

Y-12

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OAK RIDGE Y-12 PLANT

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RAPID SCANNING MASS SPECTROMETER

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ABSTRACT

This Cooperative Research and Development Agreement was used to modify Vacuum Technology's AERO VAC computer/mass spectrometer interface and electronics to allow the mass spectrometer to acquire rapid scans. The computer interface sends signals from the PC to the mass spectrometer, controlling its filament, giving scan instructions, and selecting the proper electrometer range, and detector. It then receives the detector output in the form of amplified digital signals from the electrometer. This project performed the following three upgrades on the computer interface and electronics. 1. A new electrometer was designed and built to process the signal from the detector. This new electrometer is more sensitive, over 10 times faster, and over 100 times more stable than the electrometer it will replace. 2. The controller EPROM was reprogrammed with new firmware. This firmware acts as an operating system for the interface and is used to shuttle communications between the PC and the AERO VAC mass spectrometer. The new firmware allows digital signals to be transmitted considerably faster to and from the mass spectrometer than the old firmware. The voltage regulator which causes the ion selector voltage to ramp to allow ions of selected mass to be sequentially detected was redesigned and prototyped. The redesign allowed obsolete electronics in the regulator circuitry to be replaced with more efficient circuitry. The redesigned voltage regulator can be ramped up or down more than 100 times faster than the existing regulator. Figure 4 shows a picture of the prototype voltage regulator circuit.

These changes were incorporated into a prototype unit and preliminary performance testing conducted. Results indicated that scanning speed was significantly increased over the unmodified version.

BACKGROUND

Mass spectrometers and residual gas analyzers (RGAs) are used in a variety of applications for analysis of volatile and semi-volatile materials. Analysis is performed by detecting fragments of gas molecules, based on their mass to charge ratio, which are generated in the mass spectrometer. The analysis results are typically in the form of qualitative identification, gas phase composition, or flow rate. When used as a detector for a gas chromatograph, they function as a means to quantitatively identify isolated volatile species which have been separated from other species via the gas chromatograph.

Vacuum Technology, Inc. (VTI) produces a magnetic sector mass spectrometer/RGA which is used in many industrial and laboratory environments. In order to increase the utility of this instrument, it is desirable to increase the mass scanning speed, thereby increasing the number of applications for which it is suited. This will allow VTI to package their mass spectrometer/RGA with gas chromatographs as well as enter other gas analysis markets.

OBJECTIVES

This Cooperative Research and Development Agreement (CRADA) sought to improve the processing speed of VTIs AERO VAC mass spectrometer/RGA through a variety of analog and digital software and hardware upgrades. The areas targeted for upgrades in order to improve the speed of the AERO VAC included coding of the microprocessor controller, design of the electrometer, the high voltage circuit used to control the ion source and scanning variables, and the magnet configuration.

This objective was met by significantly improving the microprocessor firmware, designing a more stable high-speed electrometer, and improving the high voltage circuit.

BENEFITS TO DOE

A potential customer for this rapid scanning mass spectrometer in the DOE nuclear weapons surveillance program, where the mass spectrometer could be used on-site at surveillance disassembly facilities at Y-12, Pantex, and Los Alamos National Laboratory.

GENERAL PROJECT DESCRIPTION

This project was used to modify VTIs computer/mass spectrometer interface to allow the mass spectrometer to acquire rapid scans. The computer interface sends signals from the PC to the mass spectrometer, controlling its filament, giving scan instructions, and selecting the proper electrometer range, and detector. It then receives the detector output in the form of amplified digital signals from the electrometer. A block diagram of this process is shown in Figure 1. This project performed the following three upgrades on the computer interface. 1. A new electrometer was designed and built to process the signal from the detector. This new electrometer is more sensitive, over 10 times faster, and over 100 times more stable than the electrometer it will replace. A picture of the prototype of this electrometer is shown in Figure 2. 2. The controller EPROM was reprogrammed with new firmware. This firmware acts as an operating system for the interface and is used to shuttle communications between the PC and the AEROVAC mass spectrometer. The new firmware allows digital signals to be transmitted considerably faster to and from the mass spectrometer than the old firmware. Figure 3 show the location of the EPROMS where this firmware resides. 3. The voltage regulator which causes the ion selector voltage to ramp to allow ions of selected mass to be sequentially detected was redesigned and prototyped. The redesign allowed obsolete electronics in the regulator circuitry to be replaced with more efficient circuitry. The redesigned voltage regulator can be ramped up or down more than 100 times faster than the existing regulator. Figure 4 shows a picture of the prototype voltage regulator circuit.

These changes were incorporated into a prototype unit and preliminary performance testing conducted. Results indicated that scanning speed was significantly increased over the unmodified version.

Additionally, an effort was undertaken to improve the sensitivity of the instrument by increasing the overall ionization efficiency at the source. Although this did not result in any changes in the AERO VAC, the results of this task lay the ground work for future developments in this area and are summarized in this report.

