LeCroy 1440 System Manual

Fermi National Accelerator Laboratory

Equipment Support Department

Authored by Tom Boes

Contributions by Hank Connor, Stew Bledsoe, Tim Kasza, Adam Walters

November 25, 2002

LeCroy 1440 System Manual

Purpose of this document

This information in this manual is primarily intended for expert users and experienced repair technicians. This manual includes technical information pertaining to the LeCroy 1440 High Voltage system that has been collected at Fermilab over the last twenty years. Specifically included are Fermilab maintenance procedures. It does not include information that LeCroy included in the original operators manuals. It does not include low-level calibration procedures for the 1441, 1442 and 1445 modules. Only qualified personnel with experience working with this type of equipment should perform the maintenance included in this manual.

This manual and other relevant information can be found at the Web address:
http://www-esd.fnal.gov/esd/catalog/main/lcrynim/1440.htm

Revision History of this Manual

Revision	Author	Date Changed	Description
Rev. A	Tom Boes	November 25, 2002	Initial Document

Table of Contents

Section 1.0 Known Issues with the LRS 1440 System 1
Section 2.0 Other Information about the 1440 System 2
Section 3.0 Abbreviated "In House" Maintenance Checklist..... 3
Section 4.0 Preventative Maintenance 4
Section 5.0 Corrective Maintenance 6
5.1 LRS 1441 Power Supply 6
5.2 LRS 1442 Power Supply 9
5.3 LRS 1443 High Voltage Card 9
5.4 LRS 1445 Controller 10
5.4.1 LRS 1445 non-volatile memory battery 10
5.4.2 LRS 1445 controller washer modification..... 11
Section 6.0 Affixing Labels and Tags on the 1440 System..... 12

Appendix A..... 14
LeCroy Power Supply Ripple Test 14
Appendix B..... 20
LRS 1443 Capacitor Replacement..... 20
Appendix C..... 22
LRS 1445 Controller Seating Modification 22
Appendix D..... 24
Lecroy 1445 Serial Cable & AD/CAM Adapter..... 24
Appendix E..... 27
VARTA Battery Data Sheet 27
Appendix F 28
Electrolytic Capacitor Data Sheet..... 28

Section 1.0 Known Issues with the LRS 1440 System

a) LRS 1441 – Electrolytic capacitors in the 1441 become defective as a function of age and may cause the low voltage power supply to become unstable. This failure can cause the High Voltage output to exceed the demand voltage. For proper, reliable operation of the low voltage power supply, the filter capacitors are replaced as a routine and preventative maintenance item. This problem was first noted at the E872 experiment in February 1997. See Section 5.1.

b) LRS 1445 – When the High Voltage is turned on, the output voltage will be the voltage that was last set in the demand buffer. A potential high voltage hazard exists since the HV cards power up to the previous voltage settings. The LeCroy 1445 demand voltage is set to 0V at the completion of testing by the Equipment Support Department. However, the user should always verify and set the demand voltage before turning the high voltage on. Refer to the LRS 1440 operators manual to find software commands used to set demand voltage.

c) LRS 1440 System - The mainframe may lock up (stop communicating) if the line voltage drops below 190v (this is contrary to the 180v specification in the LRS manual). If the mainframe is locking up, monitor the line with a line voltage monitor to see if the voltage drops below 190v, even momentarily. If so, consider changing your facilities line voltage tap to increase the voltage. LRS recommends an input AC voltage between 208-240v. This problem was first noted at the KTeV & E872 experiments in 1996.

d) LRS 1445 – Poor seating of the controller in the 1449 backplane was identified to cause an intermittent communication problem that often caused the mainframe communication to lock up. A power down of the mainframe or software reset was typically required to re-establish communication. A modification to the controller was installed to make the controller seat more deeply in the back-plane connector. This modification is installed on all Fermilab systems as a routine and preventative maintenance item. This problem was first noted at the KTeV experiment in 1996. See Section 5.4.2.

e) LRS 1443 – Aging of certain capacitors on the LRS 1443 HV card caused instability in HV output. The output voltage was measured to fluctuate as much as 50V with load and 5V without load. The specific capacitors are referenced in ECO 1002 and ECO 1010. This upgrade is installed on all Fermilab systems as a routine and preventative maintenance item. This issue was first noted by the KTeV experiment in 1996. See Section 5.3.

f) LRS 1440 System – The systems were originally shipped from LRS with 220V/10A AC input power connectors. The LRS specification for current is 15A. Replacement female plugs and receptacles with a rating of 250/20A were installed on all Fermilab systems in 1991.

Section 2.0 Other Information about the 1440 System

a) The Fermilab firmware standard for the LRS 1445 controller is Version 1.7. There are significant issues with using Version 1.7 with a LRS 1444 HV card. Refer to the 1444 LeCroy User Manual and firmware versioning information in the LRS 1440 manual to access more information about using Version 1.7 with the 1444 High Voltage Module.

b) LeCroy retired this system in 1996. The LeCroy Corporation no longer provides support for this equipment. A third party vendor currently provides support for this system and support for Fermilab 1440 systems is offered by the Equipment Support Department at Fermilab.

c) LRS 1440 System – The AC line cord (208-240VAC) at rear of system must be fully inserted and seated for a good electrical connection.

Section 3.0 Abbreviated "In House" Maintenance Checklist

- ❑ Perform preventative maintenance – Section 4.0
- ❑ Check/replace 1441 filter capacitors – Section 5.1
- ❑ Check that insulating covers are present on the filter capacitors – Section 5.2
- ❑ Check/replace 16 capacitors on the 1443 HV card – Section 5.3
- ❑ Check/replace battery on the 1445 controller – Section 5.4.1
- ❑ Check that the 1445 washer modification is installed – Section 5.4.2
- ❑ Affix appropriate labels – Section 6.0
- ❑ Run LabVIEW diagnostic

LRS 1440 "In House" Maintenance Checklist Matrix

Maintenance Items	Verify	Inspect	Replace	Install
Hardware: *handles, knobs, wires, mountings, connectors, etc…*		X	X	
Cooling Fans		X	X	
Fan Filters		X	X	X
Indicators: *AC Power On, High Voltage On, HV Enable, Ready*	X		X	
Switches: *main power on/off, HV, address*	X		X	
1441 Filter Capacitors: *replace if Manufacture Date is > 4 years*	X	X	X	
Insulating Cover for 1442 Filter Capacitors	X			X
1443 Capacitor Replacement: *must be (10uf, 50V electrolytic)*	X	X	X	
1445 Controller Battery: *replace if In Service Date is > 5 years*	X	X	X	
1445 Washer Modification	X			X
Labels	X			X

NOTE: Only qualified personnel with experience working with this type of equipment should perform the maintenance included in this manual. Only the preventative maintenance is to be performed in the field.

Section 4.0 Preventative Maintenance

Preventative maintenance is required for safe, reliable and continued operation of the LRS 1440 System. Listed below is the preventative maintenance that is to be performed periodically:

a) Inspect 1440 system hardware for broken handles, knobs, wires, mountings, indicators, switches, etc.

b) Inspect all connectors for proper connection and broken pins.

c) Verify all fans are cleaned and fully functional. Check for worn fan bearings.

d) Replace/Clean air filters.

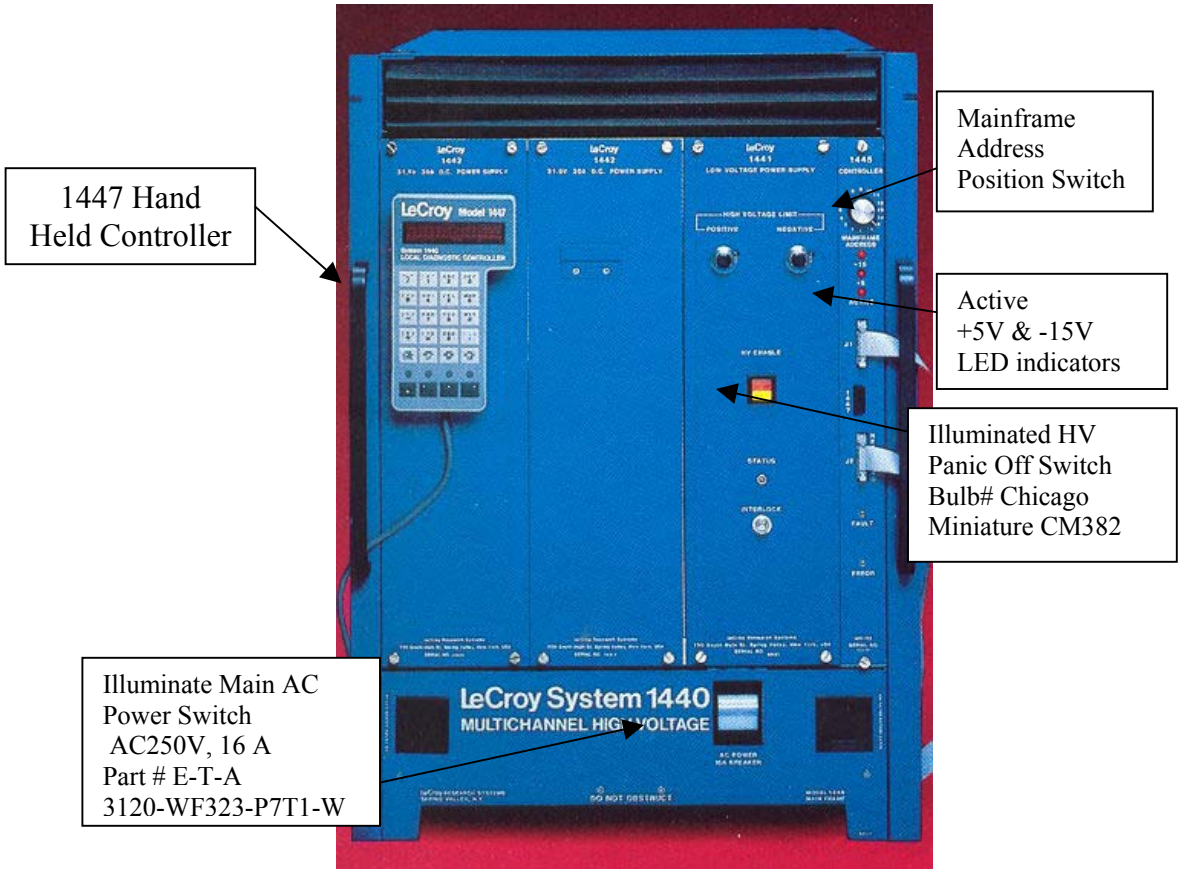
e) Inspect and reseat the AC connectors on the 1441 and 1442 power supplies. Inspect for heat damage and verify the connector is securely plugged in.

