SAMPLING HEAD THEORY OF OPERATION

Topics:

- Describe the construction and operational principles of the PIPS detector.
- Describe the circuitry of the Sampling Head preamplifier/amplifier.
- Describe the logic of the Sampling Head Multichannel Analyzer circuits, including the power supply and relay board.
- Describe procedures for bench testing the sampling head.

Sampling Head Theory of Operation Objectives

- Understand the operational principles of the PIPS detector.
- Perform basic troubleshooting of the Sampling Head to board level.
- Perform basic troubleshooting of the Sampling Head Preamplifier/Amplifier board, Multichannel Analyzer circuits, including the power supply and relay board.
- Perform bench testing of the sampling head.

8.1 Overview

Highlights:

- Block diagram of the Sampling Head Signal Processing circuits
- Overview of the signal chain operation

As shown previously in Chapter 2, the Sampling Head signal path is made up of the detector, preamplifier/amplifier, ADC, and MCA. In this chapter we will look closer at these assemblies, the CPU, power supplies, communications hardware, and flow rate sensor.

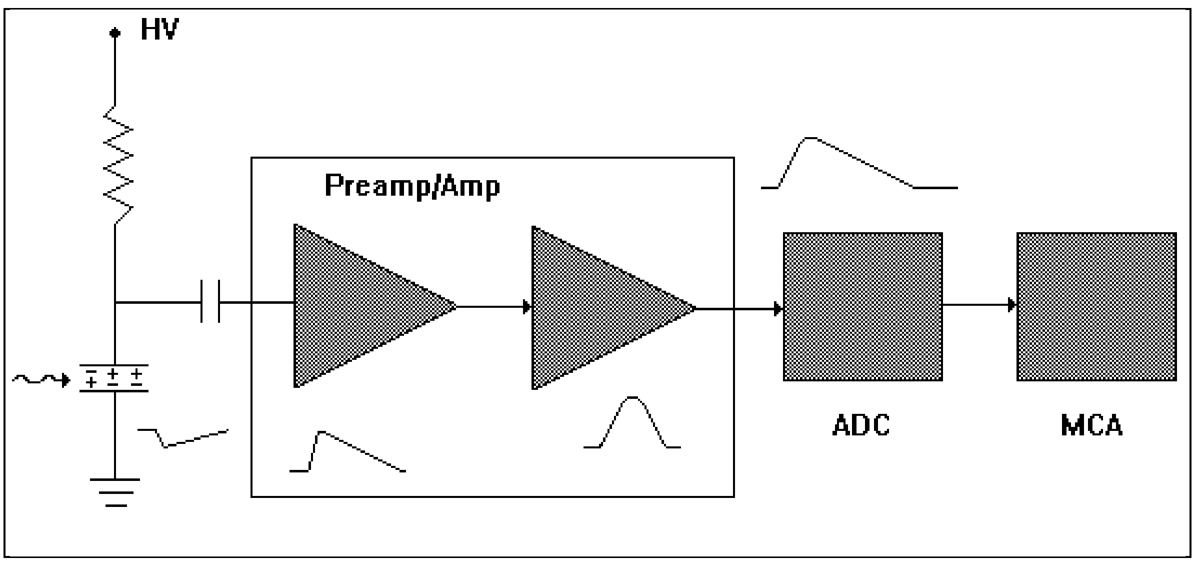

Figure 8.1 Sampling Head Signal Chain.

The sampling head signal chain starts with the conversion of the alpha particle energy into an electrical signal by the detector, represented by the capacitor symbol (with + and -) on the left of Figure 8.1. The detector converts the energy to a current pulse whose magnitude is linearly proportional to the amount of energy absorbed by the detector. This current pulse is coupled to a preamplifier that converts the current to the voltage tail pulse of proportional amplitude. The tail pulse is shaped/filtered and amplified by the amplifier before passing it along to the Analog to Digital Converter (ADC). The ADC converts each amplified and shaped pulse to the digital equivalent value over its operating range. The digital value, called the channel address, is given to the Multi-Channel Analyzer (MCA). The MCA maintains a database of these channel addresses called the spectral data memory. The channel address provided by the ADC is incremented by 1 for each event that converts to that address. Over time a "spectrum" histogram of the energy spectrum seen at the detector is built up in the MCA memory. This spectrum data can then be processed as required.

8.2 Detector

Highlights:

- Description of how semi-conductor detectors work
- Description of alpha particle detectors
- Canberra PIPS detectors, description and troubleshooting

The detector used in the Sampling Head is called a PIPS detector. PIPS stands for Passivated Implanted Planar Silicon, so named from the manufacturing process. It is a silicon semiconductor detector. We start with a discussion of semiconductor detectors in general.

Semiconductor Detectors

The basic principle involved in the detection of radiation is that the alpha particles emitted will be absorbed by the matter of the detector. The energy carried by the alpha particle is transferred to the detector material. If this relationship between the energy of the particle and the resulting transferred energy is known and the transferred energy collected (converted to electrical energy), the energy of the particle will be known. If we know the energy of the particle/photon, we can gain knowledge about its source.

Semiconductor detectors are the predominant state of the art for most types of radiation spectroscopy. These detectors essentially consist of a P-type and an N-type semiconductor material and the junction between them. The P-type material is doped with acceptor impurities, such that there are extra holes (positive ions) within the wafer. The N-type wafer is doped with donor impurities, these provide extra electrons (negative ions).

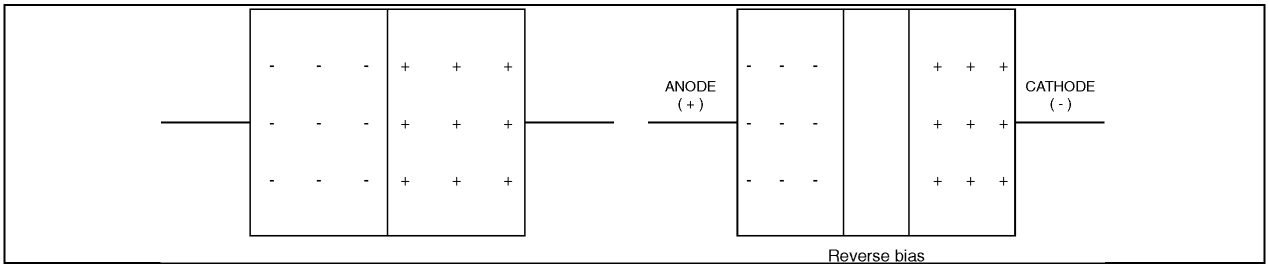

Figure 8.2 Semiconductor Detector Depletion Region

At the junction, the extra holes will seek out the electrons of the N material and the extra electrons will diffuse towards the holes of the P-material. At some point, an equilibrium is reached in which an electric field is produced across the junction which diminishes further diffusion. This results in what is called the Depletion Region, which is an area with very few charge carriers. It is in the depletion region, with its high resistivity, that the passage of radiation interacts - creating electron/hole pairs which are swept out by the electric field.

An unbiased semiconductor diode detector will detect radiation, but not very well. The electric field is not large enough to pull all the ion pairs out of the depletion region before they have a chance to be recombined or trapped by impurities. Also, the depletion region is quite small, and capacitance high, resulting in high noise at the preamplifier. By applying a reverse bias across the detector P and N contacts the electric field is enhanced and the depletion region (and thus the active volume) is widened.

As the depletion region grows thicker, the capacitance represented by the separated charges decreases, which promotes better resolution. Detector capacitance is in parallel with the preamplifier's feedback capacitance. This tends to increase the closed loop gain and raise or amplify the noise level of the preamp.

The fact that less energy is required for each ion pair produced greatly increases resolution, relative to other detection methods. This figure is 3.6 eV/ion pair for Silicon and 2.98 for Germanium (compared to about 20 eV/ion pair for NaI(Tl)). This has the effect of decreasing fluctuations in the amount of charge collected.

With the larger electric field, radiation induced charge carriers are more efficiently swept from the depletion region. All detectors will show a finite conductivity, even with the absence of ionizing radiation. This is called leakage current, which is minimized via the choice of contacts and high purity of crystal material.

Maximum operating voltage for any diode detector must be kept below the breakdown voltage to avoid a catastrophic deterioration of detector properties.

Alpha Particle Detectors

Alpha particles are counted with either gas-proportional counters (gross counts) or silicon semiconducters (spectrometers). Alpha spectrometers use either SSB (Silicon Surface Barrier) or PIPS (Partially Implanted Passivated Silicon) detectors. These type detectors are sensitive to light and should be covered when stored. They're are also sensitive (especially SSBs) to specific pressure ranges with voltage applied. And, since alpha particles lose energy quickly in air, the detector and sample of interest are usually put into a vacuum chamber. In the case of the Sampling Head a vacuum is not used so the detector to sample distance is kept at a minimum.

The entrance window for these detectors is very thin to minimize the interaction, and thus energy attenuation, and should never by handled. Care must be taken when attempting to clean contamination from the window surface.

This metal to semiconductor junction results in a depleted area free of charge carriers. The surface layer is thinner than that of the diffused junction, and does not affect the incoming particles as much. The depth of the depletion layer depends upon the impurities within the crystal and the applied reverse bias. Detectors are generally available with depletion depths of 100 to 1000 μm.

PIPs can be partially or totally depleted when bias is applied. An aluminum (or other metal) contact is made on the reverse side of the N-layer. Positive bias is applied to the electrode to attract the free charge carriers separated by the interaction of incident radiation.

Operating voltage is derived from the depletion depth desired and the available stock of crystal material. Bias is usually determined according to depletion depth, specific resistance and capacitance. PIPS as a whole work at a low operating voltage, with 24 volts positive being used in the Sampling Heads.

CAM PIPS Detectors

These are made using a photolithographic technique for geometries, ion implantation to form accurately controlled junctions and special techniques to control the oxide passivation for protection. This allows for an extremely thin entrance window of about 500 Angstroms thickness.

PIPS detectors come in five standard series as well as specials and custom design types. The standard series are Partially Depleted (PD), Fully Depleted (FD), Alpha (A), Beta (B) and CAM. The CAM PIPS detector has additional layers of aluminum and varnish which gives them a total window thickness of about 2 microns equivalent silicon.

PIPS detector is rugged enough to be safely cleaned (cotton ball soaked in acetone) and handled. Yet the entrance window is very thin in order to achieve high efficiency and good resolution for alpha particles. Therefore, do not touch the surface with anything that might cause scratches or abrasions.