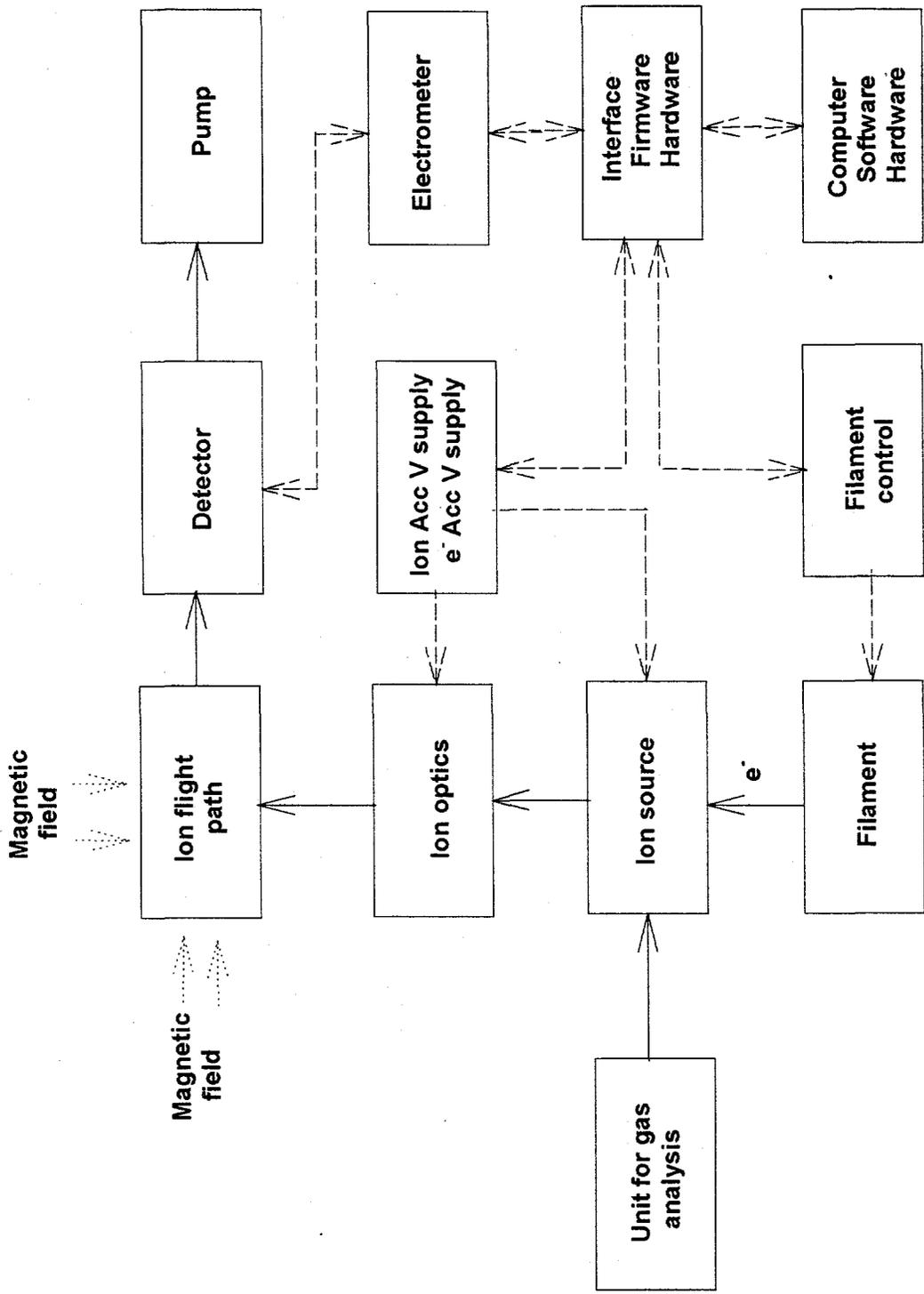


Figure 1. Block diagram of VTIs AERO VAC mass spectrometer system. Solid lines indicate the flow of gas, dashed lines indicate the flow of electronic signals, and dotted lines indicate the magnetic field. The CRADA tasks involved improvements to the ion source, ion and electron accelerating voltage supplies, electrometer, and interface firmware.

MAGNETIC SECTOR TASK

One way to improve the scanning speed of the AERO VAC is to improve its sensitivity. Larger signals will require less individual data points to be averaged, which will provide the speed improvement. Efforts to improve the sensitivity of the AERO VAC centered on increasing the overall ionization efficiency. This was done by investigating the filament emission pattern and the ion source.

The AERO VAC filament produces a broad, highly divergent electron beam. A small (~100 Gauss) magnetic field can confine the electron beam to several millimeters in diameter, increasing the current density. If the electron beam can be properly oriented relative to the source exit slit, this should translate into increases in source sensitivity.

With proper orientation of the electron beam, the ion current can be increased substantially, perhaps by as much as a factor of 30. The exact alignment of the magnets, filament and slits is critical, though, and manufacturability of such a source may be a concern.

When using magnetic confinement of the electron beam, some type of positive ion extraction, either a repeller plate or extraction optics, appears to be required. Up to moderate repeller voltages (~2.5 V across a gap of 1 cm) do not appear to substantially degrade resolving power.

Preliminary modeling of the ion optics associated with beam extraction has also been done. Experimental results indicate that only about 25% of the ions generated in the source pass through the entrance slit into the magnetic sector. Modeling indicates that addition of an independently biased ion extraction plate can substantially improve transmission into the source. This remains to be experimentally verified.

MICROPROCESSOR PROGRAMMING TASK

The controller EPROM was reprogrammed with new firmware. This firmware acts as an operating system for the interface and is used to shuttle communications between the PC and the AEROVAC mass spectrometer. The new firmware allows digital signals to be transmitted considerably faster to and from the mass spectrometer than the old firmware.

Table 1 lists the new communication commands with a brief description explaining the operation of each command. Each command has been given a unique number for its unique operation.

