

# Avionics Reference Document

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# 1 Introduction

The Avionics Reference Document (ARD) is a high level document describing what the onboard avionics system will do. The onboard avionics system is referred to as The Helix System. It consists of multiple circuit boards called Extension Boards which can read data from sensors through the rocket or interact with actuators throughout the rocket. These Extension boards are all connected together in a ring topology which allows new Extension Boards to be added or removed from the system without impacting performance of the rest of the system. These Extension Boards all connect with a central board called the Onboard Computer (OBC) which collects data, makes decisions based on data, communicates with ground support systems, and records data.

## 1.1 Purpose

The purpose of this document is to outline for non avionics members a unified reference for how the onboard computer will behave and why. Primary focus will be given to the different states that the rocket can be in (ie dry systems, leak check), what actions will be performed in each state, and what causes the transition between different states. This will be documented through extensive use of state machine diagrams.

Old version:

The purpose of this document is to act as a reference for how the OBC will behave. This includes:

1. How the system will react to failures such as disconnected sensors and over-pressurization events.
2. The states the rocket can be in including dry systems, leak check, launch, or even a failure state.
3. The ranges and accuracy of sensors in the system.
4. The rate at which sensors will be measured at.
5. System architecture and how data flows throughout the system.

## 1.2 Scope

This document includes:

1. How the system will react to failures such as disconnected sensors and over-pressurization events.
2. The states the rocket can be in including dry systems, leak check, launch, or even a failure state.
3. The ranges and accuracy of sensors in the system.
4. The rate at which sensors will be measured at.
5. System architecture and how data flows throughout the system.

Old version:

This document should be viewed from the perspective of a non-avionics member who wants to know what the onboard avionics system will do. This means outlining that steps between turning the system on to launch and recovery of the rocket. Failure modes and how to deal with errors are outlined in this document. The ARD also contains information regarding hardware that will be onboard the rocket, its specifications, and links to the relevant datasheets. Where appropriate more detailed technical information is included as reference material to the engineers designing the system.

## 1.3 Definitions and Acronyms

## 2 Hardware

### 2.1 Pressure Transducers

Model Number	MLH05KPSB01G
Serial Number	F8CEA38AA5
Usage	Helium Pressure PT
Usage	Ethanol Pressure PT
Usage	Chamber Pressure PT
Datasheet Link	<a href="#">Link</a>
Sensing Units	PSIG
Pressure Port Type	1/4-18 NPT (ANSI B1.20.1)
Accuracy	±0.25%
Pressure Range	0PSIG to 5000PSIG
Sample Rate	50Hz
Output Voltage Range	1.0 to 5.0 Volts
Input Voltage Range	8.0 to 30.0 Volts
Temperature Range	-40°to +125°Celcius

Model Number	ASUHGP1K55A1AA1A20000
Serial Number	E5C0ADEA35
Usage	LOX Pressure PT
Datasheet Link	<a href="#">Link</a>
Sensing Units	PSIG
Pressure Port Type	3/8 Inch 24 UNF Dash 3 (SAE J514)
Accuracy	±0.25%
Pressure Range	0PSIG to 1000PSIG
Sample Rate	50Hz
Output Voltage Range	0.5 to 4.5 Volts
Input Voltage Range	8.0 to 16.0 Volts
Temperature Range	-40°to +150°Celcius

### 2.2 Thermocouples

Model Number	240-080
Serial Number	BB510C3CE3
Usage	Ethanol Tank Temperature Data
Usage	Nozzle Temperature Data
Datasheet Link	<a href="#">Link</a>
Type	K
Sensing Units	Celcius
Sample Rate	10Hz
Temperature Range	-73°to +150°Celcius

Model Number	240-080
Serial Number	BB51033CE3
Usage	Unused
Datasheet Link	<a href="#">Link</a>
Type	K
Sensing Units	Celcius
Sample Rate	10Hz
Temperature Range	-73°to +150°Celcius

## 2.3 RTDs

Model Number	1PT100K2515
Serial Number	8105874731
Usage	LOX Tank Temperature
Datasheet Link	<a href="#">Link</a>
Type	PT100
Sensing Units	Celcius
Sample Rate	10Hz
Temperature Range	-200° to +150° Celcius