The PIPS detector can be cleaned to remove oil film, fingerprints, or dust particles on the surface. This should be done by first blow drying air or N_2 gas on the surface to remove particles that might cause scratches in the subsequent cleaning step. Then use a cotton ball dampened with a good grade of acetone or isopropyl alcohol. **Do not use cotton swaps, Q-tips, or methyl alcohol.**

Some recoil contamination can be removed by cleaning as well but recoil particles are often imbedded in the surface and cannot be entirely removed. Recoil contamination is the result of the recoiling daughter nucleus from the alpha decay reaching the detector face. Recoil contamination would cause an increase in background and potential continual acute or chronic alarms.

Troubleshooting PIPS detectors

The chief problem with these detectors is contamination and mechanical damage.

Measurements.
Detector leakage current is normally recorded on the data sheet which comes with the detector.
A meter for monitoring the reverse (leakage) current is useful, but observation of the noise at the amplifier output is a much more sensitive method for monitoring detector behavior because, near breakdown, the noise increases more rapidly than the reverse current. The reverse current will vary with detector area and from one detector to another, but will usually be 10s of nanoamps for PIPS.

The best way of testing the noise level of the detector is to measure the resolution of the peak created by a test pulser or using the calibration source. The pulser peak resolution should be 5 keV less than the stated resolution for the detector. The resolution at the Full-Width at Half Maximum (FWHM) point is typically 0.450 MeV for the 1700 mm^2 PIPS and 0.325 MeV for the 450 mm^2 PIPS.

Problems.
If the noise level does not decrease when bias is applied to the detector:

- make sure any test pulser is turned off and all radiation sources are removed.
- check for an open circuit between the amplifier and detector, or for a short circuit in the pulse lead.
- remove the detector from the preamplifier, the noise should decrease. If not the trouble is in the amplifier circuits.
- check for ground loop noise.

(Expected noise level in the sampling head is < 100mV with the detector installed, and < 20 mV without the detector.)

If there is excessive noise at zero bias;

- check for high resistance in pulse lead, connectors etc. between the detector and preamplifier.

- check for partial or intermittent short circuit from pulse lead to ground.

If there are short intermittent bursts of noise or extraneous counts

- check for noisy power input, pickup noise, or ground loop noise.
- could be caused by unknown source of background radiation.

If detector current is abnormally high

- there could be high ambient temperature at the detector.
- the detector may be radiation damaged.
- check for moisture or organic vapor condensation.

If amplifier output has a significant DC offset from zero there is a problem in the associated electronics.

Contamination

The PIPS detector can be cleaned with a cotton ball dampened in acetone (isopropyl alcohol if acetone is not available). Avoid excess wetting of the detector assembly, but repeat the cleaning treatment with fresh cotton to eliminate traces of contamination. Blow dry with dry air or N_2 gas (Blow dry air or N_2 gas across detector first to remove particles that might cause scratching of surface.). Make sure all moisture is removed before applying bias.

8.3 Preamplifier/Amplifier

Highlights:

- Description of the preamplifier/amplifier circuits in the sampling head
- Board layout and output signal
- Description of the latch and stretcher circuit

Most detectors can be represented as a capacitor into which a charge is deposited, (See Figure 8.1). By applying detector bias, an electric field is created which causes the charge carriers to migrate and be collected. During the charge collection a small current flows, and the voltage drop across the bias resistor is the pulse voltage.

Most preamplifiers in use today are charge sensitive, and provide an output pulse with an amplitude proportional to the integrated charge output from the detector. The output pulse is called a voltage tail pulse and is passed on to the amplifier circuits. The amplifier shapes and amplifies the signal in preparation for further processing. In the Sampling Head the preamplifier and amplifier are combined onto one circuit board.

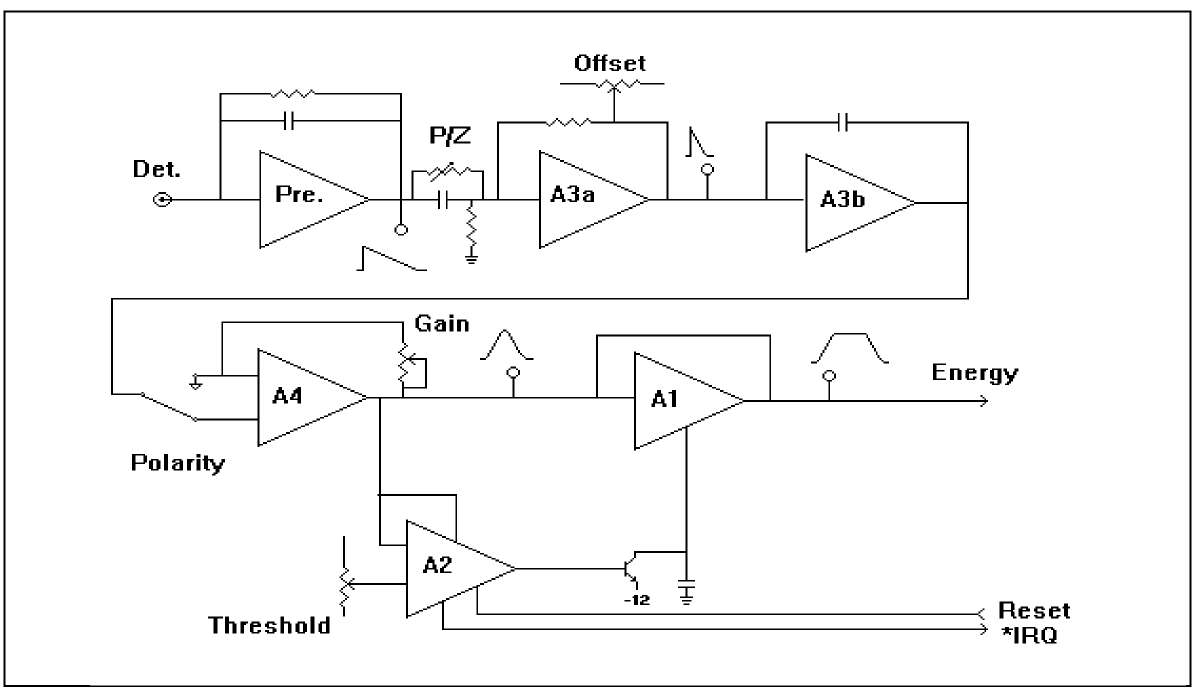

Figure 8.3 Preamp-Amp Block Diagram.

Sampling Head Preamp-Amp

The Sampling Head Preamp-Amp incorporates a low-noise charge-sensitive preamplifier and a unipolar output shaping amplifier. Refer to the block diagram Figure 8.3 and schematic drawing B-26770 included in the Sampling Head Schematic Set.

The preamplifier consists of input FET Q4, differential amplifier Q3 and Q6, output follower FET Q5, and current sinks Q1 and Q2. This group of devices functions as an inverting feedback operational amplifier whose closed-loop gain is set by the charge-integrating capacitor C30. Bias stabilization is provided by the DC feedback path through R51. This component serves to discharge C30 following each charge integration, and sets the tail-pulse shape of the preamplifier at a nominal 470 μsec decay time constant. The transfer function of this stage with a PIPS detector is about 10 mV/MEV ±25%. After particle losses the 5.49 MeV alpha from ^{241}Am is typically 40 mV at TP8.

A test input can be injected into the the circuit from the MCA board through C31 into the preamplifier. TP1 can be used if the STR_TEST signal is disconnected from the MCA Board.

Following the preamplifier integrator is a pole-zero compensated differentiator (C13, R22). RV1 is adjusted for prompt return to the baseline while looking at the Amp Output (TP5). There should be less than 50 mV overshoot or undershoot. The now abbreviated tail pulse (50 μsec decay time) is amplified by a fixed gain non-inverting feedback amplifier A3A. The preset gain of 5 raises the signal level to be compatible with the shaping process to follow. Potentiometer RV2 sets the DC output offset, A3 pin 7, to 10 ± 5 mV with respect to TP11 (Gnd).

Preliminary integration is provided by band pass filter A3B with C2 in the feedback loop. The signal is then passed through polarity selection jumpers J3 (with J4) to Gain Amp A4. The gain of A4 is controlled by RV3 which provides a gain span of 5 to 15 (input = +). RV3 is adjusted to provide a default energy calibration of .039 MeV/Channel. The amplifier output will have a pulse width of 6 to 6.5 μsec at the 50% point.

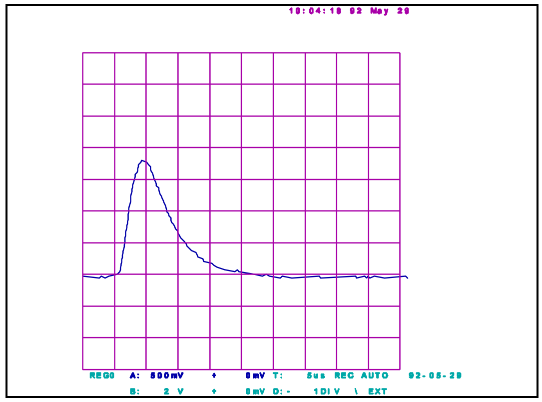

Figure 8.4 Amp Output (TP5).

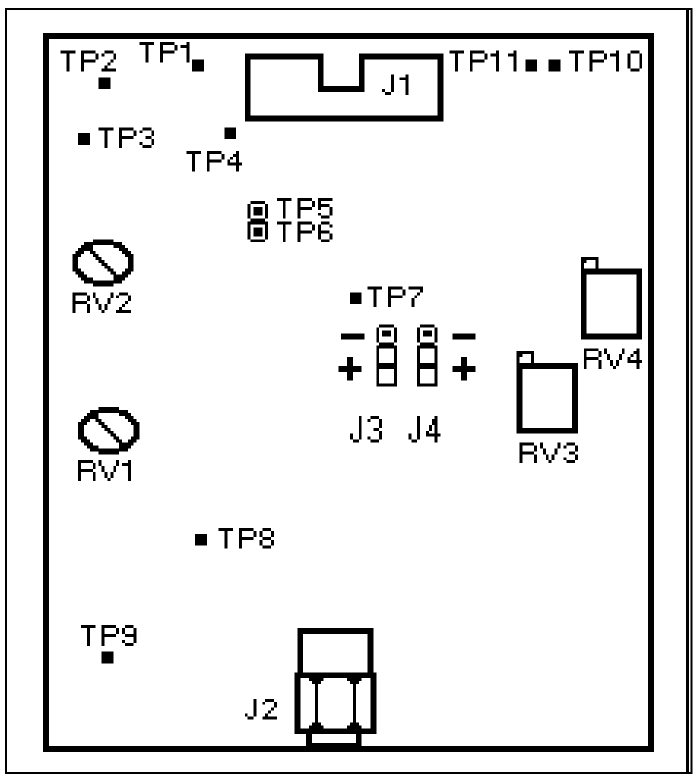

Figure 8.5 Preamp-Amp Layout.