Table 1. Communication commands

Command Number	Command
00	Reset command
01	Filament toggle on/off
02	Electron multiplier on/off
03	Electron multiplier voltage (500-3000 volts)
04	Status request
05	System error request
06	Read emission
07	Set analog parameters
08	Get analog data
09	Start an analog scan
10	Electrometer auto-range on-off
11	Set electrometer range (manual), low range (auto)
12	Set sampling frequency
13	Not used
14	Set histogram parameters
15	Get histogram data
16-99	Not used
100	Set tune parameters
101	Get tune parameters

More detail on each of the commands is listed in the following sections.

Command 00

This command resets the system.

Command 01

This command controls the filament On/Off and filament number to be turned on. If the user tries to turn filament one on while filament two is on, the firm ware will shut down filament two and start filament one. Every time any of the filament is turned off, the multiplier will automatically turn off. The first byte is the framing byte. The second byte is the packet length. The third byte is the command number. The fourth byte is filament number "1 or 2". The fifth byte is filament on/off "0 for off, 1 for on". The sixth byte is the checksum.

AE:06:01:02:01:F6 ;command sent to turn on filament # 2

AE ; is the framing byte.

06 ; is the length of the packet.

01 ; is the command number.

02 ; is the filament # 2, and "01 for filament # 1".

01 ; is the command to turn the filament on, "00 to turn the filament off".

F6 ; is the check sum.

AE:06:01:00:01:F8 ; response that would come back from the controller "Filament one is starting."

AE ; is the framing byte.

06 ; is the length of the packet.

01 ; is the command number that the controller is responding to.

00 ; is the MSB of the status byte.

01 ; is the LSB of the status byte.

F8 ; is the check sum.

Command 02

This command controls the Electron Multiplier Voltage. The voltage can be set from 0-3000 volt "ideal operation 500-3000 volt." The first byte is the framing byte. The second byte is the packet length. The third byte is the command number (02). The fourth byte is the Voltage Most Significant Bit (MSB). The fifth byte is the Voltage Least Significant Bit (LSB). The sixth byte is the checksum.

Voltage MSB = Voltage \ 256

Voltage LSB = Voltage And 255

AE:06:02:02:EE:08 ;command sent to Set the EM Voltage to 750 volts

AE ; is the framing byte.

06 ; is the length of the packet.
 02 ; is the command number.
 02 ; is the Voltage MSB.
 EE ; is the Voltage LSB.
 08 ; is the check sum.

AE:06:02:00:0D:EC ; response that would come back from the controller.

AE ; is the framing byte.
 06 ; is the length of the packet.
 02 ; is the command number that the controller is responding to.
 00 ; is the MSB of the status byte.
 0D ; is the LSB of the status byte.
 EC ; is the check sum.

Command 03

This command controls the Electron Multiplier On/Off . The first byte is the framing byte. The second byte is the packet length. The third byte is the command number. The fourth byte is EM on/off "0 for off, 1 for on". The fifth byte is the checksum.

AE:05:03:01:F6 ; command sent to turn Electron Multiplier On

AE ; is the framing byte.
 05 ; is the length of the packet.
 03 ; is the command number.
 01 ; is the command to turn the EM On, "00 to turn the EM Off".
 F6 ; is the check sum.

AE:06:03:00:0D:EA ; response that would come back from the controller.

AE ; is the framing byte.
 06 ; is the length of the packet.
 03 ; is the command number that it is responding on.
 00 ; is the MSB of the status byte.
 0D ; is the LSB of the status byte.
 EA ; is the check sum.

Command 04

This command request the status of the system. The status of the system is always updated internally to the firm ware upon each execution of commands. Also, the firm ware will do an internal check on the operation of the system such as filament's status or electron multiplier's status. The first byte is the framing byte. The second byte is the packet length. The third byte is the command number. The fourth byte is the checksum.

AE:04:04:F8 ; command sent to request the system status

AE ; is the framing byte.
 04 ; is the length of the packet.
 04 ; is the command number.
 F8 ; is the check sum.

AE:06:04:00:01:F5 ; response that would come back from the controller.

AE ; is the framing byte.
 06 ; is the length of the packet.
 04 ; is the command number that it is responding on.
 00 ; is the MSB of the status byte.
 01 ; is the LSB of the status byte.
 F5 ; is the check sum.

Command 05

This command requests the system error status. The system will flag an error by setting the MSB in the status word. When this command is executed, it will reset MSB in the status word to zero and reset the error byte to zero. The translation of each value of the error byte is described separately in this document. The first byte is the framing byte. The second byte is the packet length. The third byte is the command number. The fourth byte is the checksum.

AE:04:05:F8 ; command sent to request the system error status

AE ; is the framing byte.
 04 ; is the length of the packet.
 05 ; is the command number.
 F8 ; is the check sum.

AE:07:05:80:01:04:6F ; response that would come back from the controller.

AE ; is the framing byte.
 07 ; is the length of the packet.
 05 ; is the command number that it is responding on.
 80 ; is the MSB of the status byte.
 01 ; is the LSB of the status byte.
 04 ; is the error status byte.
 6F ; is the check sum.

Command 06

This command requests the Filament Emission. The emission is read periodically in the firm ware, and it is stored in a global value called emission. Therefore, every time this command is executed,

the firm ware grabs the emission value and sends it out to the communication buffer. The estimated time for the emission to be read is every 500 milliseconds to 1 second depending on the processors over head. The first byte is the framing byte. The second byte is the packet length. The third byte is the command number. The fourth byte is the checksum.

