

## Purpose of Upgrade

The purpose of this upgrade is to make the Booster high level rf system a reliable operating system for the increased operating demands over the next 10 years. The project described in this upgrade will increase the reliability of Booster high level rf system by replacing a number of key antiquated high level rf components (existing equipment 36 years old, Figure 1) with modern equipment, similar to that used in the Main Injector's rf system. Equipment to be replaced is the Cober series tube modulators located in the equipment galleries and the high power rf amplifiers located on each cavity in the tunnel.



Figure 1. Typical Booster rf station. Ling ferrite bias supply (orange), Cober series tube modulator (red), and RMU relay rack (yellow).

## Introduction

Booster rf reliability has been a significant matter for discussion over the past couple of years. Chart 1<sup>1</sup> clearly shows an increasing trend with increased numbers of downtime

entries coincident with the beginning of MiniBooNE operations in 2002. The situation today is even worse due to NuMI/MINOS as an additional customer for beam. With plans to increase the rf system's duty factor from the present 7 Hz operation to 9 Hz for the proton plan, increasing reliability is mandatory for successful operation.

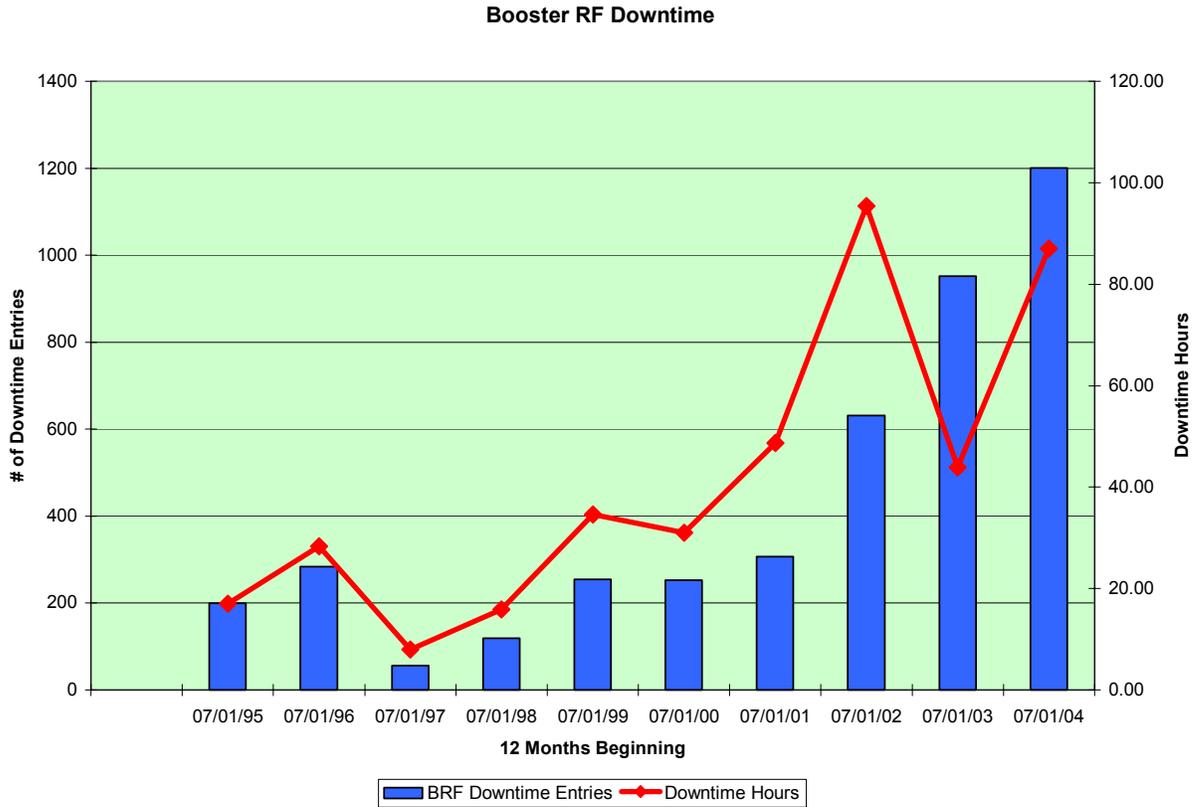


Chart 1. Downtime entries on yearly basis

Due to the increased demands on the Booster rf system for even higher repetition rates (to support MiniBooNE and NuMI/MINOS) and the increased quality of beam required for successful slip stacking, operating with a minimum peak accelerating voltage of 900 Kvolts/turn is required to maintain optimum performance.

To maintain 900 Kvolts/turn operations, requires 18 stations operating on a 24-7 basis. To maintain 18 operational stations at all times requires increasing the number of stations or decrease the downtime of the existing systems. Station # 19 has been added but has had mixed operational results. Adding rf cavities increases the rf accelerating voltage but also comes at a price by adding additional cavity induced impedance that may cause stability problems for the beam. Operationally, running with an odd number of stations complicates the balancing (A station group to B station group) for paraphasing at injection and bunch rotation at extraction. Auto switching (to compensate for loss of either an A or B station) of St #19 will be implemented during the March 2006 shutdown.

## History

For more than 12 years the rf department has proposed a program to upgrade critical Booster high level rf equipment with modern Main Injector/TEV RF style equipment. This request has been included in the annual WAPS for many years but no action or management support ever materialized. The rf group in May of 2001 upgraded Booster station 12 as a proof of principle for the proposed upgrade. This was to demonstrate the increased reliability of the station by use of a Solid state rf driver amplifier located in the equipment gallery, new PA design on cavity in tunnel, and a new series tube modulator in the equipment gallery. Figure 2 shows the installation for Booster station 12. Most of the components used in this upgrade were proven designs developed for the Main Injector. The modulator and solid state driver are very similar in design to the Main Injector. The power amplifier is also similar to Main Injector but has a different cathode circuit to allow broadband tuning of the Booster frequency. The reliability of this station has been excellent. The only downtime attributed to this station was to change the power amplifier after 3+ years of operation (end of life), one deck amplifier tube (4CW800F), and one series tube (Y-567B) but only after 4 years of operation.



Figure 2. Booster station 12 with (from L to R) Solid state driver amplifier, RMU rack, Ferrite bias supply (orange), & Series tube modulator (red).

## Present Operational Reliability Issues

The Booster rf system, compared to Main Injector and Tevatron rf systems, has the oldest equipment and exhibits, not surprisingly, the least reliability.

Table 2 is a summary of equipment failures for the Booster rf system over the past 3 years.

<b>Equipment</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>
	<b># Failures</b>	<b># Failures</b>	<b>Thru 3-26 # Failures</b>
<b>Modulator</b>	23	25	5
<b>Bias Supply</b>	3	8	5
<b>Power Amplifier</b>	20	21	3
<b>RF Cavity</b>	6	10	1
<b>Anode Supply</b>	3	3	1

Table 2. Equipment failures by year.

### Power Amplifier

The present Booster power amplifiers consist of 3 major sections, the distributed amplifier, the cascode amplifier, & finally the power module, all located on top of the accelerating cavity in the tunnel. When a failure occurs in any one of the 3 sections of the present power amplifier, a tunnel access is required to make repairs.

Figure 3 shows the cross section of the present Booster amplifier. It is a very complicated structure with a high density of water-cooled components in a small compact volume. Many of the components used in this amplifier are 20 to 36 years old.

The life expectancy of the present Booster Power Amplifier varies depending on the section of the amplifier. The Distributed Amplifier uses 6 water-cooled 4CW800F tetrodes (800 watt plate dissipation), which typically last about 12 months. The Cascode Amplifier uses 14 water-cooled 4CW800F tetrodes (800 watt plate dissipation), which also last about 12 months. It should be noted that when tubes are changed in either the distributed amplifier or cascade amplifier, they are replaced with a complete set of new tubes, 6 or 14 respectively; at a cost of \$1200.00 per tube (20 tubes cost 24,000 dollars). At the end of the 12-month life expectancy, the tubes are emission limited and will not supply the current needed to support the minimum power requirements. The proposed upgrade with a Solid State Driver amplifier will eliminate these tubes. Presently our annual tube budget for the small 800 watt tetrodes is \$432,000.