Latch and Stretcher Circuits

The gaussian shaped positive pulse if passed onto the Stretcher circuit for processing by the ADC. The stretcher is made up of A1A and A1B configured as a dual amplifier with gain of 1. Working in conjunction with the stretcher is the digital latching circuit made up of A2 and D3.

In the quiescent mode the stretcher circuit acts as an amplifier tracking the input level. As the output of Gain Amp A4 rises on the input of A2 and crosses the threshold set by RV4 the output of A2 goes positive. The threshold is factory set for 200 ± 1 mV to pin 3 of A2 with respect to TP11 (Gnd). The feedback through D3 forces A2 into a latched condition with the output high. This high biases Q8 and Q9 off.

Q9 off allows the Peak Hold capacitor C22 to charge up to the peak voltage of the signal through diode D2. When the gaussian shaped pulse falls back to the baseline C22 will maintiain the peak voltage due to the diode action. The output of A1B follows this voltage level (ENERGY) which is felt on the input of the signal processing ADC. C21, C3, D1 and R5 provide frequency compensation for the stretcher circuit.

The output of the digital latch is coupled through digital inverter Q7 which generates an interrupt request (*IRQ) to the ADC processor. At the completion of the conversion process the processor returns RESET through Q10. This forces the collector of Q10 low and resets A2. It also discharges C22 through Q9 which is now turned back on. The rise time of the stretcher pulse is 1.9 to 2.5 μsec (10 to 90%). The fall time is 1.8 to 2.5 μsec.

The stretcher output saturates at a DC level greater than 8.0 volts.

8.4 MCA Board

Highlights:

- Description of the MCA logic board components
- Serial Number of head and board - caution
- Description of the MCA Logic
- Parameter storage
- Description of ADC circuits
- Description of Power Supplies, testing locations and adjustments
- Description of relay and interface circuits

The Sampling Head's MCA board is located in the lower housing of the Sampling Head. It consists of 3 major blocks as shown on Sheet 1 of 4 of drawing B-27101, within the schematic booklet. These blocks break the circuit out according to the schematic sheet in which the circuit element is shown. The blocks are the MCA Logic (Sheet 2), Power Supply (Sheet 4), and RS485 and Relay Connections (Sheet 3). Sheet 1 also shows connector J2 which connects the MCA board to the Preamp-Amp, sensors and Relay Board.

Sheet 2 of Drawing B-27101 shows the Sampling Heads MCA logic. It consists of microcontroller chip U3, PLD U6, PROM U4, RAM U5, and a ramp generator.

MCA Logic

The heart of the Sampling Head's MCA is Microcontroller U3 which is a Motorola M68HC11A8. This is an 8 bit MCU (microcontroller unit) using HCMOS technology combining smaller size and higher speeds with low power and high noise immunity. On-chip memory systems include 8k bytes of read-only memory (ROM), 512 bytes of electrically erasable programmable ROM (EEPROM), 256 bytes of random-access memory (RAM).

Should you ever have to change the MCA board in a CAM Head, or should you decide to swap out the MCA board's processor chip, you will lose the serial number and all calibration information burned into the chip.

If the board is swapped the original processor can be installed to maintain the serial number and calibration information. However an efficiency and flow calibration is recommended.

If just the processor is changed (expected failure rate is very low) you will not be able to burn in the Head's serial number without special software and an RS-485 interface box to the CAM Head. However this does not affect CAM Head operation. You must perform calibrations if the processor is changed.

Major peripheral functions are provided on-chip. An 8 channel analog to digital converter (ADC) is included with 8 bits of resolution. An asynchronous serial communications interface (SCI) and a separate synchronous serial peripheral interface (SPI) are included. The main 16-bit, free-running timer system has three input-capture lines, five output-compare lines, and a real-time interrupt function. An 8-bit pulse accumulator subsystem can count external events or measure external periods.

The Sampling Head uses one of the ADC channels to convert the Preamp-Amps ENERGY output to a digital value. Another ADC input is used to monitor the Air Flow Rate Sensor. ADC channel 4 is used during the ASM1000 directed linearization process. The remaining ADC channels monitor the power supply voltages including the +24 V High Voltage Bias for the PIPS detector.

A +5 Volts reference for all the ADCs is provided by Zener D2 and RV1.

Clock reference for the processor is 7.373 MHz from crystal Y1. A syncronizing clock of 1.8 MHz is output from Pin 5 of U3 to drive Programmable Logic Device U6.

U6 is a Programmable Logic Device setup to act as a memory and port controller. It recieves address and data from the microcontroller. Its outputs include RAM and ROM chip enables, RAM write enable, alarm annuciator signals, and front panel LED drive signals. A final output turns the ADC linearization test ramp on.

Inputs to U6 include the DOOR latched signal from the optical sensor and part of the CAM Network Address from the Sampling Head's associated NTB box. This is passed on to the microcontroller for decodeing. Each time the ASM1000 communicates to the network the first packet of data is a Sampling Head Address. The microcontroller matches the address with the address encoded by ID0-ID2.

Buses eminating from the microcontroller include; a 16 bit Address bus (A0-A15), an 8 bit bi-directional data bus (D0-D7), the asyncronous serial interface bus (SCI0-SCI2), and the syncronous serial interface bus (SPI0-SPI3).

The address and data buses are used to interface U6, read program instructions from ROM U4, and to read or write RAM U5. U5 stores the collected spectral data.

The asyncronous communication bus is used in conjunction with RS-485 driver/buffer U8. This is connected to the CAM Network port J101, as shown on Sheet 3 of the schematic. The syncronous bus connects to board connector J2 but is not used at this time.

The test ramp generator which includes Q3 and U2A generates a 0 to 5 Volt ramp during the ADC linearization test. This test is initiated on command from the ASM1000 once each 24 hours. Each ramp takes about 8 seconds and repeats until sufficient counts are available for statistical analysis (3000 counts/channel). This normally takes about 2 minutes. The ramp voltage is converted by the microcontrollers ADC and data is stored in RAM. The ASM1000 reads the data and developes a table of adjustment factors to correct for non-linearities in the channel widths of the ADC. This table is then applied by the ASM1000 during its data analysis.

Parameter Storage

The EEPROM within the microcontroller is used to store the following parameters:

- Sampling Head serial number
- detector efficiency
- flow table values
- alarm annunciation tables
- default analysis window limits (V1.1.06 addition)
- default Acute Alarm Limit (V1.1.06 addition)

Except for the Sampling Head serial number all the values are down-loaded from the ASM1000. On Sampling Head Firmware Versions previous to V1.1.06 the analysis window and acute alarm limits had fixed defaults when the head operated in Standalone mode or was disconnected from the ASM1000. Additional space in the EEPROM is allocated for more information including calibration date/time stamps.

ADC

Channel 0 of the microcontroller's ADC is used to process signal from the Preamp-Amp board. This process is initiated upon the assertion of RDYB* which is an Interrupt Request into U3. The ENERGY output pulse from the stretcher on the Preamp-Amp board is felt on the input of the ADC. This is a flat top pulse maintaining the peak voltage level of the amplified signal. The ADC performs a summation approximation type of conversion against its +5 volt reference. This takes about 100 usec. At the completion of the conversion process the microcontroller generates STR_RST which resets the stretcher circuits on the Preamp-Amp board. The microcontroller adds 1 to the converted memory channel in the spectral data region of RAM.

The ADC is factory tested and calibrated using an Am-241 source. The energy peak of 5.49 MeV is expected to appear in channel 114 ±2. This is equivalent to .039 MeV per channel. This gives a full scale energy of about 12 MeV. The calibration is setup by adjustment of RV3, the Gain Pot on the Preamp-Amp board. The ASM1000 restricts the viewing of the spectrum to between 1 and 11 MeV.

Power Supply

The Sampling Heads Power Supply is shown schematically on Sheet 4 of Drawing B-27101. 24 VAC is recieved from the AS070 Sampling Head Power Supply or from the ASM1000 through the power connector. F1 and D15 provide overload and surge protection into CAM Transformer T1. T1 provides 3 output windings. Each output is full wave rectified and capacitively filtered into monolithic voltage regulators. Secondary winding 2 is used to generate both +12 and -12 volts. Power Supply Regulators Q1, Q2, Q4, and Q5 provide current and temperature overload protection internally.

The +12 volt regulated output from Q2 is used to generate +10 V via U1. Adjustment is made using RV2.

During normal operation the Sampling Head's processor monitors the voltages with its on-board ADCs. The inputs into the ADC are dropped down to approximately 2.5 V for each supply. If any converted value is > 6% off an instrument fault will be generated.

Power Monitor chip U7 monitors the input voltage and performs a processor RESET on Power On and Power Off. The signal XIRQ* can be used to provide an interrupt to U3 for power loss detection, but is not presently utilized.

The supplies are used as follows:

+5	all digital logic on MCA board
+10	Air Flow Sensor
+12	Ramp generator, ADC Reference, Preamp-Amp

-12	Ramp generator, Preamp-Amp
+24	Preamp-Amp (Detector Bias)

The supply's output can be monitored as follows:

NOTE: TP5 may be used as ground for the following measurements.

Location	Measurement
U8 - pin 8	+5 ± 0.25Vdc
U2 - pin 8	+12 ± 0.6Vdc
U2 - pin 4	-12 ± 0.6Vdc
Q5 - pin 3	+24 ± 1.1Vdc
D14 - Cathode	+10 to +12 Vdc
D12 - Cathode	+21 to +24 Vdc
Q4 - pin 2	-21 to -24 Vdc
Q5 - pin 1	+40 to +44 Vdc

Use an oscilloscope with a X10 probe, AC coupling, and measure the ripple at the following locations:

Location	Limit
D14 - Cathode	<150mV p-p
D12 - Cathode	<100mV p-p
Q4 - pin 2	<250mV p-p
Q5 - pin 1	<400mV p-p

Adjustments

Measure the flow sensor reference voltage at TP1 and adjust RV2 for a DVM reading of +10.000 ±0.005 Vdc.

Measure the ADC reference voltage at TP3 and adjust RV1 for a DVM reading of +5 ±0.005 Vdc.

Relay Board

The relay board for control of the Sampling Head's six-positions terminal board connects to the MCA board through J2. Relay power is provided from the power supply at about 22 volts. Each relay, trouble and exposure, is controlled by output level signals RELAY0 and RELAY1 from the microcontroller. The external device is wired in series with the active and common terminals on the relay block.