AE:04:06:F7 ;command sent to request the Filament Emission

AE ; is the framing byte.
 04 ; is the length of the packet.
 06 ; is the command number.
 F7 ; is the check sum.

AE:0A:06:00:01:3E:80:00:00:31 ; response that would come back from the controller for 0.25 milliamps emission.

AE ; is the framing byte.
 0A ; is the length of the packet.
 06 ; is the command number that it is responding on.
 00 ; is the MSB of the status byte.
 01 ; is the LSB of the status byte.
 3E ; is the MSB of high word of the Filament Emission (32 bit long).
 80 ; is the LSB of high word of the Filament Emission (32 bit long).
 00 ; is the MSB of low word of the Filament Emission (32 bit long).
 00 ; is the LSB of low word of the Filament Emission (32 bit long).
 31 ; is the check sum.

Command 07

This command sets the parameters to the analog scan . The first byte is the framing byte. The second byte is the packet length. The third byte is the command number. The fourth and fifth bytes are the start mass. The sixth and seventh bytes are the end mass. The eighth and the ninth bytes are the dwell time. The tenth byte is the checksum.

command sent to Set the Low mass = 2; High mass = 45; Dwell time = 10

AE:0A:07:00:02:00:2D:00:0A:B6 ;

AE ; is the framing byte.
 0A ; is the length of the packet.
 07 ; is the command number.
 00 ; is the Start mass MSB.
 02 ; is the Start mass LSB.
 00 ; is the End mass MSB.
 2D ; is the End mass LSB.
 00 ; is the Dwell Time MSB.

0A ; is the Dwell Time LSB.

B6 ; is the check sum.

AE:06:07:00:0D:E6 ; response that would come back from the controller.

AE ; is the framing byte.

06 ; is the length of the packet.

07 ; is the command number that it is responding on.

00 ; is the MSB of the status byte.

0D ; is the LSB of the status byte.

E6 ; is the check sum.

Command 08

This command requests the analog data that has been collected. The first byte is the framing byte. The second byte is the packet length. The third byte is the command number. The fourth byte is the checksum.

AE:04:08:F4 ;

AE ; is the framing byte.

04 ; is the length of the packet.

08 ; is the command number.

F4 ; is the check sum.

At this point, two responses might come back. The first response is no data has been collected. The second response has data included in the packet.

AE:06:08:00:1D:D5 ; the first response that might come back from the controller. Status word = 0x001D, which indicates that the scan is in progress and no data is available

AE ; is the framing byte.

06 ; is the length of the packet.

08 ; is the command number that it is responding on.

00 ; is the MSB of the status byte.

0D ; is the LSB of the status byte.

D5 ; is the check sum.

AE:10:08:00:3D:00:2D:34:12:3B:D0:34:F7:FC:03:03 ; the second response that might come back from the controller. Status word = 0x003D, which indicates that the scan is in progress and data is available. The sixth and seventh bytes are the DAC value which represent the analog mass index that the first analog point was collected. The first analog point = $1.3E-07$ which was scanned on DAC value = 45, and the second analog data point = $4.6E-07$ which was scanned on DAC value = 46.

AE ; is the framing byte.
 10 ; is the length of the packet.
 08 ; is the command number that it is responding on.
 00 ; is the MSB of the status byte.
 3D ; is the LSB of the status byte.
 00 ; is the MSB of the DAC Value.
 2D ; is the LSB of the DAC Value.
 34 ; is the MSB of high word of the first analog data (32 bit long).
 12 ; is the LSB of high word of the first analog data (32 bit long).
 3B ; is the MSB of low word of the first analog data (32 bit long).
 D0 ; is the LSB of low word of the first analog data (32 bit long).
 34 ; is the MSB of high word of the second analog data (32 bit long).
 F7 ; is the LSB of high word of the second analog data (32 bit long).
 FC ; is the MSB of low word of the second analog data (32 bit long).
 03 ; is the LSB of low word of the second analog data (32 bit long).
 03 ; is the check sum.

Command 9

This command controls the scanning mode. By sending one (1) will start a scan and sending a zero will stop it. This command has to be sent after the analog parameters has been loaded to the controller in order to start a scan.

AE:05:09:01:F1 ;

AE ; is the framing byte.
 05 ; is the length of the packet.
 09 ; is the command number.
 01 ; is to start scanning.
 F1 ; is the check sum.

The controller would respond with an acknowledgment.

Command 10

This command will set the auto-range feature while scanning to On or Off. The user can select to run in an auto-range on the electrometer, or the user can select to run on a fixed range (to be defined in command 11.)

AE:05:0A:01:F0 ;

AE ; is the framing byte.
 05 ; is the length of the packet.
 0A ; is the command number.
 01 ; is to turn the Auto-range feature On.

F1 ; is the check sum.

The controller would respond with an acknowledgment.

Command 11

This command would select the range to run in manual mode, or to be the minimum range to use for auto-ranging. The ranges are predefine as zero for the 10-12 Amp range to 6 for the 10-06 Amp range.

AE:05:0B:02:EE ;

AE ; is the framing byte.

05 ; is the length of the packet.

0B ; is the command number.

02 ; Set the electrometer to 10-10 Amp range.

EE ; is the check sum.

The controller would respond with an acknowledgment.

Command 12

This command will set the sampling frequency to a scan. The minimum frequency that can be set is a sample every five milliseconds, and the lowest frequency that can be set is every fifteen milli-seconds. This is the time delay to wait before taking the next reading while going over a peak.