## 2.4 Hall Effect Sensors

Model Number	TCS40DPR
Serial Number	6D65BA9367
Usage	LOX Fill Valve Hall Effect
Usage	Ethanol Fill Valve Hall Effect
Datasheet Link	<a href="#">Link</a>
Sensing Units	mT
Output Type	Push-Pull
Trip	$\pm 4.4\text{mT}$
Release	$\pm 0.9\text{mT}$
Input Voltage Range	8.0 to 16.0 Volts
Sample Rate	10Hz
Temperature Range	-40° to +150° Celcius



## 3 States

### 3.1 STATE LEAK CHECK

#### 3.1.1 Helium Pressure PT Data

Return values

<i>STATE_LEAK_CHECK</i>	Continue in the leak check state.
<i>STATE_IDLE</i>	Finished leak check so return to the idle state.
<i>STATE_GROUND_SAFE</i>	Return to the ground safe state because the helium tank pressure is overpressurized.

When Helium Pressure PT Data is received the CANID will be printed to stdout and the data will be printed as a string to stdout. The current time and data with milliseconds is then printed to stdout. The received `can_frame` is added to the `eventTimer` so that the received frame will be received again in 1 second. The system then continues on in the leak check state.

## 4 EEPROM Layouts

### 4.1 Layout Version IDs

VersionID	Version Name
1	Sensor Board Layout Rev 1
2	Power Distro Board Layout Rev 1

## 4.2 Sensor Board Layout Rev 1

Sensor Board Layout Rev 1 Page #0					
Byte #	Usage	Byte #	Usage	Byte #	Usage
0	Layout Rev Number	48	PT0 Min Pressure	96	PT0 Biquad Filter a2
1		49		97	
2		50		98	
3		51		99	
4	EEPROM Layout Compile Time	52	PT0 Calibration Polyfit p1	100	PT1 Data CanID
5		53		101	
6		54		102	
7		55		103	
8	Board Status	56	PT0 Calibration Polyfit p2	104	PT1 Current CanID
9		57		105	
10		58		106	
11		59		107	
12	Board VIN Voltage CanID	60	PT0 Calibration Polyfit p3	108	PT1 Data Frequency
13		61		109	
14		62		110	
15		63		111	
16	Board VIN Current CanID	64	PT0 Calibration Polyfit p4	112	PT1 Sample Rate
17		65		113	
18		66		114	
19		67		115	
20	PT0 Data CanID	68	PT0 Calibration Polyfit p5	116	PT1 Max Output Voltage
21		69		117	
22		70		118	
23		71		119	
24	PT0 Current CanID	72	PT0 Calibration Polyfit p6	120	PT1 Min Output Voltage
25		73		121	
26		74		122	
27		75		123	
28	PT0 Data Frequency	76	PT0 Calibration Polyfit p7	124	PT1 Max Pressure
29		77		125	
30		78		126	
31		79		127	
32	PT0 Sample Rate	80	PT0 Biquad Filter b0		
33		81			
34		82			
35		83			
36	PT0 Max Output Voltage	84	PT0 Biquad Filter b1		
37		85			
38		86			
39		87			
40	PT0 Min Output Voltage	88	PT0 Biquad Filter b2		
41		89			
42		90			
43		91			
44	PT0 Max Pressure	92	PT0 Biquad Filter a1		
45		93			
46		94			
47		95			

Sensor Board Layout Rev 1 Page #1					
Byte #	Usage	Byte #	Usage	Byte #	Usage
128	PT1 Min Pressure	176	PT1 Biquad Filter a2	224	PT2 Calibration Polyfit p4
129		177		225	
130		178		226	
131		179		227	
132	PT1 Calibration Polyfit p1	180	PT2 Data CanID	228	PT2 Calibration Polyfit p5
133		181		229	
134		182		230	
135		183		231	
136	PT1 Calibration Polyfit p2	184	PT2 Current CanID	232	PT2 Calibration Polyfit p6
137		185		233	
138		186		234	
139		187		235	
140	PT1 Calibration Polyfit p3	188	PT2 Data Frequency	236	PT2 Calibration Polyfit p7
141		189		237	
142		190		238	
143		191		239	
144	PT1 Calibration Polyfit p4	192	PT2 Sample Rate	240	PT2 Biquad Filter b0
145		193		241	
146		194		242	
147		195		243	
148	PT1 Calibration Polyfit p5	196	PT2 Max Output Voltage	244	PT2 Biquad Filter b1
149		197		245	
150		198		246	
151		199		247	
152	PT1 Calibration Polyfit p6	200	PT2 Min Output Voltage	248	PT2 Biquad Filter b2
153		201		249	
154		202		250	
155		203		251	
156	PT1 Calibration Polyfit p7	204	PT2 Max Pressure	252	PT2 Biquad Filter a1
157		205		253	
158		206		254	
159		207		255	
160	PT1 Biquad Filter b0	208	PT2 Min Pressure		
161		209			
162		210			
163		211			
164	PT1 Biquad Filter b1	212	PT2 Calibration Polyfit p1		
165		213			
166		214			
167		215			
168	PT1 Biquad Filter b2	216	PT2 Calibration Polyfit p2		
169		217			
170		218			
171		219			
172	PT1 Biquad Filter a1	220	PT2 Calibration Polyfit p3		
173		221			
174		222			
175		223			