Premature failures do occur due to various failure mechanisms which can be from power outages to water leaks. These failures, though small in number, must be added to the above average life expectancy for the amplifier.

In summary, 18 operational stations require a replacement rate of 1.5 amplifiers per month. However, the large power tube, Y-567B, (4CW150000E) usually lasts from 24 to 36 months. These power tubes have been very reliable and are identical to those used in the MI and TEV rf systems. The proposed new power amplifiers would use this same tube.

The time to repair a typical Booster power amplifier is about 60 man-hours or more compared to the proposed new power amplifier which can be serviced in less than 16 hours. This is due to the present Booster amplifier having 3 rf modules that makeup the power amplifier which must be rebuild independently, performance tested independently, and then assembled together as a complete unit. The complete amplifier is tested as an assembly that must meet predetermined specifications for acceptance. The amplifier is run for a minimum of 4 hours on our test station to further weed out premature failures. The complexity of these devices along with their age makes the repair process a very labor-intensive refurbishment.

Complicating the repair process in recent years is the amount of residual radioactivity present on the power amplifier. Some rf stations are much worse for activating their amplifiers (some as high as class 3 at 1 foot) and in these cases the amplifiers must be left in the tunnel's staging area for cool down. This cool down may be anywhere from 1 to 4 months before being brought upstairs for repair.

Even with this cool off period, significantly high class 1 ratings are still present and further add to the accumulated dose rate our Booster technicians receive.

### **Modulator**

The present series tube modulators are relics of the past and were outdated from day one. They use technology from the 50's with some of the tubes used in the deck amplifier chassis getting harder to procure. Other direct replacement parts are becoming more difficult to obtain and in the not to distant future, some components will have to be replaced with "newly designed" components.

The present modulators use very few printed circuit boards (see Figure 4) but contain G-10 boards with point to point wiring. This makes troubleshooting difficult and time consuming. Failures come in many ways but usually require several days to more than a week to repair and electrically test, especially if the failure mode involves high voltage arcing.

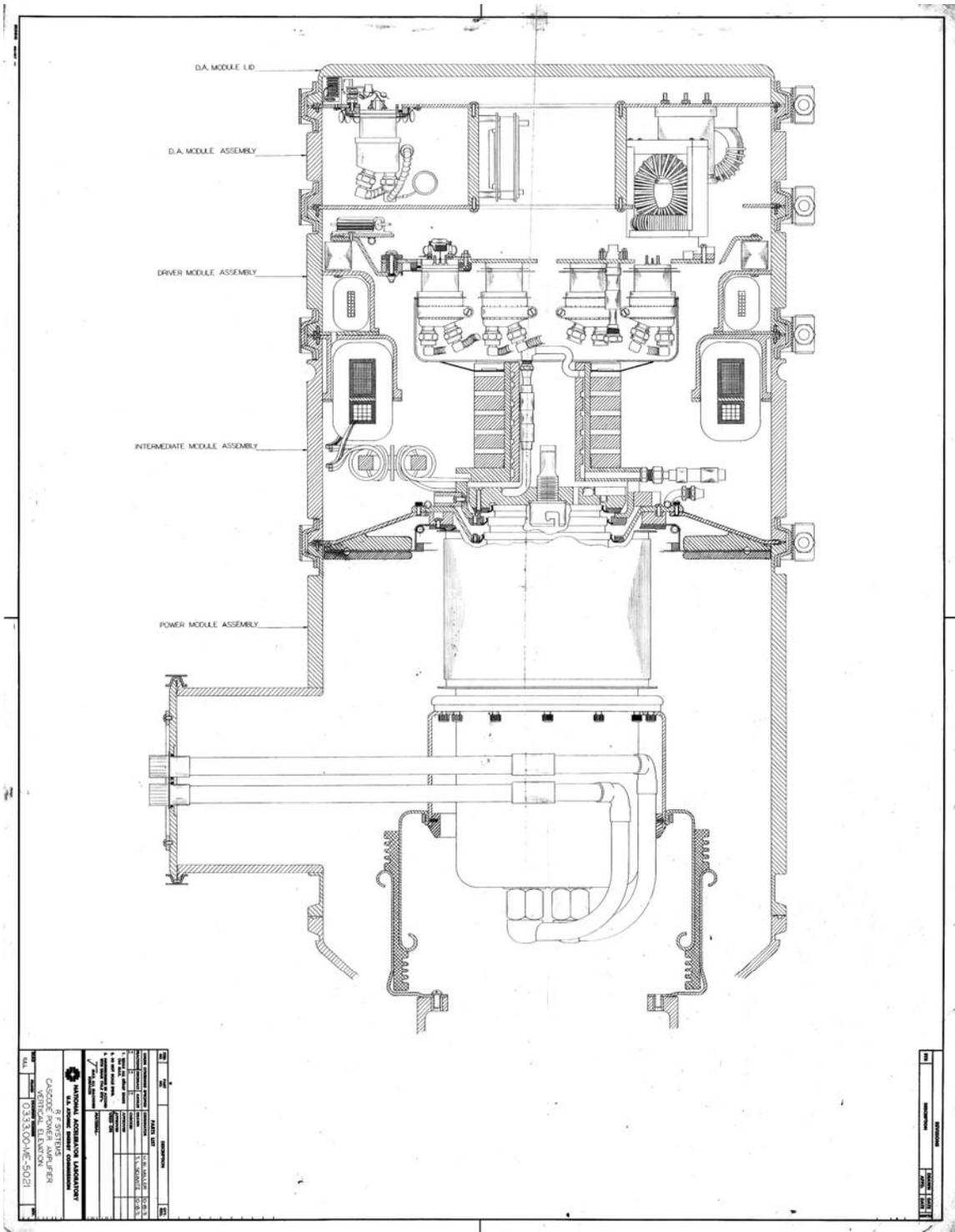


Figure 3. Cross section of present Booster power amplifier.

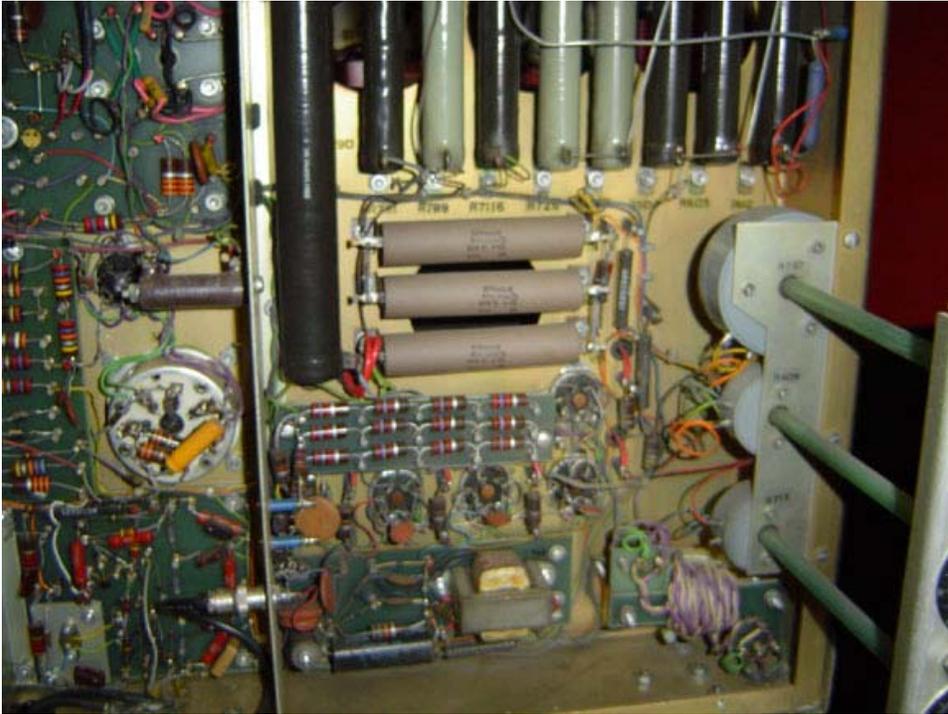


Figure 4. Typical chassis in present modulator showing electronic circuit boards.