AE:05:0C:05:EA ;

AE ; is the framing byte.

05 ; is the length of the packet.

0C ; is the command number.

05 ; Set the frequency to five milli-second.

EA ; is the check sum.

The controller would respond with an acknowledgment.

The status bits used for interrogation of the system status are defined in Table 2.

Table 2. Status bit definition

Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6-14	Bit 15	Description
0	0	0	-	-	-	-	-	Both filaments are off
0	0	1	-	-	-	-	-	Filament one is starting
0	1	0	-	-	-	-	-	Filament two is starting
1	0	1	-	-	-	-	-	Filament one is on
1	1	0	-	-	-	-	-	Filament two is on
-	-	-	X	-	-	-	-	Electron multiplier on/off
-	-	-	-	X	-	-	-	Scan in progress
-	-	-	-	-	X	-	-	Data ready bit
-	-	-	-	-	-	X	-	Not implemented
-	-	-	-	-	-	-	X	An error has occurred

Each error that occurs in the firmware has its unique number. Table 3 lists the error definitions that have been constructed in order to inform the user of the error.

Table 3. Error status description

Error Status	Description
0	No error
1	Filament did not start
2	Bad ADC conversion
3	Bad mux channel
4	Low emission
5	Bad filament number
6	Memory error
7	Filament off
8	No scan in progress
9	Communication overrun
10	Bad electrometer gain value
11	Bad sampling frequency

Communication Protocols

The communication packets are divided into bytes. Each byte represents a purpose in the packet. The value for each byte is from 0 to 0xFF (0 to 255). All commands transferred to the controller has the following format:

Frame Length Command_Number Data_transfer checksum

Frame : The framing byte of the packet. It is a Constant = 0xAE (0d174)

Length : The number of bytes in the packet from the Frame to the checksum

Command_Number : An indexed number that represents an operation to execute. Each command number has its own unique function in the controller. The next section describes each command and its structure.

Data_Transfer : The data that is tied up with the command to form its structure.

checksum : Equal to the one's complement of the summation of Length, Command_Number, and Data_Transfer.

checksum = $0x00 - (S(\text{Length} + \text{Command_Number} + \text{Data_Transfer}) \text{ And } 0xFF)$

The Controller responds to each command in similar fashion.

Frame Length Command_Respond System_Status Data_Transfer CheckSum

Frame : This is the framing byte of the packet. It is a Constant = 0xAE (0d174)

Length : is the number of bytes in the packet from the Frame to the CheckSum

Command_Respond : Equal to the command number the controller is responding to after the controller acknowledges the command.

System_Status : A two byte long MSB:LSB.

Data_Transfer : The data that the controller is sending back in result of the execution of the command.

CheckSum : Equal to the one's complement of the summation of Length, Command_Number, and Data_Transfer.

CheckSum = $0x00 - (S(\text{Length} + \text{Command_Number} + \text{Data_Transfer}) \text{ And } 0xFF)$

ELECTROMETER DEVELOPMENT TASK

A new electrometer amplifier was designed, prototyped, and tested. It features increased bandwidth to accommodate faster mass ramps, elimination of obsolete and hard-to-procure electronic components, improved manufacturability, improved reliability, accommodation of negative input currents from electron multiplier or positive input currents from Faraday Cup, more uniform time responses for different gain settings, reduced electromagnetic interference from relay switching, improved dynamic range and accuracy, electrical isolation from AERO VAC electronics to eliminate ground loops, improved drift and noise, remotely nullable offset voltage, reduced component count, reduced component cost, and decade gain steps from 10^7 to 10^{13} V/A.

A simplified schematic of the new electrometer is shown in figure 1. Operational amplifiers U1 and U2 form a switchable-gain composite amplifier. The inclusion of U2 in this first gain stage provides several advantages. Its high input impedance dramatically reduces the load that the ultra-precision amplifier U1 must drive, thus minimizing power dissipation inside U1 and improving its DC stability. U2 is much faster than U1 and has much higher output drive capability so that the composite amplifier has greater bandwidth, slew rate and drive current than an amplifier including only U1 would have. This is especially important when switch S1 is closed and the amplifier must drive the 100 Ω resistor in the feedback network directly. To further reduce a power dissipation in amplifiers U1 and U2, they are powered from ± 5 V power rails. (Other analog circuitry is powered from ± 12 V rails.) The lone electromechanical relay in the circuit, K1, changes circuit gain by a factor of 10^3 by connecting and disconnecting a 1-M Ω resistor when it is switched out of the circuit. Solid-state switch S1 bypasses the voltage divider (often called a twin-tee network) in the composite amplifiers feedback. This network multiplies the gain of the first stage by a factor of 100 without requiring the high-value, expensive, temperature-sensitive, and contamination-sensitive resistors commonly found in electrometer amplifiers. Only one node in the initial gain stage, the inverting input on amplifier U1, requires extraordinary care in guarding and leakage prevention. Gain-setting switches K1, S1, and S2 are controlled from the AERO VAC electronics which will, in normal operation, set the gain according to commands from the AERO SCAN software.

Subcircuits built around amplifiers U3A and U3B provide additional gain. Solid-state switch S2 can place an additional gain of 10 in the signal path by feeding the output of U3B to the output stage. Amplifier U4 provides a differential output to the AERO VAC main-chassis electronics. When a Faraday Cup ion collector is used, this differential signal is used with the polarity shown. If an electron multiplier is used as the detector, the polarity of this signal is reversed. This can be accomplished either electronically or with a simple mechanical switch at the input to the AERO VAC data acquisition circuitry.