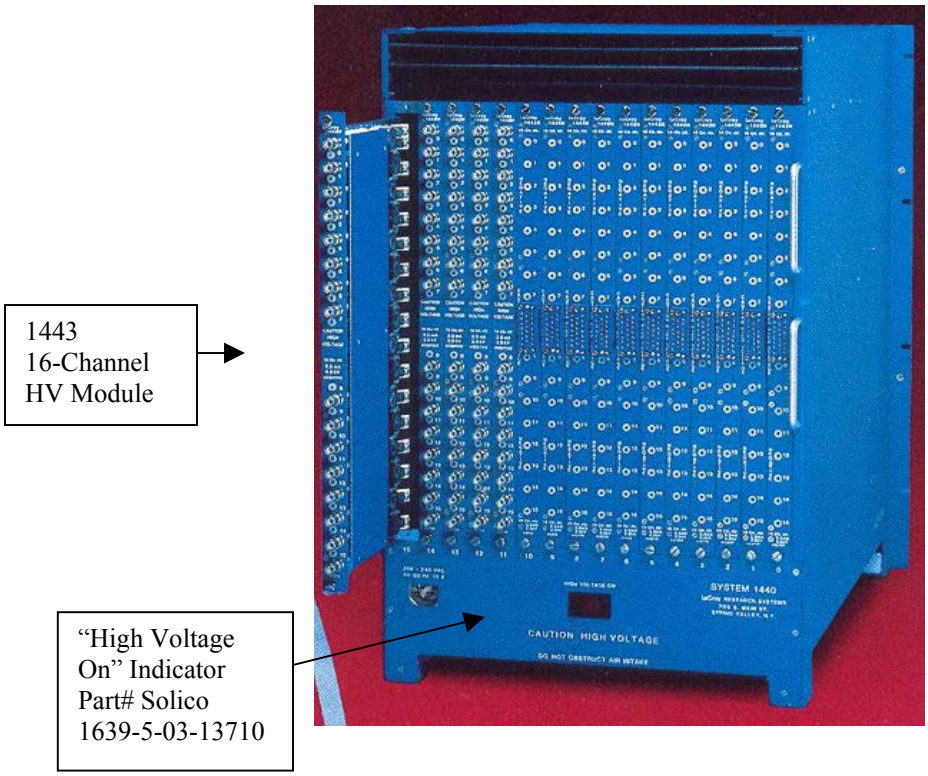
f) Verify front Main AC Power Lamps in Power Switch are operational.

g) Verify "High Voltage On" indicator lamp on the rear of the 1440 mainframe is operational. See diagram next page for location.

h) Verify all front mainframe LRS 1440 System Lamps; "HV Enable Lamps", "Ready", and "HV-ON" Lamps and Active LED indicators are operational. See diagram next page for location.

i) Verify proper operation of main power switch, HV push switch, and mainframe address position switch. See diagram next page for location.


1447 Hand
Held Controller
Mainframe
Address
Position Switch
Active
+5V & -15V
LED indicators
Illuminated HV
Panic Off Switch
Bulb# Chicago
Miniature CM382
Illuminate Main AC
Power Switch
AC250V, 16 A
Part # E-T-A
3120-WF323-P7T1-W
LeCroy System 1440
MULTICHANNEL HIGH VOLTAGE


1443
16-Channel
HV Module
"High Voltage
On" Indicator
Part# Solico
1639-5-03-13710
CAUTION HIGH VOLTAGE
SYSTEM 1440

Section 5.0 Corrective Maintenance

Corrective Maintenance is required to update older LRS 1440 systems and for continued quality performance of the systems. Listed below are the required periodic corrective maintenance items that need to be performed:

5.1 LRS 1441 Power Supply

Due to aging Low Voltage Filter Capacitors, the LRS 1441 performance will degrade over time. Under the right conditions, this failure can cause the High Voltage output to exceed the demand voltage setting and possibly cause damage to the detectors or equipment attached to the LRS 1440 outputs.

Inspect LRS 1441 Low voltage filter capacitors (three 4500uf 35 VDC electrolytics) for defects listed below.
Non-military grade aluminum electrolytic fixed capacitor has an approximate 10-year service life. The Equipment Support Department has elected to replace the low voltage filter capacitors with a manufacture date over 4 years, as a routine and preventative maintenance item as the systems pass through the repair cycle. This is because LRS 1440 systems are often issued to research experiments for 8 years or more.

Low Voltage Filter Capacitors:
UNITED CEMI-CON
Part # 747D452M035AA2A
Three 4500uf 35VDC
105`C Electrolytics or equivalent.

a) Capacitors should be inspected for the following defects:
   i. Damaged material
   ii. Mechanical (Mounting hardware)
   iii. Excessive corrosion
   iv. Electrical failure- DC leakage or Out of tolerance
   v. Date of manufacture over 4 years

b) Verify Expired Date and capacitor Manufacture Date (date code) are valid.

1. Spare Electrolytic Capacitors not issued into service within 4 years from date of manufacture cannot be used and should be disposed of.
2. **Replace the filter caps if the manufacturer's Date Markings are not readable, not present, expired, or over 4-years old.**

Note: The "4-year old capacitor replacement", as systems pass through the repair cycle, supercedes "Expired Date" for "In-House" repairs.

Labeling Information: See Figures 5.1 and 5.2

Date Code: Actual manufacturing (MFG) date printed on the electrolytic capacitor. Example: Date code 9705 stands for the 5th week of the year 1997 or MFG Date of 2/97.

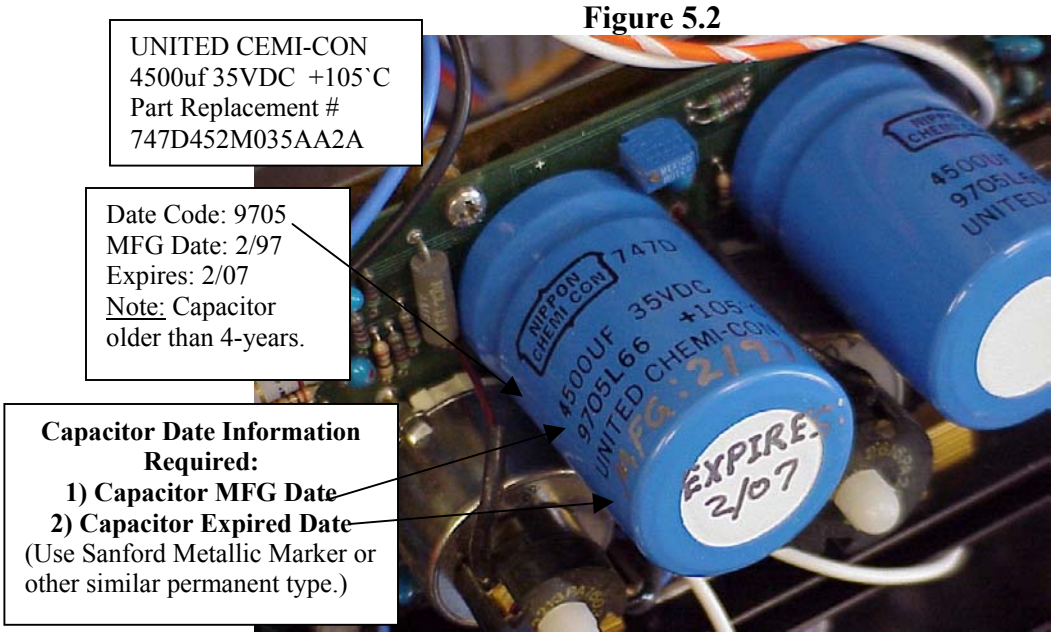
Expired Date: The Electrolytic capacitor has an approximate 10-year service life. The Expired Date is a 10-year date assigned from the date of manufacture.