RS485 Interface

The Sampling Head is linked over the network with up to 7 other Sampling Heads to an ASM1000 on a daisy chained RS-485 half-duplexed network. If networked the Sampling Head connects to the network via Network Tee Box. RS-485 networks can be extended up to 1200 m (4000 ft) but must be terminated at both ends in the characteristic impedance of the cable. In the Alpha Sentry System, the ASM1000 provides one end of the network and has an internal 120 ohm termination. There is another 120 ohm terminator on the Head at the far end of the cable. For a single Sampling Head within 7.5 m (25 ft), no additional termination is necessary.

The recommended cable is a 22 gauge twisted pair with an electrostatic shield. The lay of the cable must give at least two twists per 2.5 cm (two per inch).

Sheet 3 of Drawing B-27101 shows the RS-485 transceiver U8. The data transmission lines connect to pins 6 and 7 which are bi-directional. The differential lines are protected against ESD transients by transorbs D16, D17, and D18.

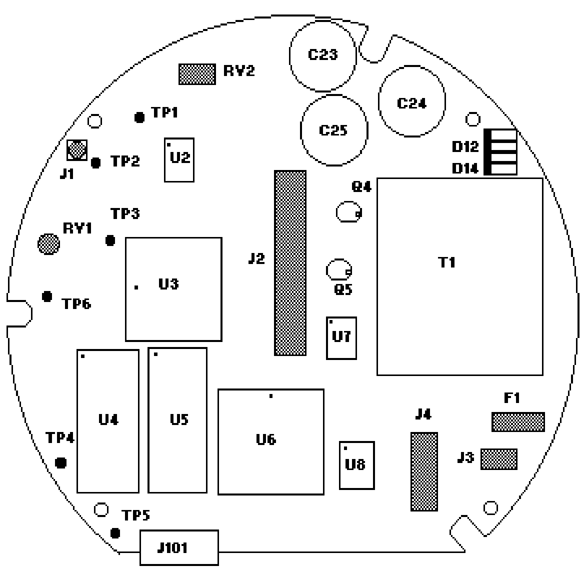

Figure 8.6 Sampling Head MCA Board.

8.5 Testing Procedures

Highlights:

- Equipment required for sampling head tests and calibration
- Visual Inspections
- Testing of sampling head
- Preparation for use after testing

This section describes some abbreviated testing procedures that might help the service technician diagonose a problem with a sampling head or to put the head back into service. Because of the specialized nature of the CAM System and the testing equipment required it is recommended that if the specialized test equipment is not available the Sampling Head be returned to the factory for serviceing.

Checking the Sampling Head

This section describes the procedure for checking the Sampling Head as a whole assembly.

Equipment Required

- Oscilloscope (Tektronix Model 465 or equivalent)
- Digital Voltmeter (≤0.1% full scale accuracy)
- AC Voltmeter (Model HP-400H or equivalent)
- Rietchle TLV6(07) rotary vane vacuum pump (Canberra AS090 or equivalent capable of drawing 3 SCFM air at a vacuum of 100 in-water.
- Calibration Flow Meter (Sierra 826-T5, 0-3.5 SCFM or equivalent).

Note: The CAM Head Leakage Test Set TEO4123 used to check the CAM Head leakage may be left connected to the test system without affecting the performance of this test.

- Model AS080 (for AS450) or Model AS085 (for AS1700) Calibration Source.
- CAM Head Power Supply Model AS070 or equivalent.
- CAM Relay Board Test Fixture (TE04127), or equivalent.
- Motorola Radius P100 Handie-Talkie or equivalent. Referred to as "Transmitter".
- In-Lie Sealing pipe TE05157
- CAM Filter Cartridge (1700-96A27220 or 450-96A27219)
- (Test computer with AS1700/AS450 test programs. With RS-232/RS-485 converter. RS-232/RS-485 converter test cables TEO8135 and TEO8136.)

Visual inspection

1. Inspect the CAM Head for obvious defects.

2. Inspect external surface, LEDs, and mechanical connections.

3. Inspect Filter Cartridge guide and Sample Holder Piston O-ring seals by looking inside the CAM Head door opening.

4. Inspect for damage to door sensor and for disconnected vacuum hoses.

5. Verify Labels with S/N certifying Leak Tested and Gapped on area under the top cover, as set at factory.

Equipment Setup

1. Connect the CAM Head to the test equipment as shown below in Figure 7.8. Subsitute an ASM1000 for the test computer and program if the latter is unavailable.

```
+-----------+3/8 inch +---------+
|Vacuum     +---------|Leak     |                            +-------------+
|Pump       | HOSE    |Fixture  +-----+                      |             |
|           |         |TE04123  |     |                      |             |
+-----------+         |         |     |                      |  Cam Head   |  +-------+
                      +---------+     |                      |  Under Test |  | CAM   |
                     (not required)   |                      |             |  | Head  |
                                      |    +-----------+3/8 inch           |  | Power |
                                      |    |Calibration+--------|          |  | Supply|
                                      +----| Flow Meter| HOSE   |          |  +-------+
                                           |           |        |J101    AC IN+----+
                                           +-----------+        +-------------+
                                                                  |
    +-------------+                                               |
    |             |                                               |
    |   Test      |  Cable     +----------+                       |
    |  Computer   |  TE08135   |  RS-232/ |   485 Cable TE08136   |
    |        COM1+-------------|  RS-425  +-----------------------+
    |with         |            | Converter|
    | ASM1000     |            |          |
    | program     |            +----------+
    +-------------+                |           +------------+
                                   |           |            |
                                   +-----------|     AC     |
                                               |  Adapter   |
                                               +------------+
```

Figure 8.7 Equipment Set Up

2. If installed in the system, switch the BYPASS VALVE on the CAM Head Leakage Test set to the FLOW CAL position.

3. The Pressure Relief Valve on the pump is to be opened only as required to reduce the flow during measurements.

4. The Pressure Relief Valve on the CAM Head Leakage Test Set must be left closed for all flow calibration tests.

5. Close door and turn knob to CLOSE position

6. Turn on power to all equipment except the vacuum pump and ASM1000 (if used).

ASM1000 (or Program) Execution

1. Verify that the Green LED labeled count is off and the Red Alarm LED is on. If an AS020 Alarm is installed, it will be alarming.

2. Turn the ASM1000 on (or run the ASM1000 Program on the test computer).

3. The program will indicate that it is scanning the CAM circuit, then it should initialize the CAM. Verify that the CAM Network Display appears and the Green Count LED is now on.

> NOTE: If the AS020 is installed, the audio alarm is silenced by pressing the (F10) or **Stop Alarm** key. The strobe will continue to flash. Do this throughout the procedure when the alarm is turned ON.

4. Press the **DATA REVIEW** key (F3), then **Alarm Log** (F2) and verify <u>only</u> CAM fault 00001 alarms and low air flow alarms are in the Alarm Log. No other fault numbers should be present.

5. Press ESC key to return to top level menu.

6. From the ASM1000 CAM Network Display, select **System Setup** (F4), **Param. Setup** (F1), then **Misc.** (F4).

7. Verify that <u>Altitude</u> = 0, and <u>Temperature</u> = 298.

Relay/Lamp Checks

1. Connect CAM Relay board Test Fixture TE04127, or equivalent, to the CAM Head under test.

2. From the ASM1000 Display on the test computer, press ESC and then **System Setup** (F4), **Calib** (F5), **Diag. Test** (F3).

3. Use the right arrow key to highlight CAM and then press <ENTER>.

4. Press the **Relay Check** key (F3) and verify the Trouble and Exposure LEDs on the test fixture. Follow this sequence:

Trouble	Exposure
NC	NC
NO	NC
NC	NO
NO	NO

and then return to their initial status of Trouble NC and Exposure NC. Press F10 (**Stop Alarm**) to silence the optional Audio Alarm.

5. Press the **Lamp Check** key (F1) and verify that just the Red LED (Alarm) turns ON for 2 seconds, then just the Green LED (count) turns ON for 2 seconds, then both LEDs go OFF and then back to their prior status of Green ON and Red ON. Press F10 to silence the optional Audio Alarm.

6. Press **Version** (F4). Verify the CAM Head Version and record. Latest version is V1.1.06.

AS020 Alarm

1. If the optional AS020 Alarm installed press **Stop Alarm** (F10) until Audio Alarm stops. Press ESCape, **System Setup** (F4), **Calib** (F5), **Diag. Test** (F3).

2. Verify the strobe flashes every 1.5 seconds. Stop the audio alarm if any, by pressing the **Stop Alarm** (F10) key on the test computer.

3. Press the **Audio Check** key (F2) from the Diagnostics menu and verify the Horn sounds (in the listed order) and the STROBE turns OFF during the Audio Check:

Continuous high volume
Pulsed Fast Rate
Continuous low volume
Pulsed Slow Rate.

4. Press **Stop Alarm** (F10) to silence the alarm.

5. Return to Network Display.

Spectrum Gain Verification

1. Open the door of the CAM Head; insert an AS080 (check source for an AS450 CAM Head) or an AS085 (check source for an AS1700 Cam Head). Close door and turn knob to close the position. Press **Stop Alarm** (F10) to clear optional Audio Alarm.

2. Run the Gain Verification test program GAIN. (Exit the ASM1000 program of the test computer by pressing the **ESC** and then **Q** keys, if necessary.)

3. Verify the position of the peak channel is 114 ± 2 channels. (Actual peak position may depend on environmental parameters such as altitude and humidity. Drier, thinner at higher altitudes may cause the peak channel to be higher. Upto channel 119 can be tolerated by the energy compensation algorithms.

4. Adjust peak position if necessary by adjusting RV3 (lower potentiometer) on the CAM Heads PREAMP/AMP board. This requires removal of a shield. The GAIN program does update the spectral dispaly dynamically and must be exited and restarted after each adjustment.

Glyptol the potentiometer if an adjustment was required. Reinstall shield after adjustment is made.

> *NOTE:* *Before making this adjustment, the CAM Head should have been powered for at least 10 minutes. Use a torque screwdriver set at 6 in/lbs to reinstall the shield.*

5. Remove the Calibration Check Source from the CAM Head. Close the door and turn the knob to the close position.

6. Type "E" and then "Y"<ENTER> to exit the Gain Verification Program.

Efficiency Calibration

If using an ASM1000 refer to Chapter 5 Calibrations and Performance Checks to perform the efficiency calibration. The following steps assume the use of a testing computer.