Digital-to-analog converter U5 generates a signal that is summed with the output of the composite amplifier and provides the means to zero out unwanted offset voltages for the entire electrometer.

Power to the electrometer circuitry can be taken directly from other AERO VAC chassis or can be

isolated through a local DC/DC converter. Control signals from the AERO VAC chassis can also be electronically isolated. (The printer-circuit layout accommodates isolated or non-isolated operation.)

Testing of a hand-wired prototype of the electrometer showed substantial performance improvements in several areas. Its bandwidth of more than 500 Hz is approximately 100 times higher than the present electrometer. Its wide dynamic range allows resolution of spectral peaks more than ten times smaller than is possible with the present unit. (This performance will probably improve even more when the printed-circuit version is constructed.) The new design eliminates several expensive relays and high-value resistors and will be much simpler to fabricate. Cleanliness, humidity, and temperature variations will prove to be about 100 times less significant than with the present design. The new design can accommodate an auto-zero function in the AERO SCAN software in which all ion current is switched off, and output from the electrometer is read by the AERO VAC electronics, and a value is calculated which, when applied to the on-board digital-to-analog converter, will null the no-current output of the electrometer.

Alternative models and/or sources for most of the electrical components in the electrometer have been identified.

VTI intends to purchase circuit boards to test a production version of this electrometer.

Prototype Electrometer VTI AeroVac Upgrade

Block Diagram

WHA
12/17/96

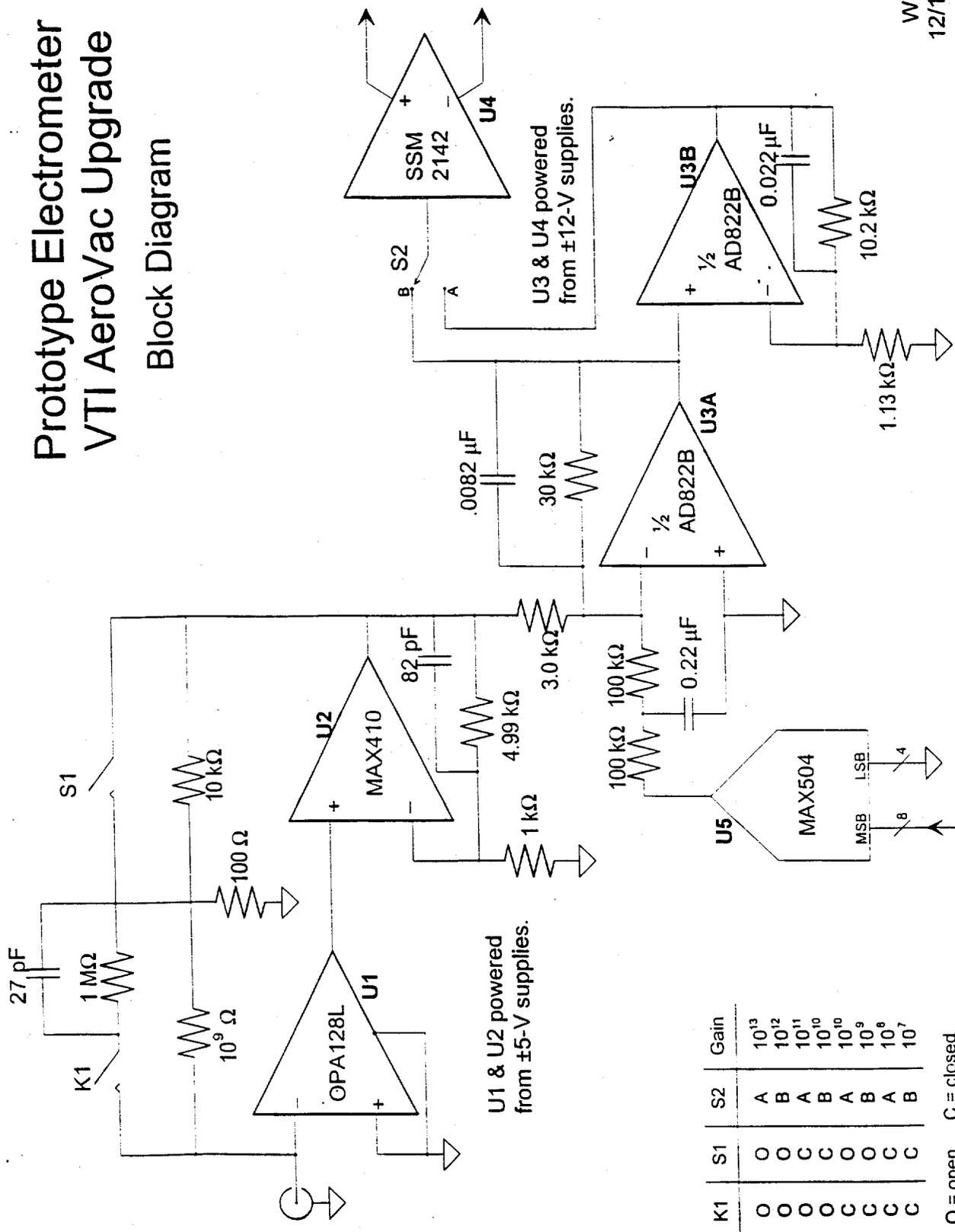


Figure 2. Prototype block diagram of upgraded VTI electrometer.