Figure 5. Opposite side to Figure 4 showing vacuum tubes.

Even though the modulators are located in the equipment gallery, they share a common anode power supply making repair impossible without shutting down a whole gallery to mechanically disconnect their HV cables (35,000 volts).

Also included in the modulator are the power supplies for the Power Amplifier. These supplies are outdated and not used for the proposed new power amplifiers. The proposed solid state driver amplifier effectively eliminates the distributed & cascode amplifiers power supplies (DA anode, DA screen, DA Grid, Cascode Cathode, Cascode screen, and Cascode grid power supplies).

Failure rates for the Booster modulators have averaged about 2 per month for the last two years. But this does not tell the whole story in that many times the modulator will trip on various power supply faults and just resetting the modulator will restore station operation. These trips become a real nuisance for operators. Sometimes technicians may need to adjust the settings of the HV deck to compensate for drifting parameters, adjust temperamental relays, and other times leaving the modulator off until it can be disconnected from the anode supply to allow for further troubleshooting.

### The Upgrade Plan

Build 22 new modulators, 150 Kwatt power amplifiers, and Solid state driver amplifiers. This would be accomplished by purchasing all major components on the outside (build per print) with final assembly of components in-house. This technique proved very successful in keeping costs to a minimum for the assembly of the Main Injector's rf equipment. Twenty-two of each will be sufficient for 19 stations with 3 spares.

### Cost

Table 3 shows the estimated M&S along with an estimate of labor required for this project. It should be noted that if this project goes forward, the funding profile must be heavily front loaded so procurement of all components can be done at one time. This assures that quantity discounts are maximized.

System	QTY	M&S	M&S	Labor T2	Labor ENG	Labor T2	Labor ENG
		Each	Total 22 Units	Each in Hrs	Each in Hrs	Total 22 Units	Total 22 Units
Power Amplifier	22	74,976	1,649,472	80	8	1760	176
Modulator	22	70,334	1,547,348	260	80	5720	1760
Solid State Driver	22	114,993	2,529,846	240	24	5280	528
Installation	AR		400,000	64	16	1088	272
<b>Total</b>		<b>260,303</b>	<b>6,126,666</b>	<b>644</b>	<b>128</b>	<b>13848</b>	<b>2736</b>

Table 3. Estimated upgrade costs

Manpower to complete this project in a timely manner (less than 2 years) is a grave concern to me. The high level rf group is already stretched very thin. Our group would require some help from other groups to assemble components. Summer students would

be a big help in loading printed circuit boards, making cables, assembling wiring harnesses, and assembling parts into the major chassis. Summer students were heavily relied upon for assembly during the Main Injector rf fabrication.

Doing the final assembly in-house allows tight control of quality and consistency of fabrication.

## Installation

This upgrade would require very little engineering effort since most of the details were worked out with stations 12 & 19. However, we know that some existing equipment (non rf stuff) will have to be moved that is now blocking the proposed solid state driver rack locations (rack locations are restricted by electrical cable lengths). Problem stations are shown in Table 4.

		Station Number
<b>Clear Stations</b>	East Gallery	3,4,5,6,7,19, 20
	West Gallery	17,10,11,12,14,15
<b>Problem Stations</b>	East Gallery	1 - Need to move HV racks G13, RR7, and a transformer 2 - Need to move racks G14-RR1 & G14-RR2. RR2 is empty 8 - Need to move damper/diagnostic racks
	West Gallery	18 - Need to work out solution for blocking access to breakers 9 - Need to work out solution for blocking access to breakers 13 - Move safety system racks 16 - Debuncher water skid control panel in the way

Table 4. Driver Rack Installation Issues

The installation can be divided into two parts, station preparation & actual component installation. Once the preparation of each station is complete (could be done on down days), conversion of a single station could be done on a two-day shutdown. Stations would be converted one at a time as down time permits. No long shutdown is needed for this upgrade. All cabling would be prefabricated and rf cables phase matched ahead of time.

Water drops have already been installed at all stations for the solid state driver. However, some modifications to the LCW return piping header will be necessary in each gallery to reduce the return pressure.

A 480 volt 30 amp and 120 volt 15 amp circuits will have to be added to each Booster rf station for the solid state driver.

## Conclusion

This upgrade is essential for reliable Booster rf operation over the next 10 years. Demands on the rf system to increase the repetition rate from the present 7 Hz to 9 Hz and then possibly to 15 Hz are not compatible with increasing reliability for much of the existing rf equipment. The new equipment will go a long way to improving reliability and at the same time reducing the radiation exposure to our technicians.

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1. Ducar, R. and Reid, J. Determine Booster RF Repetition Rate Limit & Improve Booster RF reliability. Fermilab Proton Plan WBS 1.2.1 internal note, July 20, 2005.

Appendix A: Detailed costs by subsystem

Booster SSD Upgrade Cost Estimate

Appendix A:		
SSD Component:	Solid State Driver Costs per Station in Dollars	Solid State Driver Costs PRODUCT ASSEMBLY = 22 UNITS
SSD Control Unit	3,193	70,254
SSD Metering Chassis	4,169	91,716
Diode Detector parts	435	9,563
Rack Parts	1,967	43,278
Cabling & Connectors	4,697	103,336
EMI ESS Power Supply	9,813	215,886
Combiner	10,000	220,000
Directional Couplers	5,455	120,000
SS RF Amplifiers	74,031	1,628,680
Plumbing	1,234	27,140
<b>GRAND TOTAL</b>	<b>114,993</b>	<b>2,529,853</b>

