HASP Payload Specification and Integration Plan

Payload Title: MRE II: Microwave Radiation Experiment II

Payload Class: Small [✓ Large] (circle one)

Payload ID: 09

Institution: **McNeese State University**

Contact Name: Sagar Kharel

Contact Phone: 337-304-1614

Contact E-mail: Sagar_kharel84@yahoo.com

Submit Date: June 1, 2009

I. Mechanical Specifications:

A. Measured weight of the payload (not including payload plate)

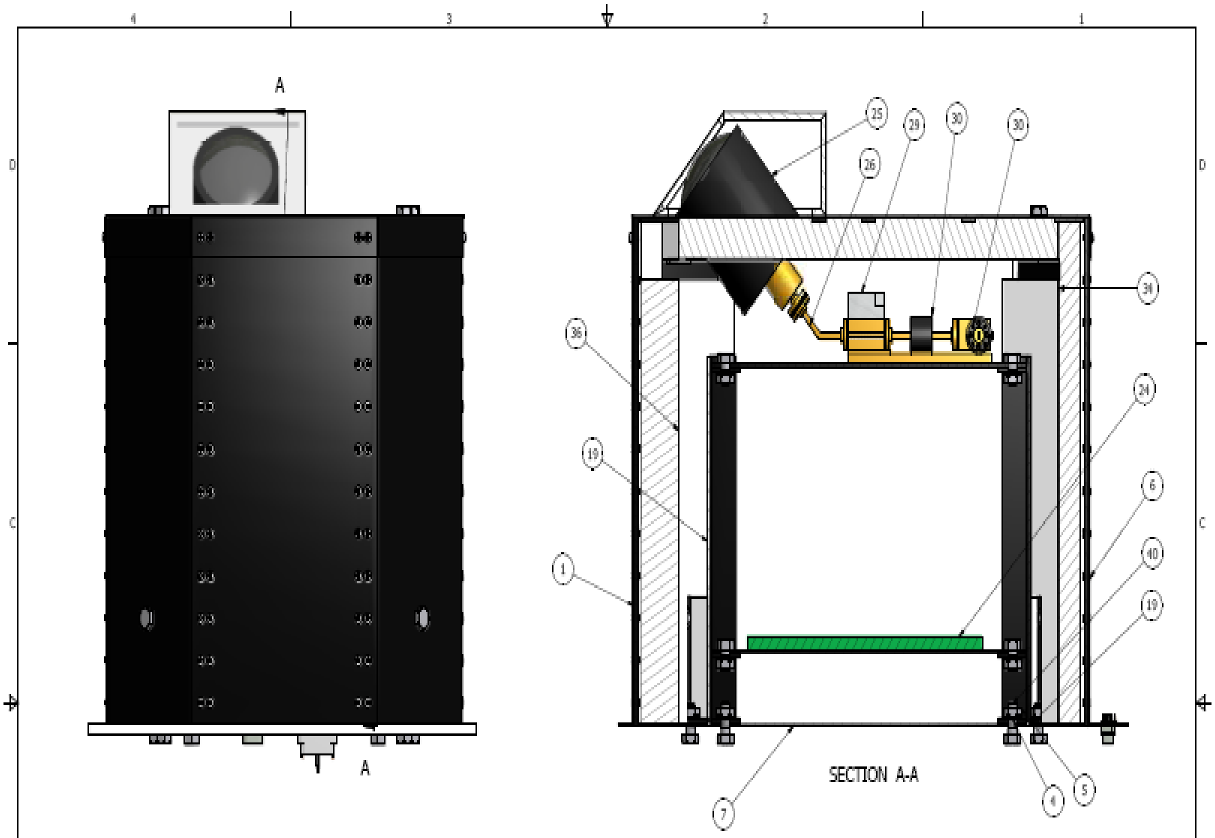
Radiometer: 2.15 Kg
Payload box: 2.385 Kg
Payload Base: 1.6 Kg

Insulating Material: 2 Kg
Heating Elements: 0.16 kg
Knots and Bolts: 0.152Kg
Mother Board and other electronics (including batteries for heaters): 5.3 Kg

Power supplies: 0.390 Kg x 2 = 0.780 Kg

Total Weight: 14.53Kg

B. Provide a mechanical drawing detailing the major components of your payload and specifically how your payload is attached to the payload mounting plate.



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	2	Long Corner	0.125" 5052 Aluminum alloy sheet
4	20	SAE J773b - 5/16. SAE Type L. narrow	Conical Spring Washer
5	24	ANSI B18.6.3 - 5/16 - 18	Hex Machine Screw Nut
6	176	AD 42 BS-02	1/8 X .1538 Std Pop Rivet
7	1	PVC Base	System Mass
19	4	L Beam For Support Structure	1"x1"x0.125" 6061 Aluminum Angle Support
24	1	RFEL Data Board	
25	1	Horn Lens Antenna	
26	1	45 degree bend	
29	1	LNA Cooling Fins	
30	2	Full Band Isolator	
34	2	Short Corner Panel	1" Expanded Polystyrene insulation
36	2	Long Corner Panel	1" Expanded Polystyrene insulation
40	4	ANSI/ASME B18.2.1 - 5/16-18 UNC - 0.75	Hex Bolt - UNC (Regular Thread - Inch)

DRAWN Raymond Fontenot	4/27/2008	Zephyr Aerospace Technologies
CHECKED Glen Monceaux	4/27/2008	TITLE Payload Front-Side Section
QA		
MFG		
APPROVED GM		SIZE C · DWG NO · REV
		SCALE · SHEET

Figure 1: General views of the payload, left exterior, right interior. The payload is attached to the base with the help of bolts and brackets.

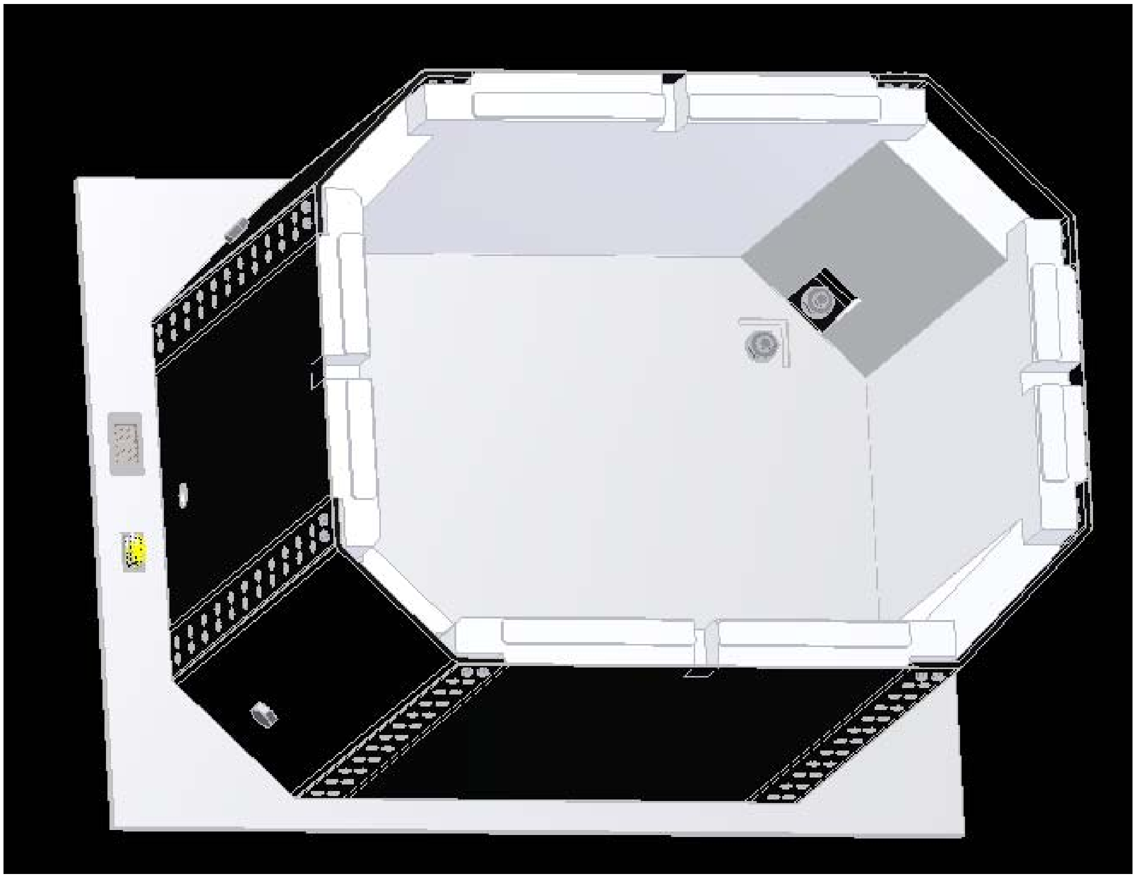
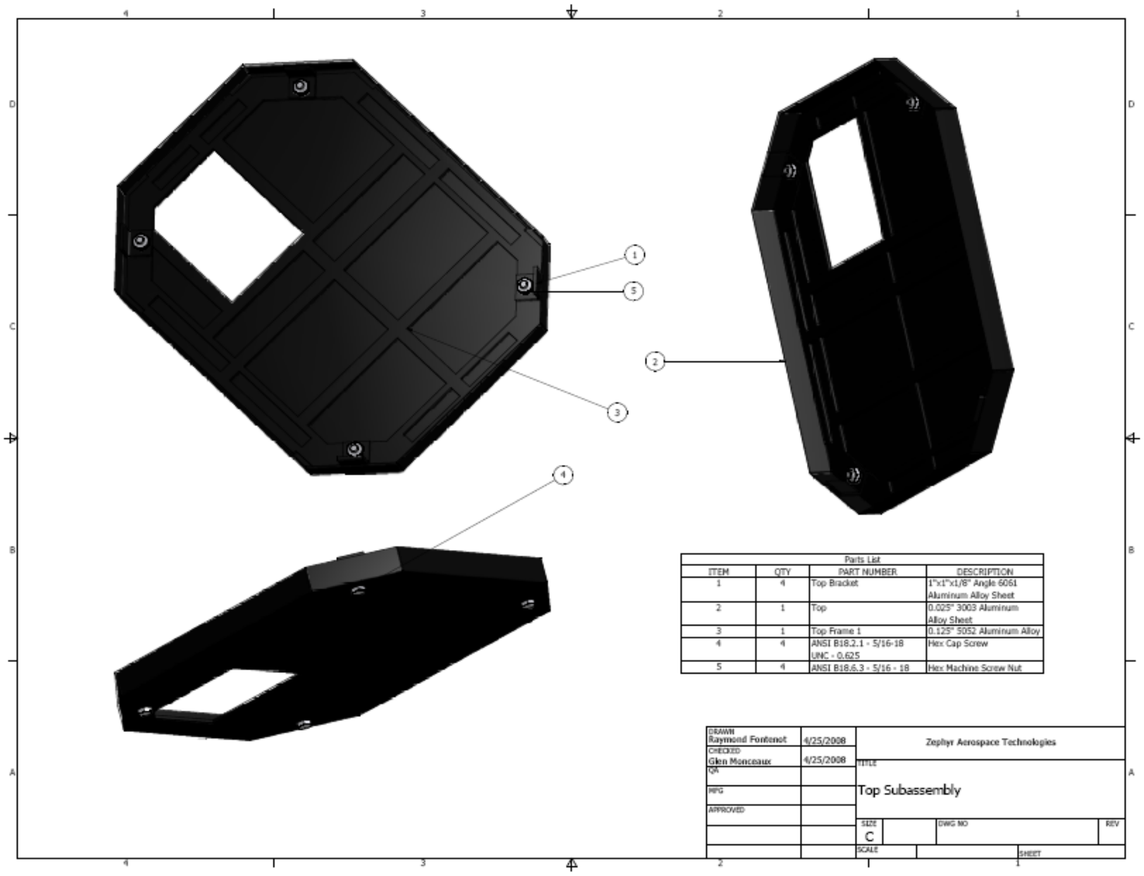