HIGH VOLTAGE CIRCUIT TASK

A completely redesigned high-voltage circuit was prototyped for evaluation. This circuitry allows the DC filament supply to be adjustable from the AERO SCAN software, provides higher filament supply output current (able to power both filaments simultaneously), provides a more sensitive and more stable filament read (grid current measurement) circuit, has over-pressure protection, has a faster, linear ramp, provides DC electron acceleration potential controllable from the AERO SCAN software, provides a DC degas heater supply, and provides improvements in performance and flexibility over the existing system. This circuitry resides inside the AERO VAC electronics chassis with the data acquisition circuitry. The design uses a number of amplifier and power modules (Figure 3) - an approach which increases materials cost. However, assembly costs will be cut dramatically and reliability will be increased because the greatly reduced number of circuit components will now mount on a single printed-circuit board. The use of printed-circuit interconnects and small, shielded DC/Dc power converter modules will reduce electromagnetic emissions in the measurement bandwidth.

The combination of a fast-slewing ion-acceleration voltage circuit and the new, wide-bandwidth electrometer amplifier will allow a mass ramp to be accomplished in less than two seconds (as opposed to more than one minute in the present system). It can ramp downward or upward. The mass-ramp circuit can perform linear or logarithmic ramps depending on the digital data fed to it by the microcontroller internal to the AERO VAC electronics. The new architecture allows filament voltages down to and even below zero volts at the beginning of the mass ramp, which makes it easier to analyze heavier ions. True CDC power for the degas heater will make it possible to leave the heater powered while making measurements, if desired.

A prototype of the new high-voltage section was prototyped but has not been tested. Filament and degas heater power can be controlled manually for early experimentation but can also be controlled from the AERO SCAN software as functionality is added to the software. The electron acceleration voltage can be controlled manually during the early prototype testing but can also be converted to computer control, as can the emission voltage.

The circuit implementation illustrated in Figure 4 has a few minor improvements over the prototype circuit and is the configuration recommended for inclusion in the next-generation of AERO VAC electronics.