Example: A capacitor with a 2-year shelf life can be installed with an "Expired Date" of 10 years from the date of manufacture. This gives 8-year service life.

Figure 5.1

Note: Expired Date and Manufacture Date are to be written on the capacitor.

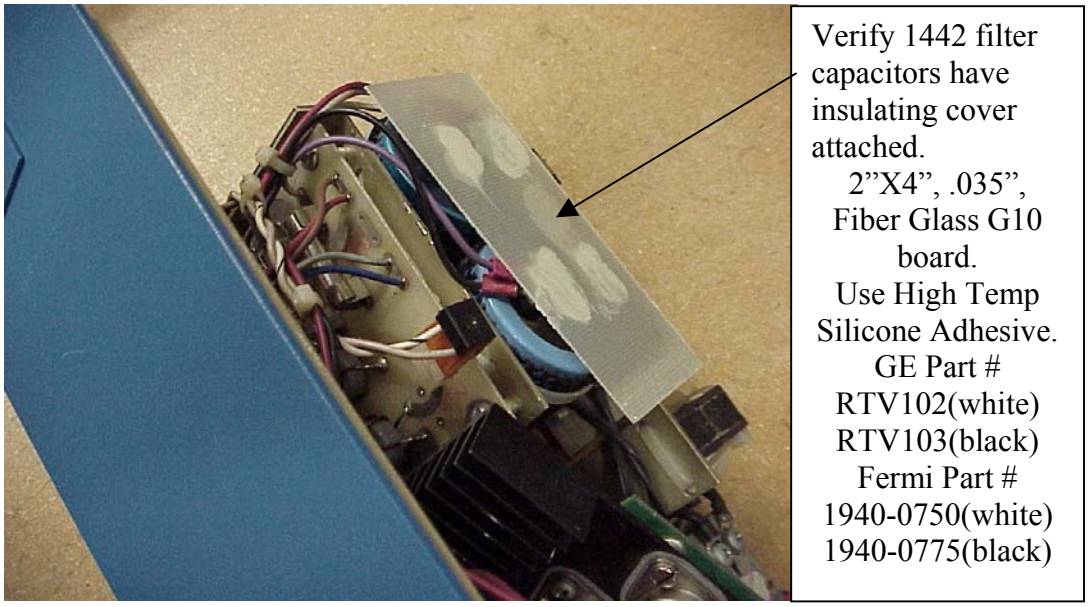
Figure 5.2



c) If the filter capacitors are under 4-years old, perform the Low Voltage Filter Capacitor performance check. If capacitors are replaced skip Low Voltage Filter Capacitor performance check.
See Appendix A LeCroy Power Supply Ripple Test documentation.

5.2 LRS 1442 Power Supply

Verify the presence of insulating covers on the 1442 filter capacitors. Covers should be present to prevent the capacitor terminals from shorting to the chassis. Newer power supplies may have clear plexiglass installed by LRS.



5.3 LRS 1443 High Voltage Card

Aging of certain capacitors on the LRS 1443 HV card caused instability in HV output. The output voltage was measured to fluctuate as much as 50V with load and 5V level without load. The specific capacitor is referenced in ECO 1002 and ECO 1010.

Inspect the LRS 1443 to ensure the capacitors shown in Appendix B are at the proper values (10uf, 50V electrolytic). One capacitor in each channel (16) must be replaced. See Appendix B for LeCroy 1443 Capacitor Change

5.4 LRS 1445 Controller

5.4.1 LRS 1445 non-volatile memory battery

The LRS 1445 controller uses a NiMH battery to backup controller setting in the random access memory. Due to battery aging, the system could drop out of operation. The NiMH battery has an approximate 7-year total service life. The Equipment Support Department has elected to replace the NiMH battery with a "In Service Date" over 5 years, as a routine and preventative maintenance item as the systems pass through the repair cycle. This is because LRS 1440 systems are often issued to research experiments for 8 years or more. See Figure 5.3

Verify Expired Date, Battery In Service Date, and capacitor Manufacture Date (date code) are valid.

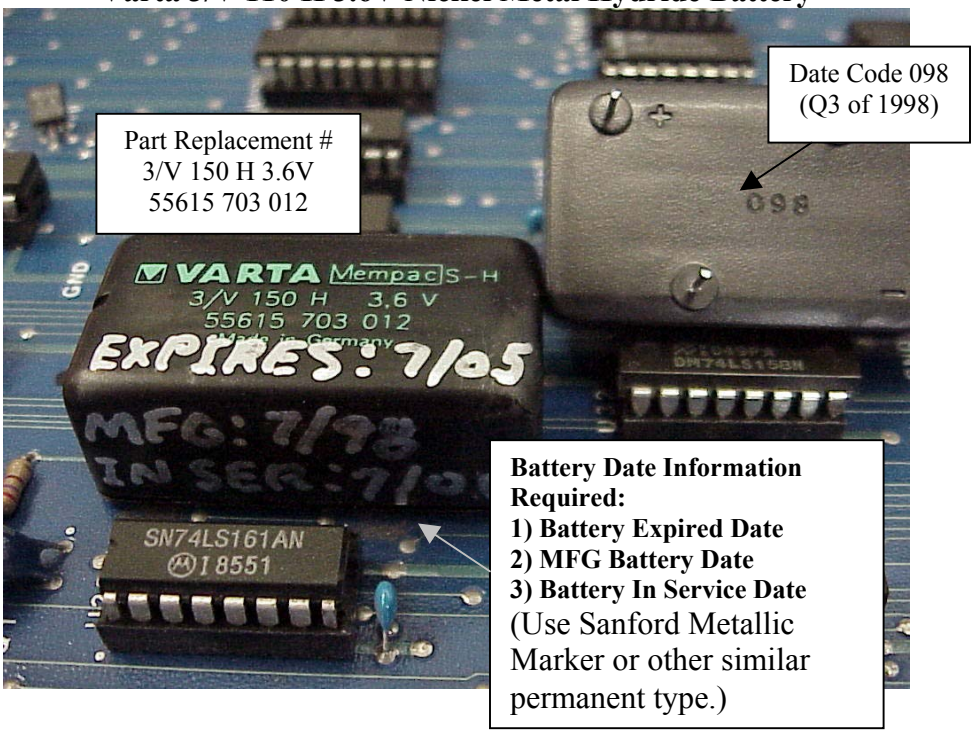
1. Spare NiMH Batteries not issued into service within 2 years from date of manufacture cannot be used and should be disposed of. (2-year shelf life)
2. **Replace the battery if the manufacturer's Date Markings are not readable, not present, or expired.**

Labeling Information: See Figure 5.3
Date Code: Actual manufactured date (MFG) printed on the battery.
Example: Date code 098 stands for Q3 of the year 1998.
Formula: First two digits=Year's Quarter. 03=Q1; 06=Q2; 09=Q3; 12=Q4.
Last digit =Year. 8=1998, 9=1999, 0=2000, 1=2001…..etc.
Battery In Service Date: Date battery installed and "In-Service".
Expired Date: 5-year date that is assigned to the battery put "In Service".

Example: A battery with a 2-year shelf life can be installed with an "Expired Date" of 5 years. Total maximum life of Battery (NiMH) = 2-year shelf life + 5-year service life. Battery's total life is then 7 years.

Note: Expired Date, Manufacture Date, and In Service Date are to be written on the battery.

Figure 5.3
Varta 3/V 110 H 3.6V Nickel Metal Hydride Battery



5.4.2 LRS 1445 controller washer modification

Intermittent communication problems with the 1445 controller can cause the mainframe communication to lock up and require the mainframe to power down to re-establish (reset) communication. A modification to the controller was implemented to make the controller seat deeper in the back-plane connector. Verify 1445 controller washer modification has been installed. Perform the modification if not installed. See Appendix C for LRS 1445 Controller Seating Modification documentation.

Section 6.0 Affixing Labels and Tags on the 1440 System

For identification, Attention, Warnings, repair, and user information, tags and labels are used. Following labels and tags are used on the 1440 HV System:
See figure 6.1 shows label and tag locations.

Directory location for Labels is:
(For Internal use only)
ESDSERVER1\DIAGS\LECROY\1440_HV_System\docs\1440HV\general\Labels

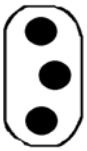
Note: Inspect and replace peeling or worn labels.

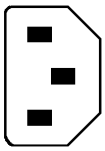
a) On-Line User Information Label.
Provides information and equipment specifications on the LeCroy 1440 HV System. Place this label on front of each module.

LRS: 1440
On-Line User Information
http://www-esd.fnal.gov/esd/catalog/main/lcrynim/1440.htm

b) AC Connector Attention Label.
The Attention label below is used to let the user know of two different AC connections used on the LRS 1441 module. Place this label on the front of the 1441 module.

ATTENTION:
There are two types of AC connections used on the LRS: 1441 module.


Old Style


New Style

Please make note of this connector before you request an exchange.

c) The Voltage Set Attention Label.
The Attention label below is used to let the user know of the LeCroy 1445 demand voltage is set to 0V and the user should verify and set the demand voltage before turning the high voltage on.

Place this tag on the 1445 Mainframe Address knob.

Attention

The LeCroy 1445 demand voltage is set to 0V at the completion of testing by the Equipment Support Department. However, the user should verify and set the demand voltage before turning the high voltage on.

Figure 6.1

Appendix A

LeCroy Power Supply Ripple Test

This test is used to determine if the LRS 1441 supply performance is degrading. This procedure will allow the technician to perform a quick check of the supply to determine if the power supply ripple is abnormally high which may forecast a mainframe failure in the near future. Under the right conditions, this failure can cause the High Voltage output to exceed the demand voltage setting and possibly cause damage to the detectors or equipment attached to the LRS 1440 outputs.

Procedure:

Only perform this procedure if you are familiar with the use of an oscilloscope and are qualified to service this equipment. You should have another person present while performing this procedure for safety reasons. Line voltage level signals are present during this test and it is critical that you do not touch any exposed components when the LRS 1441 has power supplied to it.

Figure 1

1. Turn off the power to the LRS 1440 mainframe and disconnect the line cord.

2. Move the LRS 1441 to the service position by unscrewing the module at the top, lowering the module as shown in Figure 1, and latching as shown in Figure 2. Leave all other modules in the mainframe.

Figure 2

3. Connect Oscilloscope probes to Channel 1 and 2 inputs of the scope. Perform the probe cal procedure for your particular model of Oscilloscope.

4. Configure your Oscilloscope as follows:

- Channel 1 and 2: AC Couple
- Channel 1 and 2: 1MOhm input impedance
- Channel 1 and 2: .5V/Division
- Measurement Select: Ch 2 - Ch 1 (Differential Measurement, invert and

add the 2 channels. Make sure that only the "invert and add" trace is displayed and the channel 1&2 traces are turned off)

- Timebase: Approximately 25uS/Div

Positive 15V test:

5. Connect the channel 1 probe to the +15V test point, the orange wire shown in Figure 3 and Figure 4, (your supply may have a different color). To make a good connection, you may need to push back the insulation slightly on the wire. The ground connection for the probe does not need to be connected.
6. Connect Channel 2 to analog ground which is the white cable shown in figure 3 and figure 4, (again your color may be different). The ground connection for the probe does not need to be connected.
7. Connect the line cord to the LRS 1440 system and turn the power switch on.
8. Adjust both volts/division knobs to obtain a good display, (both channels must be the same value).
9. Measure the peak to peak voltage displayed on the Oscilloscope. If the peak to peak voltage exceeds 150mV the LRS 1441 should be exchanged with PREP. You can reference the "**good**" and "**bad**" Oscilloscope displays at the end of this document.

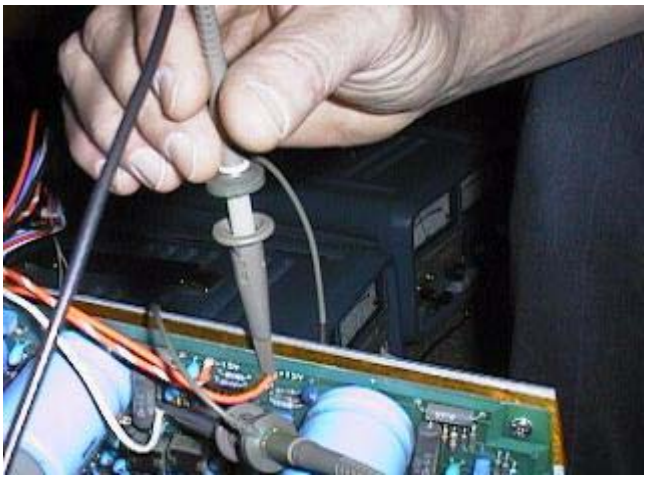


Figure 3

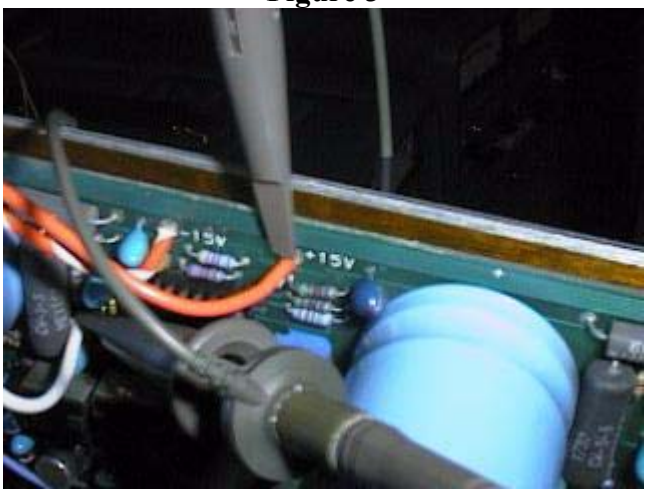


Figure 4

Negative 15V test:

10. Turn off the power switch and disconnect the line cord to the LRS 1440 system.
11. Connect the channel 1 probe to the -15V test point, the orange/white wire shown in Figure 5 and Figure 6, (your supply may have a different color). To make a good connection, you may need to push back the insulation slightly on the wire. The ground connection for the probe does not need to be connected.
12. Leave Channel 2 connected to analog ground which is the white cable shown in figure 5and figure 6, (again your color may be different). The ground connection for the probe does not need to be connected.
13. Connect the line cord to the LRS 1440 system and turn the power switch on.
14. Adjust both volts/division knobs to obtain a good display, (both channels must be the same value).
15. Measure the peak to peak voltage displayed on the Oscilloscope. If the peak to peak voltage exceeds 150mV the LRS 1441 should be exchanged with PREP. You can reference the "**good**" and "**bad**" Oscilloscope displays at the end of this document.

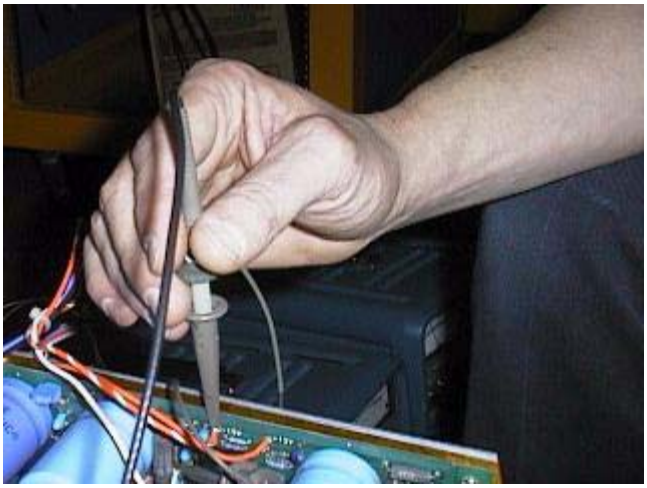


Figure 5

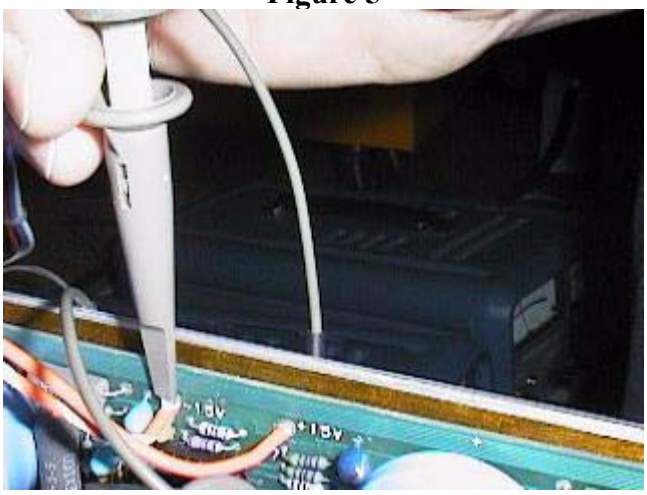


Figure 6

Positive 5V test:

16. Turn off the power switch and disconnect the line cord to the LRS 1440 system.
17. Connect the channel 1 probe to the +5V test point, the blue wire shown in Figure 7 and Figure 8, (your supply may have a different color). To make a good connection, you may need to push back the insulation slightly on the wire. The ground connection for the probe does not need to be connected.
18. Connect Channel 2 to digital ground which is the black cable shown in figure 7 and figure 8, (again your color may be different). The ground connection for the probe does not need to be connected.
19. Connect the line cord to the LRS 1440 system and turn the power switch on.
20. Adjust both volts/division knobs to obtain a good display, (both channels must be the same value).
21. Measure the peak to peak voltage displayed on the Oscilloscope. If the peak to peak voltage exceeds 150mV the LRS 1441 should be exchanged with PREP. You can reference the "**good**" and "**bad**" Oscilloscope displays at the end of this document.
22. This concludes the test. Turn off the power switch and disconnect the line cord to the LRS 1440 system.

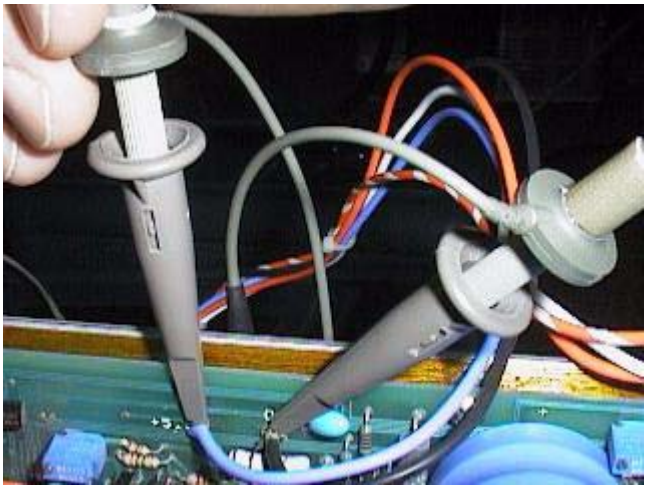


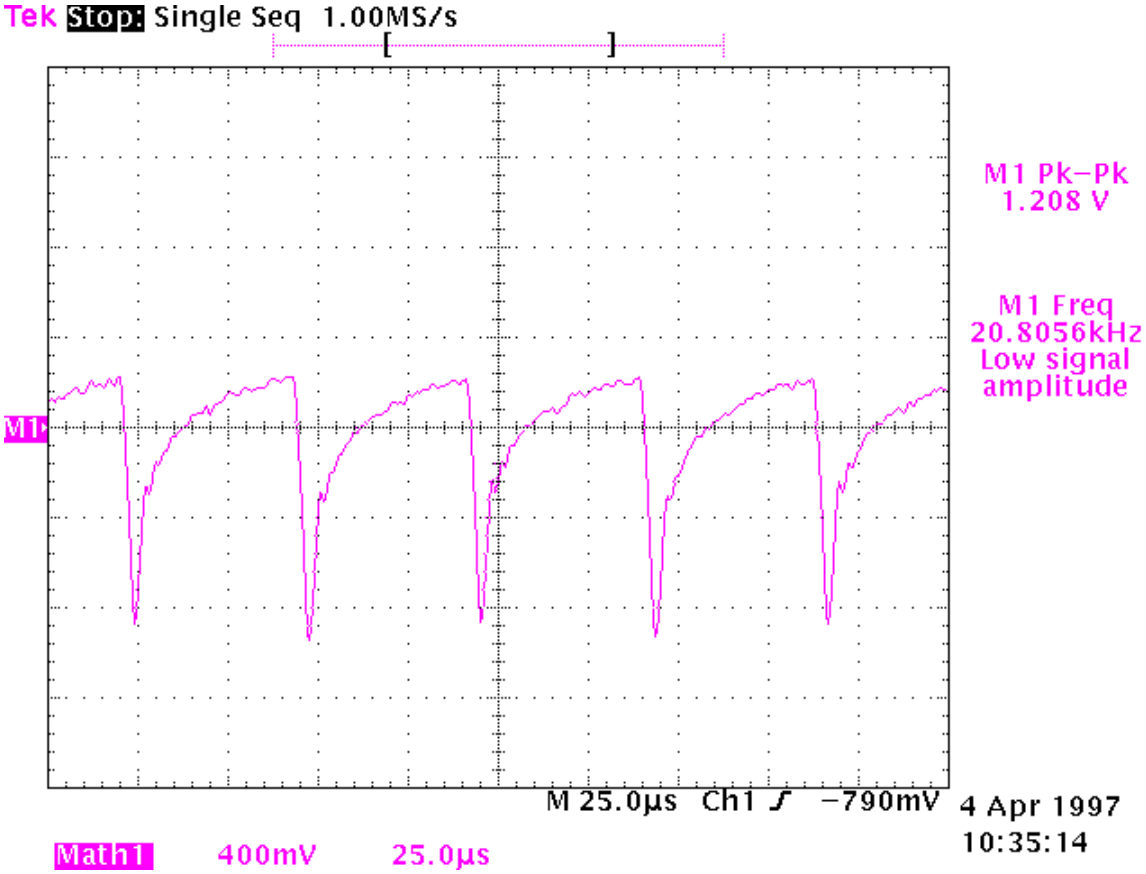
Figure 7

Figure 8

Typical Display of a “Bad” LRS 1441

Figure 9 shows a typical "Bad" unit. Note that the Peak to Peak amplitude is 1.208V and exceeds the specification of <150 mV.

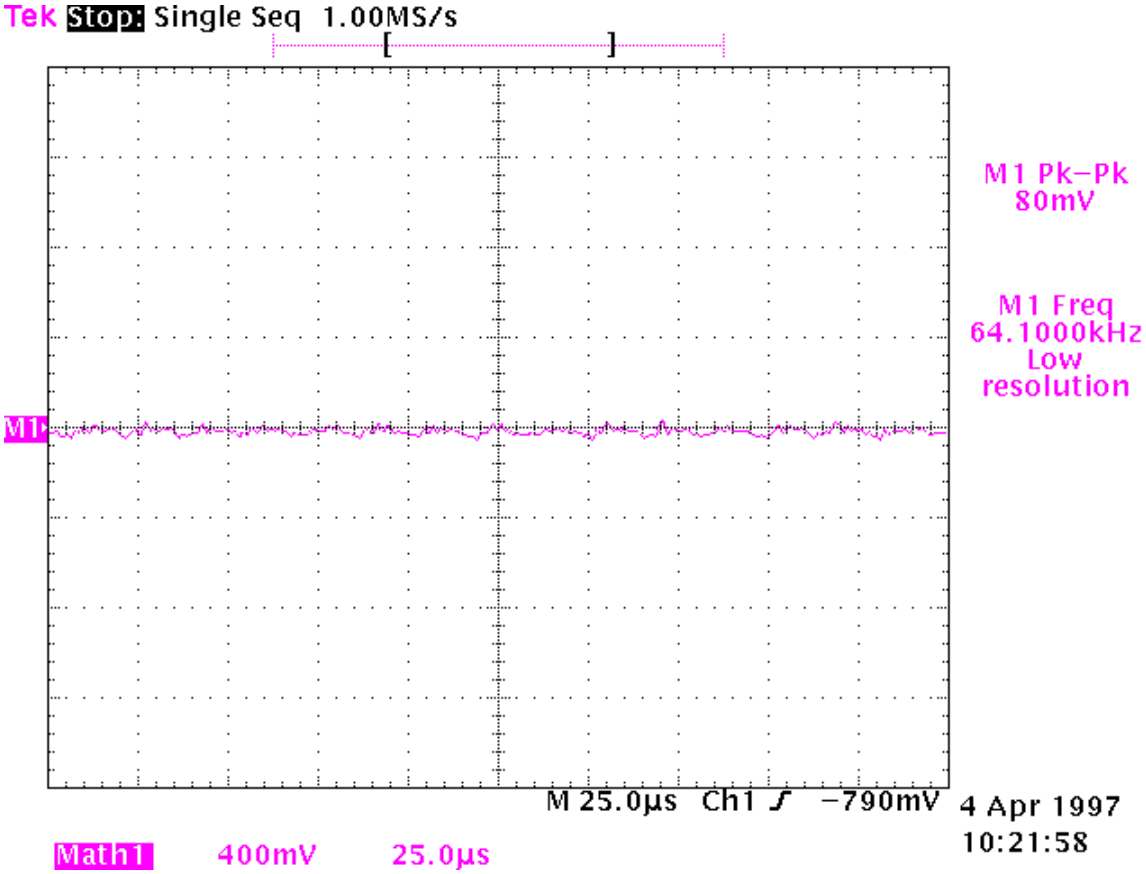
Figure 9



Typical Display of a "Good" LRS 1441

Below is an example of a good waveform, (Figure 10). Note that the peak to peak amplitude is 80mV which is less than the specification of <150mV.

Figure 10

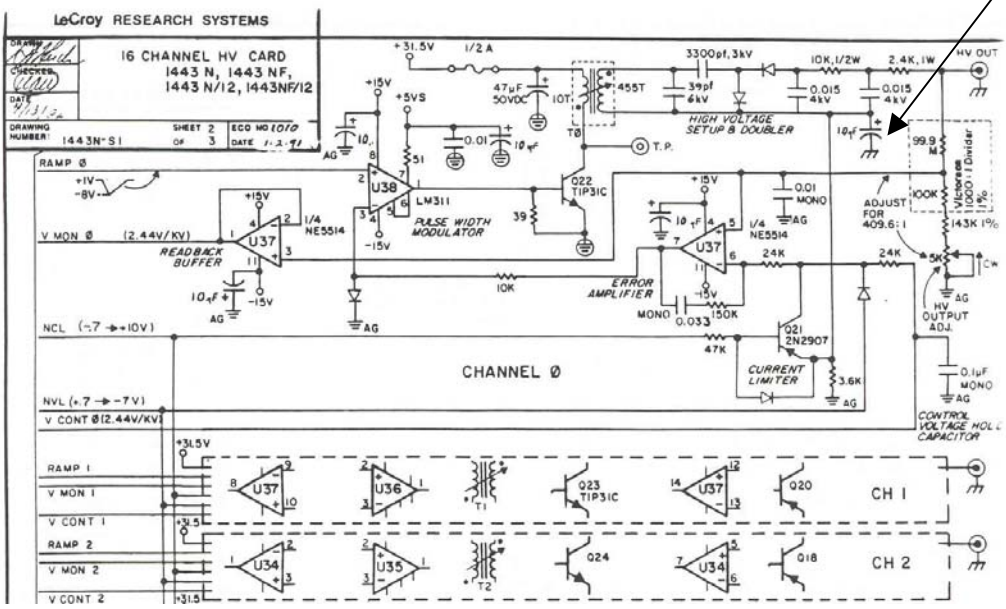


Appendix B

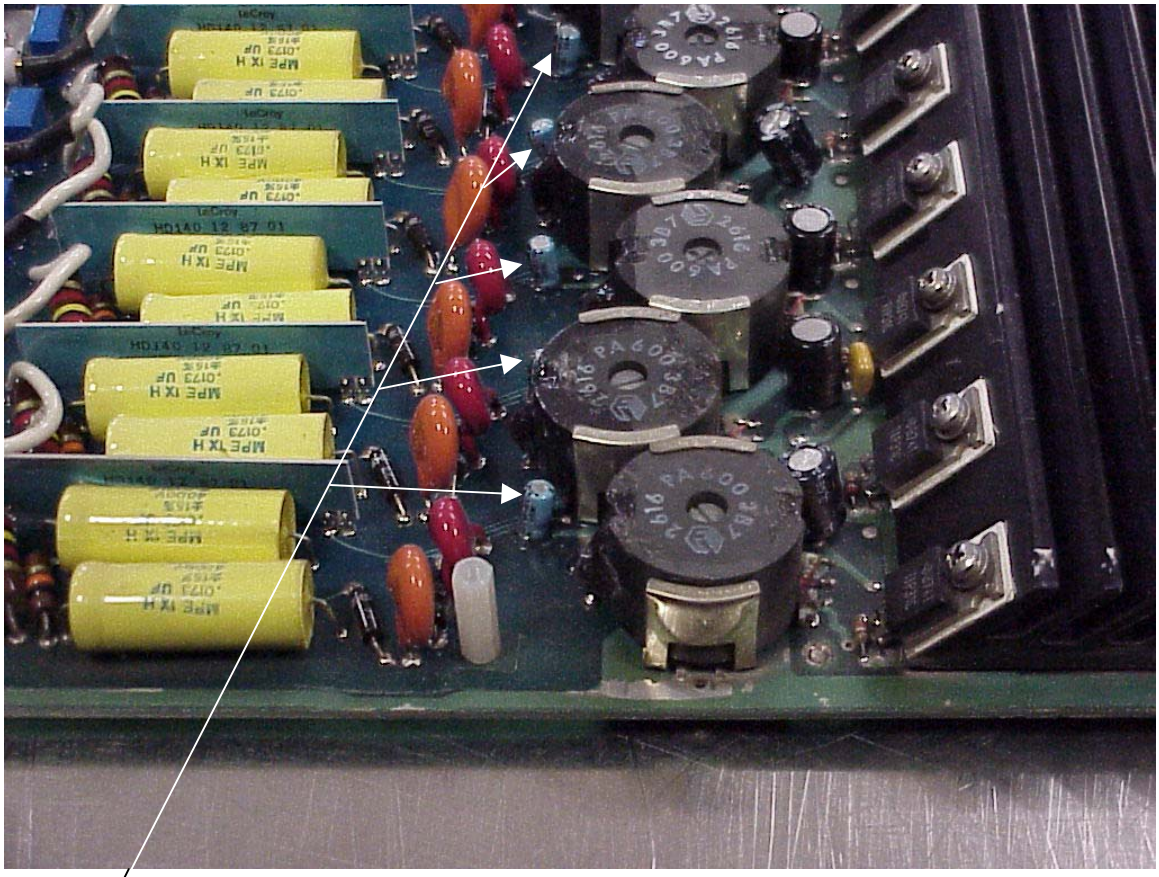
LRS 1443 Capacitor Replacement

Aging of certain capacitors on the LRS 1443 HV card caused instability in HV output. The output voltage was measured to fluctuate as much as 50V with load and 5V level without load. The specific capacitor is referenced in ECO 1002 and ECO 1010. Prior to 1982 the capacitor was a 6.8uf tantalum. ECO 1002 (July 1, 1982) changed the capacitor to a 10uf 16v electrolytic. ECO 1010 (January 1, 1991) effectively called for the capacitor to be replaced with a radial lead 10uf, 35v electrolytic capacitor. The capacitor shown below is the cause of the voltage instability and is routinely checked and upgraded with a 10uf 50v radial lead electrolytic. The capacitor is replaced in all 16 channels.

Replace with 10uf, 50v radial lead electrolytic capacitor for all 16 channels.



Schematic of the LRS 1443 High Voltage Card



LRS 1443 High Voltage Card (high voltage section is shown)

Replace with 10uf, 50v radial lead electrolytic capacitor for all 16 channels. (5 channels shown)

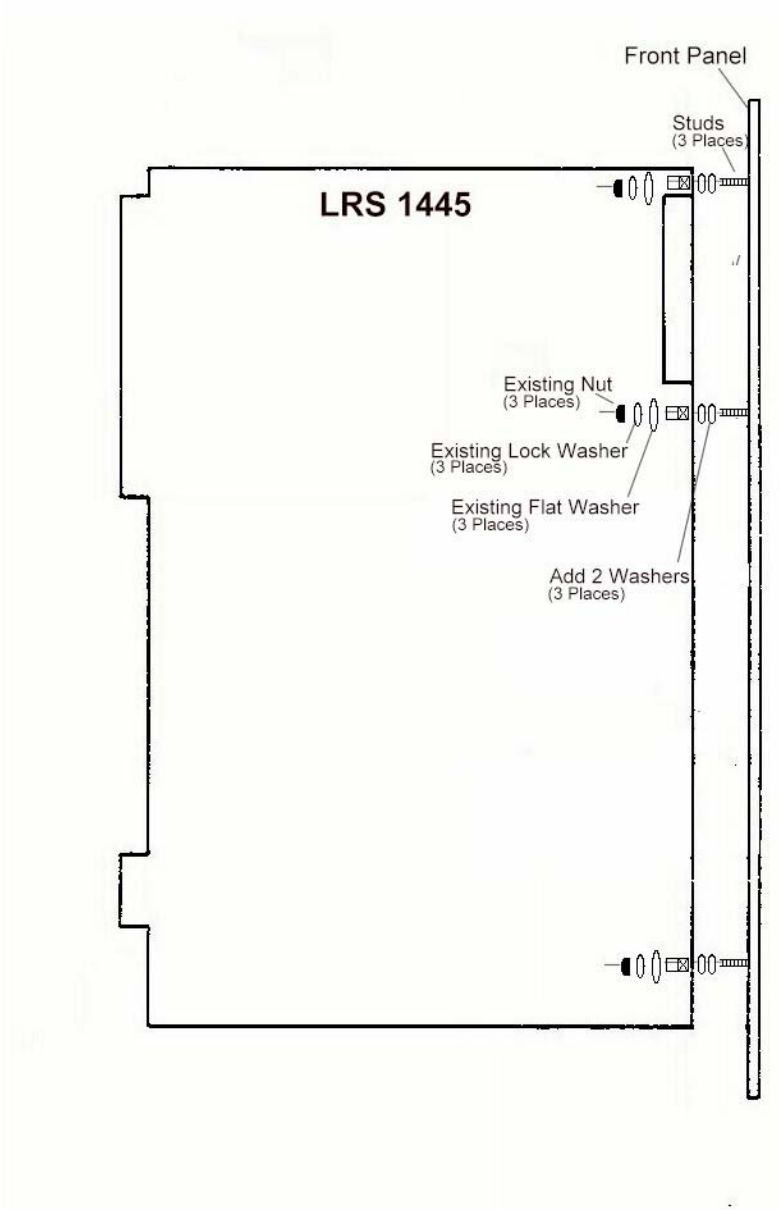
Appendix C

LRS 1445 Controller Seating Modification

A problem has been identified that causes intermittent communication, high voltage trips and other assorted quirks in the 1440 system. This has been traced to bad connections between the controller and the 1449 backplane connector. This modification adds washers behind the front panel on the 1445 controller to get the controller to seat farther into the backplane connector. The tools needed for this fix are a ¼ inch nut driver and 6 #4 flat steel washers available in the stockroom. The Fermilab Stockroom part number for the washers is 1218-0540.
Note: This modification is installed on all Fermilab systems as a routine and preventative maintenance item.
The procedure is as follows:

1. Turn power off and remove line cord to the mainframe.
2. Remove the 1445 controller from the mainframe and lay on a flat surface.
3. Locate the 3 studs that secure the front panel to the circuit board.
4. Remove the ¼ nuts, the lock washer and the flat washer that are holding the front panel on.
5. Pull on the front panel to get it to slide out of the brackets that hold it to the circuit board.
6. Place 2 #4 flat steel washers on each of the three studs that extend from the front panel.
7. Insert the front panel back into the brackets that secure the front panel to the circuit board
8. Reinstall the flat washers and lock washers and ¼ inch nut and tighten securely.
9. Reinstall the controller into the mainframe and test.

Note: do not use more than 2 washers on each stud or it could cause permanent damage.


Front Panel
Studs
(3 Places)
LRS 1445
Existing Nut
(3 Places)
Existing Lock Washer
(3 Places)
Existing Flat Washer
(3 Places)
Add 2 Washers
(3 Places)

Appendix D

Lecroy 1445 Serial Cable & AD/CAM Adapter

The serial cable allows for communication between a terminal emulator (or dumb terminal) and the 1445 controller. The AD/CAM adapter facilitates communication between a LRS 2132 and the 1445 controller using both the serial cable and AD/CAM adapter.

LeCroy 1445 Serial Cable Construction:

A. Parts Needed

1. One 16 Pin Plug, Newark Part Number 46F4657
2. One 16 Pin Plug Strain Relief, Newark Part Number 46F4667
3. One 25 Pin "D" Connector with solder cups, Fermi stock Numbers:
   1430-4300 (male)
   1430-4310 (female)
4. One 25 Pin "D" Connector Shell, Fermi stock number 1430-4320
5. Sixteen Conductor Ribbon Cable, Length not to exceed 200 feet

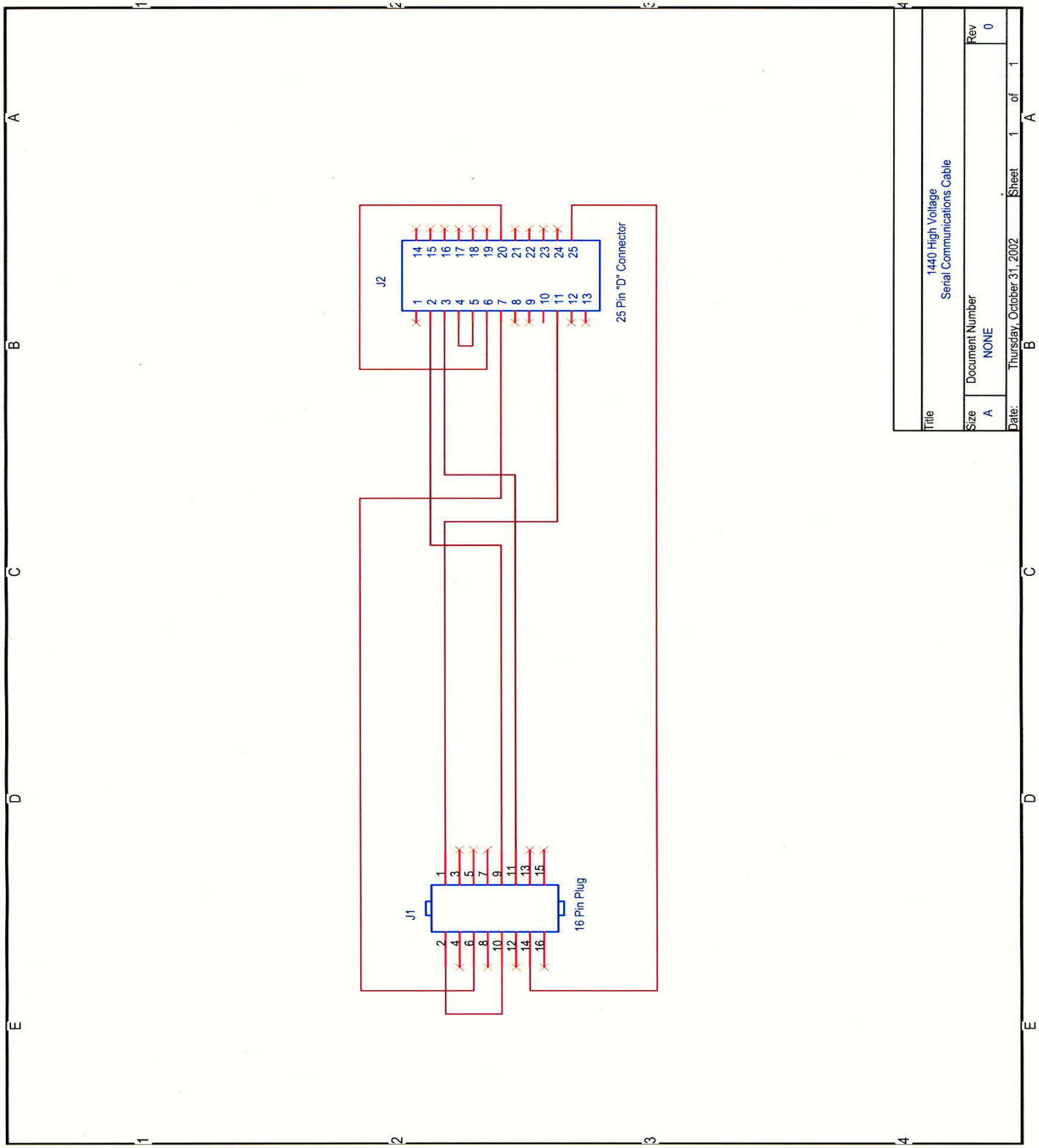
B. Construction

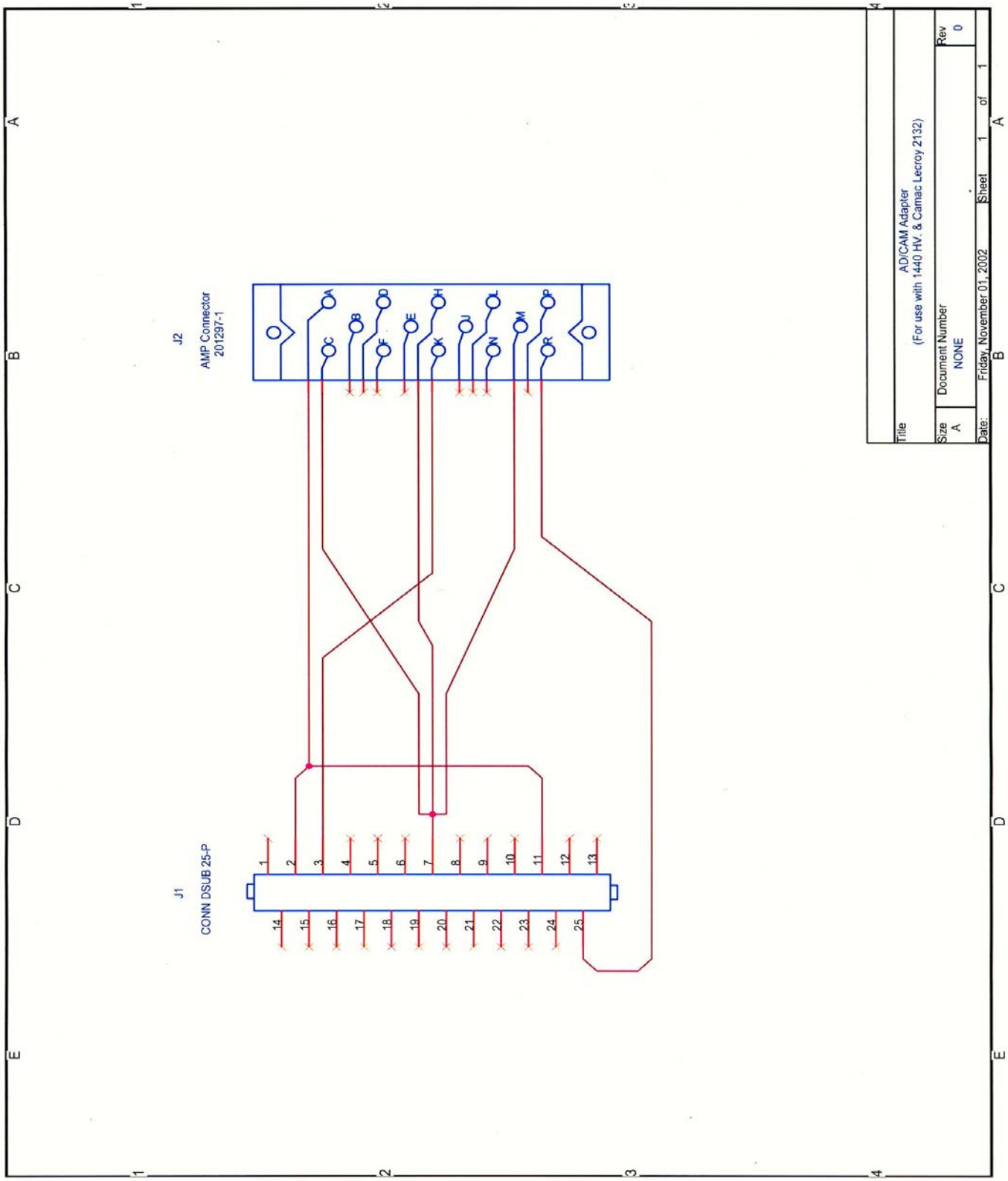
1. Install 16 Pin Plug on one end of ribbon cable. Ensure pin one on plug mates with wire one on ribbon cable.
2. Install strain relief on 16 pin plug.
3. Move to opposite end of cable.
4. On 25 Pin "D" Connector install the following jumpers:
   jumper pin 4 to pin 5
   jumper pin 6 to pin 20
5. Strip and solder the following wires as instructed:
   a. Connect wire # 1 to "D" connector pin 11.
   b. Splice wire #2 to wire #10 and apply insulation.
   c. Connect wire #6 to "D" connector pin 7.
   d. Connect wire #9 to "D" connector pin 2.
   e. Connector wire #11 to "D" connector pin 3.
   f. Connect wire #14 to "D" connector pin 25.
   g. All unused wires should be neatly trimmed back inside of "D" connector shell.
   h. Install shell on "D" connector.

C. Test

1. Install cable between terminal or PC and 1445 controller.
2. Ensure that the terminal or PC baud rate matches the baud rate of the 1445 controller. (The 1445 Controller baud rate is determined by the position of a jumper on J6 on the 1445 controller.)
3. Energize terminal of PC and wait for the completion of the initialization cycle.
4. Energize 1440 system and verify communication.

1440 High Voltage Serial Communications Cable




J2
AMP Connector
201297-1
J1
CONN DSUB 25-P
Title
AD/CAM Adapter
(For use with 1440 HV. & Camac Lecroy 2132)
Size
A
Document Number
NONE
Rev
0
Date:
Friday, November 01, 2002
Sheet
1
of
1

Appendix E

VARTA Battery Data Sheet

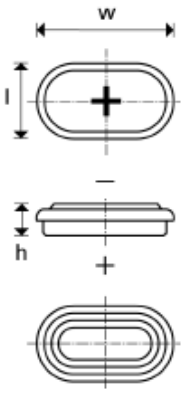
Note: Three V150 H are used. (3/V 150 H 3.6V)

VARTA
THE BATTERY EXPERTS

V 150 H

Ni-MH

Data Sheet



Type Number:	55615	
System:	Nickel Metal Hydride / KOH Electrolyte	
UL Recognition:	MH 13654 (N)	
Nominal Voltage [V]:	1,2	
Typical Capacity C [mAh]:	150	
Nominal Capacity C [mAh]: at 0.2 CA / 1.00 V	140	
Weight, approx [g]:	6	
Coding:	Manufacturing 5 digit code (123 = day/4 = year/5 = vers)	
Temperature Ranges [°C]:	min.	max.
Storage:	-40	65
Discharge:	-20	65
Charge:	0	65
Dimensions [mm]:	min.	max.
Length [l]:	13,9	14,1
Width Facing [w]:	25,45	25,6
Height [h]:	5,65	5,9
Charging Method:		
Normal Charging:	14 mA for 14-16 h	
Accelerated Charging (20°C):	28 mA for 7-8 h	
Fast Charging :	70 mA for 3 h *	
Trickle Charging :	4,2 mA	
Overcharge (20°C):	14 mA continuous 28 mA 1 year	
Charge Retention [%] at 20°C:	90	
Capacity available after 1 month storage at 20 °C		
Internal Resistance [Ohm]:	0,8	
at charged cells, 20 °C, DC: 0.2 CA/2 CA, (IEC 285)		
Impedance [Ohm]:	0,13	
at charged cells, 20 °C, AC: 1 kHz, (IEC 285)		
Typical Capacities [mAh]:		
at 1 CA / 0.90 V	88	
at 2 CA / 0.90 V	38	
Max. Discharge Current (cont.)[mA]:	280	
Life Expectancy (typical):		
IEC Cycle:	1000 Cycles	
Trickle Charge:	up to 6 years (20°C)	
Trickle Charge:	up to 3 years (45°C)	

* for fully discharged cells, 20 °C

VARTA Gerätebatterie GmbH, Daimlerstr. 1, D-73479 Ellwangen/Jagst
Tel.: (+49) 7961/83-0, Telefax: (+49) 7961/83-553

Subject to change without prior notice!
Date of Issue : 19.11.99

Appendix F

Electrolytic Capacitor Data Sheet

747D Series

UNITED CHEMI-CON

- Large Can
- Screw Terminal
- High Frequency Applications
- Low Impedance
- −55°C to +105°C Temperature Range

Actual Size

The 747D series offers a low impedance over an extended temperature range of −55°C to +105°C. With the high ripple current capability and the low impedance, the 747D is ideal for high frequency SMPS output filtering applications. The 747D series capacitors also offer a long life under normal operating conditions.

Summary of Specifications

- Screw terminals, high, low English and Metric.
- Capacitance range: 4,800 to 310,000μF.
- Voltage range: 6.3 to 35VDC.
- Operating temperature range: −55°C to +105°C.
- Leakage current in μA: $I = K\sqrt{CV}$: K = 4.0 at +25°C after 5 minutes.
- Standard capacitance tolerance: ±20%
- Nominal case size (D×L): 1.375″×1.625″ to 2.000″× 5.625″
- Rated lifetime: 2,000 hours at +105°C.

747D LARGE CAN -105°C

UNITED CHEMI-CON, INC. 9801 West Higgins Road, Rosemont, Illinois 60018 Phone 847-696-2000 Fax 847-696-9278

747D Series

747D Specifications

Item	Characteristics
Operating Temperature Range	−55 to +105°C
Rated Voltage Range	6.3 to 35VDC
Capacitance Range	4,800 to 310,000µF at +25°C, 120Hz
Capacitance Tolerance	±20% (M) at +25°C, 120Hz
Leakage Current	$I = K\sqrt{CV}$: K = 4.0 at +25°C after 5 minutes. Where I = Leakage current (µA), C = Nominal capacitance (µF) and V = Rated voltage (V)
Low Temperature Characteristics	Capacitance change: At 120Hz, capacitance at −55°C shall not be less than 80% of the specified value at +25°C. Impedance (Z) change: At 120Hz, impedance at −55°C shall not exceed 3 times the specified value at +25°C. At 20k - 100kHz, impedance at −55°C shall not exceed 30 times the specified value at +25°C.
Ripple Current Multipliers *Refer to Section 4 of the Mini-Glossary for explanation of Ripple Current Multipliers.*	Ambient Temperature (°C) +25°C: 2.0; +45°C: 1.7; +65°C: 1.4; +85°C: 1.0; +105°C: 0.5 Frequency (Hz) 120Hz: 0.90; 400Hz: 0.95; 1kHz: 0.98; 5k-100kHz: 1.00
Life Validation Test	The following specifications shall be satisfied when the capacitors are restored to +25°C after subjecting them to the DC rated voltage for 2,000 hours at +105°C. Capacitance change: ≤ 20% from initial measurement ESR change : ≤ 1.5 × initial specified limit Leakage current : ≤ initial specified limit
Shelf Test	The following specifications shall be satisfied when the capacitors are restored to +25°C after exposing them for 1,000 hours at +105°C without voltage applied. The rated voltage shall be applied to the capacitors for a minimum of 30 minutes, at least 24 hours and not more than 48 hours before the measurements. Capacitance change: ≤ 15% from initial measurement ESR change : ≤ 1.3 × initial specified limit Leakage current : ≤ 2 × initial specified limit

Part Numbering System for 747D Series

When ordering, always specify complete catalog number for 747D Series.

747D 293 M 025 BA 2 A

- A: Lead Code: A = Low Post 10-32 Screw Thread (Standard). B = High Post 10-32 Screw Thread. I = High Post M5 Screw Thread.
- 2: Case Style: 2 = PVC Sleeve.
- BA: Case Code: See Case Sizes in Tables.
- 025: DC Rated Voltage: Expressed in Volts. Zero proceeds the voltage rating when less than 100 volts. An R indicates a decimal point (e.g. 6R3 = 6.3V).
- M: Capacitance Tolerance: M = ±20%
- 293: Capacitance Value: Expressed in Microfarads. The first two digits are significant figures, the third digit indicates the number of zeros.
- 747D: Series Name: Indicates Basic Capacitor Design.