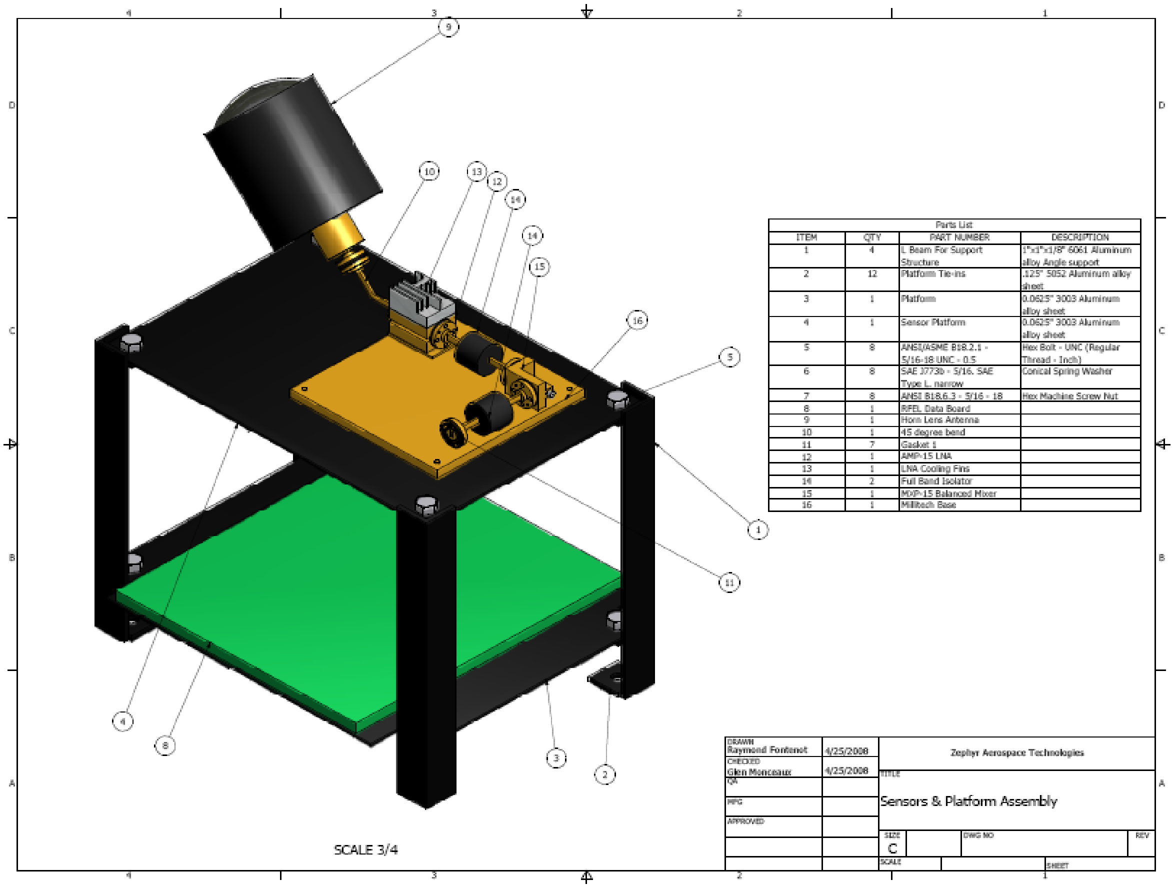
Figure 2: Payload with the insulation. The figure is showing the method of attachement of the payload shell to the base using brackets and bolts.



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	4	Top Bracket	1"x1"x1/8" Angle 6061 Aluminum Alloy Sheet
2	1	Top	0.025" 3003 Aluminum Alloy Sheet
3	1	Top Frame 1	0.125" 5052 Aluminum Alloy
4	4	ANSI B18.2.1 - 5/16-18 UNC - 0.625	Hex Cap Screw
5	4	ANSI B18.6.3 - 5/16 - 18	Hex Machine Screw Nut

DRAWN Raymond Fontenot 4/25/2008
CHECKED Glen Monceaux 4/25/2008
QA
MFG
APPROVED
Zephyr Aerospace Technologies
TITLE Top Subassembly
SIZE C
DWG NO
REV
SCALE
SHEET

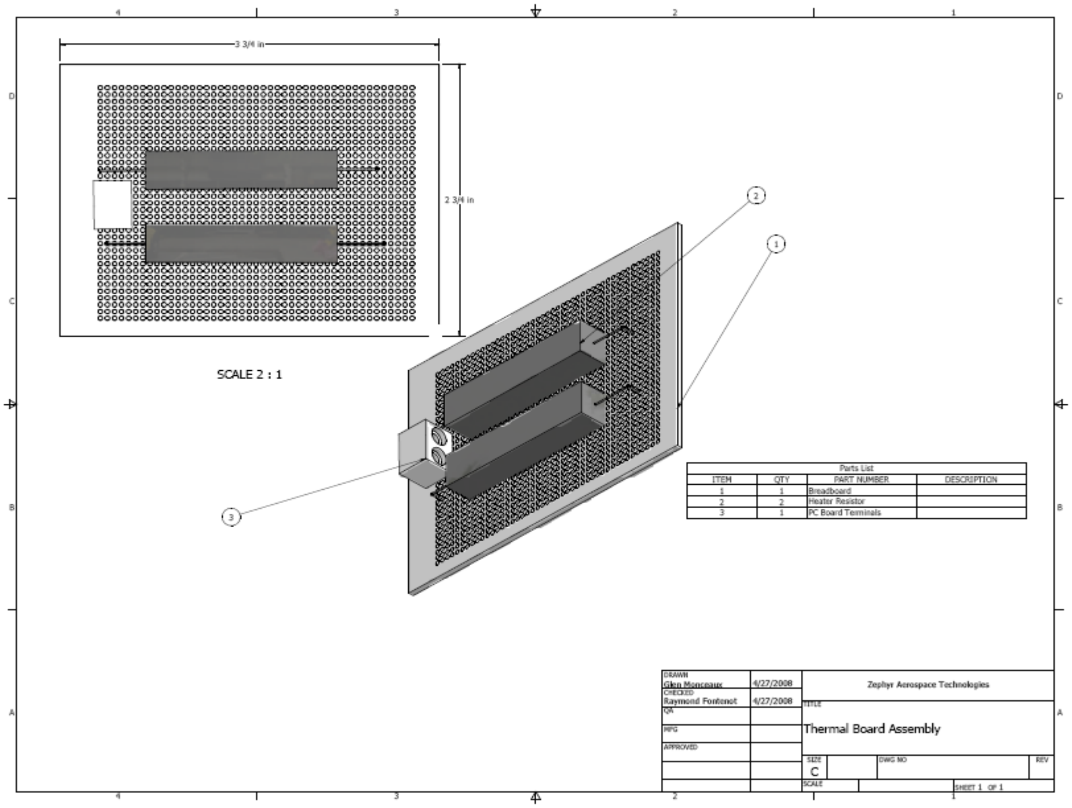
Figure 3 : Top of the shell. The aperture is covered by the antenna enclosure.



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	4	L Beam For Support Structure	1"x1"x1/8" 6061 Aluminum alloy Angle support
2	12	Platform Tie-ins	.125" 5052 Aluminum alloy sheet
3	1	Platform	0.0625" 3003 Aluminum alloy sheet
4	1	Sensor Platform	0.0625" 3003 Aluminum alloy sheet
5	8	ANSI/ASME B18.2.1 - 5/16-18 UNC - 0.5	Hex Bolt - UNC (Regular Thread - Inch)
6	8	SAE J773b - 5/16. SAE Type L. narrow	Conical Spring Washer
7	8	ANSI B18.6.3 - 5/16 - 18	Hex Machine Screw Nut
8	1	RFEL Data Board	
9	1	Horn Lens Antenna	
10	1	45 degree bend	
11	7	Gasket 1	
12	1	AMP-15 LNA	
13	1	LNA Cooling Fins	
14	2	Full Band Isolator	
15	1	MXP-15 Balanced Mixer	
16	1	Millitech Base	

DRAWN Raymond Fontenot 4/25/2008
CHECKED Glen Monceaux 4/25/2008
QA
MFG
APPROVED
Zephyr Aerospace Technologies
TITLE Sensors & Platform Assembly
SIZE C
DWG NO
REV
SCALE
SHEET

Figure 4: Support structure and electronics equipments. The top platform supports the radiometer and the lower platform supports the data acquisition system. The support structure is secured to the base by brackets and bolts.



Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Breadboard	
2	2	Heater Resistor	
3	1	PC Board Terminals	

DRAWN Glen Monceaux 4/27/2008
CHECKED Raymond Fontenot 4/27/2008
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MFG
APPROVED
Zephyr Aerospace Technologies
TITLE Thermal Board Assembly
SIZE C
DWG NO
REV
SCALE
SHEET 1 OF 1

Figure 5: Heating elements used for the active temperature control of the interior the payload. The four heating elements are anchored to insulation panels in the interior sides of the shell. Power is supplied to the heating elements by D sized batteries.

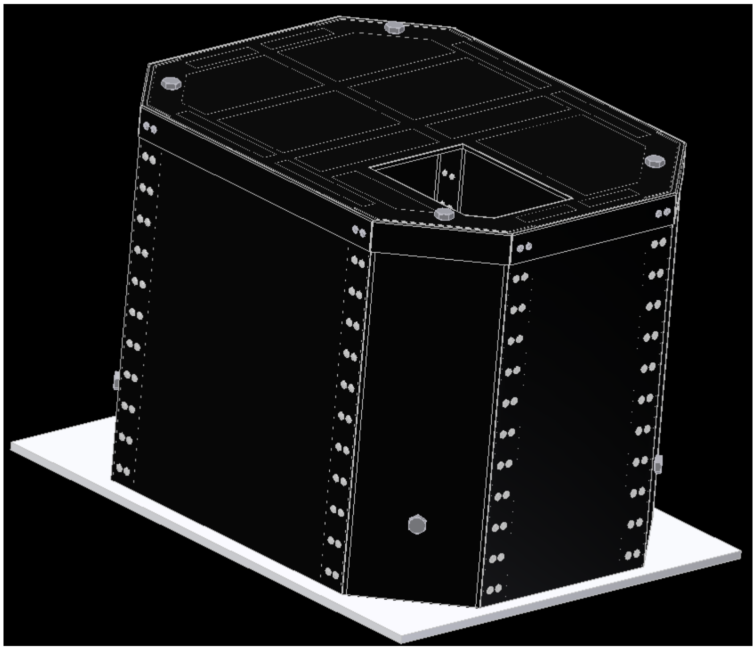


Figure 6: External view of the payload shell.

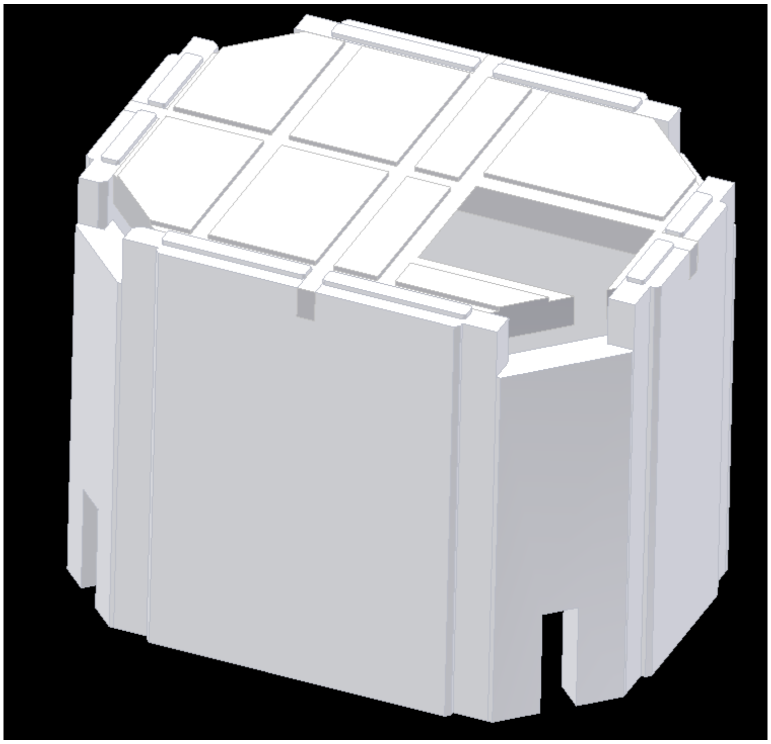


Figure 7: Insulation structure.