1. Run the ASM1000 program on the test computer.

2. After the "Initializing CAM" message disappears, press F10 to clear optional Audio Alarm. Then select **System Setup** (F4), and then **Source Info** (F2).

3. Use the down arrow key to select Units and the right arrow to highlight (dpm). Press <ENTER>.

4. If you are testing a AS1700, you should be using a AS085 Check Source. If you are testing a AS450, you should be using a AS080 Check Source. Record the model and Activity of the source being used.

5. Type in the Activity that is listed on the bottom of the Source being used and press <ENTER> on the test computer. Record the source serial number and the Date listed on the bottom of the source.

6. Verify a count time of 1 minute, the correct Activity and correct units. Verify the door on the CAM Head is closed and the knob is in the closed position. Press **ESCape** to return to **Network Display.**

7. Check that the current Date and Time are entered. From the Network Display press **System Setup** (F4), **Param. Setup** (F1), and then **Misc.** (F4). **ESCape** to return.

8. Select **System Setup** (F4), **Calib** (F5), and then **Effncy** (F1).

9. The status for CAM number 1 should say Primed and the Alarm LED on the CAM Head should be blinking. Turn the knob to the open position.

10. Open the door and insert the correct Calibration Check Source. Close the door and turn the knob to the close position.

11. The Alarm LED will stay lit for 1 minute and the CAM status will say Counting.

12. When the count cycle is complete, the Alarm LED will blink again and the status will say completed. Record efficiency value and verify it is greater than 30% for an AS1700 and 20% for an AS450.

13. Turn the knob to the open position, open the door and remove the Calibration Check Source.

14. Close the door and turn the knob to the closed position. Press F10 to clear the optional Audio Alarm.

Flow Calibration Tests

1. Connect the flow equipment as shown in the Equipment Setup section, if not previously done. Install the correct filter cartridge and close the door with the knob in the closed position. The correct cartridge is an AS031 for the AS450 CAM Head and an AS032 for the AS1700 CAM Head; a filter backer (white with an "X") must be in the cartridge. Press **Stop Alarm** (F10) to clear optional Audio Alarm.

2. Return to the **Network Display** (Press **ESCape**). Check that the current Date and Time are entered. To set date or time press **Filter Change** (F1), then **Date/Time** (F2). Then return to the Network Display.

3. From the ASM1000 CAM Network Display select **System Setup** (F4), **Calib.** (F5), then **Air Flow** (F2).

4. Use the down arrow key to select the lower Range field and then press **0.5**, <ENTER>, **1.5**, <ENTER> for the AS450 or **1.5**, <ENTER>, **2.5**,<ENTER> for the AS1700. The Limit (scfm) will get set automatically as shown in Tables 1 and 2 below.

Table 7.1 AS450 Air flow calibration points.

Calibration Points (AS450)			
Pt.	Limit (scfm)	Meter	CAM volts
1	0.5 to 0.7	0.5	x.xx
2	0.7 to 0.9	0.8	x.xx
3	0.9 to 1.1	1.0	x.xx
4	1.1 to 1.3	1.2	x.xx
5	1.3 to 1.5	1.5	x.xx

Table 7.2 AS1700 Air flow calibration points.

Calibration Points (AS1700)			
Pt.	Limit (scfm)	Meter	CAM volts
1	1.5 to 1.7	1.5	x.xx
2	1.7 to 1.9	1.8	x.xx
3	1.9 to 2.1	2.0	x.xx
4	2.1 to 2.3	2.2	x.xx
5	2.3 to 2.5	2.5	x.xx

5. Using the down arrow and right arrow keys, move the cursor to the Meter field for Pt. 1. Type in the Meter reading for that point as shown in Table 1 or 2 (0.5 for the AS450 or 1.5 for the AS1700).

6. Turn on the pump and, while reading the Calibration Flow meter, adjust the pump flow for the reading set for the Pt. 1 field.

7. When the flow is set wait several seconds until voltage reading is stable and press Enter. The CAM volts measured at that flow setting will be entered (verify a value of at least 3 volts was entered for an AS1700, and at least 2 volts was entered for an AS450), and the cursor will index to Pt. 2.

8. Continue to set the calibration for the points 2 through 5 using the Meter readings shown in Tables 1 and 2. If you make an error, use the down arrow to cycle through the points and re-enter the data.

9. When calibration is complete, press the **Air Flow** (F2) key to store the calibration data in the AS450 or AS1700 head.

10. Return to the CAM Network Display. Go to the flow calibration by selecting **System Setup** (F4), **Calib.** (F5), then **Air Flow** (F2).

11. Verify flow calibration points 2 and 4 by:

   11a. Adjusting the flow to the setting shown on the Meter column for the calibration point.

   11b. Verify that the CAM volts for the calibration point is the same as the measured volts displayed in the CAM Flow Status ± 0.2 volts.

   11c. Verify that the **CFM** and **SCFM Display** in the CAM FLOW Status are within 0.1 of the reading on the **Calibration Flow Meter.**

11d. Repeat Steps 11a thru 11d for calibration point 4.

12. Press **DETAILED DISPLAY** then enter the number of the sampling head being tested (On computer press **ESCAPE** and then F9). Verify the efficiency and Air Flow Calibration dates are correct.

13. Perform an Auto-Config on the ASM1000 by pressing **System Setup** (F4), then **Network Config** (F4), then **Auto Config** (F1). (Exit ASM1000 program by pressing the **Esc** key and then the "Q" key.) This will load the default parameters into the head.

RFI Tests

Perform this test only for an AS450R or AS1700R CAM Head.

1. Set up equipment as in Figure 7.8.

2. If installed in the system, check that the bypass valve on the CAM Head Leakage Test set is switched to the Flow Cal. position.

3. Check that no filter cartridge or source is installed in the CAM Head.

4. Connect to the ASM1000 or run the ASM1000 program.

5. From the ASM1000 CAM Network Display, select **System Setup** (F4), **Calib** (F5), then **Air Flow** (F2).

6. Adjust the air flow using the Pressure Valve on the vacuum pump for a CAM Flow Status of .97 to 1.03 cfm for the AS450R or 1.97 to 2.03 cfm for the AS1700R.

7. Set the Transmitter as follows:

OFF-V0L:	CW until on
Ch. 1/2 switch:	2
Squelch control:	Fully CW

8. Key the Transmitter and position the antenna from 0 to 0.5 inches from the CAM Head. Move the Transmitter slowly over the entire surface area of the CAM Head (except bottom), holding the antenna both horizontally and vertically. This should take 2 or 3 minutes.

9. Verify that the CAM Flow Status stays within the range of 0.90 - 1.10 cfm (AS450R) or 1.90 - 2.10 cfm (AS1700R) while moving the Transmitter.

10. Return to Network Display.

11. From the ASM1000 CAM Network Display, select **System Setup** (F4), **Param Setup** (F1), then

Alarms (F1). Use the down arrow key to select Upper Energy Limit (MeV) and enter 9. In the same way, select Analysis Window (MeV) and enter 6.5.

12. Return to Network Display.

13. From the ASM1000 Network Display, select **Filter Change (F1)**. The Alarm LED on the CAM Head should be flashing. Momentarily open then close the door on the CAM Head. The Alarm LED should extinguish. This step restarts a Count Cycle. **Stop Alarm** (F10 on computer) if alarm sounds.

14. Return to Network Display.

15. From the ASM1000 Network Display, select **Data Review** (F3), **View Spectrum** (F3), then **Current** (F3).

16. Key the Transmitter and position the antenna from 0 to 0.5 inches from the CAM Head. Move the Transmitter over the entire surface area of the CAM Head (except bottom), holding the antenna both horizontally and vertically until 6 minutes is reached on the Current Spectrum Ellap. Time (min.).

17. While moving the Transmitter note that the spectrum does not have any sudden increase in count level greater than 20 counts in any area above 2.5 MeV.

18. Verify that after 6 minutes the Current Spectrum CPM is ≤8cpm.

Sampling Head Internal Boards

This section describes the procedure for checking the Preamp/Amp and MCA boards individually.

Equipment Required

- Oscilloscope (Tektronix Model 465 or equivalent)
- Digital Voltmeter (≤0.1% full scale accuracy)
- AC Voltmeter (Model HP-400H or equivalent)

NOTE: The preamplifier is factory tested using the CAM Preamp Test Fixture (TE03120) and other specialized equipment. This equipment similates the detector input and provides special outputs. The test fixture has a lid which is closed to minimize noise pickup and ensure accurate measurements.

Off Power Checks

1. Visual inspect the preamp/amp circuit board (and detector) for loose hardware, burnt components, broken wire harness to CAM MCA board, and other obvious defects.

2. With preamp/amp board isolated from MCA board, and the detector removed. Use the Digital Voltmeter (DVM) and measure the resistance between TP9 and the center pin of the detector input connector. Verify a measurement between 18 and 22 MΩ.

NOTE: This measurement may take several seconds to stabilize.

Discriminator Levels

1. Using a DVM, monitor the DC voltage between A2 pin 3 and TP11 (ground).

2. With RV4 full CW. Verify a DC voltage between -10 and +10 millivolts.

3. With RV4 full CCW. Verify a DC voltage between +0.37 and +0.42 volts.

4. Set RV4 between 199 to 201 mV.

Offset Adjustment

1. Monitor the DC voltage between A3 pin 7 and TP11 (common).

2. Adjust RV2 to obtain a DC voltage between +5 mV and +15 mV. (This is a difficult task with the board installed in the shield.)

Amp Output

1. Verify the waveform on the Preamp/Amp AMP OUTPUT (TP5) is similar to Figure 8.4. Verify the pulse width is between 6.4 and 6.6 μsec at the 50% point.

2. RV3 controls the gain of the amplifier and is used to set the MeV/Channel calibration factor. It should not be adjusted unless required. Its span provides a gain of 5 to 15 or about a 1 to 3 span fully CW to fully CCW. You would expect the AM-241 check source to produce a signal of around 2.22 volts when the system is calibrated.

Stretcher Output

1. Set the scope's time base to 1 μs/div and the vertical sensitivity to 0.5V/div. Measure the rise time of the ENERGY OUT waveform (TP3). Verify the rise time of the waveform is between 1.9 and 2.5 μsec (10 to 90%).

2. Measure the fall time of the ENERGY OUT waveform (TP3). Verify the fall time is between 1.8 and 2.6 μsec.

3. Set the scope's time base to 0.1 ms/div and vertical sensitivity to 2V/div. Monitor the ENERGY OUT bnc.

4. Verify the ENERGY OUT signal saturates at a DC level greater than 8.0 volts.

Note: The timing diagram below is for reference only.