Plumbing

Plumbing parts list											PRODUCT ASSEMBLY	22
Description	Manufacturer	Manufacturer Part No.	Vendor	Vendor Stock No.	Qty/Assembly	Unit	Total Qty	Qty Needed	Pkgs	Price/Pkg	Total Price	
TEE, MULLER STYLE WT - 600 1/2 X 1/4 X 1/2 FPT	Mc MASTER CARR	4429K226	Mc MASTER CARR	4429K226	18	ea	360	360	0	\$4.83	\$1,738.80	
BARB, HOSE, BRASS, PUSH LOK, 1/2 HOSE X 1/2-14 MPT	PARKER-HANNIFIN	30182-8-8B	FNAL	1017-013500	4	ea	80	80	0	\$3.09	\$247.20	
BARB, HOSE, BRASS, PUSH LOK, 3/8 HOSE X 1/4-18 MPT	PARKER-HANNIFIN	30182-4-4B	FNAL	1017-012700	16	ea	320	320	0	\$1.28	\$409.60	
BUSHING, REDUCER, BRASS, IMP.EAST. 1/2 MPT X 1/4 FPT	IMP-EAST		FNAL	1020-007000	2	ea.	40	40	0	\$0.59	\$23.60	
VALVE, NEEDLE, IN-LINE, BRASS 3000 PSI, 1/4 IN. MPT	WHITEY VALVE		FNAL	1075-021500	2	ea	40	40	0	\$17.77	\$710.80	
HANGER, 3/4 IN. RIGID, 3/4 IN. EMI	MINERALLAC	P/N 1-B	FNAL	1115-280000	10	ea	200	200	0	\$0.28	\$56.00	
NIPPLE, PIPE, BRASS, 1/2 MPT X 2 IN. LG.			FNAL	1020-075500	8	ea	160	160	0	\$0.87	\$139.20	
BARB, HOSE, BRASS, 37 DEG. FLARED	PARKER-HANNIFIN		FNAL	1017-018000	2	ea	40	40	0	\$2.00	\$80.00	
3/8 IN. FEMALE FLARE X 3/8 IN. HOSE BARB, 37 DEG. FLARE	PARKER-HANNIFIN	P/N 30682-6-6B			16	ea	320	320	0	\$2.04	\$652.80	
WASHER, STEEL, PLASTER-CEILING CANOPY, 9/32 IN. ID X 1-1/4 IN. OD	MAJESTIC	PW-8A	FNAL	1125-272000	4	ea	80	80	0	\$0.02	\$1.60	
SCREW, MACH., BIND.HD., TYPE 18-8 S.S., SLOTTED, 1/4-20NC X 3/4			FNAL	1226-168000	4	ea.	80	80	0	\$0.05	\$4.00	
SCREW, CAP, HEX. HD., TYPE 18-8 S.S., CLASS-2A THD, 1/4-20NC X 1/2			FNAL	1226-050000	28	ea.	560	560	0	\$0.04	\$22.40	
WASHER, FLAT, SCREW SIZE 1/4,TYPE 18-8 S.S.			FNAL	1218-062000	28	ea.	560	560	0	\$0.04	\$22.40	
UNISTRUT,CHANNEL FITTING, NUT W/SHORT SPRING, FOR 1-1/4 IN.	UNISTRUT	P/N A4006-1420	FNAL	1240-150000	28	ea.	560	560	0	\$0.52	\$291.20	
SUPPORTS, CHSSIS, RELAY RACK, SIZE 3 X 3 X 20"	ABTRON SYSTEMS INC	NO.8102-0001	FNAL	1775-225000	7	pair	140	140	0	\$35.82	\$5,014.80	
CLAMP, HOSE WORM DRIVE, ALL S.S., 1/2 IN. MIN.X 29/32 IN. MAX.		P/N 200-08H	FNAL	1070-201000	4	ea.	80	80	0	\$0.62	\$49.60	
CLAMP, HOSE WORM DRIVE, ALL S.S., 1/4 IN. MIN. X 25/32 IN. MAX.		P/N 6606	FNAL	1070-200300	18	ea.	360	360	0	\$0.51	\$183.60	
HOSE, PARKER, PUSH LOK, 831-4 BLACK 1/4"	PARKER		Instrument Ass	831-4	5	ft.	100	100	0	\$1.70	\$170.00	
HOSE, PARKER, PUSH LOK, 831-6 BLACK 3/8"	PARKER		Instrument Ass	831-6	11	ft.	220	220	0	\$2.00	\$440.00	
HOSE, PARKER, PUSH LOK, 831-8 BLACK 1/2"	PARKER		Instrument Ass	831-8	5	ft.	100	100	0	\$2.08	\$208.00	
NIPPLE, PIPE, BRASS, 1/2 MPT X 12 IN. LG.	Monarch Supply Co. Inc.		Monarch Supply Co. Inc.		1	ft.	20	20	0	\$7.13	\$142.60	
SUPPORT SLEEVE, BRASS	PARKER-HANNIFIN	12TX-B	Catching Fluid Power	12TX-B	2	ea	40	40	0	\$1.74	\$69.60	
NUT, BRASS	PARKER-HANNIFIN	12BTX-B	Catching Fluid Power	12BTX-B	2	ea	40	40	0	\$2.49	\$99.60	
BUSHING, REDUCER, BRASS, IMP.EAST. 3/4" X 1/2 FPT	IMP-EAST		FNAL	1020-0090	1	ea.	20	20	0	\$0.82	\$16.40	
COUPLING, BRASS, 3/4" FPT	IMP-EAST		FNAL	1020-0260	2	ea.	40	40	0	\$1.12	\$44.80	
NIPPLE, PIPE, BRASS, 3/4" MPT X CLOSE	IMP-EAST		FNAL	1020-0785	2	ea.	40	40	0	\$1.04	\$41.60	
NIPPLE, PIPE, BRASS, 1/2" MPT X CLOSE	IMP-EAST		FNAL	1020-0750	8	ea.	160	160	0	\$0.58	\$92.80	
VALVE, NEEDLE, IN-LINE, BRASS, 3000 PSI, 1/4 IN. MNPT X 1/4 IN. FNPT	PARKER-HANNIFIN	4M4F-V6LN-BOR	FNAL	1020-0750	2	ea.	40	40	0	\$32.70	\$1,308.00	
COUPLING, QUICK-DISC., BRASS, BODY-FEMALE, DOUBLE SHUT-OFF, 3/4" BODY X 3/4" FPT			FNAL	1018-0125	2	ea.	40	40	0	\$28.33	\$1,133.20	
COUPLING, QUICK-DISC. BRASS, NIPPLE-MALE CONNECT DOUB. S. O. 3/4" BODY X 3/4" MPT			FNAL	1018-0200	2	ea.	40	40	0	\$10.02	\$400.80	
ADAPTER, COPPER, COP TO MPT, 3/4 IN. X 1/2 IN.	MUELLER	WC-401	FNAL	1025-0250	2	ea.	40	40	0	\$1.87	\$74.80	
ALUMINUM ROUND STOCK, 1-1/2 IN. O. D. X 1-1/8 IN. I.D. X HEIGHT (1/2 IN.), TO BE MADE INTO 1/2 IN. SPACERS. COMPANY WILL PROVIDE MATERIAL AND MACHINE AS PER SKETCH.	TW METALS - SANDY SCHROEDER (630) 690-0110	QUOTE NUMBER - 80169915	TW METALS		2	ea.	40		0	\$3.50	\$140.00	
CLAMP, HOSE WORM DRIVE, ALL S.S., INCL. SLOTTED SCREW	BREEZE	P/N 6604	FNAL	1070-2000	2	ea.	40	40	0	\$0.51	\$20.40	
Flow Turbine					1	ea.	20	20		\$650.00	\$13,000.00	
TUBING, COPPER, SOFT, 50 FT. COIL 3/4 OD X .035 WALL			FNAL	1065-0085	1	ft.	30	30	0	\$1.05	\$31.50	
TUBE X FEMALE PIPE	Mc MASTER CARR	50635K433	Mc MASTER CARR		2	ea.	40	40	0	\$1.45	\$58.00	
										<b>TOTAL COST</b>	<b>\$27,139.70</b>	









Diode Det

4 Channel Diode Detector

Item	Description	Part No.	Qty Per Board	Tot. Qty	Designation	Manufacturer	Vendor	Vendor Part No.	Unit of Mea.	Price Per Unit	Price Total
1	Cap, Ceramic	.1uF, 100V	36	3240	C2-C5, C7-C11, C13-C16		Stockroom	1415-3140	ea	\$0.11	\$356.40
					C18-C22, C24-C27, C29-C33						
					C35-C38, C40-C44						
2	Cap, Mica	100pF, 500V	8	720	C1, C6, C12, C17, C23, C28		Stockroom	1420-1140	ea	\$0.51	\$367.20
	Mica				C34, C44						
3	Diode	1N5711	16	1440	D1-D16	Fermi	Stockroom	1445-0590	ea	\$0.53	\$763.20
	(HP #5082-2800)										
4	Op-Amp	TL-081	4	360	U1, U3, U4, U6	Fermi	Stockroom	1455-1010	ea	\$0.14	\$50.40
5	Op-Amp	TLE-2144	2	180	U2, U5	T.I	Digi-Key	296-10472-5-nd	ea	\$2.27	\$408.24
6	Socket, DIP 8	508-AG11D	4	360	U1, U3, U4, U6	Tyco/AMP	Newark	14F2712	ea	\$1.87	\$673.20
7	Socket, DIP 14	514-AG11D	2	180	U2, U5	Tyco/AMP	Newark	13F703	ea	\$2.27	\$408.60
8	Pot, Trim	10K	4	360	R5, R16, R27, R38	Fermi	Stockroom	1480-1100	ea	\$0.54	\$194.40
9	Pot, Trim	100K	4	360	R9, R20, R31, R42	Fermi	Stockroom	1480-1140	ea	\$0.79	\$284.40
10	Res, 1/4W	10Ω	8	720	R10, R11, R21, R22, R32	Panasonic	Digi-Key	P10.0CACT-ND	1000/pkg.	\$33.75	\$33.75
	Carbon				R33, R43, R44						
11	Res, 1/4W	100Ω	8	720	R2, R6, R13, R17, R24, R28	Panasonic	Digi-Key	P100CACT-ND	1000/pkg	\$33.75	\$33.75
	Carbon				R35, R39						
12	Res, 1/4W	39KΩ	4	360	R1, R12, R23, R34	Panasonic	Digi-Key	P39KBACT-ND	200/pkg	\$4.88	\$9.76
	Carbon										
13	Res, 1/4W	470KΩ	4	360	R4, R15, R26, R37	Panasonic	Digi-Key	P470KBACT-ND	200/pkg	\$4.88	\$9.76
	Carbon										
14	Res, 1/8W	100K	4	360	R3, R14, R25, R36	Panasonic	Digi-Key	P100KBACT-ND	1000/pkg.	\$33.75	\$33.75
	Metal Film										
15	Res, 1/8W	150K	4	360	R7, R18, R29, R40	Panasonic	Digi-Key	P150KCACT-ND	1000/pkg.	\$33.75	\$33.75
	Metal Film										
16	Res, 1/8W	402K	4	360	R8, R19, R30, R41	Yageo	Digi-Key	402KXBK-ND	1000/pkg.	\$21.38	\$21.38
	Metal Film										
17	Connector	6 Pin	1	90	J17	Burndy	Fermilab	MS3120-E10-6P	ea	\$15.80	\$1,422.00
18	Jack, 50Ω	BNC	16	1440	J1-J16	AMP	Allied Elect	227671-1	ea	\$1.52	\$2,188.80
	Connector										
19	Lockwasher, BNC		16	1440	J1-J16		Allied Elect	512-2190	ea	\$0.13	\$187.20
	Connector										
20	Jamnut, BNC		16	1440	J1-J16		Allied Elect	512-2191	ea	\$0.15	\$216.00
	Connector										
21	Terminal		3	270	PD1-PD3	Cambion					\$0.00
22	Box, Aluminum		1	90		Bud Box	Allied Elect	736-3602	ea	\$15.00	\$1,350.00
23	Board, P.C.		1	90		Fermi	Cunningham Graphics			\$5.75	\$517.50