Figure 8 - Antenna enclosure made of foam core and Mylar window for undistorted signal.

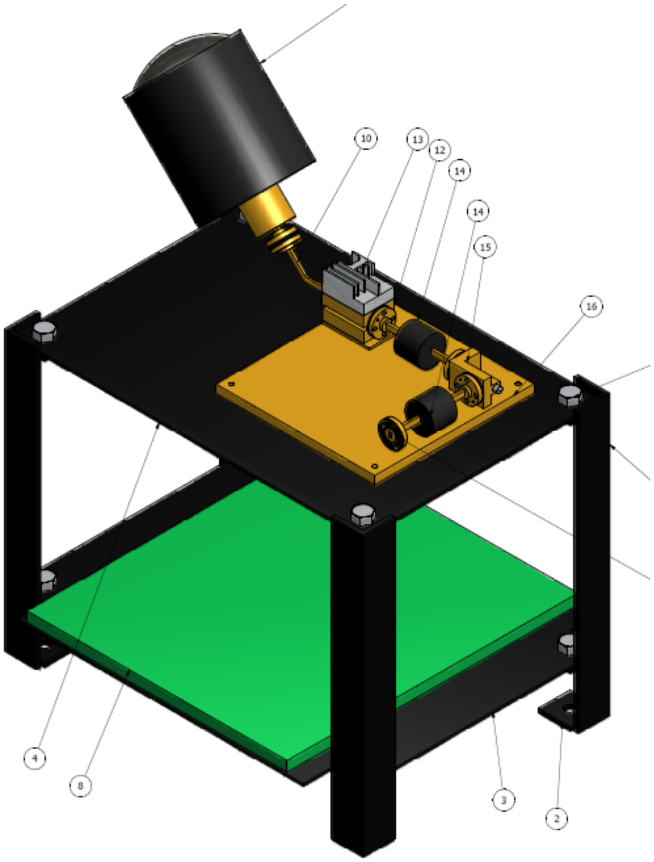


Figure 9: Support Structure is a critical mechanical component of the MRE II payload. It was overbuilt beyond specifications to guarantee stability and structural integrity during the flight.

DESIGN REQUIREMENTS

The MRE II payload is one of four 20 kilogram large class student payloads on the balloon system. All components must be included in the weight budget except the mounting plate. The large payload must fit within the large payload mounting plate mounting area. The diagram for the large mounting plate is given below in Figure 12.

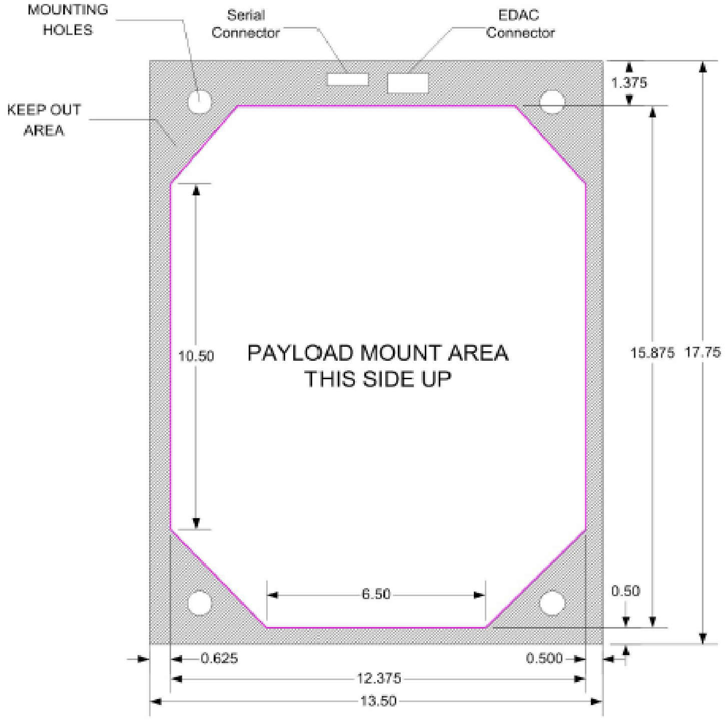


Figure 10: Large Payload Mounting Plate.

The mounting plate allows for an octagon shaped design with overall square dimensions of 12 3/8 inches by 15 7/8 inches. No overhang is allowed into the shaded area below two inches. The payload cannot be taller than one foot, although exceptions are allowed. MRE II exceeds the height requirements by 2 7/16 inches. This extra distance is necessary for the antenna to have a clear view of the sky and for all of the equipment to fit inside. HASP also dictates that the payload structure must be able to withstand a 10g vertical shock and two 5g vertical shocks. See the section on the stress analysis for validation of these shock specifications.

MATERIALS OF CONSTRUCTION

The materials for this project have been selected to withstand the physical requirements given in the initial project overview. The materials have been selected and sized with a factor of safety in order to safely survive the given conditions. Most of the material selection and sizing have come from decisions based on general commercial and industrial practices.

ALUMINUM

The payload structure solely consists of Aluminum alloys. This decision rests on the fact that Aluminum alloys are the most cost effective option for strong, light weight, structures. Aluminum also makes no ductile-brittle transition at sub-zero temperatures, meaning there will be little to no loss of strength during the flight. Aluminum alloys are also readily available in many compositions from most metal suppliers. This payload structure consists of the following Aluminum alloy compositions: 3003, 5052, and 6061. A list of the Aluminum alloys, sizes, and mechanical data selected for this project are shown in Table below.

Table 1: Selected Alloys, Sizes, and Mechanical Data

Gauge	Aluminum Alloy	Specification Code	Temper	Yield Strength (ksi)	Ultimate Tensile Strength (ksi)
0.0625"	3003	AMS-QQ-A-250/2	H14	21	22
0.0250"	3003	AMS-QQ-A-250/2	H14	21	22
0.1250"	5052	ASTM B209-07	H32	28	33
0.1250"	6061		T4	16	30

The mechanical data shown in the table above supports design decisions made in this project. The 3003-H14, available in coil, plate, and sheet is often used in sheet metal work. It is corrosion resistant and has excellent formability. The 3003 alloy was used for the pieces which are simply coverings or barriers from the environment. The 5052-H32 alloy is also available in coil, plate, and sheet. It maintains a high fatigue strength which makes it a good choice for structures with excessive vibration. It is also corrosion resistant and has excellent formability. The parts which are considered structural pieces are made of the 5052 alloy, except for the internal extruded angle member. The internal vertical support columns are made from extruded 6061 Aluminum alloy. This alloy can be extruded to form continuous shapes. This is the reason it was selected for the vertical support columns. It is also capable of being welded without excessive deformation due to heat.

EXPANDED POLYSTYRENE

The insulation material selected for this project is expanded polystyrene. It is essentially STYROFOAM board. EPS, expanded polystyrene, is a solid plastic which is blown into foam using a blowing agent. It consists of 90-95% polystyrene and 5-10% gaseous blowing agent. The board is placed along the inside surface of the walls and top of the payload. This board will also give the payload shell some damping effect from wind vibration on the outside of the payload. EPS has nominal strength properties that are best utilized when they are in compression. The strength properties of EPS are sufficient for the overall design of the payload. EPS is more important from a design standpoint thermally as it is an excellent insulator and will help keep the heat in and reduce the heat load on the heaters. It is formable by cutting and shaving with a razor knife. It can be purchased in different sizes. This project used the 1” expanded polystyrene board.

FASTENERS

The selection of metal fasteners involved the issues of weight, function, and cost. The first decision was to select a readily available carbon steel bolt and nut to rigidly attach the structural parts to one another. Aluminum bolts were not selected despite their potential weight saving benefits because their strength would not have been enough to safely secure the payload together. Grade 5 5/16” and #6 bolts were used. The 5/16” bolts are either 3/4” or 9/16” long (depending on their location) hex head bolt with accompanying nut. The Grade 5 bolts are made of medium carbon steel. These bolts have yield strengths of 85 ksi, well above any expected stress developed (see the stress analysis section for verification of this). The #6 bolts (.138” diameter) are used to fasten the top to the sides and are used in this role as opposed to rivets so the top can easily be taken off repeatedly. Using rivets would require drilling them out each time the top was taken off. These bolts are not structural. Figure 11 below is a picture of the 5/16” bolt used in this project.

Figure 11: 5/16” dia., 0.75” long bolt.

The decision for the attachment of the sheet metal to the structural parts (corners) led to the implementation of metal pop-rivets. The use of rivets in general minimizes weight when compared to using bolts in this situation. There are a total of 176 rivets, and that many bolts, undoubtedly steel, would weigh at least three times as much. Aluminum pop rivets where used instead of stainless steel pop rivets. The stainless steel rivets are much stronger but also much heavier. The high strength was not need for this application as the sides and ends are not load bearing members. The 3003 aluminum sheet metal, which makes up the outer payload shell covering, required a large number of rivets to attach it to the structural supports. The light weight and low cost of the aluminum rivets sealed the decision. However, the sizing of the rivets required some thought. The project needed a rivet that would securely attach the sides and ends to the corners. Therefore, the decision was made to use a 1/8” diameter rivet with a 1/8” grip length. This grip length was a critical dimension. If the grip length is too large, the rivet would not compress the mating materials together. However, if it is too small, the rivet would fall short of the required length to grip the two mating materials. Figure 12 displays a pop-rivet before and after it has been compressed using a pop-rivet gun.

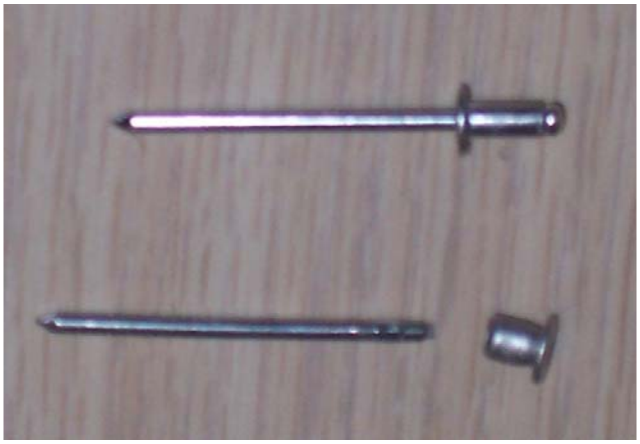


Figure 12: Pop-rivet before and after use.

Glue is used in the construction of the antenna enclosure and for securing it to the payload. The type of glue used here is Gorilla Glue. When Gorilla Glue dries, to looks very much like Styrofoam and can be worked the same. Gorilla Glue is very hard, though. Because Gorilla Glue dries like foam, it is unaffected by temperature extremes (this was verified two years ago on the MRE project). These two properties, plus the fact that Gorilla Glues anything to anything, make Gorilla Glue the perfect adhesive for this project. Gorilla Glue is not used on any structural parts.

The Payload Shell assembly is really no more than a glorified box to house electronic equipment in. The payload shell consists of the following parts: long corner, short corner, side panels, long end panel, short end panel, top, top frame, base brackets, and top brackets.

LONG AND SHORT CORNERS

The both the long corner and short corner (of which there are two each) are the main structural load bearing components of the payload shell. These pieces have to be robust in order to handle the shock received at impact. Both corners are made of 1/8” Aluminum 5052-H32 that spans the whole corner area allowed by the mounting plate. Each corner has three faces; the two short faces are bent at 45 degrees from the longest face inward. Both of these short faces are 1.025 inches long. The third, as stated previously, spans the whole corner, and its length depends on the allowable mounting area for the corner. Each corner is also 12 1/16” high. The extra 1/16” is used to recess the piece into the mounting plate to create a seal to limit air entering the payload and to reduce vibration. Each corner has a 5/16” bolt hole drilled into it 2 9/16” from its base on the longest side to allow them to be secured to the base plate. The bolt is placed at this height because no overhang is allowed lower than 2” above the base plate. The two short sides have twenty two equally space 1/8” holes for rivets that are used to secure the side panels to the assembly. Two additional holes at the top of the corners are bolt holes used to help secure the top the rest of the assembly.