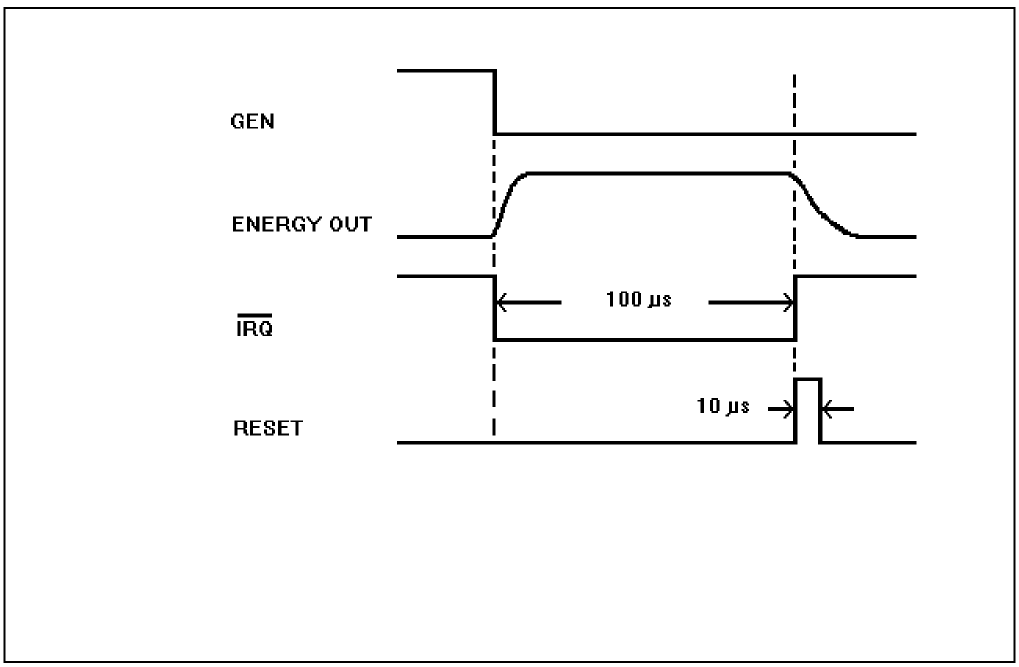

Figure 8.8 ENERGY out timing.

MCA Board Checks

1. Inspect the CAM MCA board for burnt components or other obvious defects such as loose or broken hardware.

NOTE: TP5 may be used as ground for the following measurements.

2. Use the DVM to verify the following voltage readings:

Location	Measurement
U8 - pin 8	+5 ± 0.25vdc
U2 - pin 8	+12 ± 0.6vdc
U2 - pin 4	-12 ± 0.6vdc
Q5 - pin 3	+24 ± 1.1vdc
D14 - Cathode	+10 to +12 Vdc
D12 - Cathode	+21 to +24 Vdc
Q4 - pin 2	-21 to -24 Vdc
Q5 - pin 1	+40 to +44 Vdc

3. Use the scope with a X10 probe, AC coupling, and measure the ripple at the following locations:

Location	Limit
D14 - Cathode	<150mV p-p
D12 - Cathode	<100mV p-p
Q4 - pin 2	<250mV p-p
Q5 - pin 1	<600mV p-p

4. Measure the voltage at TP1 and adjust RV2 for a DVM reading of +10.000 ±0.005 Vdc.

5. Measure the voltage at TP3 and adjust RV1 for a DVM reading of +5 ±0.005 Vdc.

6. Measure the CPU clock at pin 8 of U3. Pin 1 is middle of left side near crystal, and pins 7 and 8 bracket the lower left corner. Measure sine wave of 130 μsec period, 5 volts peak to peak.

Preparation for Use

1. Remove all cables, test fixtures and hoses.

2. Verify that the Check Source has been removed from the sampling head.

3. Tighten all Alarm Terminal Block screws. Install the terminal board cover over the Alarm Terminal Strip, if not being used.

4. If used and if removed for testing, re-install the sampling head diffusion screen by sliding it into the grooves at the top of the sampling head.

5. If the Sampling Head is NOT being used with an AS010 In-Line Manifold, install the Sampling Head top cover (if removed for testing) using the torque screwdriver set at 6 in/lbs. If the head is to be stored and not put immediately back into service then place a cardboard protective cover over the top of the diffusion screen. This completes the checkout.

6. If the Sampling Head is to be used with an AS010 In-Line Manifold, install the AS010 per Installation Diagram D-29358 and perform the following Procedure Steps.

7. Verify that 1" O-Ring is seated behind the threads of the plastic nut on the In-Line Manifold.

8. While holding the In-line Sealing Pipe from turning, thread the plastic nut onto the Sealing Pipe. Fasten HAND-tight. Over-tightening will deform the O-Ring and prevent a good seal.

9. Connect the air hose from the CAM Head Leakage Test Set to the flow port of the CAM Head.

10. Install a proper filter cartridge for the CAM Head being tested.

11. With door CLOSED, turn on the Vacuum Pump.

12. Adjust the flow gauge valve and verify that a vacuum of 2.0 in-water can be maintained with a flow of less than 85 cc/min.

13. Turn OFF Vacuum Pump, remove hose, filter cartridge, and Sealing pipe.

14. Verify that the 1" O-Ring is seated properly and has not been damaged. This completes the checkout of the In-Line Manifold and sampling head.

Notes:

9

ASM1000

Topics:

- Describe the firmware and hardware of the ASM1000.
- Describe the procedure for updating the ASM1000 firmware.
- List the information and error messages generated on the ASM1000.
- Describe functional test procedures.

ASM1000 Objectives

- Understand the firmware and hardware that make up the ASM1000.
- Perform update of the ASM1000 firmware.
- Replace components of the ASM1000.
- Perform functional test procedures.

9.1 ASM1000 Theory of Operation

Highlights:

- A discussion of how the ASM1000 program works.
- A look inside the ASM1000 chassis.
- An overview of circuit building blocks that make up the ASM1000.

Firmware Overview

The ASM1000 runs DR-DOS which is a ROM based DOS from Digital Research. The ASM1000 program is done in Multi-C. Multi-C is a DOS-based library providing a mechanism for a rather simple but effective multi-tasking environment where multiple "tasks" or "jobs" appear and execute in a concurrent manner. Multi-C provides all the necessities to create and organize such tasks in the system, as well as the necessities to communicate between them.

The operating environment itself is syncronized to an 18 Hz computer clock.

The main program creates and launches several tasks. The tasks are managed by the Multi-C core. Each task has a message queue set up as a FIFO (First In First Out) that is used for inter-task communication (function requests).

As a general rule all tasks are message-driven. That is, they will not initiate an action unless told to do so. Once a message is sent to that task, that task will accept the message and act accordingly. It will execute to completion until that message has been satisfied. It will not be pre-empted by another task even if the other task is in the 'ready state' and has higher priority than the current task.

One task is dedicated to the keyboard/monopanel hardware, whose job is to monitor operator requests, interpret the keys, and dispatch the function(s) to various tasks accordingly. The hardware will generate an interrupt and that interrupt's routine will send an appropriate message to the keyboard task for it to act upon.

The tasks are as follows:

COMM_TSK	Handles all low-level RS-485 communication to the CAMs, including re-tries, timeouts, and communication-related errors.
LAPTOP_TSK	Standard RS-232 and Host interface command handling and communication.
DSP_TSK	Maintains the display system. That is, services all display requests such as display of text, menu, etc.
KEY_TSK	Gets characters from the keyboard or monopanel, validates and classifies them (soft key, keypad, etc...) and dispatches them, mostly to MENU_TSK.
MENU_TSK	Handles all function requests. Basically it gets its instructions from KEY_TSK, parses them, and dispatches requests to other _TSKs.
DIAG_TSK	Responsible for diagnostic execution and status reporting.
IDLER_TSK	Maintains the various alarms. Responsible for setting/clearing alarms and any associated status. Performs cam-preset-reached condition by calling the analysis engine. Handles blanking and unblanking of the screen and login-timeout. Does the periodic CAM linearization algorithm.

Circuit Overview

The ASM1000 is often referred to as the DRU (Data Reduction Unit). This is in reference to its job of stripping the radon background from the spectral data read from the CAM Heads. Refering to Drawing B-27981 within the ASM1000 Schematic Booklet you can see that the ASM1000 unit is made of a number of interconnected circuits. Figure 9.1 shows the unit's layout.

The BASEBOARD and CPU Board make up the bulk of the circuit logic. These two boards are coupled together via an Interconnect Board and a 64 pin ribbon cable.

CPU Board

The CPU Board is manufactured by Megatel of Toronto, Canada and is a PC compatible CPU. The CPU board is not field repairable and schematics are not available. Therefore no discussion of the CPU circuits will be made. It contains the processor, some RAM and ROM, 2 serial interfaces and an LCD driver. In older units the CPU also maintains the data and time.

