None
TP7	COLD	92.0	.7	None	None	None
TP8	COLD	12.5	.04	None	None	None
TP11	COLD	2.5	.158	None	None	None
TP12	COLD	9.28	.41	None	None	None

Pulse Width SMPS

Trainer Familiarization

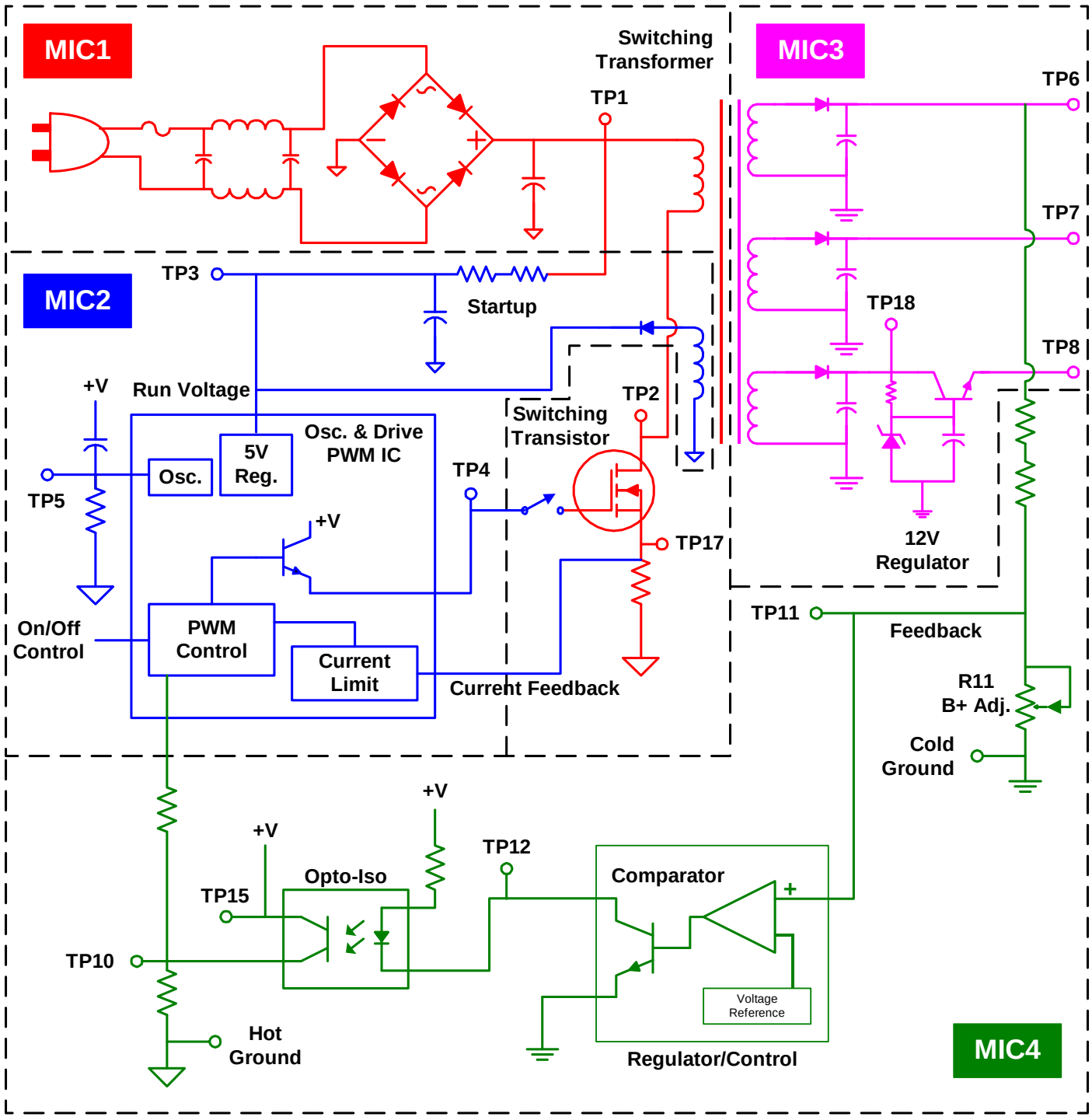
Test Point	Ground	DCV	VPP	Frequency	Timebase	Waveform
TP3	HOT	10 - 13	0 - 5.3	None	None	None
TP4	HOT	.5 - .9	1 - 6	None	5mS	

AC Input Voltage	TP6 DCV	TP4 Total Time (1 cycle)	TP4 On Time (+ going)
40VAC	150	39.2µS	14µS
120VAC	150	39.3µS	4µS

PSL5-50 Load Watts	Current PR570 Amps	Power PR570 Watts	TP6 DCV	TP4 Total Time 1 Cycle	TP4 On Time (+ going)	TP17 Delta DC
10W	.17	23	150	39.2µS	4µS	.49
20W	.25	33	150	39.2µS	5µS	.60
30W	.31	40	150	39.2µS	6µS	.72
40W	.41	52	150	39.2µS	7µS	.84
50W	.48	65	149.2	39.2µS	8µS	.97