SIDE AND END PANELS

The sides and end panels help tie the shell assembly together. While these pieces do not carry any load, they are necessary to solidify the structure for stability and to close the system thermally. Each panel is made of .025” thick Aluminum 3003-H14. Each piece is 12 1/16” tall, with the 1/16” to minimize vibration as before via recession in the mounting plate. The length of the side panels are the same, but the ends vary because of the mounting plate restriction. Both the ends and the two side panels are secured to the corners with 1/8” rivets.

BASE AND TOP BRACKETS

The four base brackets used in the shell assembly are to secure the entire shell assembly to the mounting plate, while the four top brackets secure the top and top frame to the corners. The base brackets are made from 1/8” thick Aluminum 5052-H32. The base brackets are unequal legs 3” by 1” with 5/16” holes for bolts placed centered at 2.5” on the long leg and ½” on the short leg. The top brackets are one inch equal leg angles 1/8” thick made from Aluminum 6061-T4. The top brackets are brazed to the corners 1/8” from the top of the corners to allow the top frame to sit flush. 5/16” bolt holes are placed 3/8” from the ends for securing the top and top frame to the assembly.

TOP FRAME

The most complex piece of the entire payload, the top frame had to be cut out via a water jet. The top frame also is a major load bearing piece as it will have to absorb a large amount of stress due to the reaction of the payload to the impact. The top frame is made from 1/8” Aluminum 5052. The top frame is modeled after the allowable mounting area, but with two exceptions. First, the frame is made to fit inside the sides and corners, so it is .025” shorter on the each side and end and 1/8” shorter in the corners than the allowable area. Second, the top frame is offset inward an additional 1/16” to allow for any issues that may arise in the manufacturing of the parts. The top frame consists of a 1” outer rim where holes for mounting to the top brackets and cut-outs to allow the tie-in of the side and end insulating panels are located. In the center area, the frame has various cut-outs to allow for the top insulating panel to tie-in to the frame. The panels are tied-in to the shell to help create a good thermal seal. Also, one of the cut-outs in the center area (located by the bar that runs into one of the corners) allows the antenna to protrude from the inner cavity of the shell. This cut-out measures approximately 3.75” by 5”. The main reason for all of the cut-outs is not for tying in insulation to the frame; rather, the cut-outs are a weight saving measure as over 65% of the original frame was removed. These cut-outs have the adverse effect of creating multiple stress risers, though, and are thoroughly analyzed in the stress analysis performed. Please refer to the next section of the report for this data.

TOP

The last piece of the shell assembly, the top is made from .025" thick Aluminum 3003-H14. The top's primary function is to finalize the thermal seal on the box. Its secondary application is to completely solidify the structure to help reduce vibration. The top is the same overall size as the allowable mounting area with a one inch overhang all the way around. This overhang is bent flush with the sides and corners. The overhang is used to create a better thermal seal and to secure the top to the sides and corners of the payload. This is accomplished with #6 bolts. The top is secured to the top frame with 5/16" bolts. The top also has a cut-out for the antenna the same size as the cut-out is on the top frame.

ANTENNA ENCLOSURE ASSEMBLY

The antenna enclosure assembly is the next major assembly of the payload. The antenna enclosure, constructed from 3/16" foam core, consists of seven different parts: back, base, cover, Mylar viewing pane, right side panel, left side panel, and top. The assembly is 2 7/16" tall, 4.75" wide, and 6" long. The base has a cut-out area that is the same as the top frame's and top. The cover also has a cut-out area that measures 4.25" wide by 2.94" long. The Mylar viewing pane fits over the cover and is secured via Gorilla Glue. The viewing pane is made from Mylar because it allows the light (radiation) to enter the antenna enclosure without distorting the microwaves. The side panels, top, and back are just solid pieces of foam core cut to fit and tie the assembly together. The assembly is glued together with Gorilla Glue. It is not stress tested as it is a noncritical assembly.

INSULATING PANEL ASSEMBLY

The insulating panel assembly helps control the heat transfer in and out of the interior of the shell assembly. The assembly also adds strength to the overall structure as it will be in a continuous state of compression due to the panels acting as columns for the top frame. The insulating panels are made from one inch thick expanded polystyrene insulation. There are seven parts that make up the insulating panel assembly: top, sides (2), short end, long end, short corner (2), and long corner (2). The insulating panels are made to fit securely and tight inside the payload shell assembly. The insulating panel assembly has no appreciable gap between it and the sides of the shell assembly (>.01"). The only variance from this is the 1/8" indentation on the end and side panels to allow for proper clearance for the rivets. The sides and ends are 11 7/8" tall with 1/8" extensions that fit into the top frame. These extensions help to structurally tie the insulating panels to the payload shell and aid in sealing thermally the cavity from the outside environment. The corners have a 3"x1" section removed from the bottom to allow access to the base brackets when assembled. The corners are only 10" tall allow access to the top brackets. The top insulating panel has an overall thickness of 1" with several 1/8" recessions to allow the top frame to sit flush in it. The top insulation panel also has a 3.75" by 5" cut-out to allow for the antenna to protrude through to the top. The top insulation panel has 1” long “fingers” that recess into the side and end panels for a secure fit.

SUPPORT STRUCTURE ASSEMBLY

The support structure holds and secures all of the electronic equipment (microwave reception, processing, and data storage) within the payload. This fact alone makes the support structure a critically stressed and vibrated assembly. Both of these analyzes are seen later in the report. The support structure has four major components: angled support columns (4), platform tie-ins (12), sensor platform, and platform.

The support columns are 1/8” thick 1” equal leg angles made from Aluminum 6061-T4. The columns are recessed into the mounting plate 1/16” to reduce vibration. The columns are secured to the mounting plate via four of the platform tie-ins with 5/16” bolts. The platform tie-ins are to be brazed or welded to the columns to eliminate any holes into the columns that might weaken the structure. The platform tie-ins are 1/8” thick 1” by 1” and made from Aluminum 5052-H32. The platform tie-ins are also used to secure the sensor platform and platform to the structure. The platforms are bolted to the tie-ins with 5/16” bolts. The sensor platform measures 7.5” by 11” and will sit nearly flush with the top of the columns.. The platform will sit lower on the structure and hold the processing and data storage equipment. The platform has the same overall dimensions as the sensor platform but also has an inch added to each end and 7/8” to each side. These extensions are added so a wide range of sizes on processing units (possibly a computer motherboard) could be used. Both the sensor platform and platform are manufactured from 1/16” Aluminum 3003-H14

C. If you are flying anything that is potentially hazardous to HASP or the ground crew before or after launch, please supply all documentation provided with the hazardous components (i.e. pressurized containers, radioactive material, projectiles, rockets…)

   No hazardous components or materials are present in the MRE II payload.

D. Other relevant mechanical information

   We will need an unobstructed view of the sky at about 45 degrees from the top of the payload. See mechanical drawing for a reference of the location of the horn antenna its orientation towards the sky.

STRESS ANALYSIS:

INTRODUCTION

The stress analysis is performed as verification that all designed structures will not fail due to any loads applied to them. The HASP project guidelines dictate that any structure must be able to withstand a 10 g vertical shock as well as two 5 g horizontal shocks. These loads are to be expected whenever the gondola lands. The project has two main structures of interest for analysis: the payload shell and support structure. For the structure to pass the stress analysis, the structure must have a minimum overall safety factor of between 1.15 and 1.25, which is the acceptable range for aerospace applications.

STRESS ANALYSIS SOFTWARE

The analysis is performed using the FEA software Algor. Algor takes a CAD model, Inventor in the case of this project, and processes it into three dimensional matrices which can then be combined to determine the maximum stresses given a specified load. Algor requires that the loads, material, size of mesh, and type of mesh be specified before an analysis can be performed. The user defined loads on a part or assembly can take many forms, but this analysis looks at shock loads, which is interpreted by Algor as a static load (i.e. very short duration). Algor also has a very wide selection of materials that can be selected for a part. Selection of a material is important because Algor takes the material properties and uses them to solve the load matrices. Mesh size specifies the size of the load matrix. The smaller the mesh, the larger this matrix becomes and the longer the analysis will take to process. The type of mesh depends on whether or not the part or assembly is 2 or 3-D. Tetrahedron is the recommended mesh style for three dimensional objects because it tends to better describe mathematically what the part or assembly is.

PAYLOAD SHELL ANALYSIS

The payload shell, as described earlier in the payload design section, consists of four 1/8 inch corners with walls with a thickness of .025 inches. The corners are mounted to the mounting plate with four 1x3x1/8 inch brackets. The payload shell is tied together at the top by the top frame with four 1x1x1/8 inch brackets. The top covers this frame and overhangs the sides of the payload. The corners, top frame, and base brackets were specified as Aluminum 5052-H32. The top brackets were specified as Aluminum 6061-T4. The PVC base was specified as fluorinated ethylene propylene. This was because Algor did not have PVC in the material libraries, and FEP was chosen due to its similar strength properties. Before meshing occurred, all bolts and rivets were removed from the assembly. This is because Algor tends not to handle these items very well in the processing (mesh) stage, especially with large models such as this. Also, all of the .025 side panels and top were removed from the model. Originally, these were going to be included in the analysis, but Algor could not process the mesh with these items included in the model, though all of the sides meshed on their own. The top, however, refused to mesh altogether for no apparent reason. Removing these items does not take away from the legitimacy of this analysis, though. The sides and top were not designed to be load bearing; only the corners were designed to withstand the shock that would be experienced upon landing.

The shell was processed to a 67% mesh. This mesh was used because it did not have any water tightness issues (meaning that if you could take the part and fill it with water it would not leak), and it was the convergent mesh for the stress output. The output is given both graphically and in pdf form (this is given in Appendix B). The stress data for the payload shell can be seen graphically below in Figure 13.

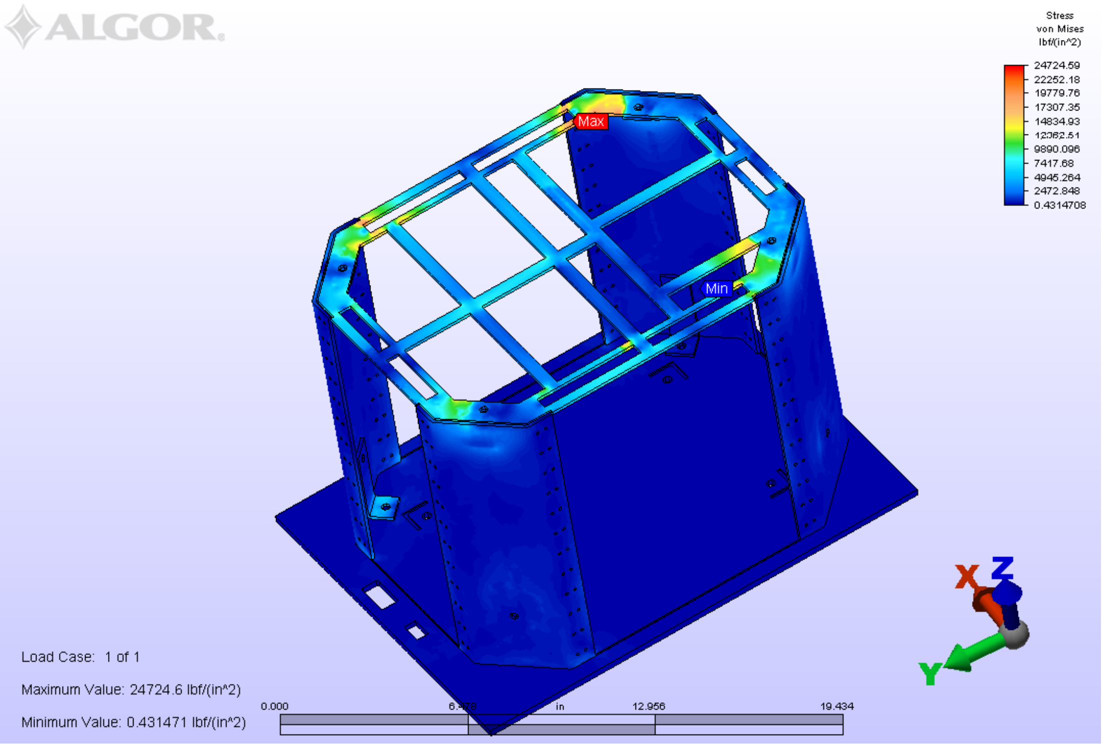


Figure 13: Stress data for payload shell.