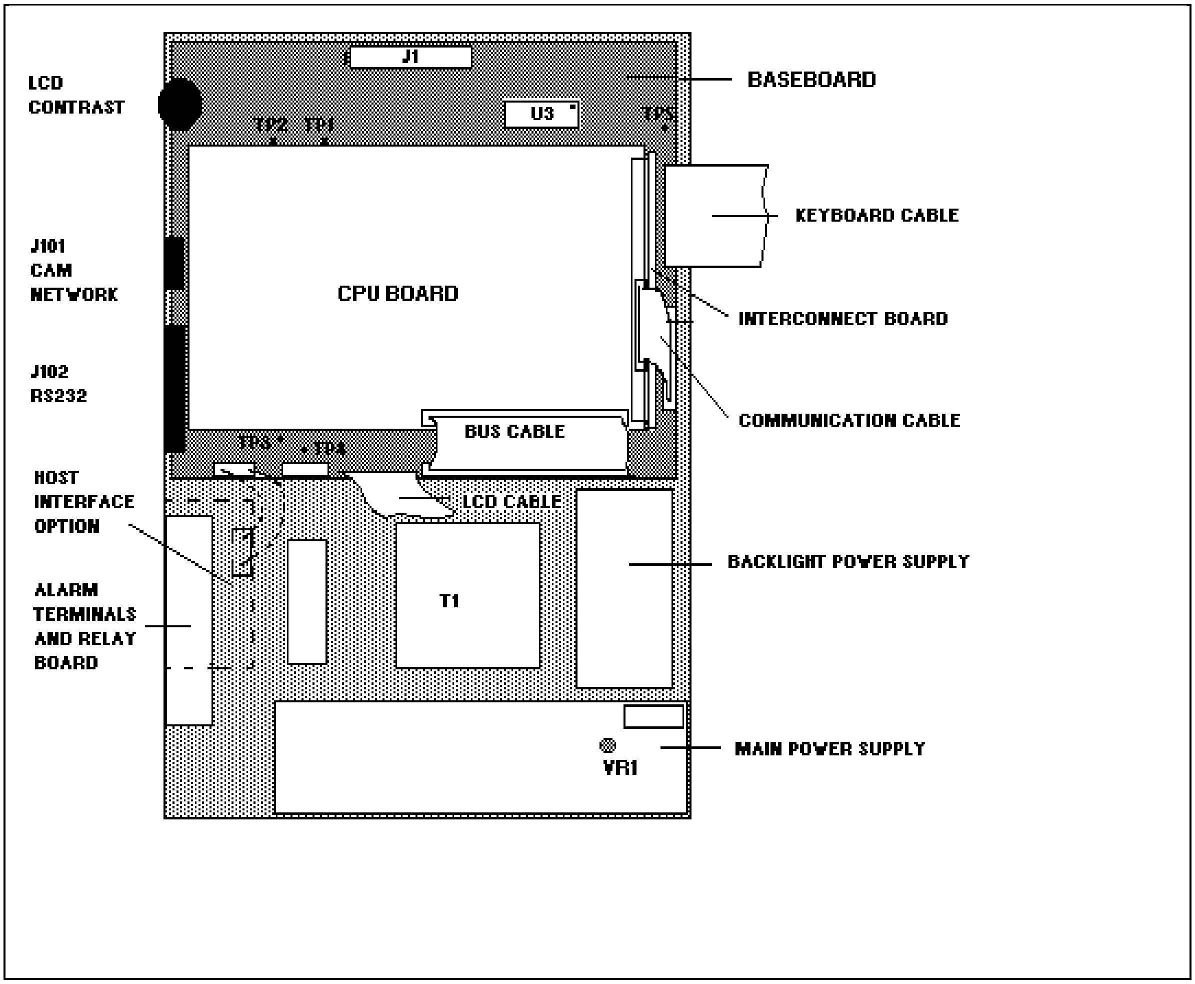

Figure 9.1 ASM1000 Layout.

The interconnect board connects the LCD drive signals, and the 2 serial interface signals through the 96 pin Euro-Card connector on the CPU (3 groups of 32 pins) to a 26 pin ribbon cable connected to the Baseboard. COM1 of the CPU is used for the standard RS232 communication to a serial printer or the computer used for external setup. COM2 is used for the optional Host Computer communication.

The 64 pin ribbon cable brings the CPU's bus to the Baseboard which contains programmable logic, RAM, EPROM, and EEPROM among other buffering circuits.

Power Supply

The Power Supply is a separate board connected to the Baseboard by a 15 pin wire harness. The LCD Display panel and keyboard assembly is a separate assembly connected to the baseboard by 2 flexible in-line cables. Power (approximately 400V) for the LCD Backlight is provided by the CCFT Power Inverter circuit. A ribbon cable connects the Baseboard to the relay board which is mounted together with the Remote Alarm Terminal Strip to the side of the chassis.

Power supplies can be checked as follows (It is okay to remove the LCD/Monopanel to make these measurements);

- Measure voltage on ASM baseboard IC U3 pin 16 using TP1 as DVM ground. Verify reading of +5 ±0.1 Vdc. Adjust VR1 on Power Supply Board if necessary.

- With the DVM, measure the voltage on the ASM baseboard J1 pin 5 and verify a reading of +12 ±0.6 Vdc. Use TP1 as DVM ground.

- With the DVM, verify the voltage on TP4 (using TP5 as common) is -23 ±0.1 Vdc.

  NOTE: Power must have been applied for more than 2 minutes to make this measurement, since the CPU does not turn this supply on immediately.

- CAM Power should be 22.5 to 24 VAC under load.

The CAM Network (J101) and the standard RS232 port (J102) are mounted directly on the Baseboard. Optional RS232 or RS485 interfaces are mounted on the left side panel and connected via ribbon cable to the baseboard.

Baseboard Circuit Blocks

As can be seen on Sheet 1 of Drawing B-27268 there are 6 blocks to the circuits of Baseboard; PC Interface, RAM/ROM Memory, RS485, Keyboard and Alarms, connections, and Host Options.

Sheet 2 shows PC Interface circuits which include the 64 pin PC BUS connector that interfaces the local program logic with the CPU board. The PC Bus includes 8 bits of bi-directional data which is buffered by U27 and 20 bits of address which are buffered, in part, by U25, U23, and U26. Bits A17 - A19 connect directly to Programmable Logic Device U10.

PLD U10 decodes the bus addresses and data and generates chip selects for the memory array. It also generates other chip select and enable signals on CONTROL0 - CONTROL6. The function of the control bits are:

CONTROL0 set trouble relay on (Sheet 5, goes to relay board)

CONTROL1 set exposure relay on (Sheet 5, goes to relay board)

CONTROL2 turns on HORN1 which is the loud tone on alarm horn on top of unit (Sheet 6)

CONTROL3 turns on trouble (amber)light on top of unit (Sheet 6)

CONTROL4 turns on exposure (red) light on top of unit (Sheet 6)

CONTROL5 turns on HORN2 which is the soft tone (Sheet 6)

CONTROL6 turns the LCD display on once the processor does all its power on self-test.

Sheet 3 of the schematic shows the memory array. This consists of EPROM U24, EEPROMs U17-U20, and RAM U11. EPROM U24 contains the power on bootstrap load routines for starting the system. The EEPROMs or "Flash Proms" contain the bulk of the system's program. The use of the EEPROMs allows field updates of the firmware. Dallas RAM chip U11 has been upgraded on newer units to include the Time/Date function.

Sheet 4 shows the RS485 CAM Network interface circuits. It consists of I/O chip U1, which acts as the interface's UART, and RS485 Transceiver U8. U8 translates the serial output from the UART into the RS485 differential lines and converts the incoming differential signals into the serial TTL input (RXD). U1 contains additional control registers which are used to turn on and off the LCD Backlight (CCFT_ON), and turn on the program bit for the flash prom (VPP_ON).

Sheet 5 shows the keyboard interface. When a key is pressed, its code in the form of X and Y coordinates is latched into U12. U12 generates a Data Available at pin DAV. This is processed as KRDY and KRDYD*. This causes the Port Controller U10 to send an interrupt to the CPU via IRQ5. The CPU reads the key code through U21.

Sheet 6 shows the 26 pin ribbon header J3 that connects to the CPU Board through the interconnect board. On this connector you'll see the LCD scan clocks and data which are sent from the CPU to the LCD through J8 of the baseboard. Power for the LCD is +5 and -23 volts. The -23 volts is generated by regulator U5, is adjusted with RV2, and can be tested at TP4 and connects through pin 12 of J8. The LCD contrast pot is directly mounted on the Baseboard and sends a variable voltage, between +5 and -23 volts, to the LCD through pin 13 of J8.

The serial interface signals for COM1 of the CPU Board are connected directly to J102 the RS232 interface port. Various other RS232 signals for the standard interface are pulled up by resistor pack RN1.

Sheet 7 shows that the COM2 signals from the CPU are sent to the optional interface connector through U14 and J6. Header J6 would be connected to the ASM02 RS232 Host Interface option. This board simply passes the transmit and received signals through to the 25 pin RS232 connector. U14 inverts and passes serial data onto RS485 transceiver U15 (and possibly U16). The Header J5 connects to optional ASM01 RS485 Host Interface board.

9.2 Firmware Update

Highlights:

- Instructions on upgrading the firmware in the ASM1000.
- Model S379 and computer with serial port required.

The application program that runs the ASM1000 is stored in several EEPROM memory chips. These are non-volatile memory; that is, the code stored in these chips are retained when power is removed. But in contrast with other types of memory, they can be changed in-circuit if required.

If a program update is necessary, Canberra can provide the Model S379 Alpha Sentry Firmware Update, which allows you to enable or disable the Acute Test function and to update your ASM1000 firmware to the current version. It includes all components necessary to update your system. You will need an Industry Standard personal computer running DOS V3.3, V5.0, V6.0 or equivalent operating system, a 3½ inch high density floppy disk drive, and a 9-pin serial port. Connect the provided cable between the computer and J102 (RS-232) on the ASM1000.

Installing the Model S379

To install the S379 Firmware Update, connect the Model C2004 cable between the computer and J102 (RS-232) on the ASM1000.

In the ASM1000, configure the Standard RS-232 port to SETUP mode and any baud rate (19.2K normally). This is done from the Network Display menu by pressing

F4 - System Setup
F1 - Param. Setup

F3 - Commun.

Then using the Index keys to set the parameters, accept each with ENTER. Then press **Network Display** to exit the dialogue.

Now insert the S379 floppy disk into the drive. Select drive A (or B) by typing:

```
A:  (or B:)
```

at the DOS command line, followed by ENTER

Now type one of two commands:

```
UPDATE
```

to update your ASM1000 firmware, or

```
ACUTE
```

to enable (or disable) the Acute Test option.

then press ENTER and follow the on-screen instructions.

9.3 Test Procedures

Highlights:

- Test procedures that might be done outside of the factory.
- Other procedures require special test fixtures.

These procedures are taken from the Canberra factory test procedure. The purpose of this test procedure is to verify the operation of an ASM1000 Alpha Sentry Manager.

Equipment Required

This section lists the equipment required to test the ASM1000. For informational purposes specialized test equipment used at Canberra is listed (in parenthesis, e.g. TE10015). It is expected that the most facilities will not have such equipment and therefore the use of the special equipment and testing software is written out of the procedure.

- Variable Autotransformer (VARIAC) Superior Electric Model 146 or equivalent (TE10015).
- DVM 0.1% accuracy (floating common).
- C2003 Power Cable for 1 Sampling Head.
- At least 1 Sampling Head (or CAM Load Simulator TE10139).
- C2000-10 CAM Network data cable (9-pin to 9-pin).

Visual Inspection

1. Inspect the ASM1000 without cover and LCD/Monopanel in place. Cables to J8, J2, Active LED, and CN3 (backlight supply) must be disconnected.