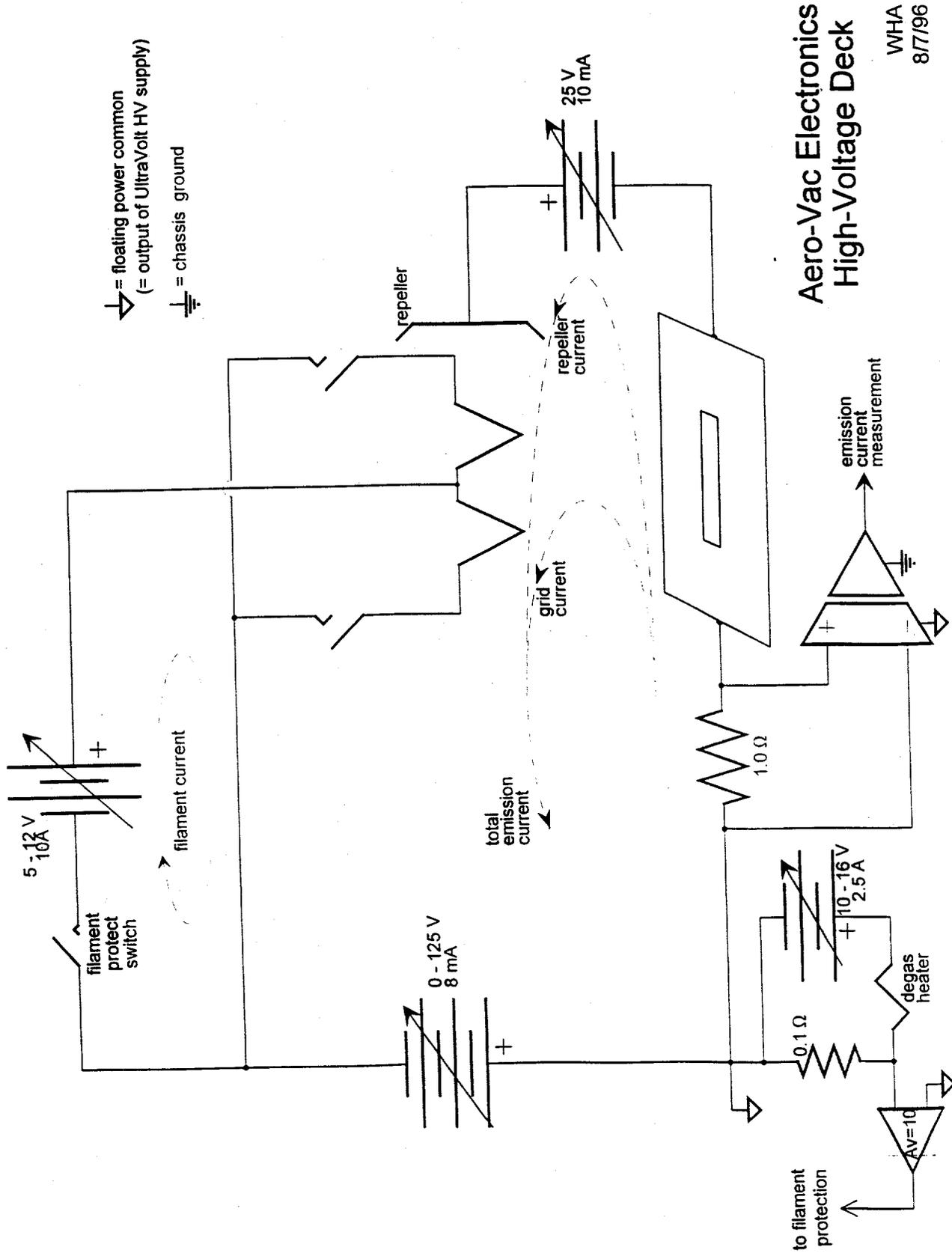
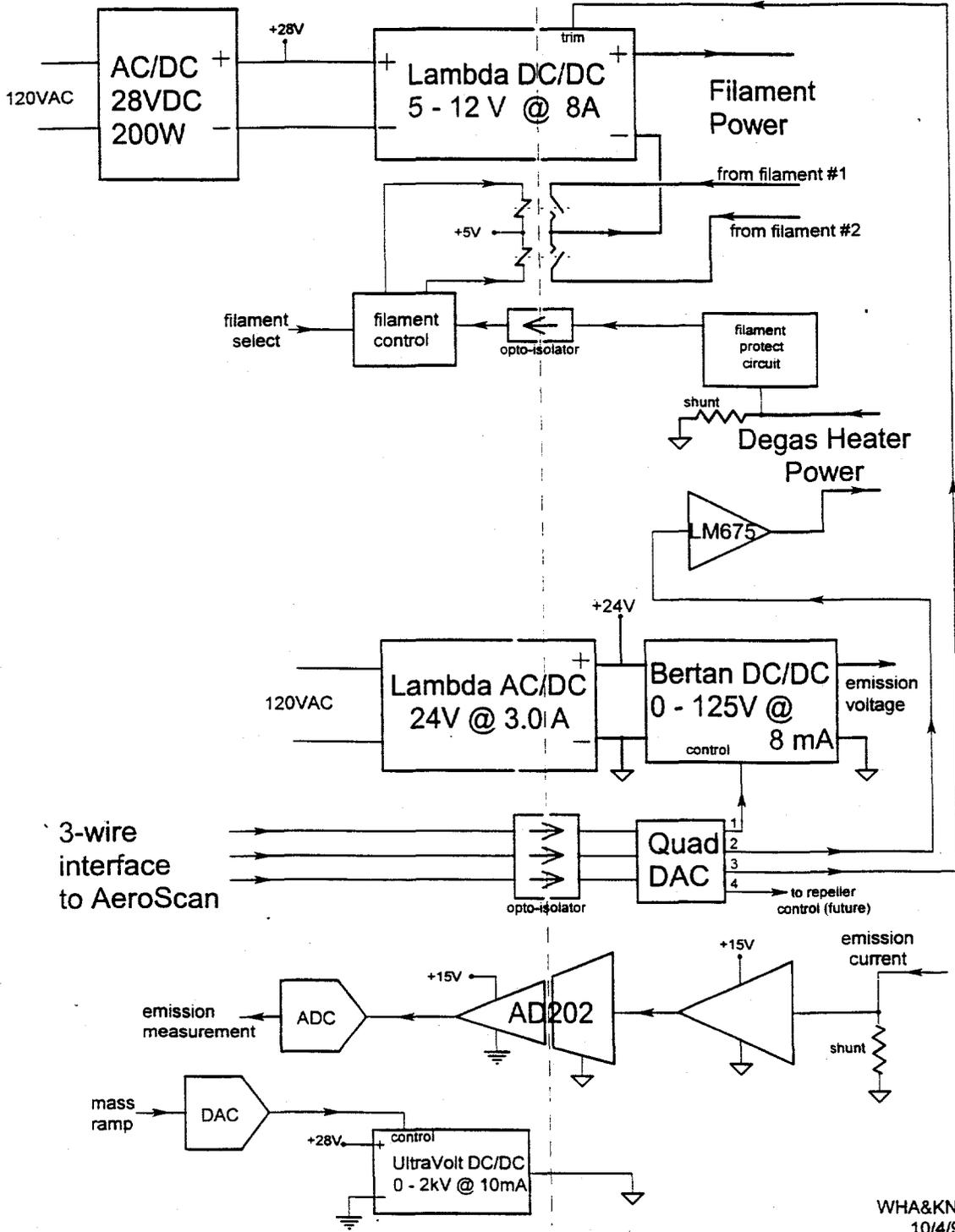


Figure 3. AERO VAC electronics high-voltage deck block diagram.

Signal and Power Transmission To/From High-V Deck



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Figure 4. Signal and power transmission to and from high-voltage deck block diagram.

INVENTIONS

There were no inventions made or reported as a result of this CRADA.

COMMERCIALIZATION POSSIBILITIES

The product of this CRADA was a significantly upgraded mass spectrometer/RGA prototype capable of rapidly acquiring mass spectral data. VTI will be marketing this improved system in mid-1997 and has an annual sales goal of 40 to 60 units of this type.

PLANS FOR FUTURE COLLABORATION

There are no plans for future collaboration between VTI and any DOE sponsored agencies as a result of this CRADA. Lockheed Martin Energy Systems will consider purchasing this instrument for its nuclear weapons stockpile surveillance program when the instrument is available and if programmatic funds are available.

CONCLUSIONS

This CRADA has been successful at improving the scanning speed and data acquisition speed of VTI's AERO VAC mass spectrometer/RGA. When available for purchase, this instrument could be used by Lockheed Martin Energy Systems for gas sampling in its nuclear weapons stockpile surveillance program.

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