From the figure, the maximum stress obtained is 24.57 ksi. The maximum stress (and largest stresses for the system in general) occurs on the top frame. This is due to stress risers present from the cutouts made in the frame for the insulation. Also, intuitively, the maximum stress should occur on the top plate because this is where impact load will be resisted. The stresses observed on the top plate would primarily be due to bending resulting from the impact. The maximum stress observed is below the yield strength of the Aluminum Alloy (5052) of 29 ksi. This gives a safety factor of 1.18. This is within the acceptable range of safety for aerospace applications, so the structure passes the stress analysis.

9.4 SUPPORT STRUCTURE ANALYSIS

The support structure, as described earlier in the payload design section, consists of four aluminum 1”x1”x1/8” columns with two platforms. These platforms are secured to the columns by 1” square brackets, or platform tie-ins. These tie-ins are welded to the columns. The columns are specified as Aluminum 6061-T4. The platforms are specified as Aluminum 3003-H14, while the tie-ins are specified as Aluminum 5052-H32. All the bolts of the support structure were removed so Algor could handle the analysis. Unlike the analysis of the Payload Shell, the PVC base was not included. This was because Algor could not process the matrices with it in it. The PVC base has no real load applied, though, as determined by the analysis performed on the Payload shell (.4 psi).

Like the Payload Shell, the mesh that converged and had no water tightness issues was 67%. The output is given both graphically and in pdf form (this is given in Appendix H). The stress data for the payload shell can be seen graphically below in Figure 14.

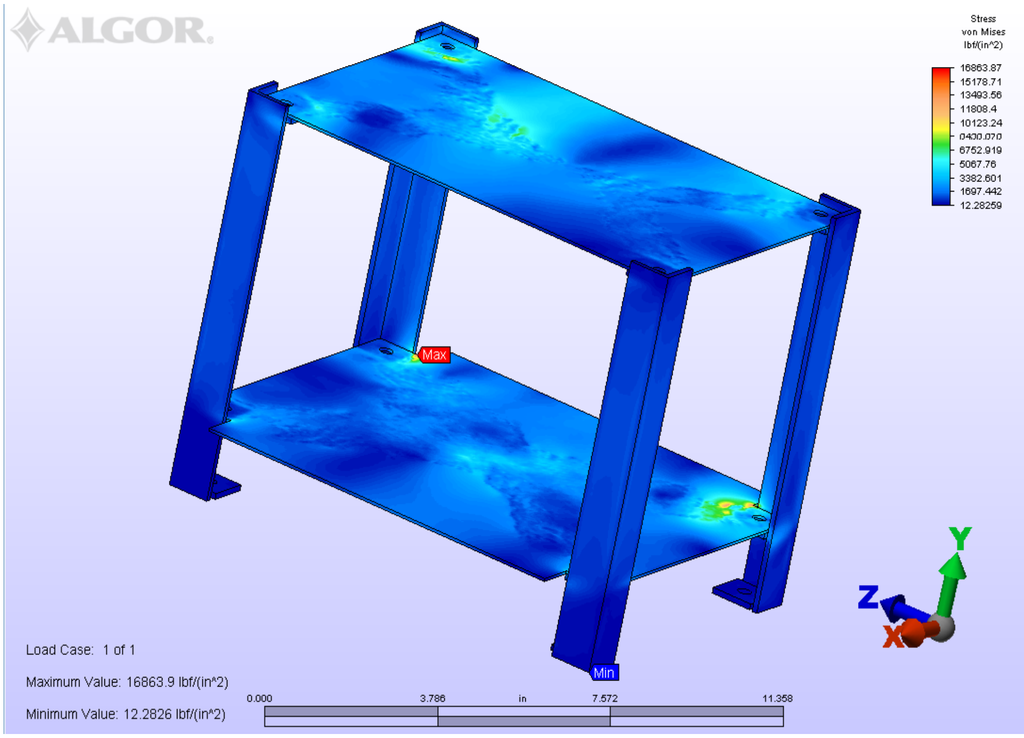


Figure 14: Stress data for support structure.

From the figure, the maximum stress obtained is 16.8 ksi. The maximum stress (and largest stresses for the system in general) occurs on the first platform around the platform tie-ins. This occurs because upon impact the platforms will experience buckling, especially around the tie-ins. This effect is clearly visible in Figure 9.2 as eddies in the platforms. The maximum stress observed is below the yield strength of the Aluminum Alloy (3003) of 24 ksi. This gives a safety factor of 1.42. This is actually above the acceptable range of safety for aerospace applications, so the structure passes the stress analysis.

VIBRATIONAL ANALYSIS

A major concern for any operation using electrical equipment is vibration. Vibration is highly detrimental because it can induce noise to the system that can wreak havoc on an incoming signal. Vibration can also damage the equipment if the frequencies of oscillation reach the natural frequencies of the equipment or the structure that the equipment is sitting on. Whenever a natural frequency is reached, resonance occurs. Resonance creates large amplitudes of oscillation and, if not quickly passed, will rip structures and equipment apart. Therefore, a vibration analysis is important for two reasons: 1) to determine the noise that will be induced to a system so it can be accounted for and possibly canceled out by prefiltering or 2) to determine the natural frequencies and the frequencies of oscillation to properly design structures and equipment to avoid resonance. The analysis performed here is concerned about the gondola that the balloon payload will sit upon and the support structure that the radiometer and processing equipment will sit upon.

The support structure is analyzed as a two degree of freedom system with base excitation. This base excitation is present from two sources: the oscillation induced by gondola and the wind hitting the sides of the payload. The focus on the analysis for the support structure is on the modes and natural frequencies of the structure. The natural frequencies will be used to check and see if resonance is reached. There will be two natural frequencies because the system has two degrees of freedom because the number of natural frequencies of oscillation is proportional to the degrees of freedom. The modes will show the relationship between the motions of each platform. The structure is made of four aluminum columns with two platforms for electrical equipment to mount to. Each of these columns is analyzed as cantilever beams with an end load applied to determine their respective stiffness as seen in Figure 14.

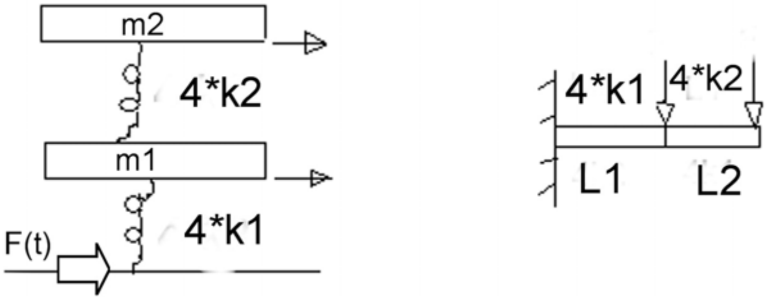


Figure 14: System diagram of support structure depicting cantilever assumption.

These end loads are the platforms and the equipment. As the columns are considered in parallel, their stiffnesses are additive. The MathCAD worksheet, “Frequencies and Modes of The Support Structure,” shows this in Appendix I. To determine the modes and frequencies of the support structure, the forcing function (base excitation) need not be known or applied at this time. Performing the analysis requires the differential equations describing the motion of the platforms. The results of this analysis are displayed below in Table 2.

Table 2: Natural frequencies and modes of support.

1^{st} Natural Frequency	714 rad/s
2^{nd} Natural Frequency	14135 rad/s
1^{st} Modes	1
	1.004
2^{nd} Modes	1
	-1.48

The first natural frequency is mid range and could pose a problem for resonance. The second natural frequency is high and should never be excited, but both of these will be checked when the analysis is performed for the gondola. The first mode shows that the first platform will move at the same rate as itself and at 1.004 times the rate of the second platform in the same direction. The second mode shows that the second platform will move at the same rate as itself and at -1.48 times the rate of the first platform but in the opposite direction. Both of these solutions are valid and possible, but which of the modes would occur would be unknown until data from the flight were taken and compared. We will use accelerometers attach to the structure to acquire these data during the flight.

The gondola is important for the system analysis because it will provide the excitation for the support structure. The gondola is excited by the wind present at the different layers of the atmosphere throughout the flight profile. The wind data is taken from two sources: rocket sounding data taken from the 1960's in California and from real time wind data taken using lasers in White Sands, NM. The horizontal wind velocity derived from these data sources is shown below in Figure 15.

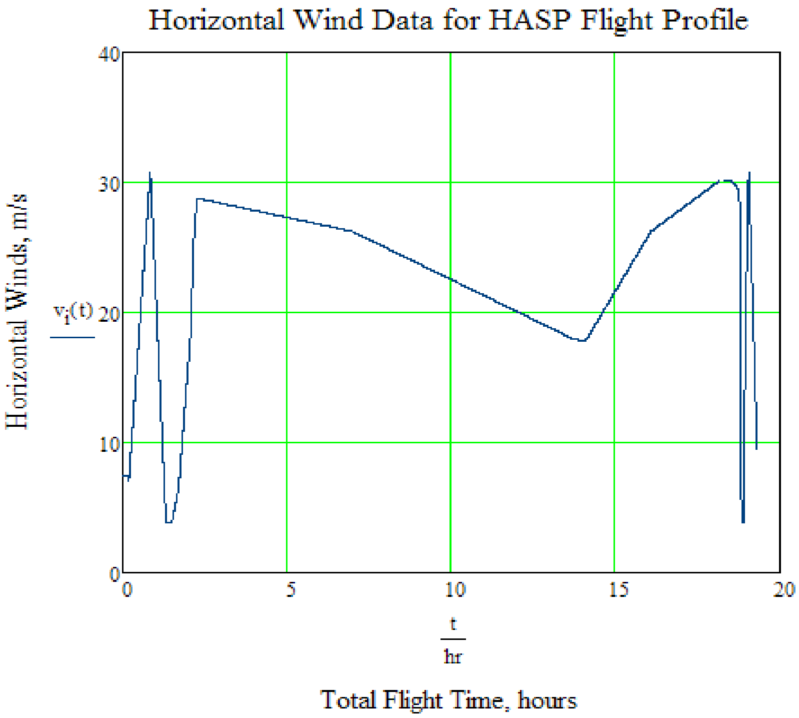


Figure 15: Horizontal Wind Data for HASP Flight Profile

The gondola experiences fluid-induced vibration due to vortex shedding. This analysis is possible because the gondola can be considered a blunt body (cube) present in a flow stream (atmospheric winds).This analysis requires that the mass of the gondola be known as well as the size, moment of inertia, Modulus of Elasticity, hydraulic diameter, and characteristic Strouhal number. Since there is no data given by HASP on the gondola other than the total weight (2000 lb), the actual size of the gondola was assumed to be an four foot cube (validity of this assumption can be checked in NASA’s “National Scientific Balloon Facility Recommendations for Gondola Design: April 1, 1986” presented in Appendix M). The gondola is also assumed to be constructed of mostly Aluminum. Both the moment of inertia as well as the hydraulic diameter is easily determined from the assumed dimensions of the gondola. The Strouhal number is a characteristic quantity that relates the velocity of the flow the frequency of oscillation that is constant for a wide range of flow regimes (i.e. wide range of Reynolds numbers). For a cube, the Strouhal number is given as .143 from Applied Scientific. This analysis will give the natural frequency of the gondola, as well as the velocity required to induce resonance. The actual frequencies of oscillation can also be determined from the analysis. From the analysis, the natural frequency as well as the exciting velocity can be seen below in Table 3.

Table 3: Gondola fluid-induced vibration analysis.

Natural Frequency	27968.87 rad/s
Excitation Velocity	37.95 km/s

Notice how high the natural frequency of the gondola is as well as the magnitude of the excitation velocity. The maximum wind reached during the flight is only about 30.8 m/s; therefore, it can be said with very high confidence that resonance will never occur for the gondola. Figure 16 displays the frequencies of oscillation for the gondola as well as the payload itself.