2. Verify that all boards are securely mounted and all wires/cables are connected.

3. Verify jumper(s) on Megatel Board are installed as shown in Figure 9.2. Note there are two versions of Megatel boards.

```
+------------------------------------------+
|                                        +-|
|                             JU5       +--|
|                            +---+      |  |
|                            |o o|o     |  |
|                            +---+      |  |
|            JU1          JU2           |  |
|           +---+        +---+          +--|
|           |o o|o       |o o|o          +-|
|           +---+        +---+             |
+------------------------------------------+
               PC +254 Board

+------------------------------------------+
|                                        +-|
|                                       +--|
|                                       |  |
|                  +---+                |  |
|                  | o |                |  |
|                  | o |J1              |  |
|                  +---+                +--|
|                    o                   +-|
+------------------------------------------+
              PC +i062 Board
```

Figure 9.2 Megatel Board Jumper Positions

4. Verify that on the ASM Main Board jumpers installed W1 from 1 to 2, W3 from 1 to 2, and that there is no jumper in W2. Refer to Figure 9.3.

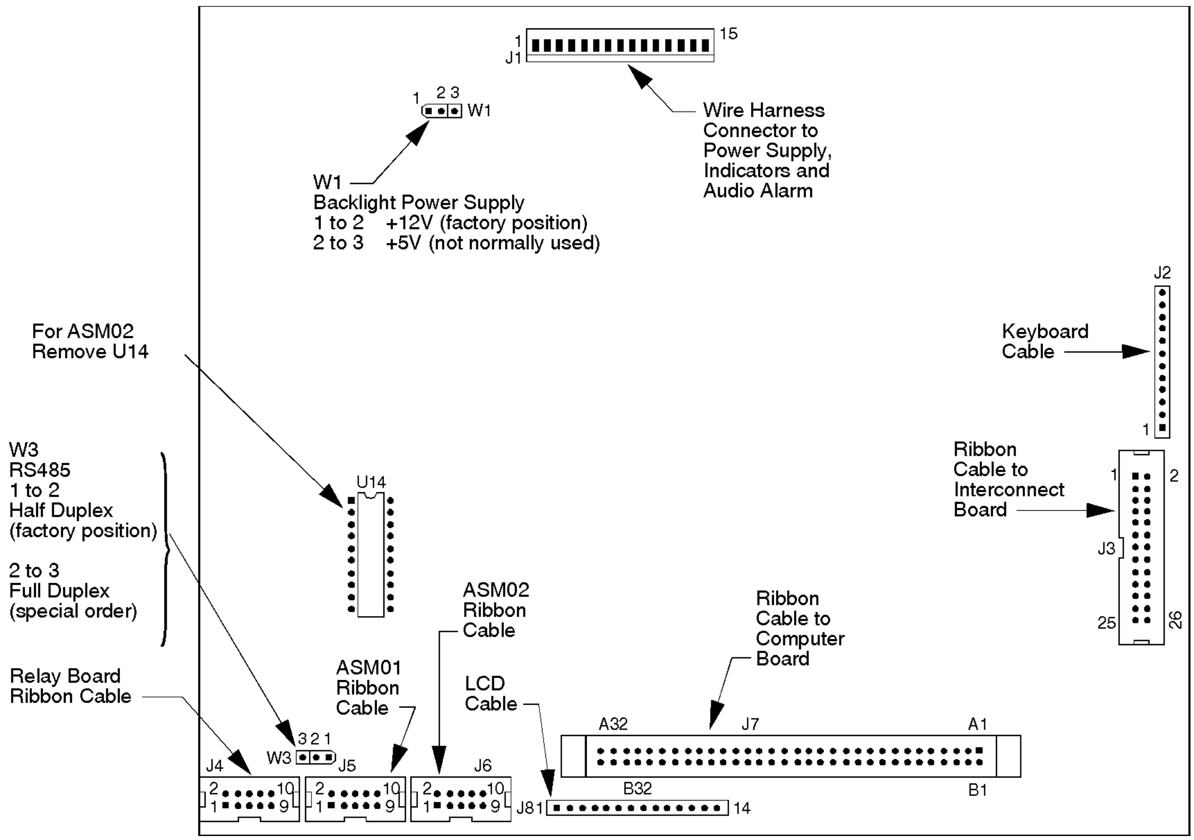

Figure 9.3 ASM1000/ASM1001 Baseboard.

Voltage/Checks and Adjustments

1. Set voltage on Variac to 0 volts A.C..

2. Set up equipment as shown in Figure 9.4.

```
+-----------------+   +----------------+           (TE10139)
¦                 +---¦115V AC         ¦           +-------+
¦                 ¦   ¦                ¦J104       ¦       ¦
¦ Autotransformer ¦   ¦   ASM1000      +----------¦       ¦
¦                 ¦   ¦    Under       ¦   C2003   ¦       ¦
¦                 ¦   ¦    Test        ¦           +-------+
¦                 ¦   ¦                ¦             CAM
+-----------------+   +----------------+             LOAD
```

Figure 8.4 Equipment Setup.

3. Remove the four pin connector from the power supply board (bottom of ASM) P2 connector.

4. Adjust the variable autotransformer (variac) output for 115VAC (or, if appropriate 230 VAC). Plug the ASM1000/ASM1001 power cord into this output.

5. With the DVM measure the voltage on pin 4 of the P2 power supply connector using pin 3 as common. See Figure 4 below.

```
                               PINS
                          1     2     3     4
                      +------------------------+
                      ¦  +-+   +-+   +-+   +-+ ¦
     VR1              ¦  +-+   +-+   +-+   +-+ ¦
    +---+           +----------------------------+
    +-+-¦           +----------------------------+
    +---+
```

Figure 9.5 P2 Connector on Power Supply.

6. If necessary, adjust VR1 on the Power Supply for a DVM reading of +5 ±0.1 volts D.C.

7. With the DVM measure the voltage on pin 1 of P2 using pin 2 as common. Verify +12 ±0.6 Vdc.

8. Turn OFF power to the ASM1000 and reconnect four pin connector to power supply P2 connector. Remove J1 to ASM board. Turn Power ON and verify: +5 ±0.1 Vdc. on J1 pins 6 and 7, +12 ±0.6Vdc on J1 pin 5. Use unpainted chassis or a connector shield as ground point. Turn Power OFF and reconnect J1 to ASM board.

9. Turn Power ON and measure voltage on ASM board IC U3 pin 16 using TP1 as DVM ground. Verify reading of +5 ±0.1 Vdc.

10. With the DVM, measure the voltage on the ASM board J1 pin 5 and verify a reading of +12 ±0.6 Vdc. Use TP1 as DVM ground.

11. With the DVM, verify the voltage on TP4 (using TP5 as common) is -23 ±0.1 Vdc.

NOTE: Power must have been applied for more than 2 minutes to make this measurement.

12. With VARIAC set at 115 VAC, use the DVM to verify that 22.5 to 24 VAC is measured at the Sampling Head (meter BNC on the CAM Load Simulator).

13. Monitor U3 pin 16. Adjust VARIAC between 100 and 130 VAC. The +5V should change by less than 25 mVdc.

14. Monitor J1 pin 5. Adjust VARIAC between 100 and 130 VAC. The +12 V should change by less than 60 mVdc.

15. Remove plug from Autotransformer AC supply and reconnect LCD/Monopanel cables J8, J2, Active LED (pin 1 is the short lead), and CN3 (backlight supply board).

16. Reattach the monopanel.

Functional Test

This test the basic functionality of the ASM1000, without any sampling heads attached.

Power On and Diag Tests

1. With power off, disconnect any sampling heads.

2. Plug in power cord on ASM1000 into a 115VAC outlet.

3. Verify that after a slight pause the Active LED lights on the ASM1000.

4. Verify after about two minutes the backlight for the LCD comes on and that the Display Menu appears. (LCD contrast on the side of the ASM may need adjustment).

5. After the "Scanning for CAMS" and the "No CAM Response" error appears, press the **Network Display** key to clear the error.

6. Press the NETWORK DISPLAY key, then **System Setup** (F4), then **Calib.** (F5), then **Diag.**

Test (F3).

7. Use the **Horiz Index** key to highlight ASM and then press **Enter**. The Device Under Test should now be (ASM).

8. Press the **Lamp Check** key (F1) and verify that first the amber lamp on the top of the ASM1000 goes on for two seconds, then the red lamp goes on for two seconds.

9. Press the **Audio Check** key (F2) and verify that the Audio Alarm beeps continuous high volume, then pulsed fast, then continuous lower volume, and then pulsed slow.

10. Press the **Relay Check** key (F3) and verify that you hear the relays click.

11. Verify Time and Date:

For Firmware V2.06 and Higher, the time and date appear on the top line of the display.

For Firmware V2.02, You must press the **System Setup** (F4), then **Param.Setup** (F1), then **Misc.** (F4) keys to access the Misc. Parameters Screen.

If the date or time had been previously set and is now incorrect it may indicate a problem in the CPU board.

Display Contrast/Backlight Check

1. From the Network Display screen, press **System Setup** (F4), the **Param. Setup** (F1), then **Misc.** (F4) to access the Misc. Parameters screen.

2. From the Misc. Parameters screen, use the **Vertical Index** key to highlight Timeouts (min) LCD Backlight field.

3. Use the monopanel to set this field to 1 and then press ENTER.

4. Verify that after one minute the LCD backlight turns off if no keys are pressed.

5. Verify that after pressing a monopanel key the LCD backlight turns on.

6. Use the **Vertical Index** key to highlight Time outs (min) LCD Backlight field, set the field to the on-line operational value (Factory=15) and then press <ENTER>.

7. Turn the LCD Contrast knob fully counter-clockwise and verify a totally blue display.

8. Turn the LCD Contrast knob fully clockwise and verify an almost white display.

9. Turn the LCD Contrast knob counter-clockwise to obtain best display contrast.

Monopanel Key Check

1. Press the **Network Display** Key and verify CAM Network Display appears.

2. Simulate an Alarm by disconnecting a networked sampling head or by other means.

3. The ASM1000 should Alarm. Press the **Stop Alarm** key and verify the alarm stops. Depending on the type of alarm another Alarm may sound shortly after. If it does, use the **Stop Alarm** key to clear this error.

4. On the ASM1000 press the Detailed Display key and verify that the Detailed Display appears.

5. Press **System Setup** (F4), **Source Info.** (F2), then use the **Vertical Index** to the Activity field.

6. Press the **Clear** key and verify the field is now blank.

7. Press the **1**, **2**, **3**, **4**, **5**, **6**, **7**, **8**, **9**, **0** keys and verify the field contains 1234567890.

8. Press the **Clear** key, then the (**.**) key, and verify the field contains a dot.

9. Press the **Cancel** key and verify the field returns to its original contents.

10. Verify a beep was heard for each key press during the monopanel key check.

Notes: