West Virginia University

HASP Student Payload Application for 2009

Payload Title:
Distant Aerial Cosmic Radiation Acquisition Package

Payload Class: (circle one)	**Institution**:	**Submit Date**:
Small ~~Large~~	West Virginia University	12/19/2008

The damaging effects of cosmic radiation on human cells and electrical devices have been a significant obstacle in both space exploration and high altitude research. This team proposes to measure and classify cosmic radiation energy in the Earth's atmosphere at various altitudes and various sunlight exposures over a specified flight time.

The team has designed and built a package, capable of flying on high altitude balloons, to measure the radiation in the atmosphere, process, and store this data for further analysis. The main components of the package include a scintillation detector, comprised of a Sodium Iodide (NaI) crystal and a photomultiplier tube, a voltage divider, and a multi-channel analyzer. These components are controlled via a single board computer (SBC) and an analog-to-digital conversion circuit. The data produced by the scintillation detector and multi-channel analyzer is processed on the SBC and stored on a memory card. This data will then be downloaded and analyzed after the flight.

The West Virginia University High Altitude Research Team is comprised of two faculty advisors, Dr. John Kuhlman and Dr. Mike Palmer, a graduate student in aerospace engineering, a senior in mechanical and aerospace engineering and physics, and a junior in computer science.

Team Name:	**Team or Project Website**:
West Virginia University High Altitude Research Team (WVU HART)	http://www2.cemr.wvu.edu/~satellite.balloon/HASP/haspindex.htm

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1 Theory and Background

1.1 Theory

The term "cosmic rays" is generally used to refer to all types of radiation coming from outer space. Some of this radiation, for example the cosmic microwave background radiation, consists of very low energy photons that are the remnants of the early universe. The higher energy class of cosmic rays is the result of violent phenomena, such as supernovae and black holes in the Milky Way galaxy. These high-energy particles are mostly deflected by magnetic fields before reaching Earth. However, some are still energetic enough to pass through these magnetic fields and eventually bombard the Earth's atmosphere at the flux of 1000 cosmic particles per square meter per second [1]. These particles are called "primary" cosmic rays, and the phenomenon is generally referred to as an "air shower." Most of the primary cosmic rays interact very rapidly in the atmosphere and form lighter particles called "secondary" cosmic rays, which are much lower in energy. The secondary cosmic rays are generally harmless to humans on Earth; however, their intensity grows proportionally with altitude to a level when they are dangerous to pilots and astronauts. These high-energy particles can damage human cells and cause mutations in DNA, commonly known as cancer. Another source of high-energy cosmic rays is the Sun. During solar flares, the flux of solar particles bombarding the Earth's atmosphere can increase by a factor of 10^2 to 10^6 [2]. Thus, the intention of the West Virginia University High Altitude Research Team (WVU HART) is to measure the energy of cosmic radiation in the presence of the Sun, as well as in the absence of the Sun, to create a model for the energy of cosmic particles under varying conditions.

1.2 Background

Cosmic rays were first discovered by Victor Hess in 1912, when he noticed that an electroscope discharged more rapidly as he ascended in a balloon [2]. It was first believed that cosmic rays were part of the electromagnetic spectrum. It has since been deduced that they must be electrically charged because they are affected by magnetic fields. Before man-made particle accelerators were developed that could reach the GeV range, cosmic rays were a focus of research for the area of High Energy Physics. Initially, cosmic ray research led to the discovery of the positron, among other high-energy particles. Now, this research field is focused more on the astrophysical questions of where they originate, how they are accelerated to such high velocities, and what their composition tells scientists about the galaxy. The other aspect of cosmic rays that has become an area of major concern in the scientific community in recent years, are the effects that these high-energy particles have on humans and electronic devices. The best way to study and measure these cosmic rays is with detectors on spacecraft, or more cost-effectively with high altitude balloons. The West Virginia University High Altitude Research Team's Distant Aerial Cosmic Radiation Acquisition Package targets research on measuring the energy of cosmic rays at various altitudes and sunlight exposure levels.

1.3 Mission Goals and Objectives

The main objective of the WVU HART payload is to measure the energy of cosmic particles versus both altitude (on both ascent and decent) and time (day vs. night). Time will be used to partially distinguish between the solar particles and other particles coming from other sources outside the solar system. The time discrimination, in conjunction with the altitude data, will be used to classify and model the distribution of cosmic particles in the Earth's atmosphere, based on their energy levels. The range of particle energies that can be detected and categorized by this experiment depends on the properties of the scintillation material used. It is expected that the 3 in. x 3 in. cylindrical NaI(Tl) crystal to be used in this experiment, will allow for detection of particles in an approximate range up to 12 to 16 MeV and below. This range of particle energies is expected to encounter mostly secondary cosmic radiation, as this experiment will be conducted within Earth's atmosphere.

2 Payload Description

2.1 Experiment Description

A general schematic of the payload designed and built by the WVU HART can be seen in Figure 1. A scintillation detector built by Saint-Gobain Crystals, which is comprised of a 3 in. x

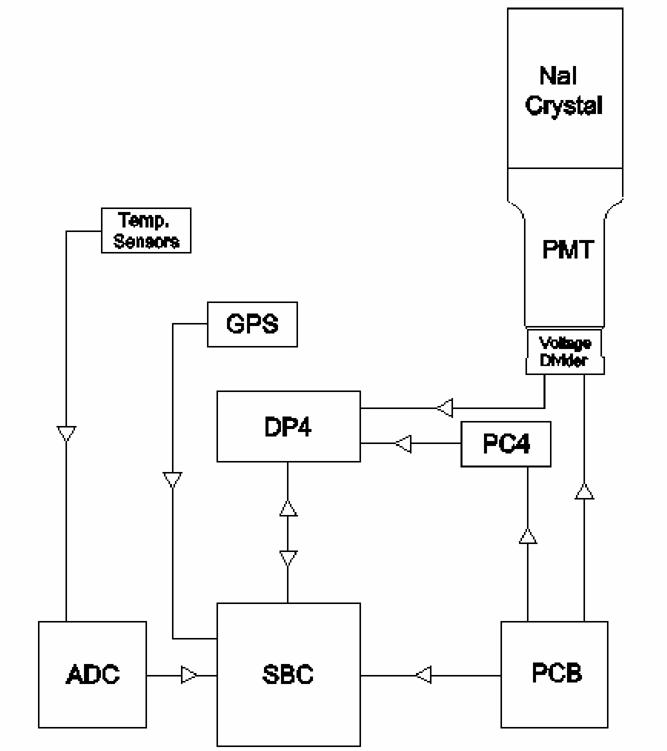

Figure 1: General Payload Schematics

3 in. cylindrical Sodium Iodide, NaI(Tl), crystal and a photomultiplier tube, PMT, is placed vertically inside an aluminum frame. The crystal intercepts the passing cosmic particles, and the interaction of the particles with the scintillation material is detected by the PMT. These events are sent to a voltage divider in the form of electrical signals with different voltage levels, depending on the intensity of each event. The voltage divider receives the signals from the PMT and sends them to a multi-channel analyzer, namely an Amptek DP4, which is powered by an Amptek PC4-2 power supply board. The DP4 receives the voltages from the regulator, processes and filters them based on a predefined configuration file, and then generates an energy vs.

frequency spectrum of the detected particles. The DP4 accumulates the data for 10 minutes, and then sends the average energy spectrum data to a TS-5400 single board computer (SBC) to be processed and stored. The SBC controls all the components of the payload. The configuration file for DP4 is stored on the SBC. The SBC includes a memory card that stores all the data received from DP4 and other sensors. In addition, a GPS receiver will be connected to the SBC via serial port to record time and altitude data. A TS-9700 analog to digital convertor (ADC) board converts the data coming from diagnostic voltage measurements and three temperature sensors, and sends that data to the SBC. Two temperature sensors measure the internal temperature of the payload, while one measures the atmospheric temperature**.** A power conversion board (PCB), designed and developed by Dr. Mike Palmer, WVU HART faculty co-advisor, receives the power from the primary HASP payload, and supplies the SBC, PC4-2, and PMT with power. Figure 2 presents a display of the significant components that comprise the WVU HART payload.

Figure 2 (From Left to Right): PC4-2, DP4, Scintillation Detector Contained within the Structural Frame, TS-5400, TS-9700, shown with two radiation test sources on the left

2.2 Payload Specifications

2.2.1 Structural Specifications

The structural components of the payload that contains the Distant Aerial Cosmic Radiation Acquisition Package, were designed with HASP specifications, strength, and versatility as primary design considerations, while all other factors served secondary roles. With those factors in mind, the WVU HART has designed, developed, and constructed a payload structure to meet the HASP specifications, protect the package from any harm, thereby providing the best environment for success, and provide a base structural platform from which the future WVU HARTs may build or design payloads from, with structural integrity and ease.

The payload structure consists of three primary components, the structural frame, the HASP-provided mounting plate, and the Styrofoam® case. First, the WVU HART designed, developed, and constructed an aluminum frame to serve as the primary structural component. Figure 3 presents a photograph of the frame, while Figure 4 provides a schematic of the frame, including physical dimensions. One may note from Figure 4 that the generically symmetric, and thus versatile, nature of the frame allows for one cross-sectional view, and provides mounting surfaces for all of the electrical components as well as structural integrity. In addition, the frame was designed well within the limits of the HASP specifications, from the *HASP – Student Payload Interface Manual* [3], of a 15 cm x 15 cm (5.857 in x 5.875 in) footprint and a height of 12 in. The reasons for this will become obvious shortly. Furthermore, the structural frame connects to the ¼” thick, HASP-provided, PVC mounting plate via eight ¼”-20 brass flat head bolts, as shown in Figure 5 with physical dimensions, each with head diameters of 0.477 in. and