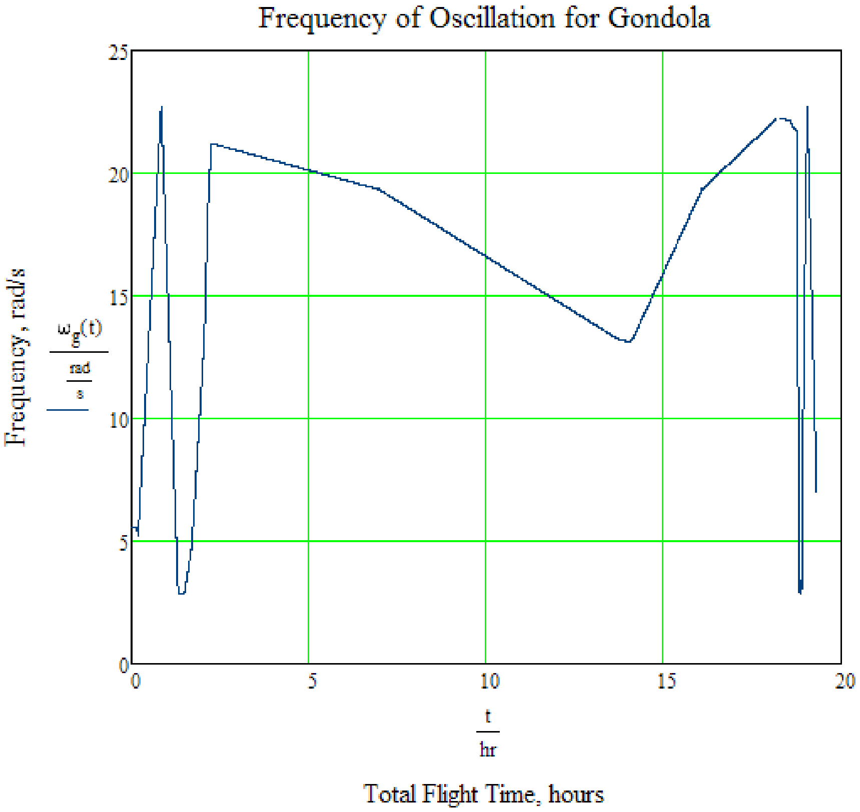


Figure 16: Frequency of Oscillation for Gondola

This figure shows that the maximum amplitude of oscillation is only 22.7 rad/s, well below the natural frequencies of both the gondola and support structure. Vibration is therefore a trivial structural problem for the balloon payload as resonance will never be reached. As for the electronics, the noise induced by vibration of the system is only at maximum 3.6 Hz, well below the range of interest for this experiment (55-65 GHz), so vibration should not be a major component of the total noise. We will compare these theoretical data with experimental data obtained by our payload through accelerometer placed in our payload.

II. Power Specifications:

A. Measured current draw at 30 VDC:

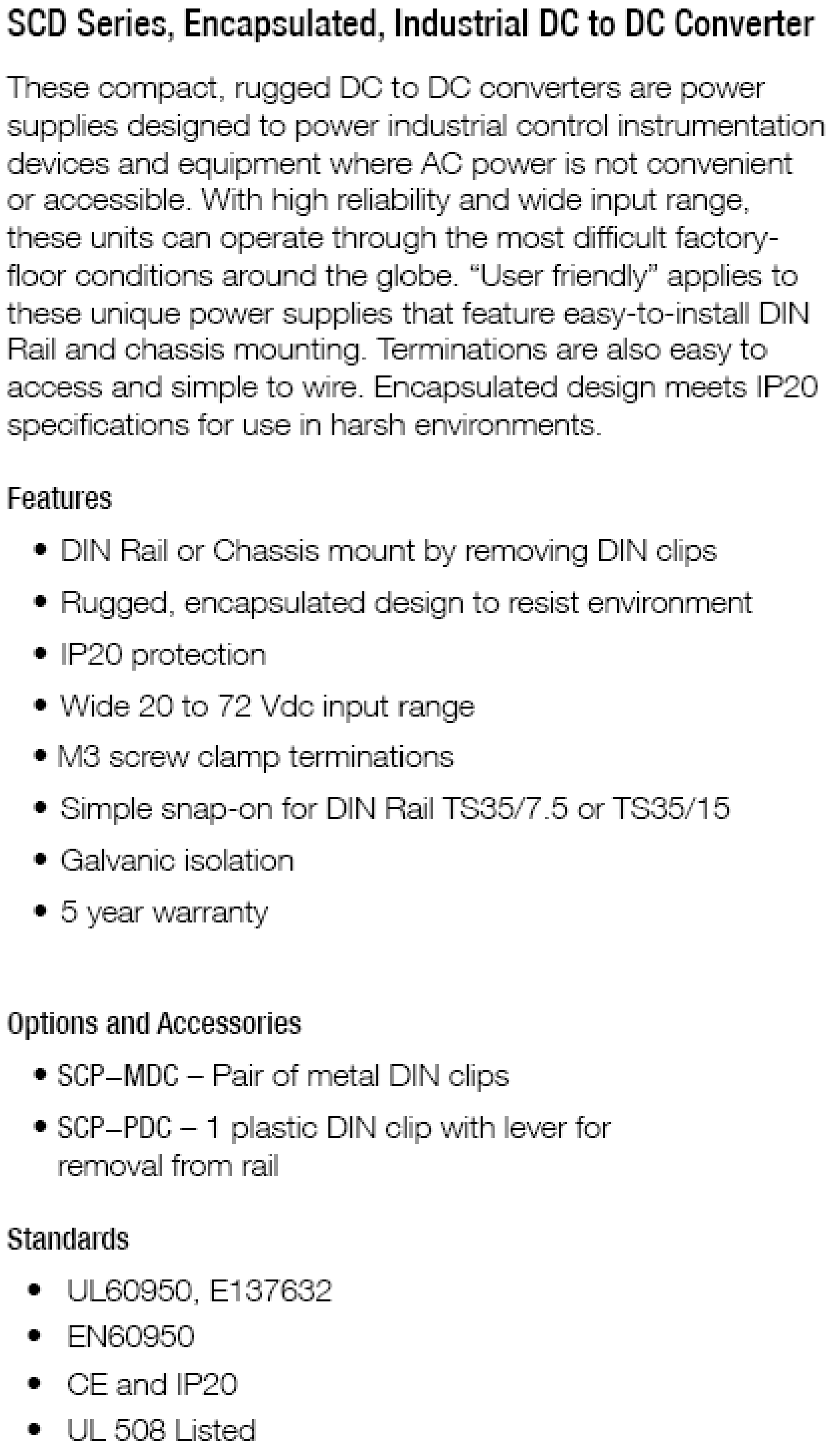
We will connect in parallel, using the EDAC 516 connector, two main systems:

1) The microwave radiometer, operating with a voltage of 15 volts.
2) The data acquisition unit a Intel Desktop DG4SFC w/Intel Pentium Dual Core motherboard that will operate at a voltage of 12 volts. The motherboard will also supply a reference voltage (from 0 to 5V) for the VCO in our radiometer.

According to our lab tests the current draw for the radiometer is 1.78 amps. This gives a power consumption of 26.7 Watts for the radiometer. The power will be supplied by a DC-DC switching power supply and converter, model Sola SCD30S15-DIN. The power supply will be powered by the HASP 30 Volts battery and it will convert the 30 Volts into the 15 Volts operating voltage of the radiometer electronics.

The current draw for the motherboard will be equal to 2 amps. The expected power requirement of the motherboard is around 30 watts.

The conversion from 30 VDC to 12VDC will be achieved by a DC-DC power supply and converter, model Sola SCD30S12-DN switching power supply. Following are the description and specifications of these electronic components.



SCD Series, Encapsulated, Industrial DC to DC Converter

These compact, rugged DC to DC converters are power supplies designed to power industrial control instrumentation devices and equipment where AC power is not convenient or accessible. With high reliability and wide input range, these units can operate through the most difficult factory-floor conditions around the globe. “User friendly” applies to these unique power supplies that feature easy-to-install DIN Rail and chassis mounting. Terminations are also easy to access and simple to wire. Encapsulated design meets IP20 specifications for use in harsh environments.

Features

- DIN Rail or Chassis mount by removing DIN clips
- Rugged, encapsulated design to resist environment
- IP20 protection
- Wide 20 to 72 Vdc input range
- M3 screw clamp terminations
- Simple snap-on for DIN Rail TS35/7.5 or TS35/15
- Galvanic isolation
- 5 year warranty

Options and Accessories

- SCP–MDC – Pair of metal DIN clips
- SCP–PDC – 1 plastic DIN clip with lever for removal from rail

Standards

- UL60950, E137632
- EN60950
- CE and IP20
- UL 508 Listed

UL 508 Listed
IND. CONT.
EQ.E61379

UL 60950
E137662
CUL/CSA-
C22.2
No. 234-M90

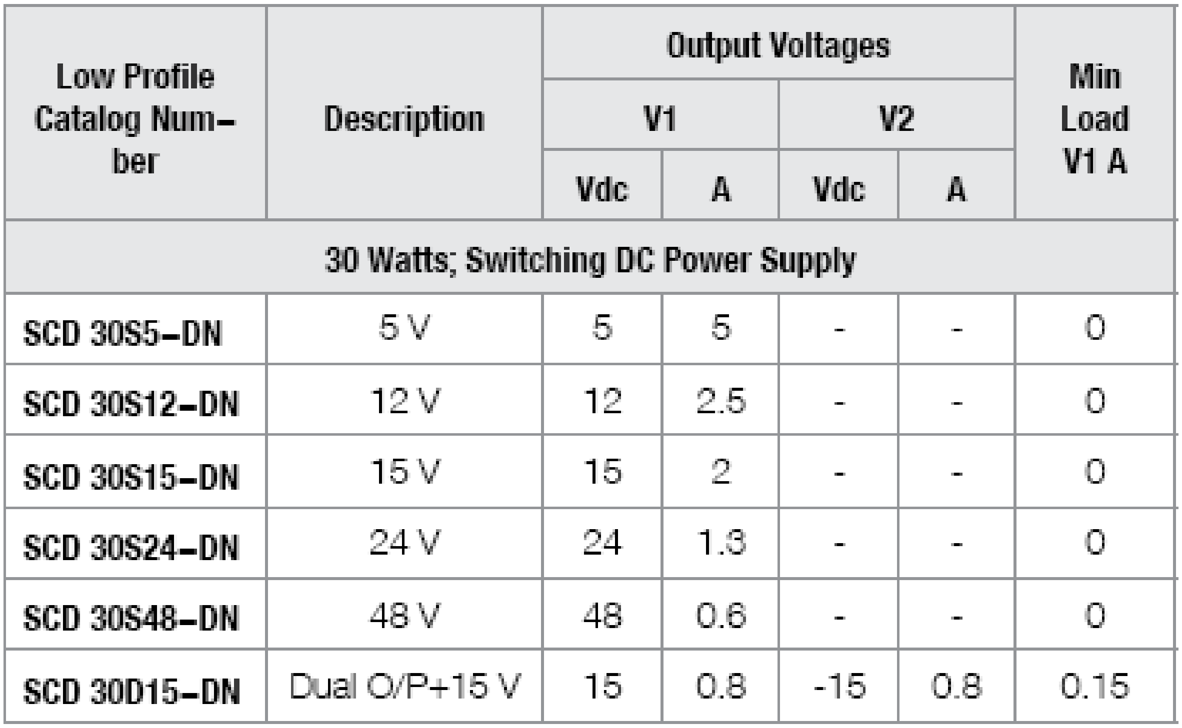
EMC and
Low Volt.
Directive

Applications

These units regulate voltage for sensitive electronic equipment run from battery power. For example, a 24 Vdc battery system where the battery voltage can be 30 volts, sometimes higher during charging, and dip below 22 volts under heavy load. The SCD can be used to stabilize the voltage for those devices not designed to handle wider voltage swings.

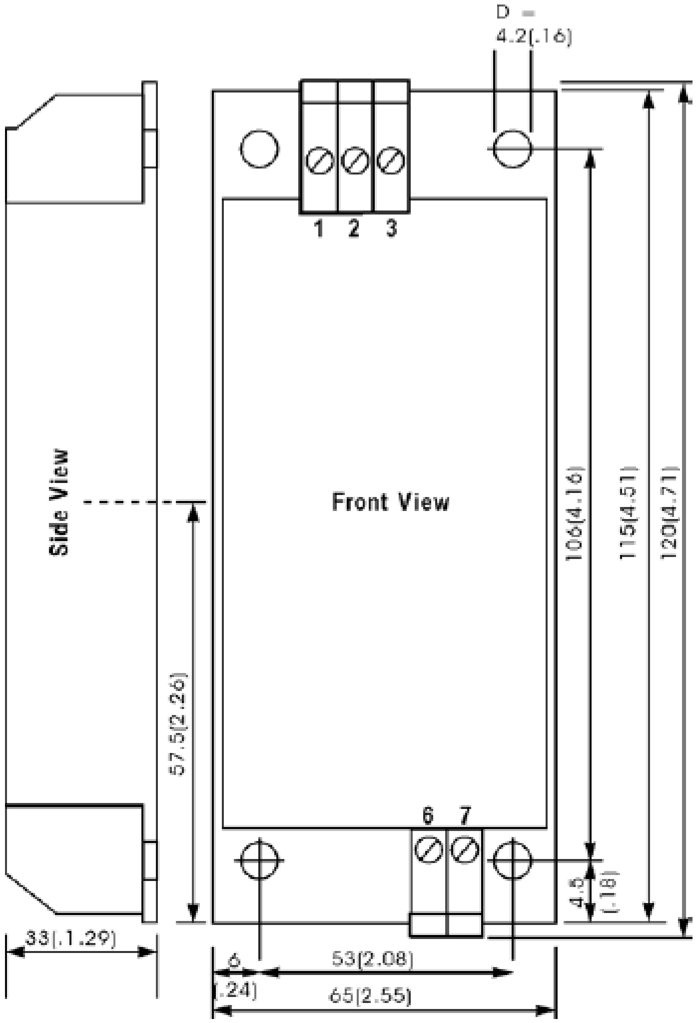
They are also a convenient and inexpensive alternative to running AC power through a large industrial machine. The SCD can use 24 Vdc commonly available on many parts of the machine to create other voltages needed to run sensors, transducers and other devices that the machine requires to work properly.

- Industrial
    - Encoders, special sensors, communications and instrumentation
- Telecommunications systems
- Remote Site/Harsh Environment



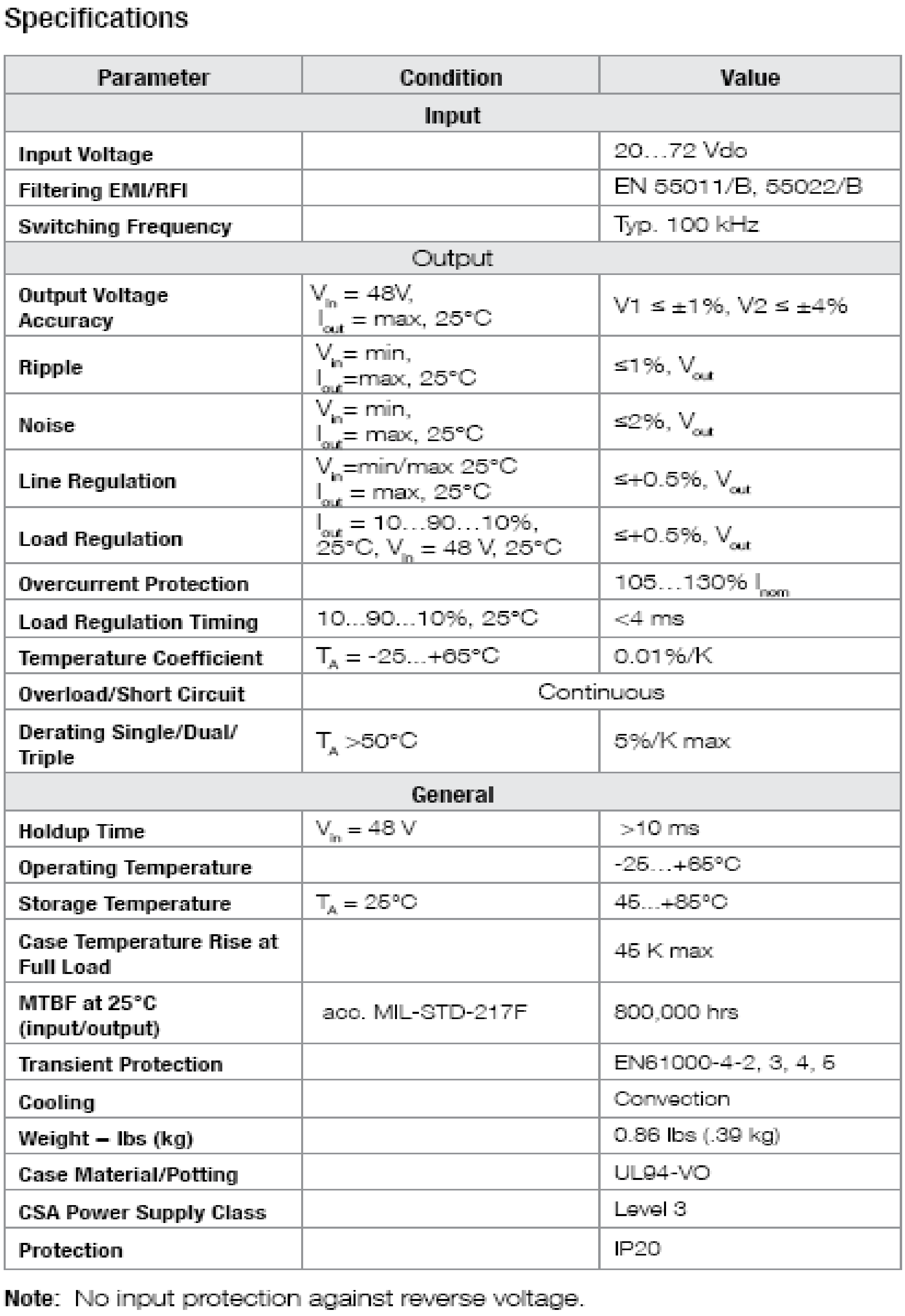
Low Profile Catalog Number	Description	Output Voltages				Min Load V1 A
		V1		V2		
		Vdc	A	Vdc	A	
30 Watts; Switching DC Power Supply						
SCD 30S5–DN	5 V	5	5	-	-	0
SCD 30S12–DN	12 V	12	2.5	-	-	0
SCD 30S15–DN	15 V	15	2	-	-	0
SCD 30S24–DN	24 V	24	1.3	-	-	0
SCD 30S48–DN	48 V	48	0.6	-	-	0
SCD 30D15–DN	Dual O/P+15 V	15	0.8	-15	0.8	0.15

Dimensions



Pin-Out

SCD 30	1	2	3	6	7
Single	+V1	-V1		+IN	-IN
Dual	V1	COM	V2	+IN	-IN



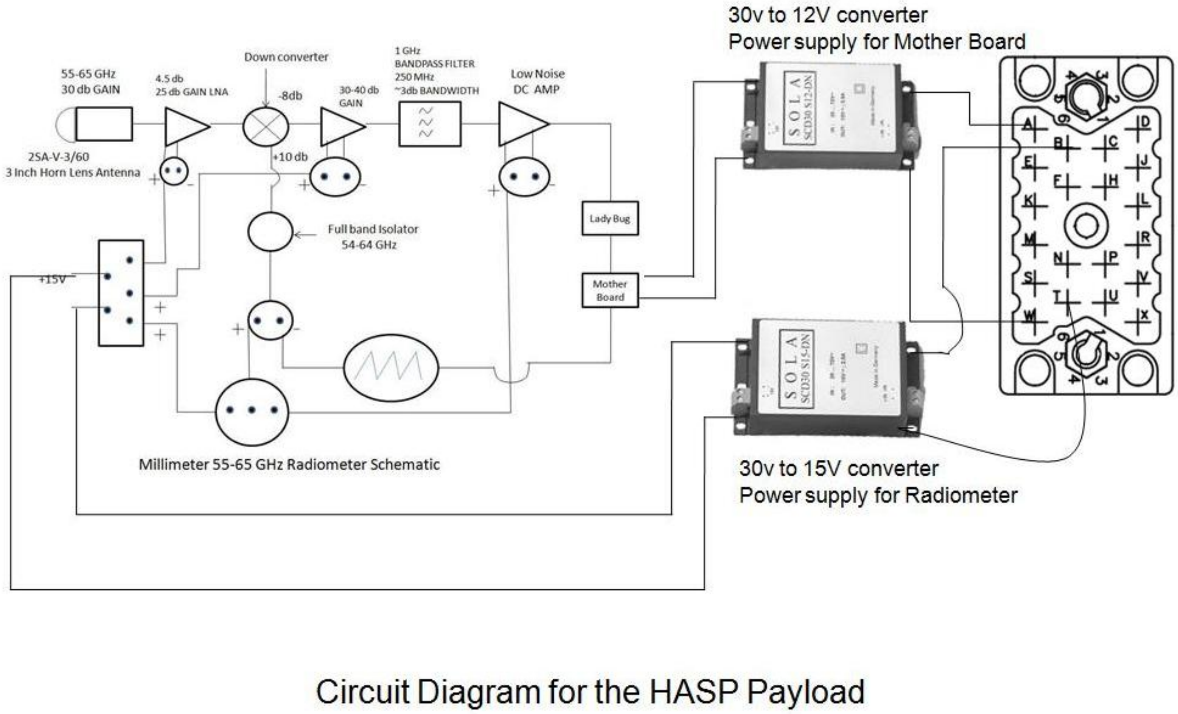
Specifications

Parameter	Condition	Value
Input		
Input Voltage		20…72 Vdc
Filtering EMI/RFI		EN 55011/B, 55022/B
Switching Frequency		Typ. 100 kHz
Output		
Output Voltage Accuracy	V_{in} = 48V, I_{out} = max, 25°C	V1 ≤ ±1%, V2 ≤ ±4%
Ripple	V_{in}= min, I_{out}=max, 25°C	≤1%, V_{out}
Noise	V_{in}= min, I_{out}= max, 25°C	≤2%, V_{out}
Line Regulation	V_{in}=min/max 25°C I_{out} = max, 25°C	≤+0.5%, V_{out}
Load Regulation	I_{out} = 10…90…10%, 25°C, V_{in} = 48 V, 25°C	≤+0.5%, V_{out}
Overcurrent Protection		105…130% I_{nom}
Load Regulation Timing	10...90...10%, 25°C	<4 ms
Temperature Coefficient	T_A = -25...+65°C	0.01%/K
Overload/Short Circuit	Continuous	
Derating Single/Dual/ Triple	T_A >50°C	5%/K max
General		
Holdup Time	V_{in} = 48 V	>10 ms
Operating Temperature		-25…+65°C
Storage Temperature	T_A = 25°C	45...+85°C
Case Temperature Rise at Full Load		45 K max
MTBF at 25°C (input/output)	acc. MIL-STD-217F	800,000 hrs
Transient Protection		EN61000-4-2, 3, 4, 5
Cooling		Convection
Weight – lbs (kg)		0.86 lbs (.39 kg)
Case Material/Potting		UL94-VO
CSA Power Supply Class		Level 3
Protection		IP20

Note: No input protection against reverse voltage.

B. If HASP is providing power to your payload, provide a power system wiring diagram starting from pins on the student payload interface plate EDAC 516 connector through your power conversion to the voltages required by your subsystems.

Electrical Diagrams of MRE II payload:



Circuit Diagram for the HASP Payload

Figure 17: Schematics of the power connections to the EDAC 516 connector for the MRE II payload.