**TOTAL \$9,563.44**



Modulator\_Parts\_List\_3\_31\_06a.xls

Appendix A:	Modulator Parts List & Cost						3/30/02	
DESCRIPTION	Manufacturer	PART #	Resource Names	Resource #	Drawing Number	Qty.	Unit Price	Total
3/8" x 1" x 16" Adhesive Foam								\$0.00
4CW800F, Tube Socket, Grounded Grid Assembly:					1735.02-MD-63804	1	\$1,682.00	\$1,682.00
Insulating Mount					1735.02-MC-63807			
Screen Flange Connector					1735.02-MC-63808			
Screen Flange Clamp					1735.02-MC-63809			
Deck Chassis Conn.-Conn.					1735.02-MD-63810			
Cathode Connector					1735.02-MC-63811			
Grounded Grid Connector					1735.02-MC-63816			
Grounded Grid Plate					1735.02-MC-63817			
Deck Chassis Connector					1735.02-MC-63818			
Angle, Equal Leg	Glastic	2878	Electric Insulation			1	\$11.57	\$11.57
Blower	Joy	AVR61-4301535				2	\$750.00	\$1,500.00
Bracket, Aluminun, T4, for P & B relay			Machine Shop		9530-MB-181352	1	\$50.00	\$50.00
Breaker, Circuit, 10 A, 480 V	General Electric	TED124010WL	Tri Star Supply Inc.	TED124010WL		1	\$137.75	\$137.75
Breaker, Circuit, 15 A, 480 V	General Electric	TED134015WL				1	\$179.08	\$179.08
Breaker, Circuit, 30 A, 480 V	General Electric	TED134030WL				1	\$179.08	\$179.08
Cable, High Voltage, 12 ft.		QA93 1092 14150	BIW Cable Systems Inc.			12	\$18.00	\$216.00
Cable, RG-58, Red HV			Stockroom	1170-0360		20	\$0.14	\$2.80
Cable, Twinax			Stockroom	1170-0390		50	\$0.25	\$12.50
Capacitor, 0.1 uF, 40 KV	NWL	Model 12233	NWL	Model 12233		1	\$428.00	\$428.00
Capacitor, 0.47 uF, 600 V	Sprague	430P474X9600	Newark Electronics	50F2587		3	\$3.66	\$10.98
Capacitor, 1000 uF, 25 V		675D108MD25DS3D				3	\$4.00	\$12.00
Capacitor, 2000 uF, 450 V, Alluminum Electrolytic		CGS202T450X5C				4	\$82.50	\$330.00
Capacitor, 470 pF, 1 KV, ceramic disc						5	\$0.28	\$1.40
Capacitor, 470uF @50V	Mallory	SKR471M1HJ21V				5	\$0.50	\$2.50
Capacitor, 60uF @ 250 V, Axial Lead						5	\$0.60	\$3.00
Capacitor, Door Knob, 2500pF, 40KV	Vishay	40DKD25	Newark Electronics	46F5301		4	\$91.78	\$367.12
Capacitor, Feedthru, 1000 pF, 600 V						45	\$0.70	\$31.50
Capacitor, general purpose ceramic, 1.0 uF, 100 V								\$0.00
Channel, Glastic, 120"/length	Glastic	1177	Electric Insulation			1	\$69.12	\$69.12
Channel, Glastic, 120"/length	Glastic	1788	Electric Insulation			1	\$69.12	\$69.12
Channel, Glastic, Hat Shaped, 120"/length	Glastic	2091	Electric Insulation			1	\$64.28	\$64.28
Clamps, 1 1/4", for water pipes			Mc Master Carr	3023T61		3	\$4.50	\$13.50
Clamps, 1", for water pipes			Mc Master Carr	3023T59		2	\$4.25	\$8.50
Clamps, cable, 1/2"			Fermilab Stockroom	1150-0760		50	\$0.09	\$4.50
Clamps, for ceramic pipes	Machine Shop		Fermilab		1735.02-MC-63930	2	\$50.00	\$100.00
Clips for Globar resistors, 1"	Ceswid	#35268				8	\$4.50	\$36.00
Clips for Globar resistors, 3/4"	Ceswid	#35267				20	\$4.00	\$80.00
Connectors:								\$0.00
10 pos. , cable end		MS3126F12-10S	Fermilab Stockroom	1430-2160		1	\$18.49	\$18.49
10 pos. , cable end		MS3126F12-10P	Fermilab Stockroom	1430-2040		1	\$14.08	\$14.08
12 pos. , cable end		G6F14-92	Fermilab Stockroom	1430-3020		1	\$18.56	\$18.56
12 pos. , panel mount		GOB14-92	Fermilab Stockroom	1430-3220		1	\$14.07	\$14.07
2 pos. , panel mount		MS3100A10SL-4P				1	\$35.00	\$35.00
3 pos. , panel mount		MS3120E12-3P	Fermilab Stockroom	1430-2260		1	\$35.00	\$35.00

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32 pos. smooth bantam, cable end		MS3126F18-32P			1	\$35.00	\$35.00
32 pos. smooth bantam, panel mount		MS3122E18-32S			1	\$35.00	\$35.00
4 pos. , cable end		G6F10-4SNE	Fermilab Stockroom	1430-3090	2	\$16.44	\$32.88
4 pos. , cable end		MS3106A20-4S			1	\$35.00	\$35.00
4 pos. , panel mount		GOB-10-4SNE	Fermilab Stockroom	1430-3290	1	\$8.33	\$8.33
6 pos. , cable end		MS3126F10-6P	Fermilab Stockroom	1430-2000	1	\$13.07	\$13.07
8 pos. , cable end		G6F12-88PNE	Fermilab Stockroom	1430-3000	1	\$28.80	\$28.80
8 pos. , cable end		G6F12-88SNE	Fermilab Stockroom	1430-3100	1	\$24.80	\$24.80
8 pos. , panel mount		GOB12-88SNE	Fermilab Stockroom	1430-3300	1	\$9.83	\$9.83
Banana plug, female	H H Smith		Fermi Spec. Proc. Sprs.	Bin 186 & 187	2	\$4.00	\$8.00
Banana plug, male	H H Smith		Fermi Spec. Proc. Sprs.	Bin 186 & 187	2	\$4.00	\$8.00
BNC, Bulkhead Feedthru			Fermilab Stockroom	1435-0800	33	\$6.50	\$214.50
BNC, cable crimp, RG-174			Fermilab Stockroom	1435-2950	26	\$6.58	\$171.08
BNC, cable crimp, RG-58			Fermilab Stockroom	1435-2850	1	\$4.41	\$4.41
Card Edge, 6 Contacts	Cinch	50-6A-20			1		\$0.00
Card Edge, 18 Contacts	Cinch	50-18A-20					\$0.00
Card Edge, 22 Contacts	Cinch	50-22A-20					\$0.00
Connector, for current sensor	Amphenol	165-34			1		\$0.00
Crouse Hines, 480 V	Crouse Hines	NPJ3484		1110-2240	1	\$213.45	\$213.45
HN, bulkhead feedthru		UG-1019/U			2		\$0.00
HN, cable crimp		UG-59B/U			4		\$0.00
N, bulkhead feedthru			Fermilab Stockroom	1435-0670	2	\$14.18	\$28.36
N, cable crimp			Fermilab Stockroom		4		\$0.00
SMA, cable crimp, RG-174					1		\$0.00
SMA, straight bulkhead					1		\$0.00
Stud-Type Junction Block (feedthru)	Cooper	Part # C5898	Connector Concepts Inc.	C58898	2	\$10.00	\$20.00
Trim Trio	Burndy	GOB104PNE			1		\$0.00
Twinax, bulkhead feedthru			Fermilab Stockroom	1435-0690	3	\$11.20	\$33.60
Twinax, cable crimp			Fermilab Stockroom	1435-3050	6	\$9.81	\$58.86
Twinax, cable crimp, blue cable					1		\$0.00
Copper Sheet, 5 mil.,					1		\$0.00
Core, Toroidal, Iron Powder		T520-2			2		\$0.00
Counter, Spark, Mini LX Totalizer	Veeder-Root	799806-212			1		\$0.00
Coupling, Vaccum		S100-KM			4		\$0.00
Current Sensor	F.W. Bell	IA-5025P	Golbeck Milota		1		\$0.00
Diode		A115B			1		\$0.00
Diodes, for meters		1N4723			4		\$0.00
Enclosure, Modulator Frame	Send out for Bid				1	\$7,300.00	\$7,300.00
Fast I Sensor Assembly					2	\$350.00	\$700.00
a. Housing - Cable Side				1735.02-MD-180969			\$0.00
b. Housing - Flange Side				1735.02-MD-180970			\$0.00
d. Ferrite Core ( Mn 100 )				1731.01-MB-180387			\$0.00
e. Spring Fingers							\$0.00
f. Resistors							\$0.00
g. Connector, BNC bulkhead to cable crimp, RG-174							\$0.00
FET		VFN320			1	\$16.00	\$16.00
Filter, Air, 8" x 8" x 1"	FRAM	525-G19	Midwest Air Filter		3	\$2.25	\$6.75
Filter, Line	Corcom	10R6	Newark Electronics	15F2477	4	\$40.68	\$162.72
Filter Reactor	Stancor	C-2690			1	\$42.60	\$42.60
Finger Stock, All purpose gaskets		0097-0536-07					\$0.00

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Finger Stock, Large enclosure series		0097-0436-07						\$0.00
Finger Stock, Strips		0097-0410-07						\$0.00
Finger Stock, Strips		0097-0300-07						\$0.00
Fitting, Tube to Female Pipe, Female Connector		4-4 GBZ-SS						\$0.00
Fitting, Tube to Tube Union, Bulkhead Union		4-4 WBZ-SS						\$0.00
Fitting, Tube to Male Pipe, Male Connector		5-4 FBZ-SS						\$0.00
Fittings, plumbing, for 800F tap off								\$0.00
Fuse, 10 A,	Cooper	KTK-10	Newark Electronics	28F205		1	\$14.04	\$14.04
Fuse, Holder, 30 A, 600 V	Cooper	HPS 30A, 600V	Newark Electronics	94F2236		1	\$5.34	\$5.34
Ground Stick Assembly					9530-MC-181343			\$0.00
Aluminum Rod, 1/4" diam. x 10" long								\$0.00
Nut, S.S., 1/4 -20								\$0.00
Washer, S.S., Split Lock								\$0.00
Phenolic Rod, 3/4" diam. x 36" long								\$0.00
Ground Shield, 1/2" wide x 5' 8" long								\$0.00
Compression Lug, 8 STR, 1/4" stud								\$0.00
H.V. Deck Chassis						1	\$2,000.00	\$2,000.00
Frame Assembly								
Center Divider Panel								
Top Cathode Panel								
Back Divider Panel								
Meter Panel								
Bottom Panel								
Front Panel								
Left Panel								
Right Panel								
Rear Panel								
Top Door Panel								
Amplifier Deck Chassis								
Amp. Deck Chass. Support Plate								
P.C. Board Chassis								
Location / Welded Panels								
Heatsink for IRF-320					9530-MC-181406			
Misc. Items					9530-MB-181353			
Isolation X-FMR Bracket					9530-MC-181347			
H.V. IN/OUT Support Rods					9530-MB-181345	2	\$25.00	\$50.00
H.V. Output Choke Support					9530-MC-181348	1	\$50.00	\$50.00
Hose, coil, water, 1/4", 6 ft.	Coilhose Pneum.		McMaster Carr	5245K13				\$0.00
Insert, Fastor Fitting, for coilhose, 1/4" I.D.		TS-04-SS						\$0.00
Insert, for Paraflex Plastic Tubing, 1/4" O.D.		4 TIZ (.170)-SS						\$0.00
Kapton Sheet, 9 1/8" x 13 1/2"								\$0.00
Kapton Tape, 1 inch wide								\$0.00
LED holder								\$0.00
LED, green								\$0.00
Lexan Sheet, 3/32" thick								\$0.00
Light fixture		508-7545-504				2	\$5.00	\$10.00
Light indicator, red		507-4538				2	\$4.50	\$9.00
Marker Strip	Cinch	MS-16-141				1	\$2.00	\$2.00
Marker Strip	Cinch	MS-16-142				1	\$2.25	\$2.25
Marker Strip	Cinch	MS-20-141				1	\$2.25	\$2.25

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Marker Strip	Cinch	MS-3-150				1	\$2.25	\$2.25
Marker Strip	Cinch	MS-4-140				1	\$2.25	\$2.25
Meter, Panel, 2-1/2, FS=0-1 A	Simpson	2122-17400	Inotek			1	47.00	\$47.00
Meter, Panel, 2-1/2, FS=0-1 KV	Simpson	2122-17458	Inotek			4	63.50	\$254.00
Meter, Panel, 2-1/2, FS=0-500 mA	Simpson	2122-17443	Inotek			3	\$87.00	\$261.00
Meter, Panel, 2-1/2, FS=025 VAC	Simpson	2152-17687	Inotek			1	54.50	\$54.50
Meter, Panel, 3-1/2, FS=0-10 VDC	Simpson	2123-17527	Davis Inotek Instruments			3	\$92.00	\$276.00
Meter, Panel, 4-1/2, FS=0-10 VDC	Simpson	2124-17620	Inotek			2	55.25	\$110.50
Meter, Panel, 2-1/2, FS=0-10 VAC	Simpson	2152-17685	Inotek					\$0.00
MOV		V130LA20A	ACCESS Electronics					\$0.00
MOV for 4CW800F		V420LA20A	ACCESS Electronics					\$0.00
MOV for Y567B Screen		V1000LA160B	ACCESS Electronics					\$0.00
Water Flow Module						1	\$500.00	\$500.00
Fast Current Monitor						1	\$500.00	\$500.00
Program Adjust Module						1	\$500.00	\$500.00
Transmitter Inhibit Module						1	\$500.00	\$500.00
F.O. Transmitter						1	\$500.00	\$500.00
V / I Monitor						1	\$500.00	\$500.00
Modulator Control Unit						1	\$750.00	\$750.00
Nuts, Corona, 3/3" x 3/4" x 1/4-20 tap	Ross Engineering					2	\$50.00	\$100.00
Panel, Modulator Front Meter Panel					9530-MD-181351			\$0.00
PC Board Guides	Birtcher	Type 17B-12-3	Newark					\$0.00
Perforated Sheet								\$0.00
Pipe, Ceramic, 3/4" I.D. x 1" O.D. x 24"	Coors Porcelain	HD-998-Cast Alumina						\$0.00
RC Network, End Plate					9530-MB-181344			\$0.00
RC Network Wall Plate					9530-MB-181350			\$0.00
Plate, Aluminum T-4, for current sensor								\$0.00
Plumbing Assembly:								\$0.00
Clamp					1735.02-MC-63930			\$0.00
Return Line					9530-MD-181401	1	\$500.00	\$500.00
Adapter Cu. Fitting to FPT, 1" x 1"								
Adapter, Cu., COP to FPT, 1/2" x 1/4"								
Coupling, Reducing, COP to COP, 1" x 5/8"								
Coupling, Vacuum								
Elbow, Cu, 90°, fitting to COP 1"								
Elbow, Cu., 90°, 5/8" x 5/8", COP to COP								
Fitting, Tube to Male Pipe, Male Connector								
Flex-Sleeve,								
Hose Barb Insert, 1" hose I.D. to 1" MPT								
Nut, Brass								
Nut, S.S., Water Jacket, Y-567B								
Pipe, Cu., 1" I.D.								
Pipe, Cu., 1/2" I.D.								
Pipe, Cu., 5/8" I.D.								
Pipe, ceramic, 3/4" I.D. x 1" O.D. x 24"								
Sleeve, Brass, 1" O.D. Tubing								
Tee, Cu., COP to COP, 1" x 1/2" x 1"								
Tubing, Cu., 1" O.D.								
Turbine Flow Meter								
Supply Line					9530-MD-181402	1	\$300.00	\$300.00