Figure 3: Assembled Structural Frame

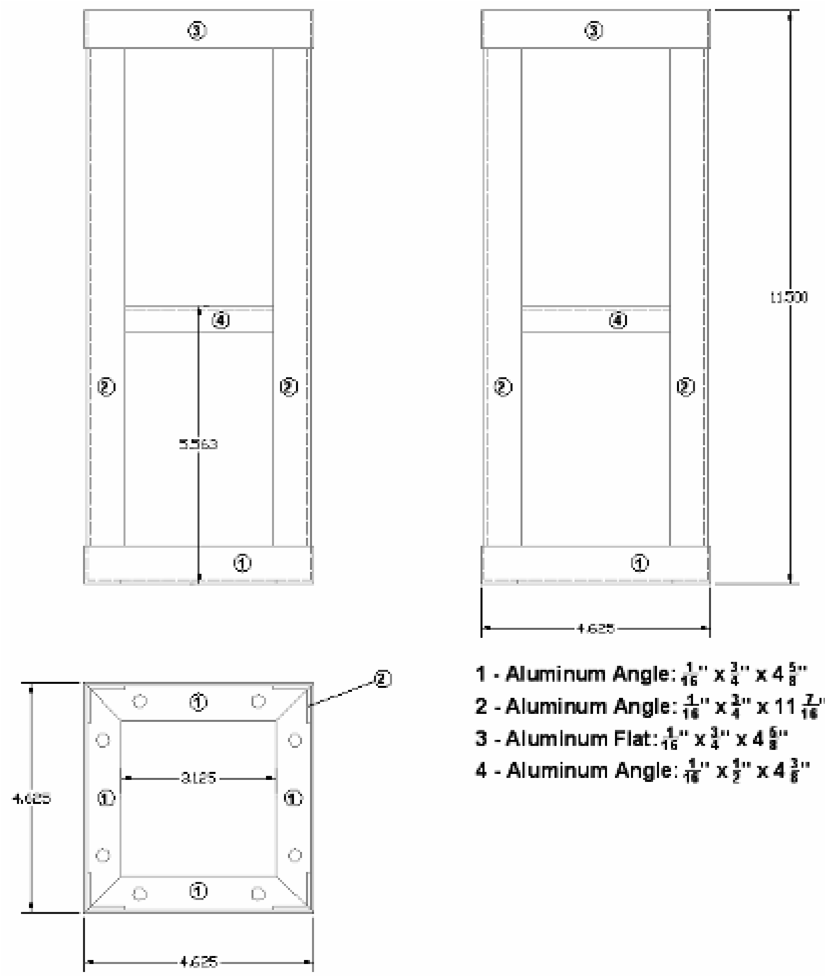

Figure 4: Structural Frame Schematics

yielding head areas of 0.18 in^2. Assuming that the WVU HART payload reaches the maximum specified weight of 3 kg, for a small class payload, the WVU HART package would “weigh” 294

N (66.09 lb_f) in a 10g vertical loading and 147 N (33.05 lb_f) in a 5g horizontal loading. Therefore, under the 10g vertical loading, each bolt would carry 369.8 psi, while each bolt would carry 184.9 psi under the 5g horizontal loading, based on the yielding head areas. However, based on the specifications on McMaster-Carr's website for these bolts, each bolt has a minimum tensile strength of 53,000 psi, producing factors of safety of 143 and 287, under the 10g vertical loading and 5g horizontal loading, respectively [4]. Hence, it is expected that the frame alone could withstand any reasonable loadings that may occur over the duration of the flight aboard the HASP.

In addition to the frame and the mounting plate, the Styrofoam® case will provide the third structural component. The WVU HART has also designed, developed, and constructed a Styrofoam® case that helps to protect the rest of the package from environmental effects. The case and core that protects the scintillation detector, displayed in Figure 6, were made with ½"-thick Styrofoam® R3 Residential Foam Sheathing, and adhered together with Loctite® Quick Set 5-Minute Epoxy. The case will eventually be sealed in aluminum duct tape to add an extra layer

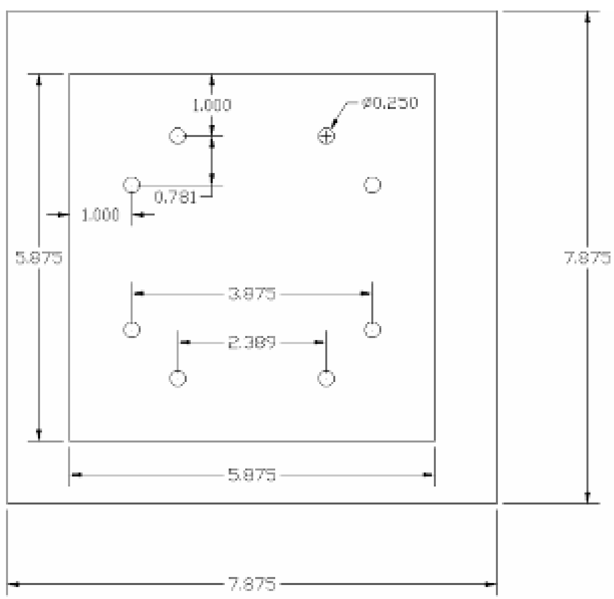

Figure 5: HASP-Provided PVC Mounting Plate Footprint Schematic

of protection, after final modifications to the fully assembled package have been made. In addition to environmental protection of the package, the case will serve to thermally insulate the package. The electronics of the package will emit a significant amount of heat relative to the volume within which it is contained. Thus, as the case is made from insulation, it is expected that the package will be self-sufficient for its own thermal management. In addition, the extra layer of aluminum duct tape will partially seal the package from the ambient air, and despite the metallic nature of the tape, will actually tend to heat up in the presence of infrared radiation in the upper atmosphere, providing another layer of thermal management. Furthermore, the same Styrofoam® was used within the package to form a "core" within which the scintillation detector is stabilized. The core is also held together with the same epoxy, and essentially cuts the internal volume of the package nearly in half. A full cross-sectional view of the Styrofoam® assembly is presented in Figure 7, which also provides appropriate physical dimensions. Thus, the circuitry is expected to remain at a relatively warm temperature, while operating within a structurally sound and environmentally protected space. These conditions will need to be verified using NASA's Columbia Scientific Balloon Facility (CSBF) Thermal and Vacuum Chamber.

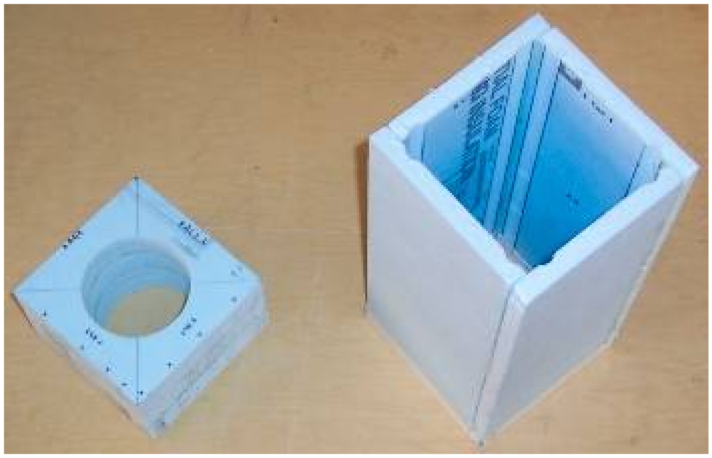

Figure 6: Styrofoam Protective Core (left) and Case (right), Without the Top

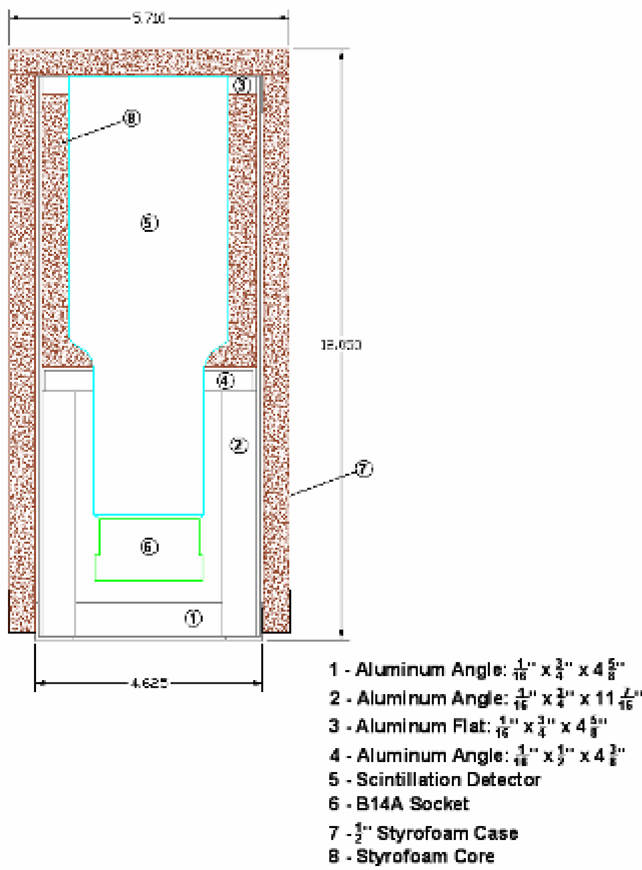

Figure 7: Styrofoam® Assembly Schematic

2.2.2 Electrical Specifications

Contained within the skeleton of structural elements is a sophisticated set of electrical components. The umbilical cord to the primary HASP payload will provide the nominal +30

VDC needed for the WVU HART payload to operate. Connected to the HASP payload will be a power conversion board (PCB) developed by Dr. Mike Palmer, one of the WVU HART's faculty advisors. The PCB will convert the +30 VDC supplied by HASP into three different voltages. Specifically, both the TS-5400, also known as the single board computer (SBC), and the Amptek PC4-2 power supply board require a regulated +5 VDC source, and the scintillation detector requires a 1500 VDC source, converted through a 12 VDC power conversion. The high voltage power supply will not pose a significant challenge, as members of the WVU HART have had extensive experience with the use of high voltage power supplies at high altitude. Additionally, all leads will be encased in a high-strength, non-conductive epoxy. The TS-5400 will power any peripherals that are connected to it, including a compact flash memory card, a Lassen iQ GPS receiver externally mounted atop the Styrofoam® case, and the TS-9700 analog-to-digital conversion board, which will also connect to temperature sensors and monitor the 30 VDC, 12 VDC, and 5 VDC power sources. The PC4-2 board will supply the Amptek DP4 multi-channel analyzer with +5 VDC, -5 VDC, and 3.3 VDC sources for proper operation. Lastly, a voltage divider, directly connected to the scintillation detector, will manage the 1500 VDC input source, while simultaneously sending electrical signals created by the scintillation detector to the DP4 for analysis. Further information about the four primary circuit boards, namely the TS-5400, the TS-9700, the Amptek DP4, and the Amptek PC4-2 may be obtained from the information in Appendix B.