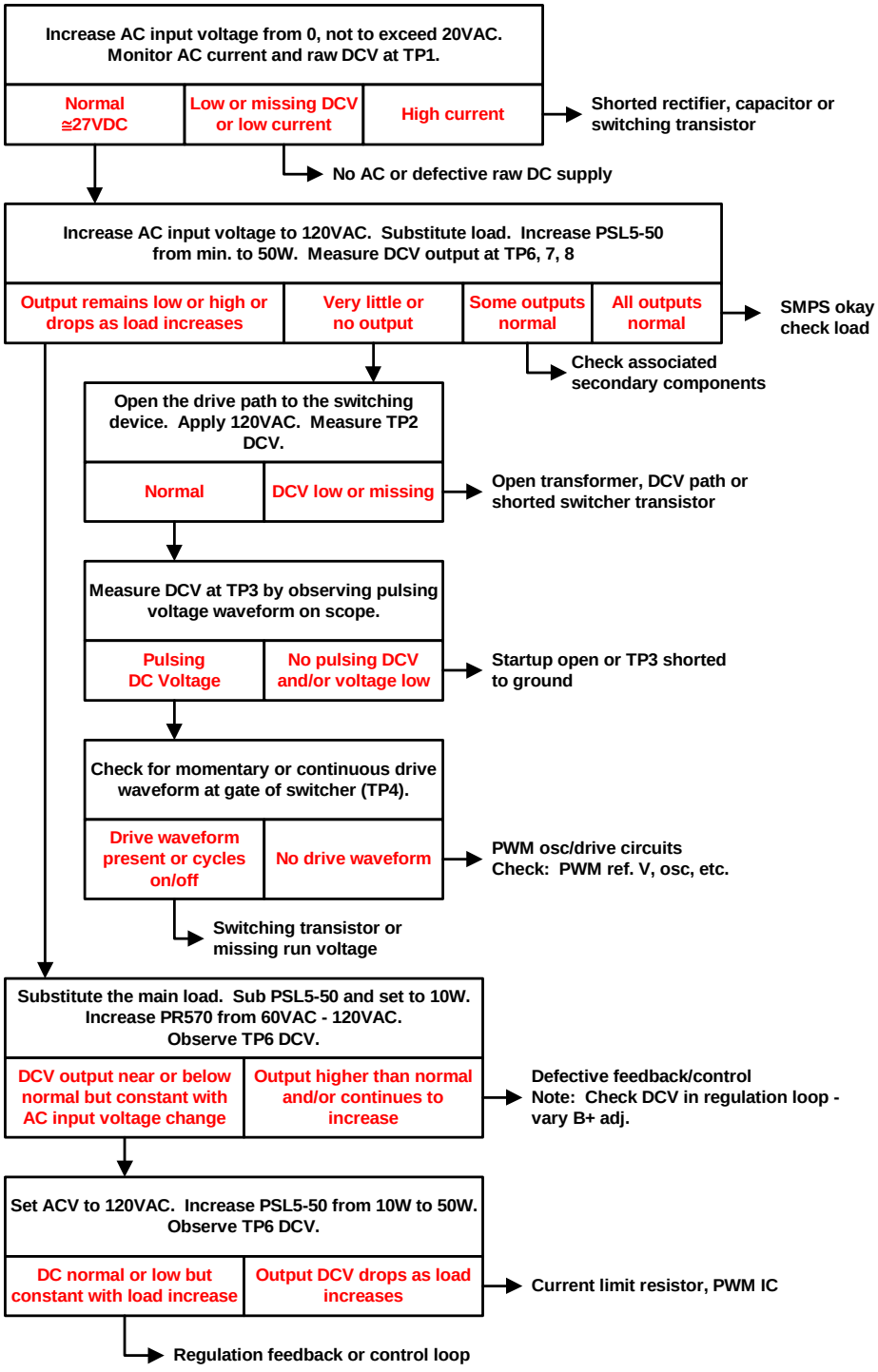
Simplified Schematic

Pulse Width SMPS
pg. 26



Troubleshooting Tree

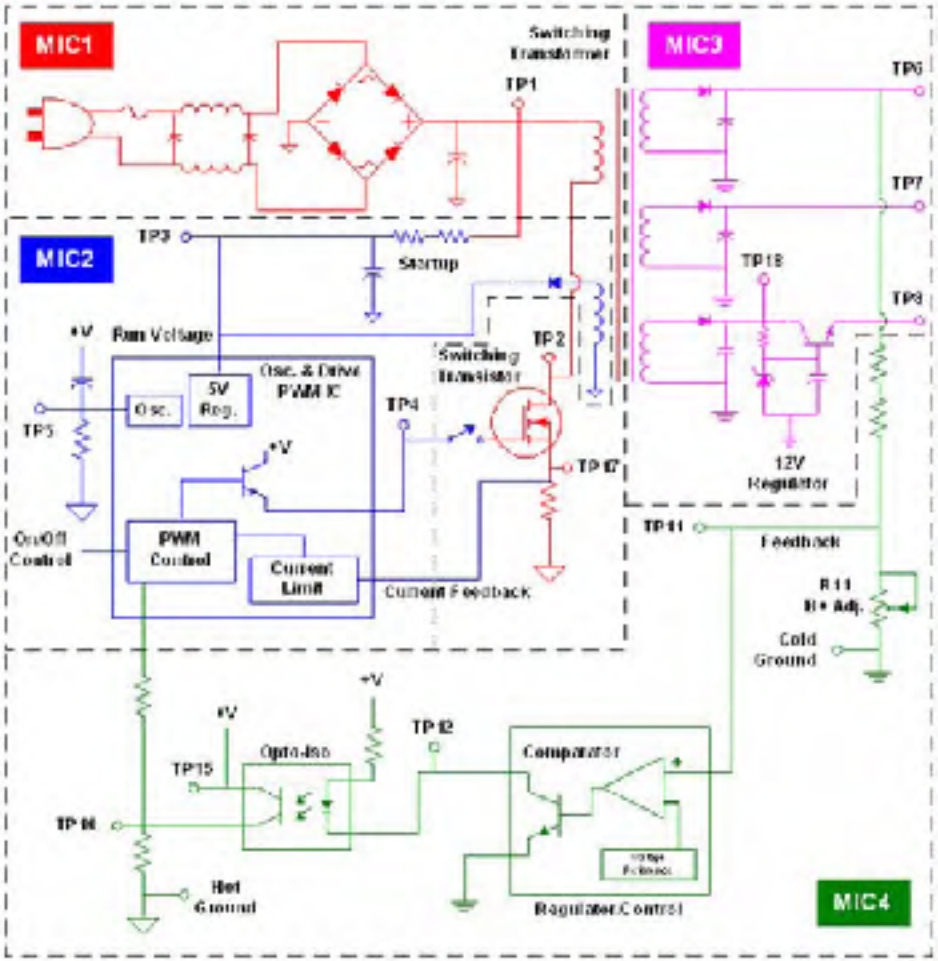
Pulse Width SMPS pg. 27



Troubleshooting

- ☑ **Check Raw DC Supply**
- ☑ **Check Regulated Outputs**
- ☑ **Check Primary DCV**
- ☑ **Check Startup**
- ☑ **Check PWM Osc/Drive**
- ☑ **Check Regulation/Feedback Control**
- ☑ **Check Current Control**

Simplified Pulse Width Modulated (PWM) SMPS



- Raw DC Supply
- Regulated DC Outputs
- Primary DCV
- Startup DCV
- PWM Oscillator & Drive
- Regulation Feedback Control
- Current Control

Troubleshooting Tree

Increase AC input voltage from 0, not to exceed 20VAC. Monitor AC current and raw DCV at TP1.

- Normal ≥27VDC → Increase AC input voltage to 120VAC. Substitute load. Increase PSLS-50 from min. to 50W. Measure DCV output at TP6, 7, 8
- Low or missing DCV or low current → No AC or defective raw DC supply
- High current → Shorted rectifier, capacitor or switching transistor

Increase AC input voltage to 120VAC. Substitute load. Increase PSLS-50 from min. to 50W. Measure DCV output at TP6, 7, 8

- Output remains low or high or drops as load increases → Open the drive path to the switching device. Apply 120VAC. Measure TP2 DCV.
- Very little or no output → Open the drive path to the switching device. Apply 120VAC. Measure TP2 DCV.
- Some outputs normal → Check associated secondary components
- All outputs normal → SMPS okay check load

Open the drive path to the switching device. Apply 120VAC. Measure TP2 DCV.

- Normal → Measure DCV at TP3 by observing pulsing voltage waveform on scope.
- DCV low or missing → Open transformer, DCV path or shorted switcher transistor

Measure DCV at TP3 by observing pulsing voltage waveform on scope.

- Pulsing DC Voltage → Check for momentary or continuous drive waveform at gate of switcher (TP4).
- No pulsing DCV and/or voltage low → Startup open or TP3 shorted to ground

Check for momentary or continuous drive waveform at gate of switcher (TP4).

- Drive waveform present or cycles on/off → PWM osc/drive circuits Check: PWM ref. V, osc, etc.
- No drive waveform → Switching transistor or missing run voltage

Substitute the main load. Sub PSLS-50 and set to 10W. Increase PR570 from 60VAC - 120VAC. Observe TP6 DCV.

- DCV output near or below normal but constant with AC input voltage change → Defective feedback/control Note: Check DCV in regulation loop - vary B+ adj.
- Output higher than normal and/or continues to increase → Defective feedback/control Note: Check DCV in regulation loop - vary B+ adj.

Set ACV to 120VAC. Increase PSLS-50 from 10W to 50W. Observe TP6 DCV.

- DC normal or low but constant with load increase → Current limit resistor, PWM IC
- Output DCV drops as load increases → Current limit resistor, PWM IC

Regulation feedback or control loop

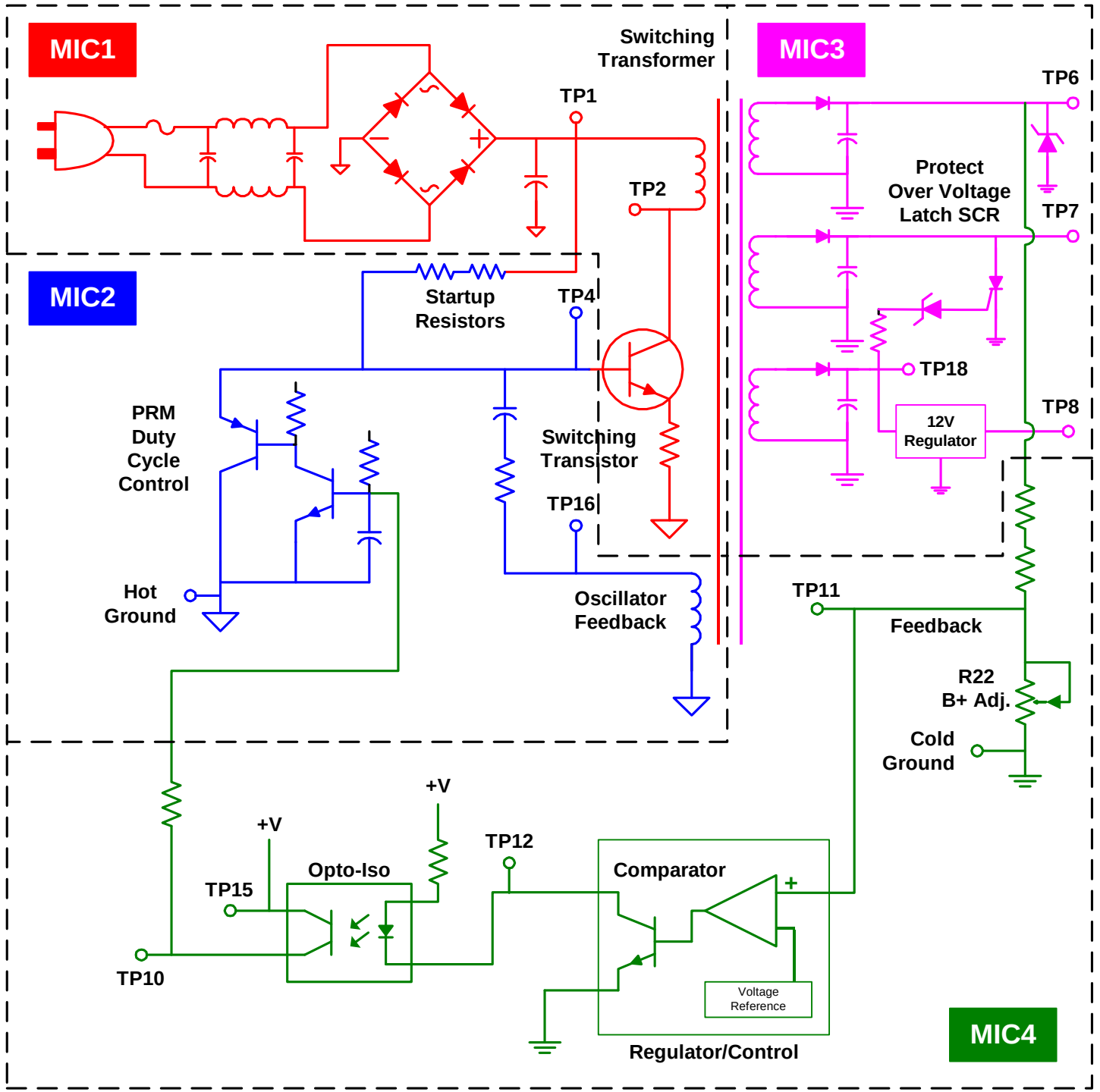
Troubleshooting

- ☑ **Check Raw DC Supply**
- ☑ **Check Regulated Outputs**
- ☑ **Check Primary DCV**
- ☑ **Check Startup**
- ☑ **Check PWM Osc/Drive**
- ☑ **Check Regulation/Feedback Control**
- ☑ **Check Current Control**

Simplified Schematic

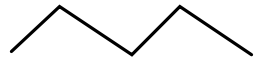
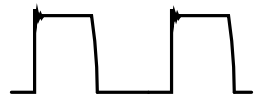
Pulse Rate SMPS

- Able to self-protect
- "Crowbar shutdown



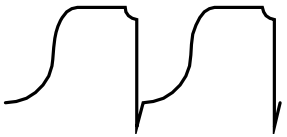
Pulse Rate SMPS

Trainer Familiarization

Test Point	Ground	DCV	VPP	Frequency	Timebase	Waveform
TP1	HOT	160	3.8	120Hz	2ms	
TP2	HOT	160	291	53KHz	5µS	
TP4	HOT	-.07	4	53KHz	5µS	
TP10	HOT	-.42	3.3	None	None	None
TP15	HOT	3.86	.35	None	None	None
TP16	HOT	0	12.6	53KHz	5µS	
TP6	COLD	180	.16	None	None	None
TP7	COLD	71.4	.07	None	None	None
TP8	COLD	12	.01	None	None	None
TP11	COLD	2.5	.08	None	None	None
TP12	COLD	8.95	.46	None	None	None
TP18	COLD	14.9	.06	None	None	None

Pulse Rate SMPS

Trainer Familiarization

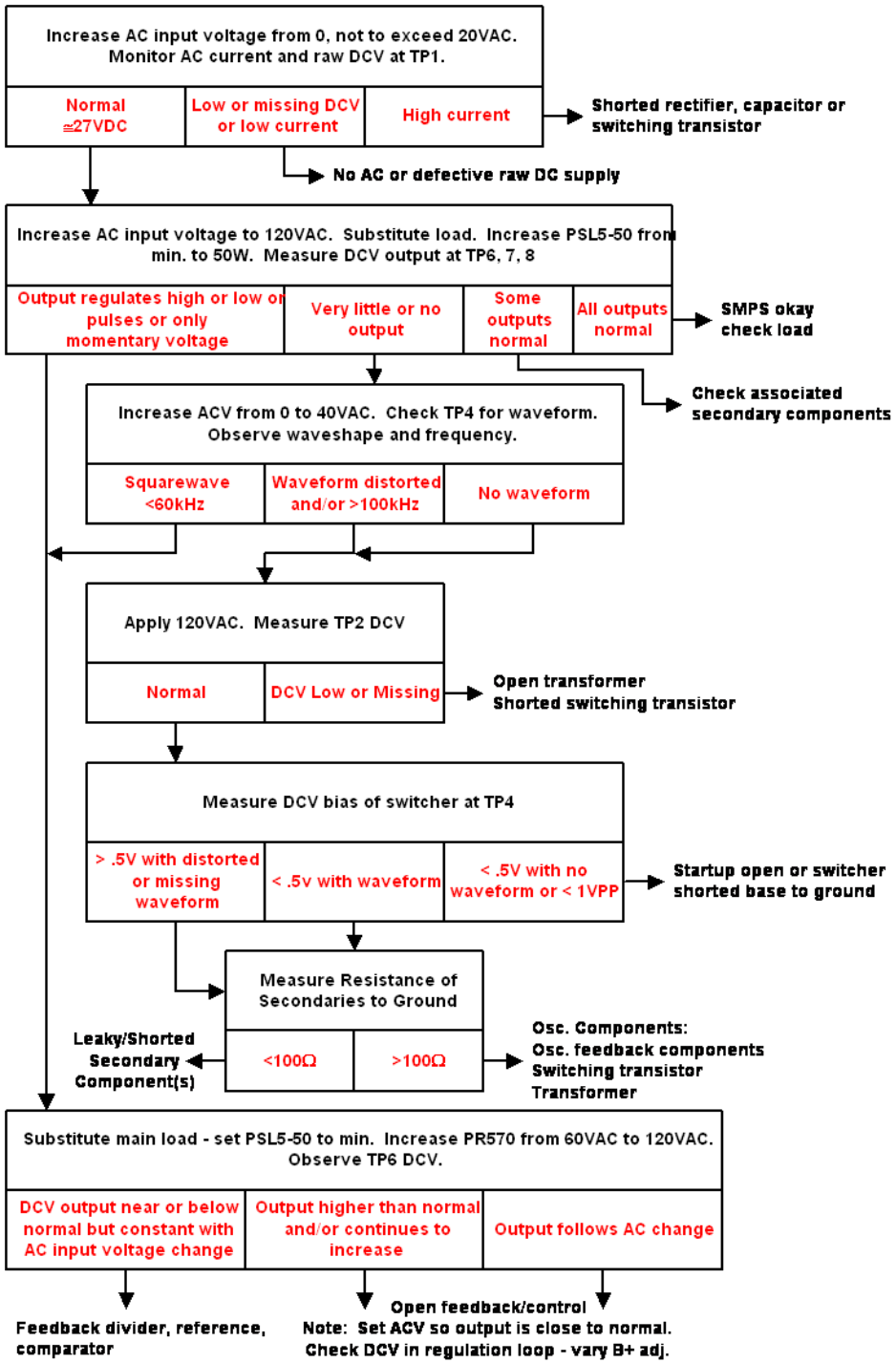
Test Point	Ground	VPP	Frequency	Timebase	Waveform
TP4	HOT	1 - 3	≅ 40KHz	5µS	