Adapter, Cu., COP to FPT, 1/2" x 1/4"								
Adapter, Cu, Fitting to FPT, 1" x 1"								
Barb, Hose, Barb Insert, 1" hose I.D. to 1" MPT								
Coupling, Reducing, COP to COP, 1" x 5/8"								
Coupling, Vacuum								
Elbow, Cu., 90°, COP to COP, 1"								
Elbow, Cu., 90°, Long Radius, 5/8" x 5/8", COP to COP								
Flex-Sleeve, 60 FLV								
Nut, S.S., Water Jacket, Y567B								
Pipe, ceramic, 3/4" I.D. x 1" O.D. x 24"								
Pipe, Cu., 1" I.D.								
Pipe, Cu., 1/2" I.D.								
Pipe, Cu., 5/8"								
Tee, Cu., COP to COP 1" x 1/2" x 1"								
Tension Rod					1735.02-MB-63932			
Power Supply, +/-15 V			Stock Room					\$0.00
Power Supply, +5 V			Stock Room					\$0.00
Power Supply, +/- 750 Vdc Assembly:						1	\$500.00	\$500.00
Diode								
Diode								
Diode								
Diode								
Capacitor, Ceramic Disk, .001 uF, 2 KV								
Capacitor, 2000 uF, 450 V, Alluminum Electrolytic		CGS202T450X5C						
Resistor, 100 Ω, 5 W								
Resistor, Variable, 25 Ω, 50 W						1		
Resistor, 10 KΩ, 25 W						1		
Resistor, 110 Ω, Globar								
Resistor, 25 KΩ, 25 W		L25J25K	Newark Electronics	02F2304		1		
Resistor, 51 KΩ, 2 W								
Heatsink for 70HF100								
Heatsink for 1N2995								
Support Bracket for 25 Ω resistor								
Support Bracket for 110 Ω resistor								
Standoff, Ceramic, round, 3/4" x 1" long, 10-32 tapped								
Terminal Block, 8 contacts								
Transformer, Grid/ Deck	SNC Mfg.	P13584	SNC Mfg.	P13584	1735.02-EC-63708	1	\$341.65	\$341.65
Power Supply, P.A. Grid					ED-180349	1	\$1,500.00	\$1,500.00
Power Supply, P.A. Screen					EC-63989	1	\$1,500.00	\$1,500.00
Power Supply, P.A. Filament						1	\$2,000.00	\$2,000.00
Power Supply, NIM	Mech-Tronics	Model 159	Mech-Tronics	Model 159		1	\$1,500.00	\$1,500.00
Relay, Interlock	Potter & Brumfield	KRP11AG				1	\$50.00	\$50.00
Relay, Mercury Displacement	Magnecraft	WM35AA-120A	Newark Electronics	57F1328		2	\$95.55	\$191.10
Relay, Solid State	Crydom	D2440				3	\$50.00	\$150.00
Resistor, 0.1 Ω Shunt Assembly						1	\$375.00	\$375.00
a. Base					1735.02-MD-63965			
b. Top					1735.02-MD-63966			
c. Conn. Insulator					1735.02-MB-63967			
d. Conn. Conductor					1735.02-MB-63968			
e. Top Cover					1735.02-MB-63969			

f. Threaded Insert					1735.02-MB-63970			
g. Standoff, G-10, 3/8" diam. x 1 3/4" long, 6-32 tap								
Resistor, 10 K $\Omega$ , 1 W			Stockroom	1487-2380				\$0.00
Resistor, 10 $\Omega$ , 15 W Glomar		885AS100JDS				3	\$65.00	\$195.00
Resistor, 100 $\Omega$ , 15 W, Glomar		885AS101JDS				2	\$65.00	\$130.00
Resistor, 15 K $\Omega$ , 2 W			Stockroom	1487-2890				\$0.00
Resistor, 2 K $\Omega$ , 1/2 W	Allen-Bradley							\$0.00
Resistor, 2 K $\Omega$ , Wire Mesh	Ohmweeve	ASC-1-1287				2	\$22.00	\$44.00
Support-Upper			Machine Shop		1735.02-MB-63973			\$0.00
Support-Lower			Machine Shop		1735.02-MB-63974			\$0.00
Resistor, 2 K $\Omega$ , Wirewound Potentiometer		129826						\$0.00
Resistor, 300 M $\Omega$ , 100 K $\Omega$ tapped								\$0.00
Resistor, 470 $\Omega$ , 1/2 WATT	Allen-Bradley							\$0.00
Resistor, 470 $\Omega$ , 2 W	Allen-Bradley							\$0.00
Resistor, 7.5 K $\Omega$ , 60 W, Glomar		888A752K				2	\$100.00	\$200.00
Resistor, Bleeder Assembly:						1	\$1,250.00	\$1,250.00
Adhesive Foam								
Air Duct Transition, PVC Tube					9530-MC-181400			
Air Vane Switch		103A-SPDT						
Enclosure for air Vane Switch					9530-MB-181354			
Bottom Perforated Plate					9530-MC-181356			
Fan Blower Spacer Ring					9530-MC-181358			
Joy Blower	Joy	AVR61-4301535				1		
Resistor H.V. Plate					9530-MC-181355			
Resistor Housing					9530-MC-181357			
Resistor, 12 M $\Omega$								
Standoff, G-10, 3/4" x 8 5/8"								
Standoff, 5/8 " dia. x 3 " long, Aluminum								
Rod, Threaded, 8-32, 36" long			Stockroom	1550-2020				\$0.00
Sheet, Steel, Perforated								\$0.00
Socket for P & B relay						1	\$20.00	\$20.00
Socket for Y567B	EIMAC	SK-2000	Varian Assoc. Inc.			1	\$3,000.00	\$3,000.00
Standoff, Aluminum, Hexagon, 1/4" x 1" long, 6-32 tapped								\$0.00
Standoff, Aluminum, Hexagon, 1/4" x 1/2" long, 6-32 tapped								\$0.00
Standoff, Aluminum, round, 1/2" x 7/8" long, 6-32 tapped								\$0.00
Standoff, Aluminum, round, 1" dia. x 3" long								\$0.00
Standoff, G-10, 1/2" x 1 7/8" long, 6-32 tapped								\$0.00
Standoff, G-10, 1/2" x 5/8" long, 6-32 tapped								\$0.00
Standoff, insulated,, 1", 4-40 to solder								\$0.00
Standoff, Isolation, 1/4" x 1" long, 4-40 stud to solder pin								\$0.00
Stock, G-10, 1/2" x 5/8" x 4 1/2"								\$0.00
Switch, SPDT, Door Intlk.	Microswitch	2AC59	Arrow Electronics	2AC59		6	\$24.75	\$148.50
Switch, Vane Airflow	Henry G. Dietz	Model 103B	Henry G. Dietz Co. Inc.	Model 103B		3	\$68.47	\$205.41
Terminal Blocks:3 Contacts	Cinch	3-150	Newark Electronics	29F732		1	\$5.42	\$5.42
Terminal Blocks:4 Contacts	Cinch	4-140	Newark Electronics	28F702		2	\$1.99	\$3.98
Terminal Blocks:6 Contacts	Cinch	6-150	Newark Electronics			1	\$3.00	\$3.00
Terminal Blocks:16 Contacts	Cinch	16-141	Newark Electronics	28F881		1	\$7.16	\$7.16
Terminal Blocks:16 Contacts	Cinch	16-142	Newark Electronics	28F889		1	\$11.43	\$11.43
Terminal Blocks:20 Contacts	Cinch	20-141	Newark Electronics	28F885		1	\$8.92	\$8.92
Terminal Lug, 24 blue, 1/4" stud						50	\$0.24	\$12.00

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Terminal Lugs, Heavy Duty:	Burndy	YAV10H	Burndy			50	\$0.24	\$12.00
Terminal Lugs, Heavy Duty:	Burndy	YAV10H3	Burndy			50	\$0.24	\$12.00
Terminal Lugs, Heavy Duty:	Burndy	YAV14H	Burndy			50	\$0.18	\$9.00
Terminal Lugs, Heavy Duty:	Burndy	YAV14H2	Burndy			50	\$0.20	\$10.00
Terminal, Fork Tongue, 22-18, #6 stud			Stockroom	1110-4100		1	\$11.45	\$11.45
Terminal, Fork Tongue, 22-18, #8 stud			Stockroom	1110-4105		1	\$11.45	\$11.45
Toroidal Core, ferrite, 3E2A		3E2A						\$0.00
Transformer, 2.3KVA, 480 VAC to 115 VAC	Tech-Tran	L-13876	Hunterdon Transformers			1	\$769.00	\$769.00
Transformer, Grid/ Deck	SNC Mfg.	P13584	SNC Mfg.	P13584	1735.02-EC-63708	1	\$341.65	\$341.65
Transformer, Isolation	Tech-Tran	L-13873				1	\$1,654.00	\$1,654.00
Transformer, Isolation	Tech-Tran	L-13878				1	\$1,430.00	\$1,430.00
Transformer, Regulating, 2000 VA	Sola	23-23-220-8	Newark Electronics	46F3371		3	\$2,183.00	\$6,549.00
Transformer, Isolation, for 4CW800F filament						1	\$150.00	\$150.00
Transformer, Variable	GE	9T92A0027	Tri Star Supply Inc.			1	\$255.00	\$255.00
Tube, 4CW800F	Eimac	4CW800F	Varian Assoc. Inc.			1	\$1,700.00	\$1,700.00
Tube, Y567	Eimac	Y567B	Varian Assoc. Inc.			1	\$15,750.00	\$15,750.00
Tubing, Copper, 3/8", 15 ft.						15	\$0.51	\$7.65
Tubing, Copper, 1/4", 2 ft.						2	\$0.36	\$0.72
Turbine Flowmeter						1	\$400.00	\$400.00
Turbine pick-up						1	\$75.00	\$75.00
Turbine pick-up connector						1	\$25.00	\$25.00
Washer, Flat, 1/4"			Stockroom	1218-0620		100	\$0.24	\$24.00
Washer, Flat, 5/16"			Stockroom	1218-0640		100	\$0.37	\$37.00
Washer, Flat, Type 18-8 S.S., #6 screw			Stockroom	1218-0560		100	\$0.01	\$1.00
Washer, Flat, Type 18-8 S.S., #8 screw			Stockroom	1218-0580		100	\$0.01	\$1.00
Washer, nylon, 1/4"								\$0.00
Washer, Split Lock, #6			Stockroom	1218-1020		100	\$0.01	\$1.00
Washer, Split Lock, #8			Stockroom	1218-1040		100	\$0.01	\$1.00
Washer, Split Lock, 1/4"			Stockroom	1218-1060		100	\$0.01	\$1.00
Washer, Split Lock, 5/16"			Stockroom	1218-1080		100	\$0.02	\$2.00
Wire Letters, A-Z								\$0.00
Wire Numbers, 100-300	Raychem							\$0.00
Wire, 18 AWG, 3 KV,								\$0.00
Misc. Cost of material and machining of various G-10, Lexan,						1	\$5,000.00	\$5,000.00
Aluminum pieces shown above without prices.								\$0.00
							<b>Total Price / ST</b>	<b>\$70,344.41</b>

Appendix A:	FNAL Drawing Number	200 Kwatt Power Amplifier		
		QTY	Cost Each	Total Cost / ST
CPI Eimac Y 567B Tetrode		1	17750	17750
Fabricate Power Module Outer shell	MD-181892	1	5000	5000
Fabricate Tube Seating Assembly	MD-5330 Rev. F	1	200	200
Fabricate Control Grid Kapton Insulator	9530-BC-181381	1	100	100
Fabricate Control Grid Kapton Insulator	9530-BC-181382	1	100	100
Fabricate Screen Grid Kapton Insulator	9530-BC-181383	1	100	100
Fabricate Screen Grid Kapton Insulator	9530-BC-181384	1	100	100
Fabricate Filament bypass Insulator	0333-MC-181772	2	25	50
Fabricate Center Ground Plate Assbly	9530-MD-181279 Rev. A	1	2000	2000
Fabricate Control Grid Electrode	9530-MD-181107	1	1000	1000
Fabricate Screen Grid Electrode	9530-MD-181103	1	1000	1000
Fabricate Filament Bypass Cap Electrode	0333-MC-181771	1	150	150
Fabricate Cathode Outer Shell	0333-MD-181768	1	1500	1500
Fabricate Cathode Inner Conductor	0333-MD-181767	1	900	900
Fabricate Copper Anode Shroud	0333-MD-5823 Rev. D	1	2500	2500
Fabricate Corona Ring	0333-MD-22596	1	750	750
Fabricate Water Connection Panel	0333-MC-62987 REV. A	1	350	350
Fabricate LCW Manifold Support "D"	9530-MB-181367	2	30	60
Fabricate LCW Manifold Support "D"	9530-MB-181368	2	30	60
Fabricate LCW Manifold Support "C"	0333-MB-122017 Rev. A	2	20	40
Fabricate LCW Manifold Support "C"	0333-MB-22014 Rev. A	2	20	40
Fabricate PM Outer Shell Cover Plate	0333-MB-22173 Rev. A	1	30	30
Fabricate Nameplate Holder Clamp	9530-MB-181424	2	5	10
Fabricate Cathode Support	MD-181111 Rev. A	1	75	75
Fabricate Screen Grid Assembly	Eimac P/N PRC-2228	1	700	700
Fabricate Filament Collet Assembly	Eimac P/N PRB-2499	1	500	500
Fabricate Grid Ring Assesmbly	Eimac P/N PRB-2500	1	500	500
Fabricate Cathode Collet Assembly	Eimac P/N PRB-2501	1	500	500
Fabricate Control Grid Bracket	MD-181108 Rev. A	1	650	650
Fabricate Cooling Block	MC-181361 Rev. B	1	400	400
Fabricate Cathode Contact Bracket	MC-63599 Rev. B	1	600	600
Fabricate Top Grid Capacitor Plate	9530-MD-181110 Rev. A	1	1750	1750
Fabricate Bottom Grid Capacitor Plate	9530-MD-181101 Rev. C	1	1750	1750
Fabricate Top Filament Capacitor Plate	0333-MD-181770	1	250	250
Fabricate Bottom Filament Capacitor Plate	0333-MD-181769	1	250	250