In addition, the WVU HART will regulate its power load via the PCB. High efficiency switching power supplies have been incorporated into the design of the PCB such that they will sequentially power up each of the major electrical components contained within the package, enabling a slow, soft startup of the electronic hardware. The sequential power up will limit startup transients, preventing blown fuses on the primary HASP payload. First, the WVU HART will power on the SBC and its peripherals, drawing a maximum current of approximately 750 mA at its regulated 5 VDC, and wait for the startup transients to damp out. However, assuming an overall efficiency of 0.8 for the 5 VDC switching supply, the maximum nominal current would require a mere 4.7 W from the HASP power source, drawing only about 170 mA, due to the high efficiency power supplies. After the startup transients to the SBC stack, including the TS-5400, TS-9700, temperature sensors, and Lassen iQ GPS receiver that draws 27 mA, have settled, the PCB will power on the Amptek stack, including the PC4-2 and DP4 boards, drawing approximately a maximum of 220 mA. After the startup transients for the Amptek stack have damped, the scintillation detector will be powered up. Just as the SBC draws only 170 mA, due to the high efficiency switching power supplies, at an efficiency of 0.8, the total measured steady-state current draw at 30 VDC from the WVU HART payload is expected to be approximately 270 mA.

2.2.3 Communications Specifications

The WVU HART payload will require both serial and analog downlink capabilities, in addition to serial uplink capabilities. The SBC has two RS232 ports, but will require the use of three. Thus, one of the serial ports will be shared to accommodate two devices, most likely the GPS and HASP communications, while the DP4 communications will remain open. An RS232 switch within the WVU HART payload has been designed and constructed such that it will regulate the communications traffic. When the WVU HART payload is recording cosmic radiation data, the RS232 switch will close the serial circuit between the TS-5400 SBC and the GPS, and the WVU HART payload will not be in direct communication with the primary HASP payload. However, at regular 10-minute intervals, the switch will close between the SBC and the primary HASP payload, allowing for communication between the two. During this time, the switch will remain closed until basic diagnostic and scientific data packets have been transferred to the primary HASP payload as a backup data copy, while the majority of data will be stored onboard the WVU HART payload on a compact flash memory card. The downlink transfer rate will occur at 1200 baud, as specified for the small payload class in the *HASP-Student Payload Interface Manual* [3]. In addition, during this time, the WVU HART payload will send the analog downlink information to provide ground-monitoring diagnostic capabilities at a 1200 baud rate. After the packetized data has been backed up and transmitted, the switch will again close to allow for data recording from the DP4 to the SBC, which communicate at 57.6k baud, while the SBC and the GPS communicates at 4800 baud.

Additionally, during the HASP flight line restart procedure, or other extraordinary power interrupt events, the WVU HART will require as-yet-to-be-developed uplink commands to be sent to its package, at a 1200 baud rate, for a soft restart, as regulated by the PCB. Otherwise, the WVU HART will not require any other uplink commands.

2.2.4 Payload Weight Budget

As with any payload that is scheduled to leave the Earth's surface, weight is a significant issue. Table 1 provides a detailed list of the components to be included in the WVU HART's payload, each component's respective weight in units of grams, and a brief description regarding that individual component. By far, the heaviest component of the package is the scintillation

Table 1: WVU HART Estimated Weight Budget

Payload Item	Weight [g]	Brief Item Description / Notes
Specified Payload Mounting Plate:	552.00	PVC, including wiring / Provided by HASP
Insulation and Protection Case:	148.00	Protective Styrofoam Case
Fully Assembled Frame:	390.00	Aluminum Frame, including Plate Mounting Bolts
Scintillation Detector Protective Core:	60.00	Protective Styrofoam Core, including plastic
Scintillation Detector:	1788.00	Provided by Saint Gobain, including B14 Sockets
Amptek DP4 Circuit Board:	38.00	Provided by Amptek
Amptek PC4-2 Circuit Board:	20.00	Provided by Amptek
Technologic Systems TS-5400 (estimated):	100.00	Single Board Computer from Technologic Systems
Technologic Systems TS-9700 (estimated):	50.00	ADC Board from Technologic Systems
Power Conversion Board (estimated):	20.00	Designed and Produced by Dr. Mike Palmer
GPS (w/ Antenna and Cable):	27.00	Designed and Produced by Dr. Mike Palmer
RS232/TTL Converters (w/ Cables):	35.00	Electronic Components
Measured Total Weight (w/ Plate, w/o Misc.):	3228.00	Measured Weight with HASP PVC Mounting Plate
Measured Total Weight (w/o Plate, w/o Misc.):	2676.00	Measured Weight without HASP PVC Mounting Plate
Misc. Components (conservative estimate):	162.00	Includes weight of wiring, and yet-to-be-added components, like Temp. Sensors
Estimated Total Weight (w/o Plate):	2838.00	Includes Miscellaneous Components
Maximum Allowable Weight:	3000.00	Maximum Small Payload Class Weight, as Specified by HASP
Weight Limit Check:	Good	Ensures Measured Total Weight Without Mounting Plate is Within HASP Limits

detector at 1.788 kg, primarily due to the density and size of the NaI(Tl) scintillation material. Furthermore, one may note that the total weight including the PVC mounting plate exceeds the maximum allowable weight of 3000 g for a small payload. However, as specified in the *HASP – Student Payload Interface Manual*, the mounting plate should not be included in the weight calculation for the payload [3]. It is simply listed here to give an estimation to the true weight of the payload, as that information may prove to be useful in the future. Moreover, one may note that the current payload maintains a weight, under the maximum allowable weight, of 2.838 kg, leaving 162 g of weight that provides a weight tolerance and can also be used to add other components to the package, if necessary.

2.2.5 HASP Integration

Several simple, but necessary, procedures will have to be performed for a successful integration and operation with the primary HASP payload. Simply stated, the WVU HART will have to ensure that its package is functioning properly, under the proper conditions. To do so, the WVU HART will perform a mechanical inspection of its payload to confirm that all of the structural components of its payload are properly secured to the HASP mounting plate, to ensure that all of the circuitry is properly mounted and secured, and to verify that its Styrofoam® case is properly installed. In addition to a mechanical inspection, the WVU HART will perform electrical diagnostics. The electrical diagnostics will include manual measurements of the electrical components to ensure correct voltage levels and appropriate power draw. Especially important are the regulation of start-up transients that must be monitored to ensure proper start/restart capabilities. In addition to electrical hardware inspections, a software simulation of flight conditions will be performed to confirm that the software is operating as expected. After it has been decided that the payload can operate properly, and within HASP-specified limits, the WVU HART would then connect to the primary HASP payload to ensure proper communications. In addition to these steps, the WVU HART would also like to request the use of the NASA's CSBF Thermal and Vacuum Chamber to test the operation of its payload under the proper environmental conditions. This test will be especially important for any electronics packages, to ensure that no electrical arcing occurs under cold temperature and vacuum conditions, specifically at the high voltage power supply or PMT on the WVU HART payload. If the payload does not require any further repairs, adjustments, or modifications, and properly communicates and integrates with the primary HASP payload, the WVU HART will consider its payload to have been successfully integrated. The WVU HART payload may be affixed to the primary HASP payload at any position that is convenient for the overall success of the HASP project, but must be mounted normal to the fiberglass arms that are affixed to the HASP payload, along the general orientation of the gravity gradient of the Earth as a fixed and known orientation.

2.3 Payload Progression

During '07-'08 HASP program, the WVU HART also attempted to build and fly this payload, but encountered several technical, and personal, obstacles that prevented the flight of the payload. However, since then, significant developmental progress has been made to this payload, based on the lessons learned from those difficulties. So much progress has been made, in fact, that the WVU HART believes in the successful potential of this payload more than ever before.

2.3.1 Previous Technical Difficulties

As mentioned, several technical difficulties emerged that prevented the flight of this payload last year. First, the original custom circuits designed specifically for the WVU HART payload had hardware issues, as it was the first design of the processing circuits. Originally, it was proposed that the processing stack have two separate CPUs, each with specific tasks. However, after developing and debugging software for the processing hardware, it was discovered that it was indeed the hardware that had the fatal error. At that point in last year's schedule, it required the acquisition of off-the-shelf hardware for this specific task, in addition to the development of software. This presented a significant obstacle given the short time in which the WVU HART would have to develop the sophisticated software, needed for the new hardware, from scratch.

The second and third issues occurred nearly simultaneously, and were discovered to be indirectly related. Second, the previous version of the PCB contained hardware required to run the custom processing circuits, and various other hardware that connected to it. However, now that the processing circuits were found to be faulty, the WVU HART was scrambling to ensure that its other hardware may be compatible, under a different configuration, with other hardware. After a short time, it was found that an isolated power supply was causing problems in that hardware, causing the hardware to malfunction. Third, the damage from this event was far-reaching, and had caused damage to both the PCB and a new model of Amptek's DP4 multi-channel analyzer. Once again, due to the time schedule, it was impossible for the WVU HART to send the DP4 back to Amptek for diagnostics, if it was going to attempt to fly with HASP. So, the WVU HART, in collaboration with Amptek support staff via telephone, performed extensive and time-intensive diagnostics at WVU. The WVU HART was able to diagnose the failure of the DP4 to damaged capacitors on the PC4-2 power supply board, and a damaged inductor on the DP4. However, to repair the damage would take time and specialty tools. The WVU HART was able to find the tools, but could not deal with the issue of time in order to make the flight a real possibility.

2.3.2 Current Progress and Future Outlook

Despite the aforementioned difficulties, the WVU HART has been able to learn from these obstacles, rebound from them, and repair and develop new payload components that are superior to the original versions. The original PCB has been redesigned, and a new PCB has been developed that successfully integrates with the current hardware configuration. In addition, the PC4-2 and the DP4 have been repaired. Diagnostic tests to the Amptek hardware reveal that they operate just as they did when the WVU HART received them in new working condition. In fact, the WVU HART has simulated radiation detection using test sources, and has produced test energy spectra successfully. To overcome the processing circuit issue, the team has opted to use Technologic Systems hardware, namely the TS-5400 (SBC) in conjunction with the TS-9700 (ADC), and develop software for that hardware system using the C programming language. Furthermore, to take the lead in the software development arena, the WVU HART has added a new team member, Lee Blake, a junior computer science major with extensive programming experience. As the team has had to prepare for difficult circumstances, other team members that have been studying C programming will be able to assist Lee with the software development, and create a truly multi-disciplinary project.

As the WVU HART has had to overcome these obstacles, much has been learned, and the future outlook for the team and its payload are extremely positive. The past obstacles have enabled the team to take on an extreme learning curve, and each member has had to play interdisciplinary roles, allowing them to branch their learning outside of the classroom into areas they may never have had to encounter before. This interdisciplinary learning has had a positive effect on the student team member's academic experience, and each is looking forward to more interdisciplinary work on this project this coming year. In fact, this project has progressed so far, to the point that the team is hoping to test the technology it has developed thus far before flying aboard the HASP payload, on a balloon flight to be conducted in West Virginia this spring using a 1500 g – 3000 g class latex balloon, to ensure successful operation aboard HASP. This project has become more exciting than ever for the student members, who cannot wait to see what the future holds, as they feel this payload will not be anything but successful in the future.

3 Project Management

The WVU HART is comprised of five members. Two faculty advisors, namely Dr. John Kuhlman and Dr. Mike Palmer, advise a team of three student members, namely Mehran Mohebbi, Kyle Phillips, and Lee Blake. Lee Blake is a student from the WVU Lane Department of Computer Science and Electrical Engineering, while both faculty advisors and the two other team members hail from the WVU Department of Mechanical and Aerospace Engineering. The team's point of contact is Mehran Mohebbi. Table 2 displays the team structure.

Table 2: WVU HART Structure

Name	Dr. John Kuhlman	Dr. Mike Palmer	Kyle Phillips	Mehran Mohebbi	Lee Blake
Title	Project Manager / Logistician	Technical Supervisor / Primary Mentor	Hardware Developer / Software Support	Team Lead	Software Developer
Academic Rank	Faculty	Faculty	Graduate Student	Senior	Junior
Department	Mechanical and Aerospace Engineering	Mechanical and Aerospace Engineering	Mechanical and Aerospace Engineering	Mechanical and Aerospace Engineering & Physics	Lane Department of Computer Science and Electrical Engineering
eMail	John.Kuhlman@mail.wvu.edu	gmpalmer@verizon.net	kphilli1@mix.wvu.edu	mmohebbi@mix.wvu.edu	leepaulblake@hotmail.com

The WVU HART has held a weekly meeting schedule for over a year, and is planning to convene regularly during bi-weekly meetings until the HASP integration day. Each team member updates the rest of the team during each meeting, to ensure that all of the elements of the project are interfacing properly and that the tasks are accomplished according to the new timeline, which was generated in November 2008. This timeline may be observed in Figure 8 and Figure 9.

To develop data analysis software and assure that all of the components of the payload are within the HASP requirements, it is planned that the team will conduct a simulated lab flight in mid-March. Also, depending on the availability of the team's resources, it is planned that the team will conduct a small-balloon/low-altitude field test flight in late March, as the last step to diagnose and resolve any software or hardware issues, before the HASP integration.

Due to the fact that one of the objectives of this team is to measure cosmic radiation energy in both daytime and nighttime, the WVU HART prefers a September (Ft. Sumner) launch for its longer airborne period (~20 hrs). However, a Palestine launch would also be beneficial for the team in terms of achieving its objectives, if necessary. The anticipated participants for both integration and launch will vary depending on the dates. However, at least three members are anticipated to attend either launch.

All of the equipment necessary for the success of the WVU HART payload has been purchased using the funding provided by the NASA West Virginia Space Grant Consortium (WVSGC) and the West Virginia University College of Engineering and Mineral Resources (WVU CEMR). The travel expenses, to and from the HASP integration and launch, will be covered by WVSGC and WVU CEMR as well.

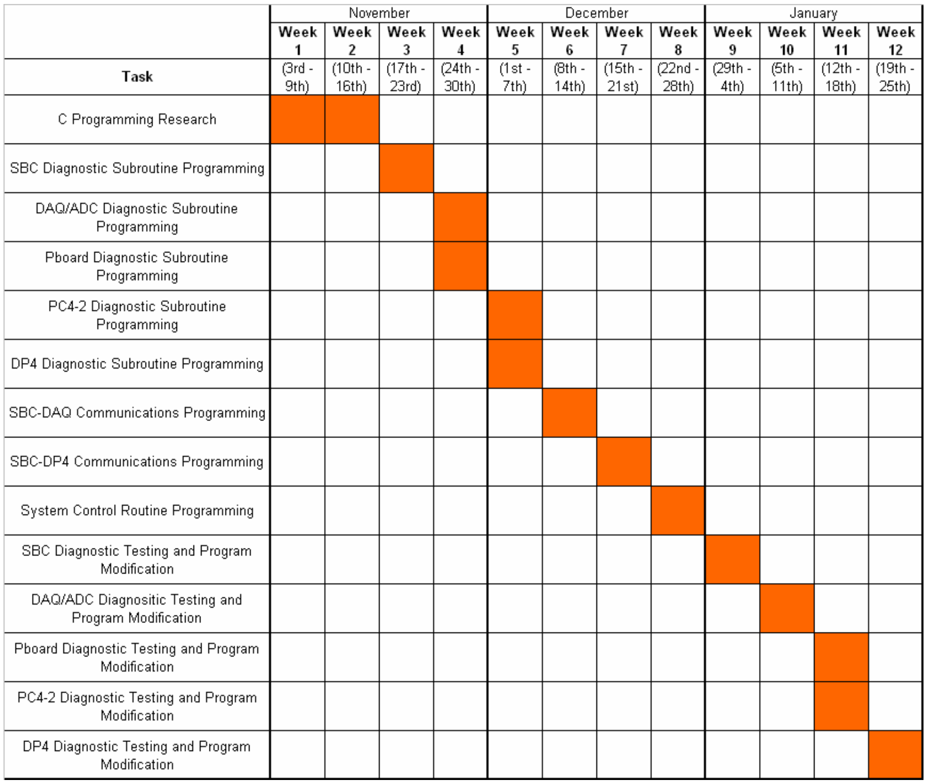

Figure 8: WVU HART Timeline - Phase I

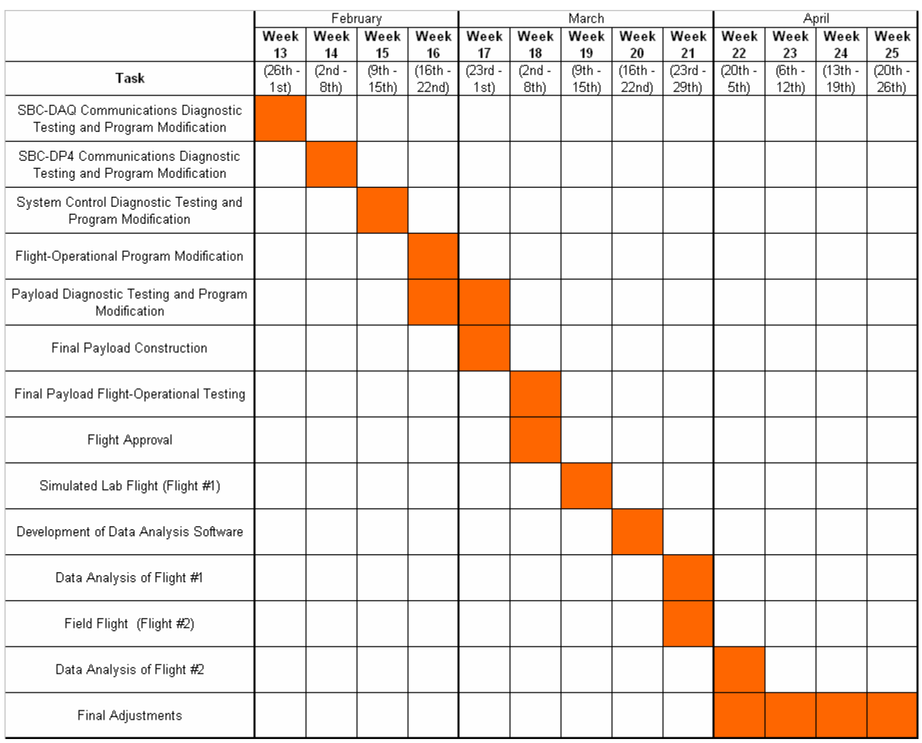

Figure 9: WVU HART Timeline - Phase II

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Appendix A

Mechanical Specification Diagrams

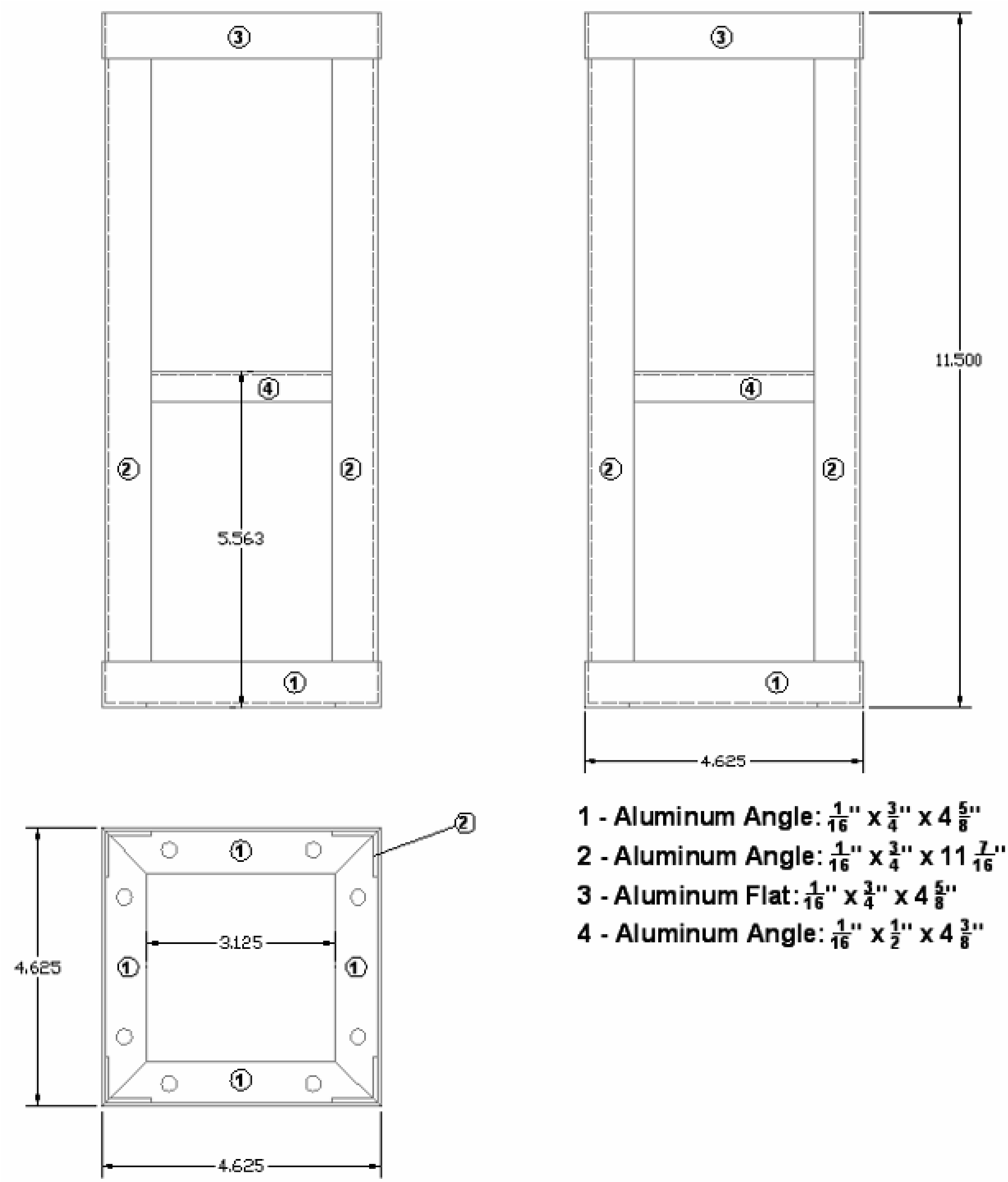

Figure 10: Cross-Sectional and Top-Down Structural Frame Schematics

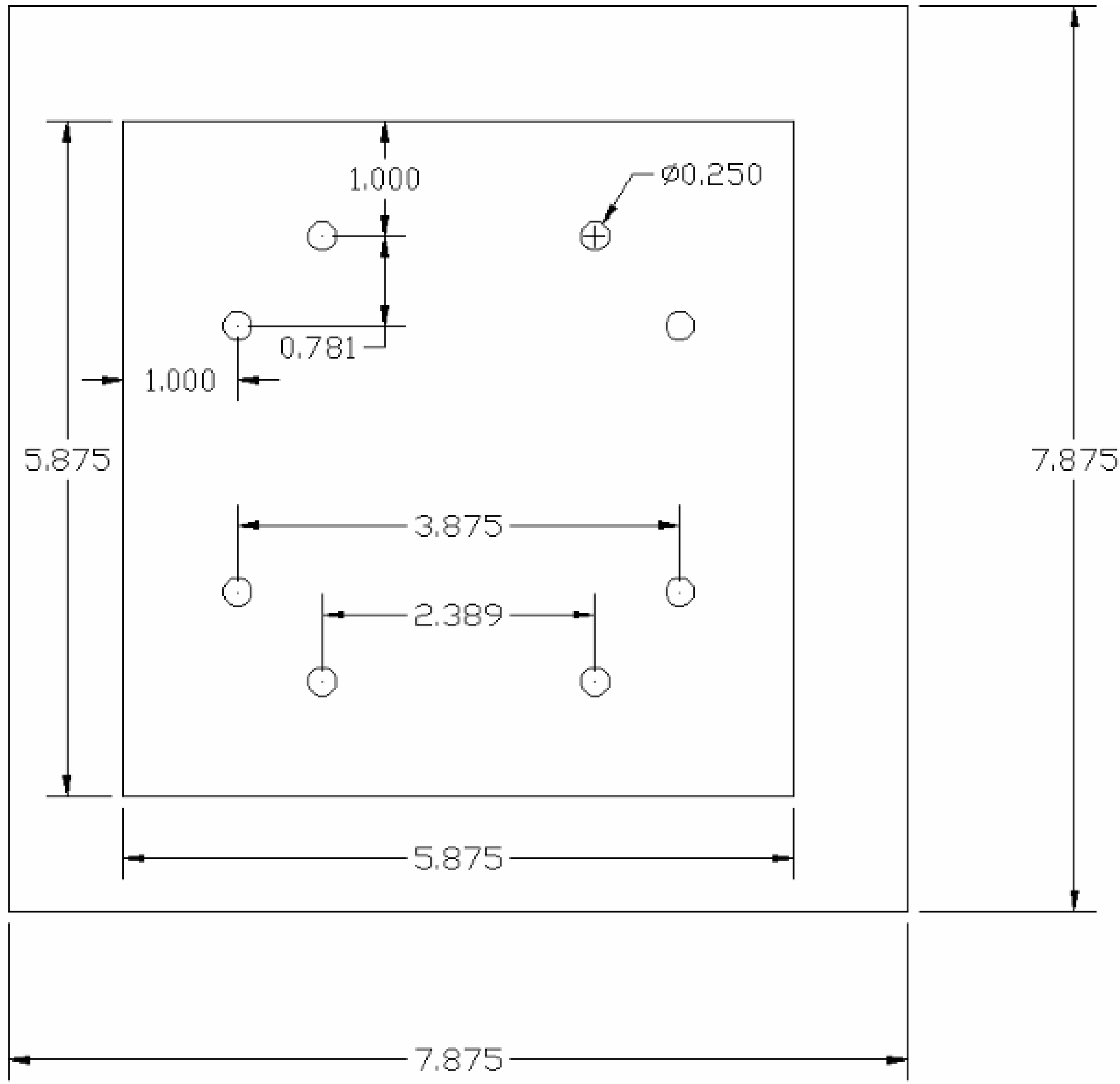

Figure 11: HASP-Provided PVC Mounting Plate Footprint Schematic

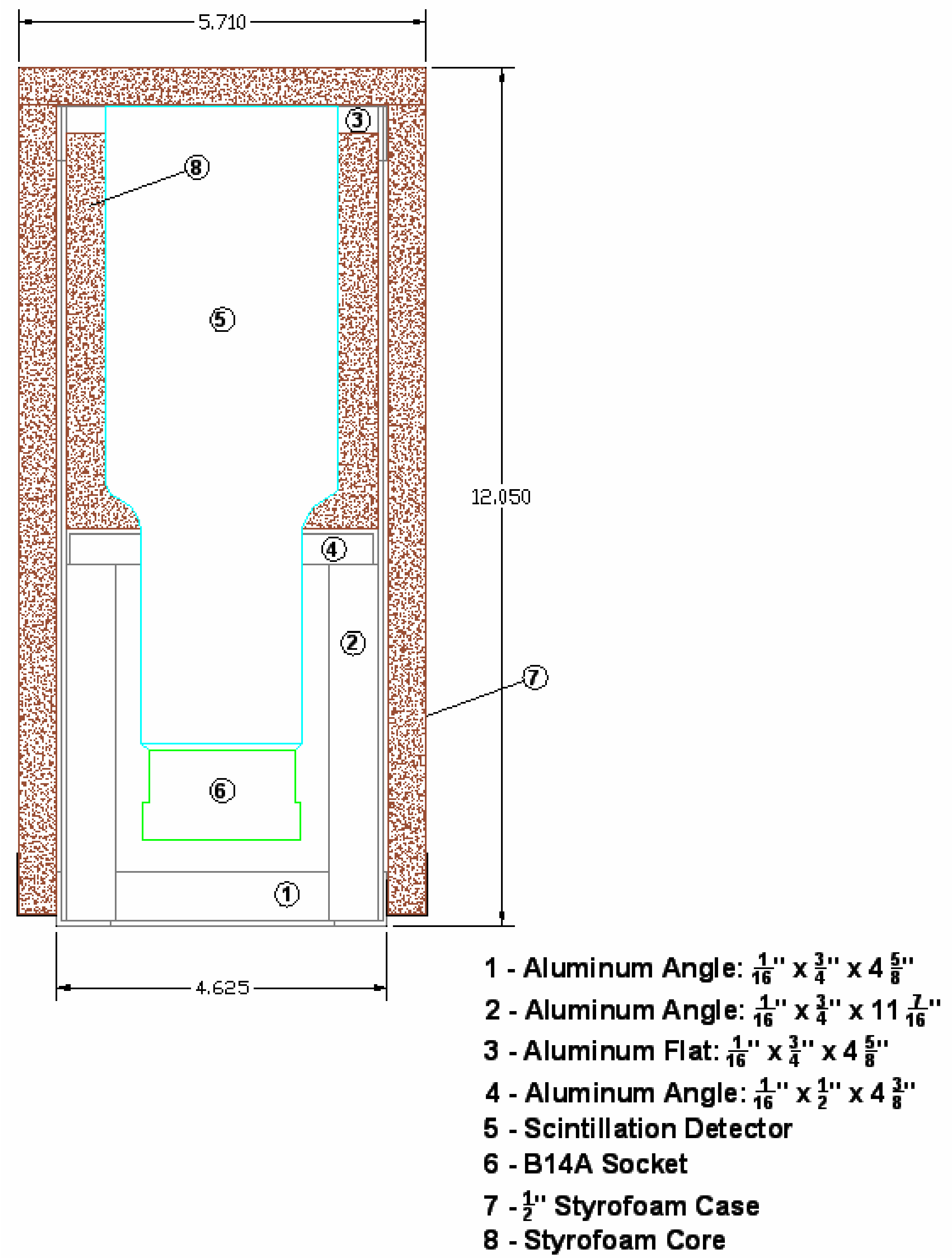

Figure 12: Styrofoam® Assembly Schematic

Appendix B

Electrical Specification Sheets

Specifications

Pulse Processing Performance

Gain Settings: Four programmable coarse gain settings are available: x10, x20, x50, x100. Fine gain is adjustable between 0.75 and 1.25.

Full Scale: 100 mV input pulse @ x10 gain.

Pulse Shape: Trapezoidal. A semi-gaussian amplifier with shaping time τ has a peaking time of 2.2 τ and is comparable in performance with the trapezoidal shape of the same peaking time.

Peaking and Flat Top Times: Twenty four programmable peaking times between 0.8 and 102 µsec. For each peak time, sixteen flat top durations are available, > 0.2 µsec

Max Count Rate: The pulse processing electronics have a cycle time of 1 µsec. With a peaking time of 0.8 µsec, a 1MHz periodic signal can be acquired.

Throughput: Dead time is 1.25x peaking time. Unlike an analog system, there is no separate dead time for digitization and events can be counted less than a full pulse width apart.

Pile-Up Reject: Pulses separated by more than the fast channel resolving time, 600 nsec, and less than 1.25x peaking time are rejected.

MCA Performance

Number of channels: Commandable to 256, 512, 1k, 2k, 4k, or 8k channels.

Bytes per channel: 3 bytes (24 bits)
16.7 M counts per channel

Minimum Acquisition Time: < 10 msec

Data Transfer Time: 1k channels in 10 msec (USB) or 0.5 sec (RS-232)

Hardware

Microprocessor: Cypress CY7C64613 'EZUSB FX' with 8051-compatible core

Memory: 32K MCA memory, 8K EEPROM, 8K µC RAM

Firmware: Signal processing is programmed via firmware, which can be upgraded in the field.

Communications

RS-232: A standard RS-232 serial interface is available at up to 57.6 Kbaud. This is used in the demonstration software.

USB: A standard USB interface is available in the demonstration software. (Compatible with USB 1.1 and 2.0 at full-speed (12 mbps).)

I^{2}C: The µC contains an I^{2}C port, allowing the DP4 to interface with peripherals.

Auxiliary: Four additional lines connect to the µC for additional interfacing options.

Connections

Analog Input: The analog input accepts positive or negative going pulses from a charge sensitive preamplifier.

Maximum Input: 100 mV @ x10 gain.

Power and Serial Interface: The power and serial interface are provided on a single 16 pin connector. The power inputs are +3.3 V and ±5 V. The serial connections include RS-232, USB, and I^{2}C.

DAC Output: This output is used in oscilloscope mode, to view the shaped pulse and other diagnostic signals. Range: 0 to 1 V.

Power

+3.3 V Average current 100-200 mA, depending on configuration. Start-up current is 500 mA.

±5 V Average current 10 mA each.

Physical

Size: 3.5" x 2.5 "

Weight: 28 g

Software

See page four.

Figure 13: DP4 Specifications [5]

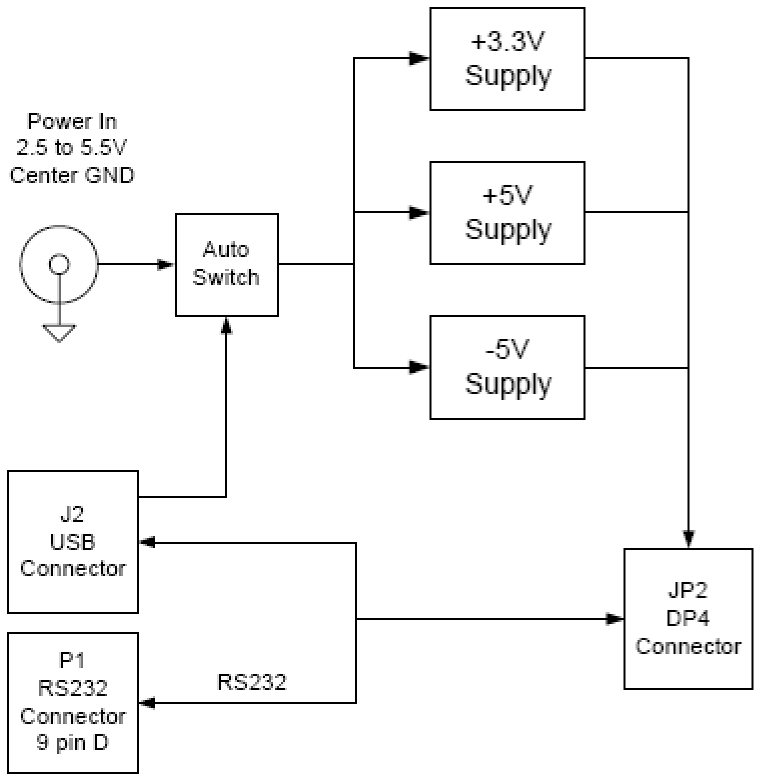

Figure 14: PC4-2 Schematic [6]

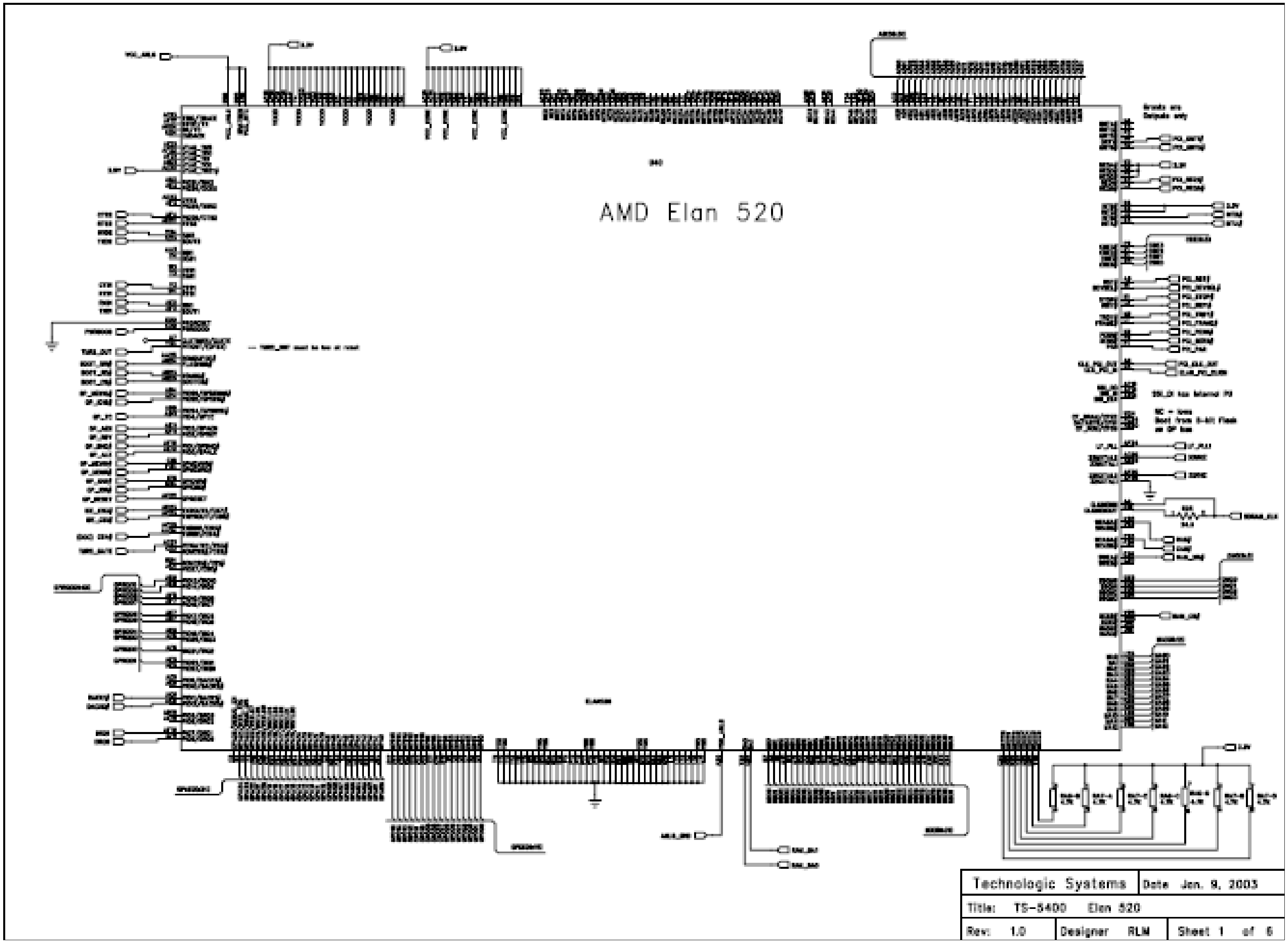

Figure 15: TS-5400 Schematic A [7]

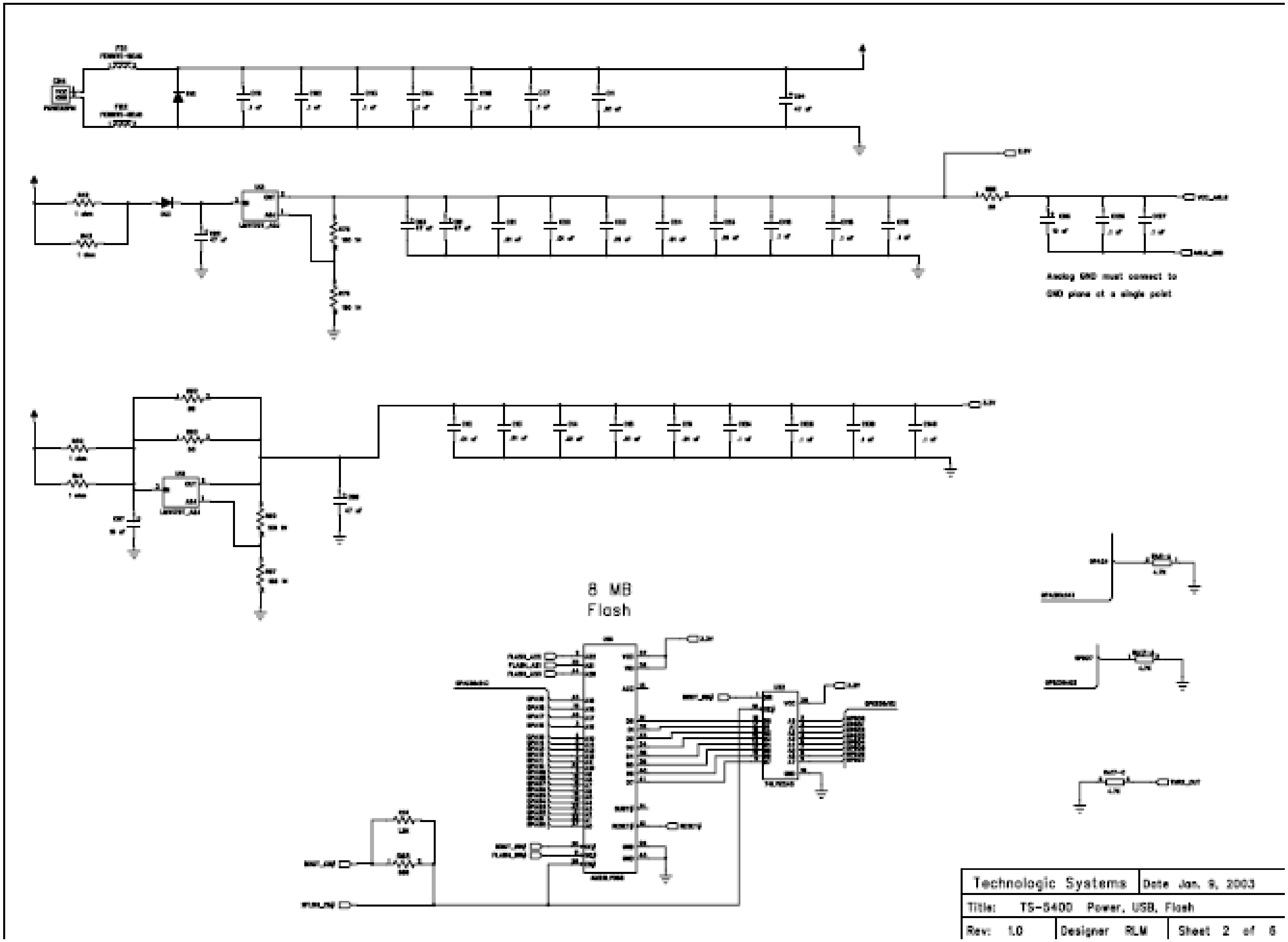

Figure 16: TS-5400 Schematic B [7]

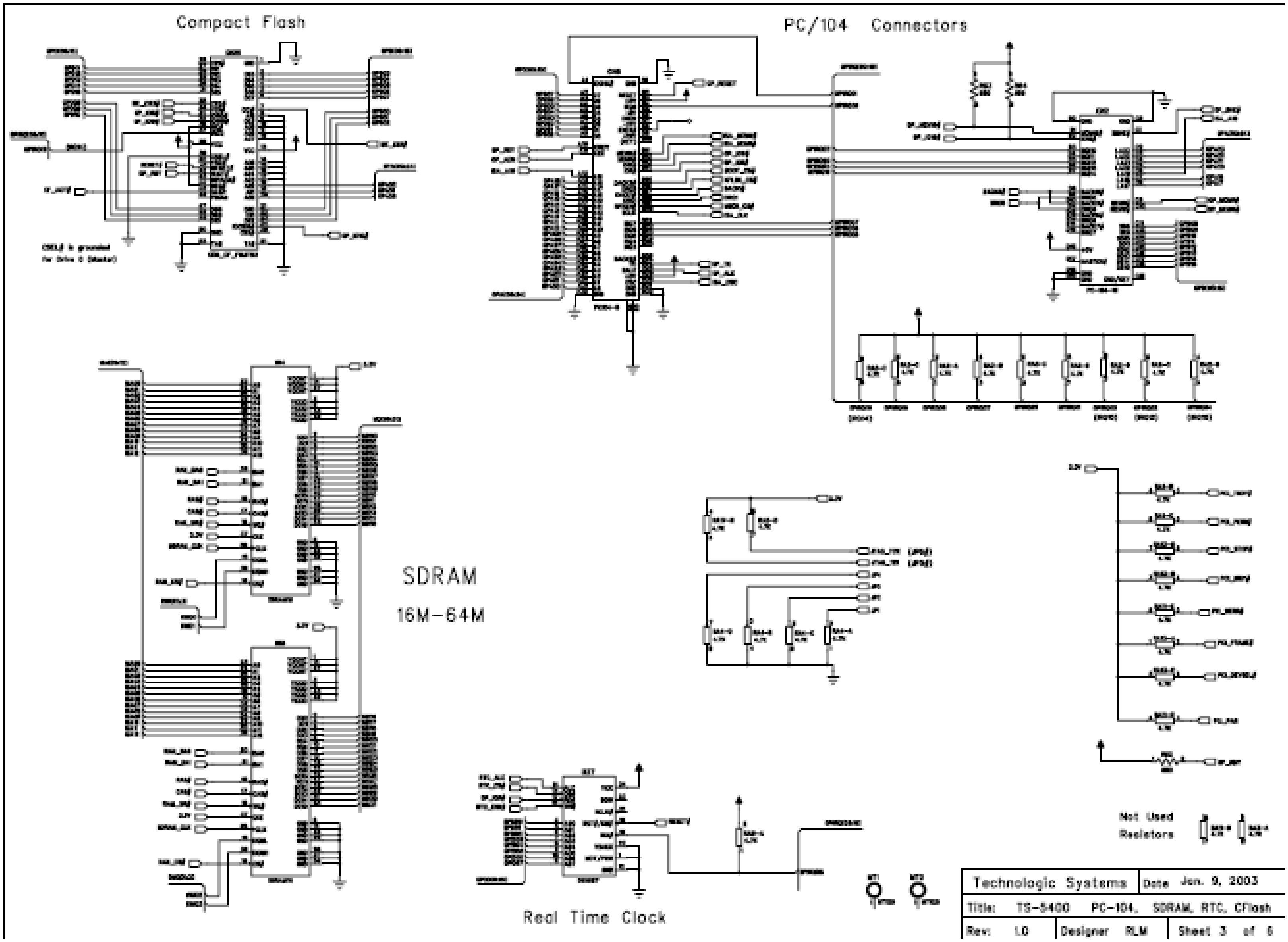

Figure 17: TS-5400 Schematic C [7]

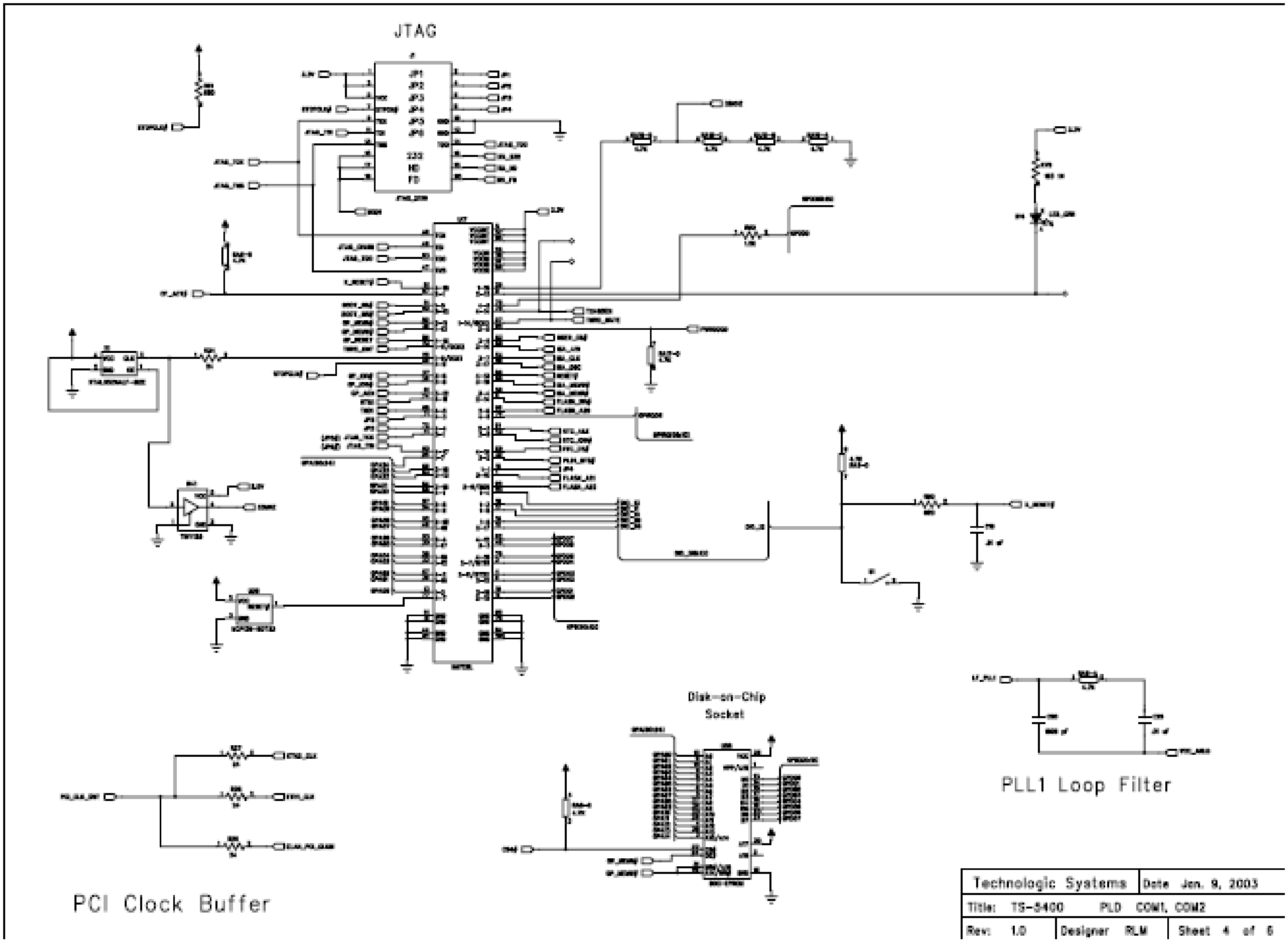

Figure 18: TS-5400 Schematic D [7]

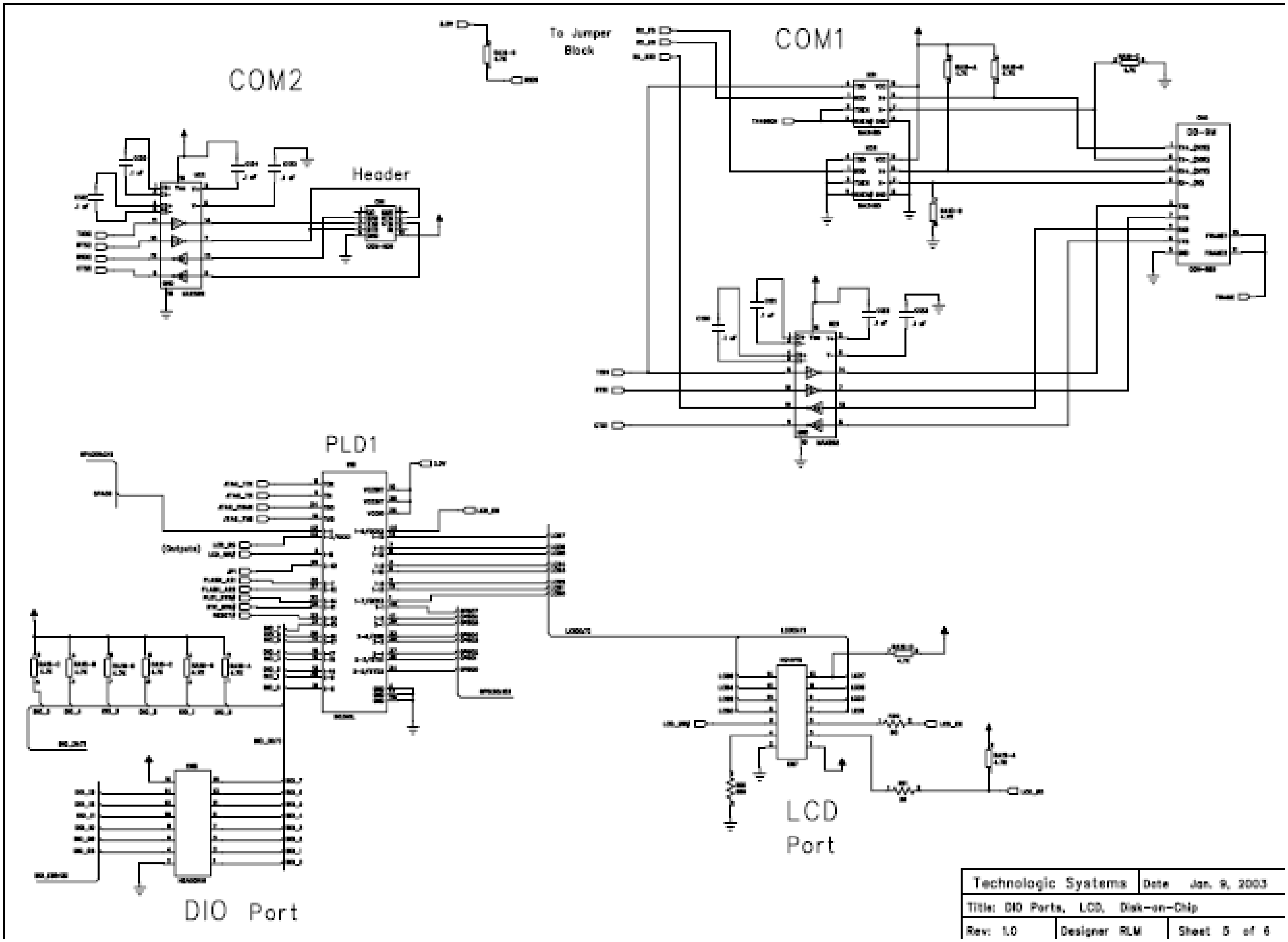

Figure 19: TS-5400 Schematic E [7]

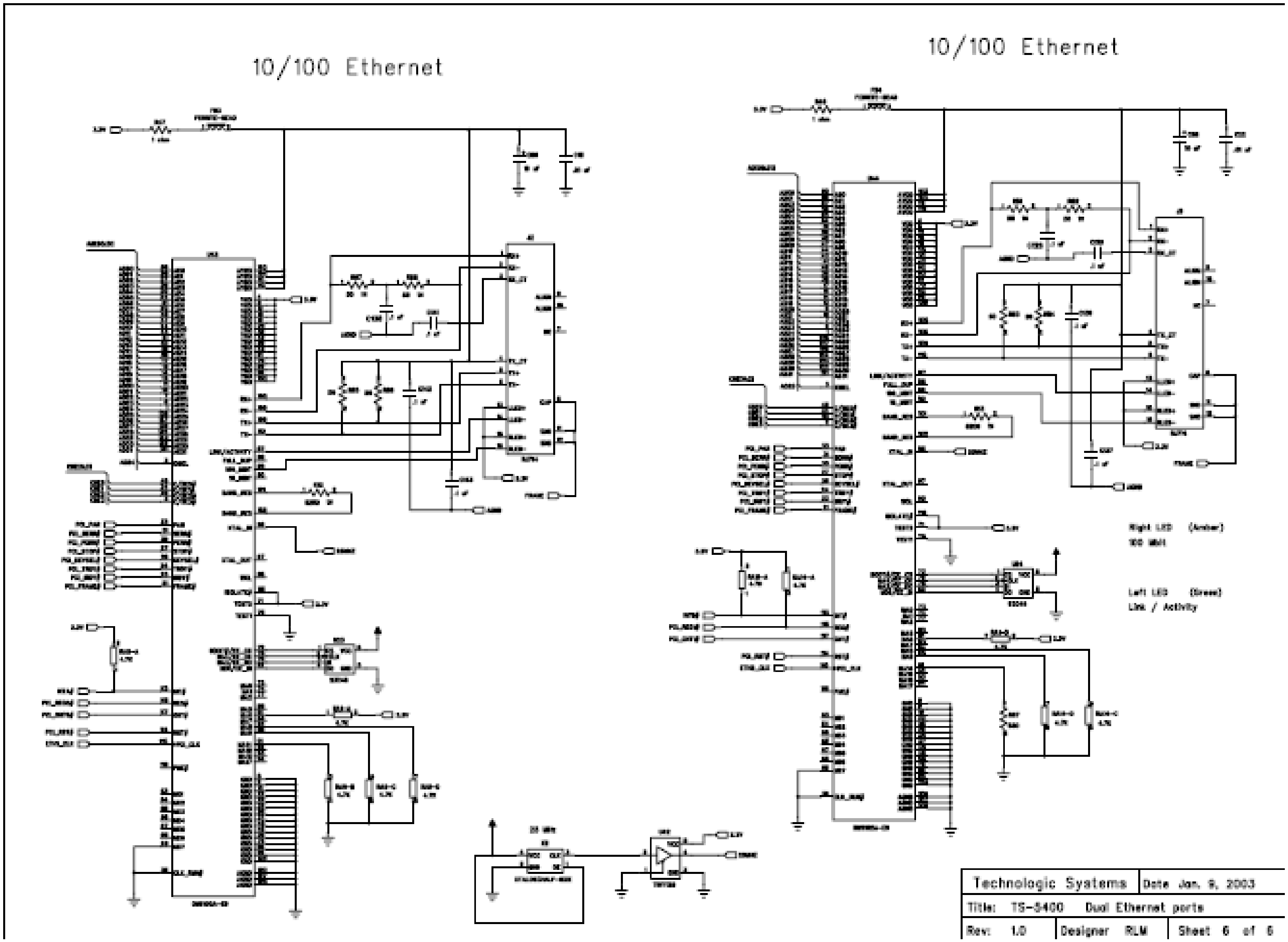

Figure 20: TS-5400 Schematic F [7]

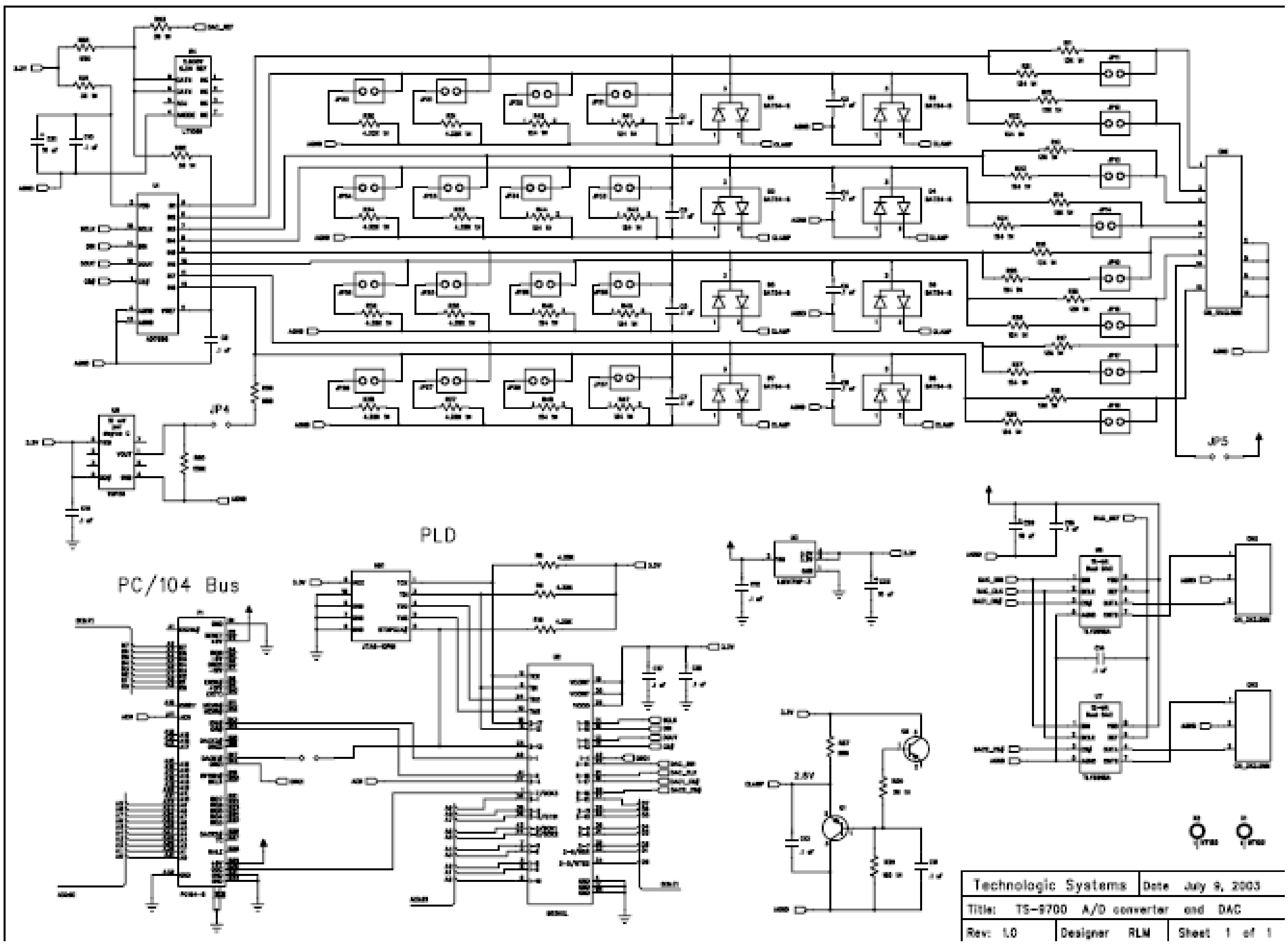

Figure 21: TS-9700 Schematic [8]