AC Input Voltage	TP6 DCV	TP4 Frequency	TP4 Waveform
40VAC	180	28KHz	
120VAC	180	77KHz	

PSL5-50 Load Watts	Current PR570 Amps	Power PR570 Watts	TP6 DCV	TP4 Frequency	TP4 Waveform
10W	.15	20	180	77KHz	
20W	.30	36	180	68KHz	
30W	.38	45	180	56KHz	
40W	.52	62	180	43KHz	
50W	.60	70	180	33KHz	

Troubleshooting Tree

Pulse Rate SMPS



- ☑ **Check Raw DC Supply**
- ☑ **Check Regulated DC Outputs**
- ☑ **Check Self-Oscillation (waveshape/freq.)**
- ☑ **Check Primary DCV**
- ☑ **Check Startup**
- ☑ **Check Regulation/Feedback Control**

Isolating Defective Components

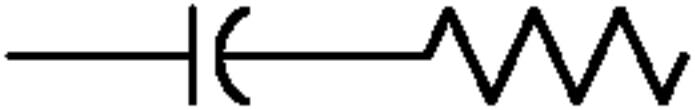
- Once a defect has been localized, the suspect components should be tested
  - Only components that test bad should be replaced
- Random component replacement greatly increases the potential for error
- Many SMPS circuits are unforgiving
  - Component replacement errors may damage other components or create a second symptom or problem that may remain hidden, further complicating an already difficult repair
- SMPS circuits are less tolerant of components that age and change parameters

Isolating Defective Components

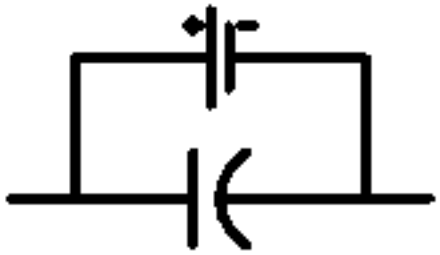
Capacitors fail in one of four ways

- Value Change
- Excessive dielectric absorption (DA)
- Excessive leakage
- High equivalent series resistance (ESR)

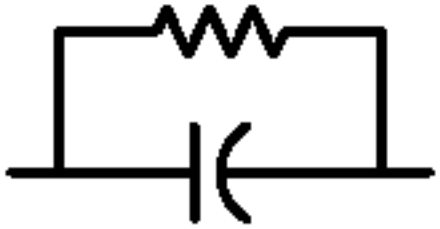
Value Change



ESR



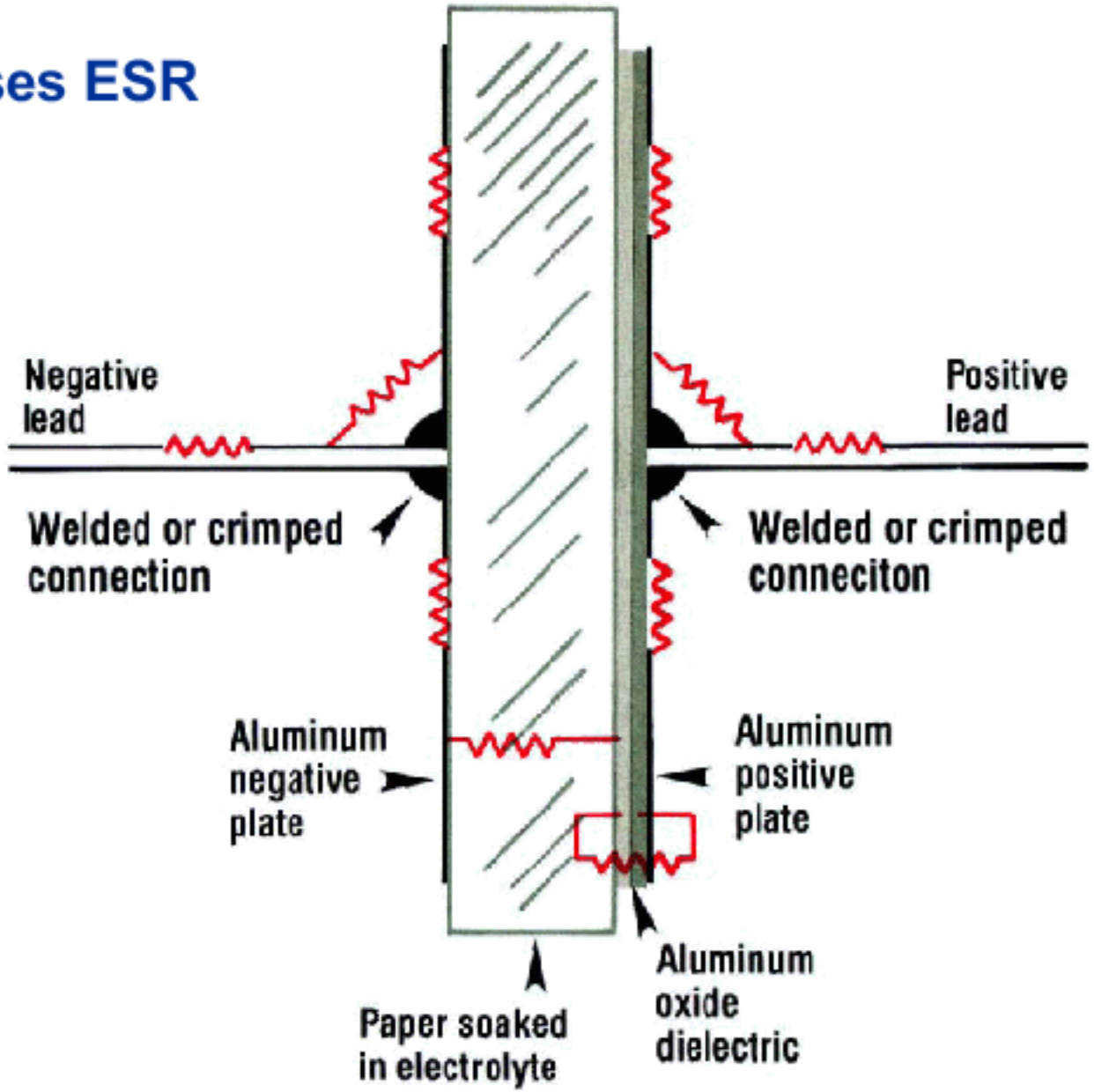
Dielectric Absorption



Leakage

A value change alone is rare

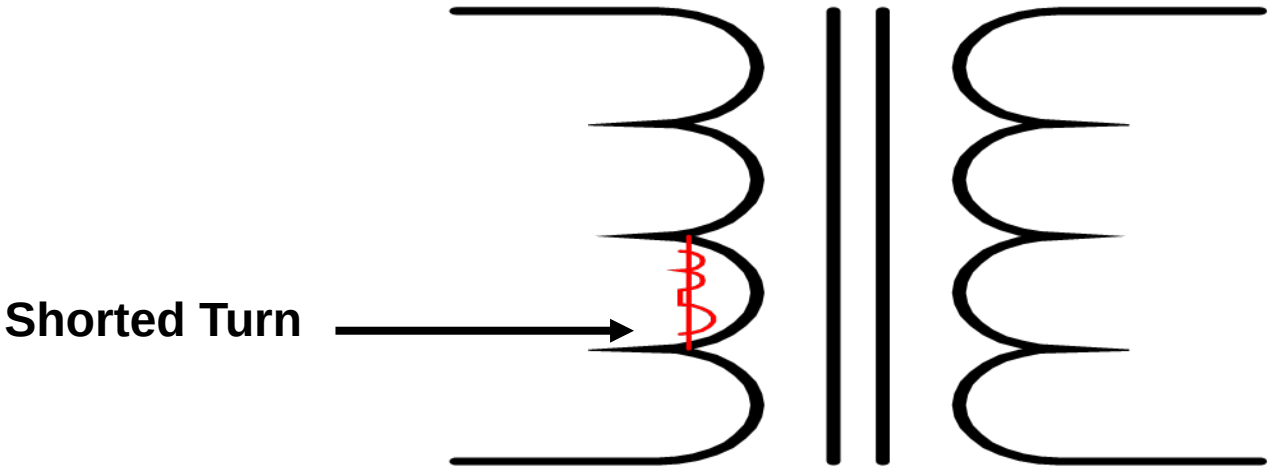
What causes ESR



Isolating Defective Components

Inductors and transformers fail in one of four ways

- Open
- Short
- Value change
- Shorted turn



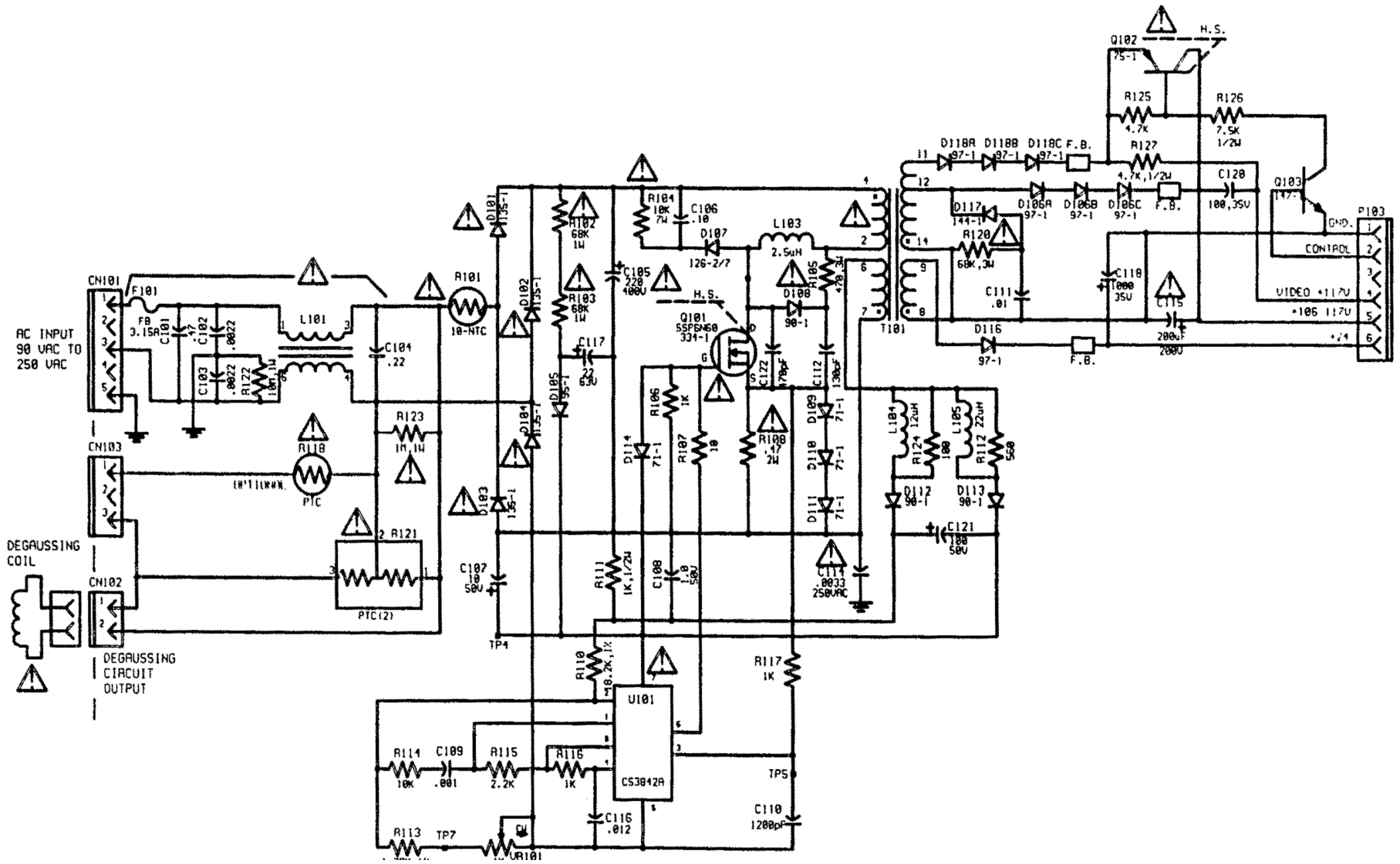
The most common inductor and transformer failure is a single shorted turn within a winding

Isolating Defective Components

Transistors and diodes can fail in many ways

- **Short**
- **Open**
- **Leaky**
- **Insufficient gain (beta)**

Efficient SMPS troubleshooting requires the use of a thorough method to analyze components


AC INPUT
90 VAC TO
250 VAC
CN101
F101
FB
3.15A
C101
C102
.0022
C103
.0022
R122
180,1W
L101
C104
.22
R101
10-NTC
R123
1M,1W
CN103
R118
(OPTIONAL)
PTC
DEGAUSSING
COIL
CN102
R121
PTC(2)
DEGAUSSING
CIRCUIT
OUTPUT
D101
D102
D103
D104
D105
R102
68K
1W
R103
68K
1W
C105
220
400V
R104
10K
2W
C106
.10
D107
126-2/7
L103
2.5uH
R105
470
3W
D108
90-1
H.S.
Q101
SSP6N60
334-1
C117
22
63V
C122
C112
130pF
R106
1K
R107
10
R108
.47
2W
D114
71-1
D109
D110
D111
71-1
C107
10
50V
R111
1K,1/2W
C108
1.0
50V
C114
.0033
250VAC
TP4
R110
18.2K,1%
U101
CS3842A
R114
10K
C109
.001
R115
2.2K
R116
1K
C116
.012
R113
TP7
VR101
TP5
R117
1K
C110
1200pF
T101
Q102
75-1
H.S.
R125
4.7K
R126
7.5K
1/2W
D118A
D118B
D118C
97-1
F.B.
R127
4.7K,1/2W
C120
100,35V
Q103
D117
144-1
D106A
D106B
D106C
97-1
F.B.
R120
68K,3W
C111
.01
C118
1000
35V
C115
200uF
200V
D116
97-1
F.B.
L104
12uH
L105
22uH
R124
100
R112
560
D112
90-1
D113
90-1
C121
100
50V
P103
GND.
CONTROL
VIDEO +117V
+105 117V
+24

SENCORE

10 Key Computer Monitor Waveforms

Waveform	Located At Block Diagram Test Points
1 	R,G,B Video 11, 12, 13, 14, 21, 22, 23, 24, 31, 32, 33, 34

Vert Atten : 1 VPP to 10 VPP
Waveform Analyzer Setting:
Timebase : 5 µsec Horiz. (VGA)
: 10 msec Vert.

Waveform	Located At Block Diagram Test Points
2 	Vertical Sync. Buffer Input, Output, 40

Waveform Analyzer Setting:
Vert Atten: 1 VPP
Timebase: 10 msec

Waveform	Located At Block Diagram Test Points
3 	Vertical Oscillator 41

Waveform Analyzer Setting:
Vert Atten: 1 VPP
Timebase: 10 msec

Waveform	Located At Block Diagram Test Points
4 	Vertical Driver Output 42

Waveform Analyzer Setting:
Vert Atten: 1 VPP
Timebase: 10 msec

Waveform	Located At Block Diagram Test Points
5 	Vertical Output 43

Waveform Analyzer Setting:
Vert Atten: 20 VPP
Timebase: 10 msec

Waveform	Located At Block Diagram Test Points
6 	Horizontal Sync Buffer Input, Output, 50

Waveform Analyzer Setting:
Vert Atten: 1 VPP
Timebase: 5 µsec

Waveform	Located At Block Diagram Test Points
7 	Horizontal Osc. 51

Waveform Analyzer Setting:
Vert Atten: 2 VPP (VGA)
Timebase: 5 µsec

Waveform	Located At Block Diagram Test Points
8 	Horizontal Driver Output Collector * 52

Waveform Analyzer Setting:
Vert Atten: 50 VPP
Timebase: 5 µsec

Waveform	Located At Block Diagram Test Points
9 	Horizontal Output Base Drive * 52

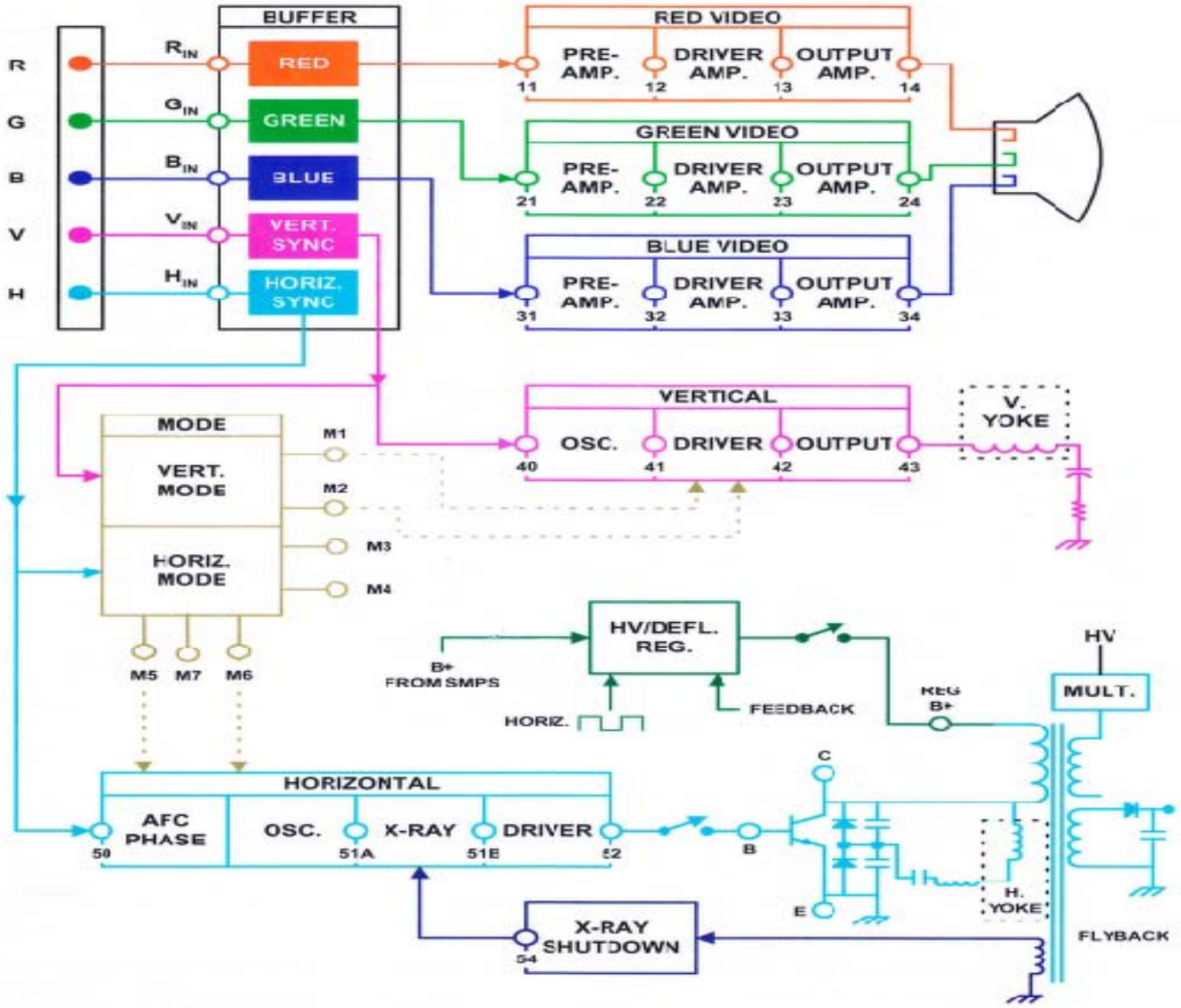
Waveform Analyzer Setting:
Vert Atten: 5 VPP
Timebase: 5 µsec

Waveform	Located At Block Diagram Test Points
10 	Horizontal Output Collector ** 53

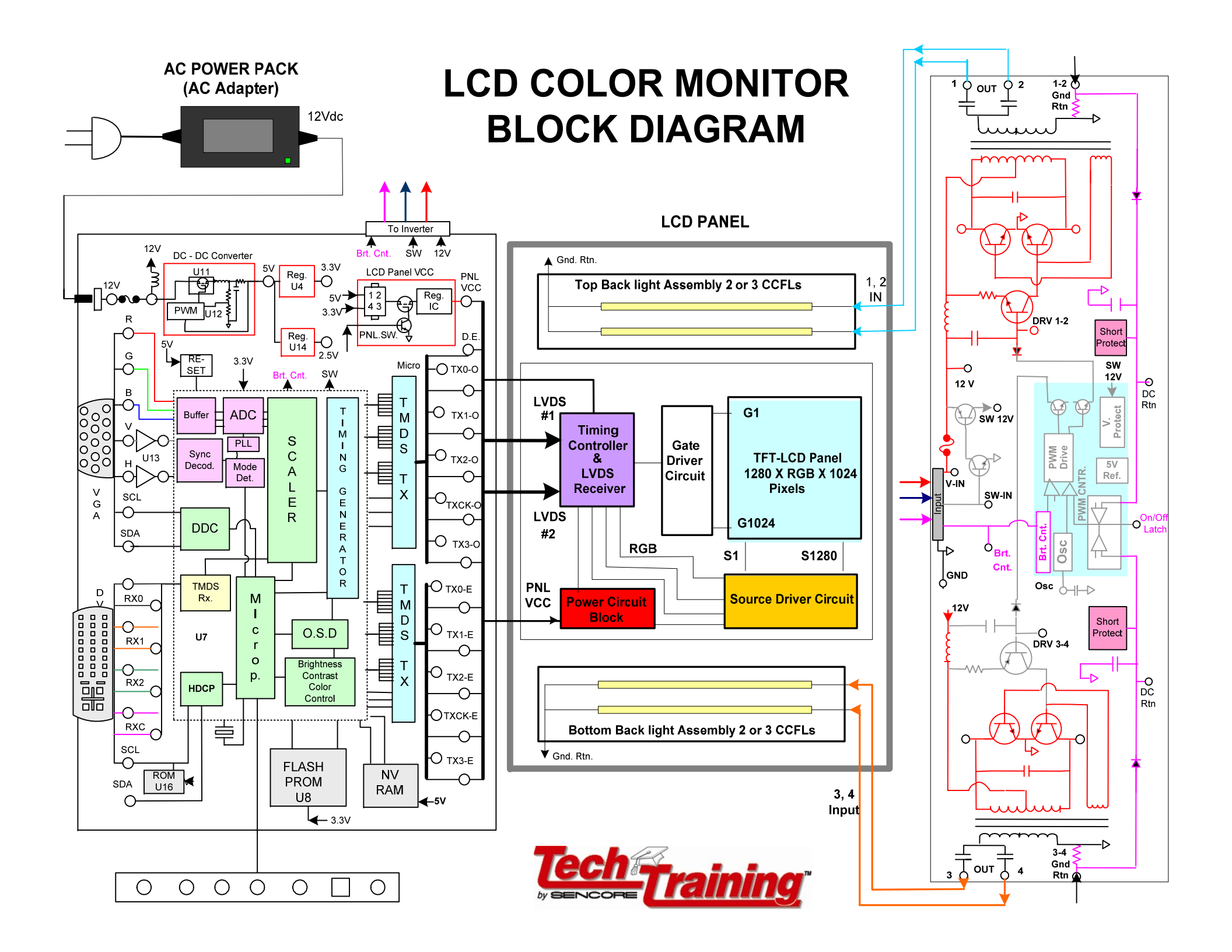
Waveform Analyzer Setting:
Vert Atten: 200 VPP
Timebase: 5 µsec

* One test point location with two waveforms represents voltage output waveform transformed to a current input waveform.
** "Caution" – Most oscilloscopes can be damaged attempting to measure this waveform.

Universal Computer Monitor Block Diagram

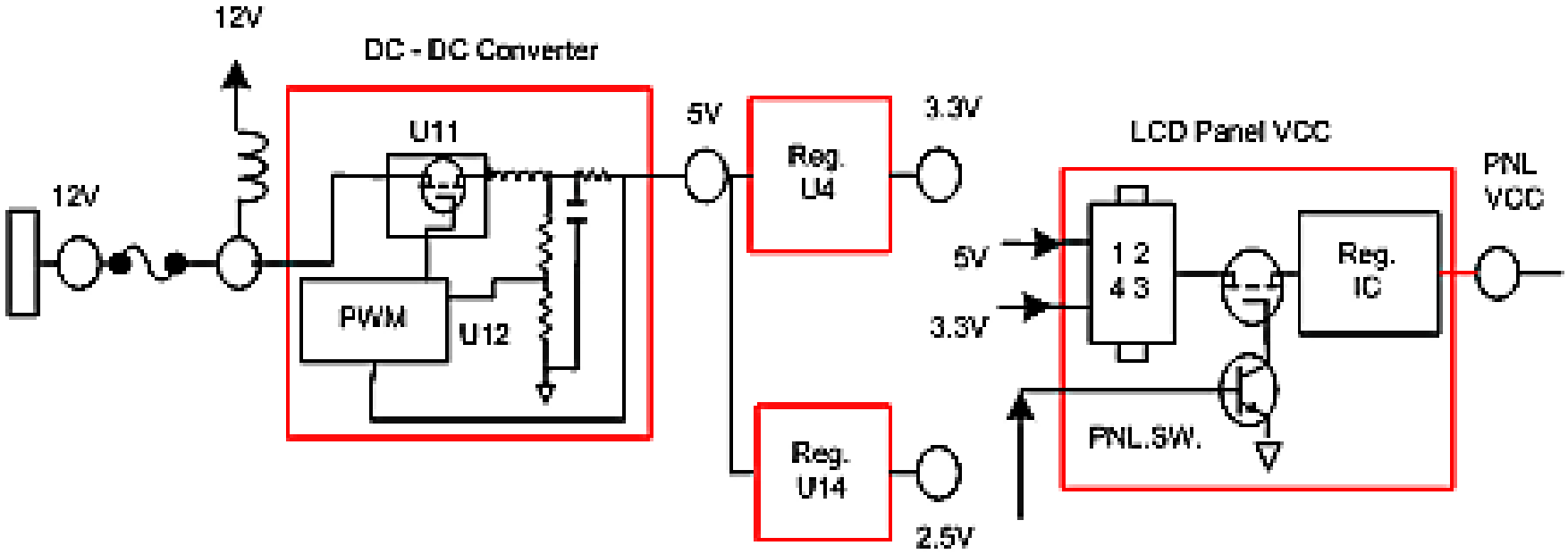


LCD COLOR MONITOR BLOCK DIAGRAM



Tech Training by SENCORE

Main Signal Processing/Controller Board Power Supplies



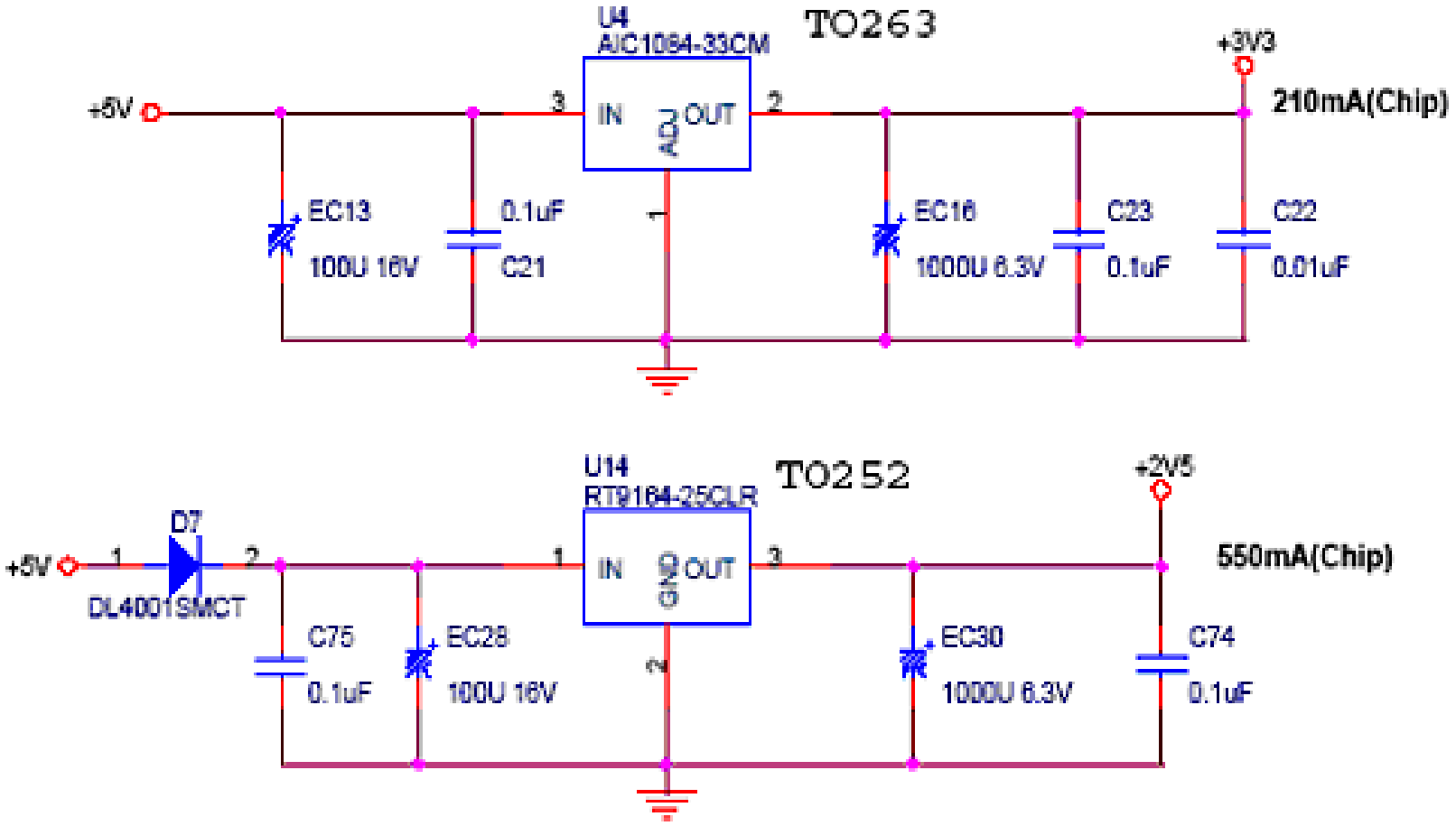
The main signal processing/controller board typically requires 3 power supply voltages - 5V, 3.3V, and 2.5V power supply.

A DC-to-DC converter is a switching power supply that bucks the input 12V down to 5V. The converter outputs a stable regulated 5V