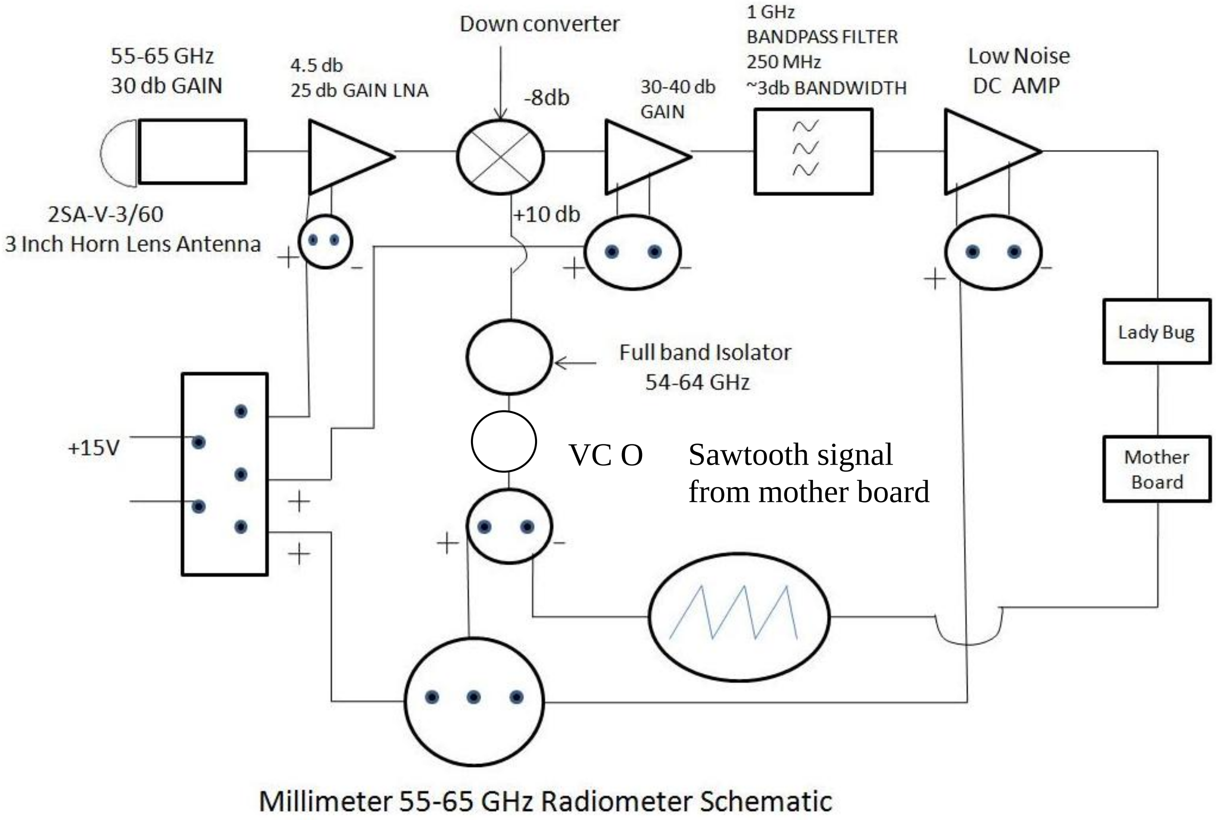


Figure 18: Details of the radiometer electrical connections and components. The 15V power source Sola SCD30S15-DIN is connected in parallel to DC amps and VCO. The total current draw is 1.78 amps.

Subsistems:

3 LN Amplifiers, operating voltage between 15 and 10 Volts.

1 VCO, operating voltage 15 volts.

Motherboard, operating voltage 12 volts 30 Watts at full power.

C. Other relevant power information

THERMAL SYSTEM POWER INFORMATION:

Given the power dumped in the payload box and preliminary thermal tests done at the McNeese lab we expect that interior of the payload box will be within operational temperatures. In case of excessive heat the mother board will shutdown saving the last collected data. We inserted heat sinks in our design which consist of copper strips that physically connect the ladybug and motherboard heat radiator blades with the aluminum shell of the payload, in order to dump heat first through conduction and then radiation in the environment surrounding the box (or through convection in the lower atmosphere).

In case the temperature inside the box (near critical components) reaches a temperature closer to the lower values of our operating range (we would not like to reach a temperature below 0 centigrade) we will have the support of heaters.

The heaters, 4 sets of ceramic power resistors will be powered by batteries inside the MRE II payload and will not require power from HASP. The heaters will be fused and controlled by the motherboard through analog signal. The motherboard will sense the internal temperature of the payload (near the motherboard itself and near the ladybug power sensor which are critical components that have near room temperature operating temperatures.
Power resistors were used by a McNeese's La-ACES team in the past and they worked better than expected on that project. Figure 19 displays the power resistor used.

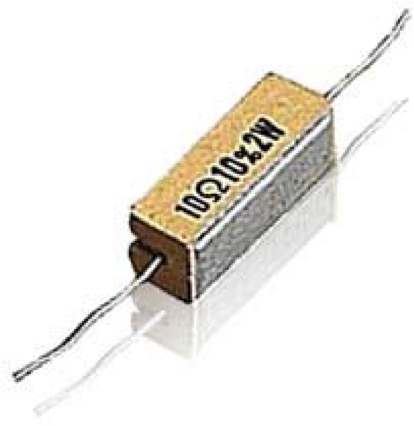


Figure 19: Wirewound power resistor from Radioshack.

In order to accommodate power usage two sets of 50 ohm power resistors will start at 15°C and cut off at 27°C. Those two sets are called the primary resistor set. The secondary resistor set, with resistances of 12 ohm each, will start at 10°C and cut off at 20°C which reduces the amount of energy that is necessary to the thermal system.
The thermal system will be powered by D sized lithium ion batteries that are used for military projects going into the atmosphere. Figure 20 displays the military grade D batteries used for the project.

Figure 20: LS 33600C Saft D Batteries.

The primary system will use 6 of these batteries in series, and the secondary will use 3 series. The secondary system will use fewer batteries since the secondary system is not expected to run as long as the primary system. The primary system however is designed to run for the whole flight time just in case such a scenario was to occur. The power output from these batteries is acquired from Ohm's Law which allows for the life of the batteries to be determined as well.

III. Downlink Telemetry Specifications:

A. Serial data downlink format: [✓ Stream] Packetized (circle one)

B. Approximate serial downlink rate (in bits per second)

(binary data)

17 bytes x 8 bits x 2 data streams x 34 samples per second = 4624 baud = 9248 bits per second.

This is within the large payload serial downlink limits.

C. Specify your serial data record including record length and information contained in each record byte.

Table 4: serial data record format and information.

Byte	**Bits**	**Description**
1	0-7	Record type indicator
2-5	0-31	Timestamp (seconds since Jan 1, 1970)

6-9	0-31	Timestamp (nanoseconds past the last second)
10-11	0-15	Record Size
12	0-7	Least significant 8 bits of the recorded checksum
13-16	0-31	Data: Power average over last 1/34 of a second
17-20	0-31	Data: Temperature inside the box over last 1/34 of a second

D. Number of analog channels being used:

2.

E. If analog channels are being used, what are they being used for?

1) Temperature inside the box (for comparison with downlinked data).
2) Solar light intensity outside the box (to compare with microwave background power).

F. Number of discrete lines being used:

None.

G. If discrete lines are being used what are they being used for?

NA

H. Are there any on-board transmitters? If so, list the frequencies being used and the transmitted power.

No transmitter present.

I. Other relevant downlink telemetry information.

Data will also be recorded and write to file in the onboard data acquisition system. The sampling rate will be of 104 samples per second. This is 3 times higher sampling rate than the one for the downlinked information. If it is possible and relatively easy to do for the operator we will like to access the analog information during the flight, even if few times per hour. This is not a critical need and we can easily forfeit this request if flight operation conditions do not allow.

IV. Uplink Commanding Specifications:

A. Command uplink capability required: [✓ Yes] No (circle one)

B. If so, will commands be uplinked in regular intervals: [✓ Yes] No (circle one)

C. How many commands do you expect to uplink during the flight (can be an absolute number or a rate, i.e. *n commands per hour*)

3 per hours (only if needed).

D. Provide a table of all of the commands that you will be uplinking to your payload.

Table 5: Uplink commands.

Command 1	Turn on or off heaters (if needed)	If temperature goes above or below certain values and automated temperature control code is now working properly we will turn on or off the heaters manually through this command.
Command 2	Restart data acquisition codes (if needed)	If the data acquired through downlink are not in the expected range and inconsistent we will try to restart the data acquisition codes.
Command 3	Restart onboard MRE II computer (if needed)	If Command 2 doesn’t ameliorate the condition in row 2, column 3 of this table, we will try to restart the operating system of our payload onboard computer.

E. Are there any on-board receivers? If so, list the frequencies being used.

None.

F. Other relevant uplink commanding information.

The uplink command will be used only if flight conditions require them. If our data is somehow corrupted we could try to restart the data acquisition codes or even reboot the entire system.

V. Integration and Logistics

A. Date and Time of your arrival for integration:

August 1nd 2009, 1:00 PM.

B. Approximate amount of time required for integration:

About 5 hours.

C. Name of the integration team leader:

Sagar Kharel.

D. Email address of the integration team leader:

Sagar_kharel84@yahoo.com

E. List **ALL** integration participants (first and last names) who will be present for integration with their email addresses:

Sagar Kharel, team leader.

Giovanni Santostasi, advisor.

F. Define a successful integration of your payload:

The payload is not obstructed by any structure of the HASP gondola. The electronics of the radiometer are working continuously over the integration testing period, in the condition similar to the one encountered during a typical flight. The data acquisition system works properly at the specified sampling rate. Data is stored and written to file in the memory of the mother board. The mother board can produce the required analog signal to control the VCO of the radiometer. The mother board communicates with the HASP dowlinking instrumentation. Uplinking commands are executed properly. Analog data is communicated properly to HASP. Heaters and heat sinks work properly, temperature inside the box doesn’t go over established operational range.

G. List all expected integration steps:

Mechanical:

1) Secure payload to the HASP frame.
2) Check all the internal structural parts of the payload.

3) Close and secure payload top.

Electrical:

1) Connect payload through power connector.
2) Check voltage and current of power supplies.
3) Check voltage and current across radiometer.
4) Check voltage and current output of motherboard (for VCO).

Data acquisition:

1) Connect USB cable of LadyBug power sensor to motherboard
2) Check Ladybug power sensor works properly (use display mode)
3) Check Ladybug logger works and writes to text file
4) Check MatLab code reads textfile and produces binary data for downlink
5) Check timestamp is correct in text file

Downlink:

1) Connect serial connector to motherboard
2) Check data format and rate
3) Check consistency of dowlinked data with textfile
3) Check analog signals and sensors

Uplink:

1) Test correct operation of 3 uplink commands
2) Test time delay between sending of commands and execution of commands

Temperature:

1) Load battery holders with batteries
2) Thermal sensors testing

H. List all checks that will determine a successful integration:

Mechanical:

1) Bolts and fasteners are secure
2) Payload internal structures are tied and secure

3) Top of shell is fastened securely

Electrical:

1) Power connector is secured
2) Voltage and current of power supplies, amplifiers and mother board as expected
3) Voltage and current at amplifier is within expected values.
4) Motherboard power output for VCO is correct (0-5 V)

Data acquisition:

4) USB cable of LadyBug power sensor is connected to motherboard
5) Ladybug power sensor works properly (use display mode)
6) Ladybug logger works and writes to text file
4) MatLab code reads textfile and produces binary data for downlink
5) Timestamp is correct in text file (use reference clock in laptop)

Downlink:

1) Serial connector is connected to motherboard
2) Data format and rate are correct
3) Dowlinked data is consistent with textfile
3) Analog signals and sensors are ok

Uplink:

1) 3 uplink commands work
2) Time delay between sending of commands and execution of commands is within few minutes (how many?)

Temperature:

1) Battery holders have batteries
2) Thermal sensors are working

I. List any additional LSU personnel support needed for a successful integration other than directly related to the HASP integration (i.e. lifting, moving equipment, hotel information/arrangements, any special delivery needs…):

Dr. Guzik and/or Mr. Jim Giammanco for possible consultation on data acquisition and electronic issues.

J. List any LSU supplied equipment that may be needed for a successful integration:

None.