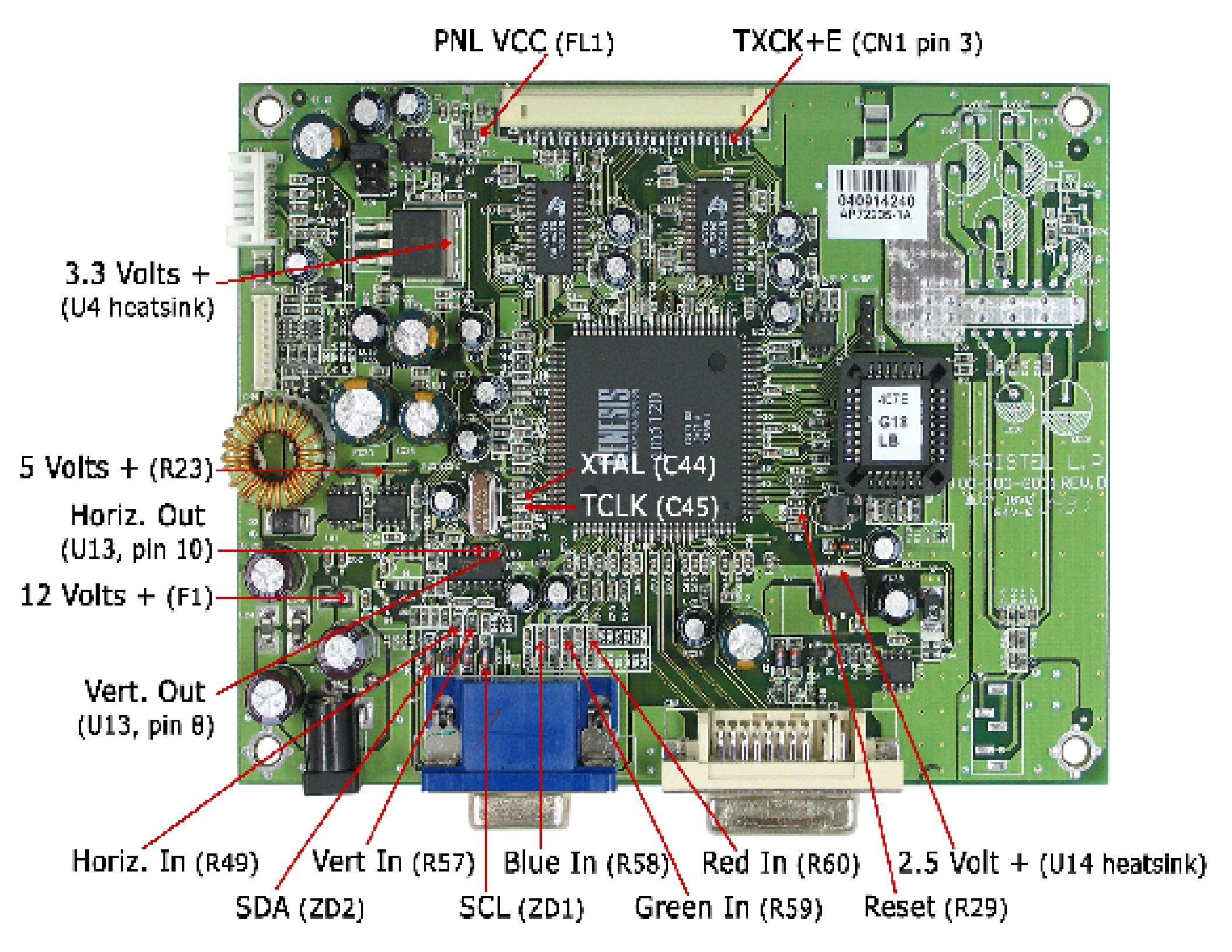
The 5V output feeds linear regulator ICs to drop voltages down to 3.3V and 2.5V outputs. The 3.3V and 2.5V DC supplies are conventional fixed voltage regulators.

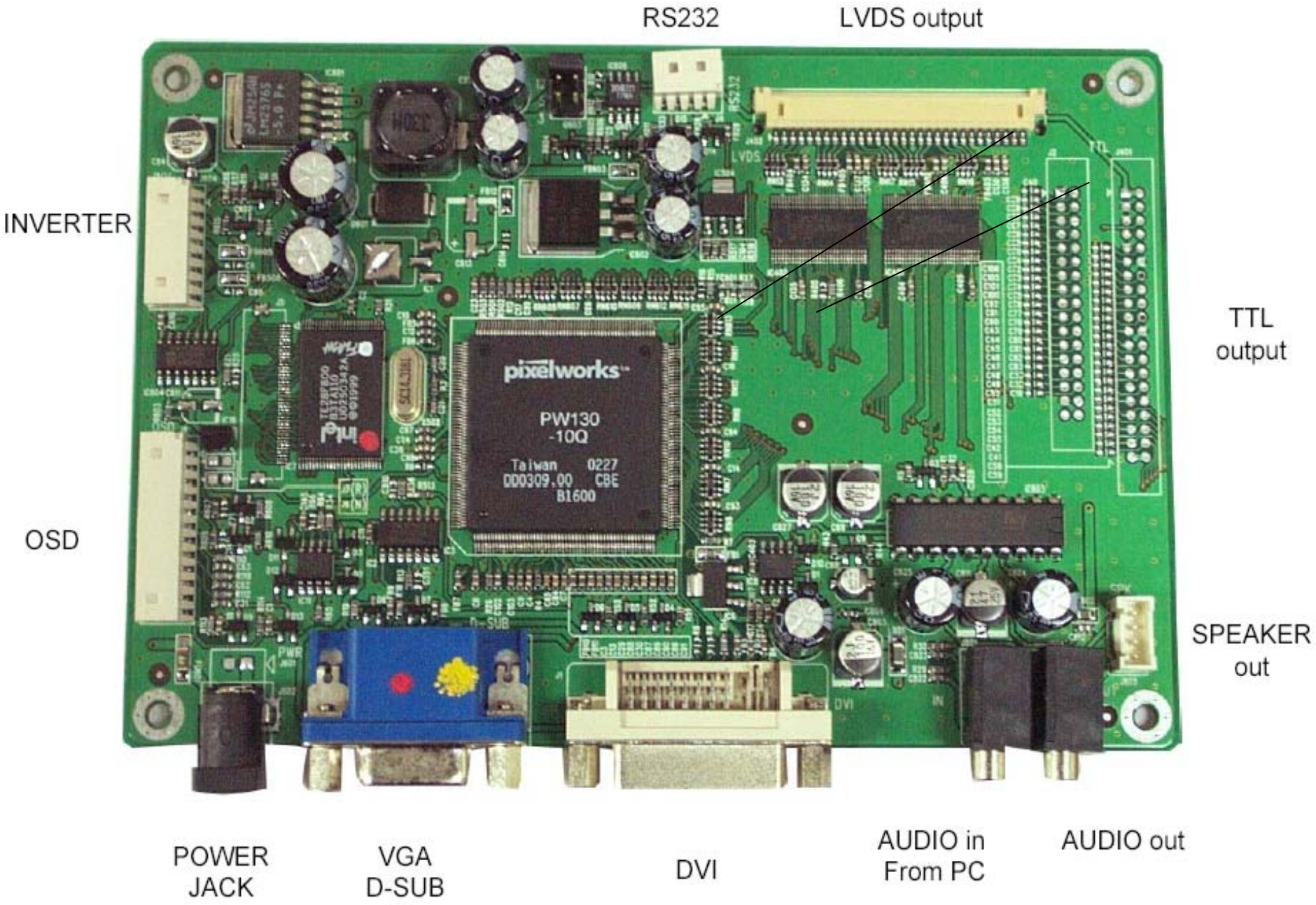
A Panel VCC supply selects (mechanical jumper) an input voltage and the microprocessor switches it (on/off) to the LCD panel.

Main Signal Processing/Controller Board Power Supplies



The 3.3V and 2.5V power supplies operate the digital ICs on the signal processor/controller circuit board. These supply voltages are derived from the 5V power supply. U14 is a surface mount linear regulator IC that outputs a regulated 2.5V. It is an IC package TO-252 and a suitable replacement is a PJ1117CP-2.5. U4 is also a linear regulator but physically larger. A suitable replacement is PJ1084CM.


PNL VCC (FL1)
TXCK+E (CN1 pin 3)
3.3 Volts +
(U4 heatsink)
5 Volts + (R23)
Horiz. Out
(U13, pin 10)
12 Volts + (F1)
Vert. Out
(U13, pin 8)
XTAL (C44)
TCLK (C45)
Horiz. In (R49)
Vert In (R57)
Blue In (R58)
Red In (R60)
2.5 Volt + (U14 heatsink)
SDA (ZD2)
SCL (ZD1)
Green In (R59)
Reset (R29)



Signal processor/controller circuit board. (Courtesy Ceronix)

Welcome

Amusement & Music Operators Association

LCD Power Supply Troubleshooting Tech Seminar

INSTRUCTOR: Ray Holdren,
Kokopelli Consulting LAS Vegas
Instructor for CSN's Workforce Development Group
Teacher for College of Southern Nevada, Cheyenne Campus, North Las Vegas, NV

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