Sensor Board Layout Rev 1 Page #2					
Byte #	Usage	Byte #	Usage	Byte #	Usage
256	PT2 Biquad Filter a2	304	HE2 Sample Rate	352	TC1 Biquad Filter b0
257		305		353	
258		306		354	
259		307		355	
260	HE0 Data CanID	308	TC0 Data CanID	356	TC1 Biquad Filter b1
261		309		357	
262		310		358	
263		311		359	
264	HE0 Current CanID	312	TC0 Data Frequency	360	TC1 Biquad Filter b2
265		313		361	
266		314		362	
267		315		363	
268	HE0 Data Frequency	316	TC0 Sample Rate	364	TC1 Biquad Filter a1
269		317		365	
270		318		366	
271		319		367	
272	HE0 Sample Rate	320	TC0 Biquad Filter b0	368	TC1 Biquad Filter a2
273		321		369	
274		322		370	
275		323		371	
276	HE1 Data CanID	324	TC0 Biquad Filter b1	372	RTD0 Data CanID
277		325		373	
278		326		374	
279		327		375	
280	HE1 Current CanID	328	TC0 Biquad Filter b2	376	RTD0 Data Frequency
281		329		377	
282		330		378	
283		331		379	
284	HE1 Data Frequency	332	TC0 Biquad Filter a1	380	RTD0 Sample Rate
285		333		381	
286		334		382	
287		335		383	
288	HE1 Sample Rate	336	TC0 Biquad Filter a2		
289		337			
290		338			
291		339			
292	HE2 Data CanID	340	TC1 Data CanID		
293		341			
294		342			
295		343			
296	HE2 Current CanID	344	TC1 Data Frequency		
297		345			
298		346			
299		347			
300	HE2 Data Frequency	348	TC1 Sample Rate		
301		349			
302		350			
303		351			

Sensor Board Layout Rev 1 Page #3					
Byte #	Usage	Byte #	Usage	Byte #	Usage
384	RTD0 Biquad Filter b0	432	RTD1 Biquad Filter a2	480	
385		433		481	
386		434		482	
387		435		483	
388	RTD0 Biquad Filter b1	436	CS0 Data CanID	484	
389		437		485	
390		438		486	
391		439		487	
392	RTD0 Biquad Filter b2	440	CS0 Biquad Filter b0	488	
393		441		489	
394		442		490	
395		443		491	
396	RTD0 Biquad Filter a1	444	CS0 Biquad Filter b1	492	
397		445		493	
398		446		494	
399		447		495	
400	RTD0 Biquad Filter a2	448	CS0 Biquad Filter b2	496	
401		449		497	
402		450		498	
403		451		499	
404	RTD1 Data CanID	452	CS0 Biquad Filter a1	500	
405		453		501	
406		454		502	
407		455		503	
408	RTD1 Data Frequency	456	CS0 Biquad Filter a2	504	
409		457		505	
410		458		506	
411		459		507	
412	RTD1 Sample Rate	460		508	
413		461		509	
414		462		510	
415		463		511	
416	RTD1 Biquad Filter b0	464			
417		465			
418		466			
419		467			
420	RTD1 Biquad Filter b1	468			
421		469			
422		470			
423		471			
424	RTD1 Biquad Filter b2	472			
425		473			
426		474			
427		475			
428	RTD1 Biquad Filter a1	476			
429		477			
430		478			
431		479			

### 4.3 Power Distro Board Layout Rev 1

Power Distro Board Layout Rev 1 Page #0					
Byte #	Usage	Byte #	Usage	Byte #	Usage
0	Board Status	48		96	
1		49		97	
2		50		98	
3		51		99	
4	Offboard Battery Voltage CANID	52		100	
5		53		101	
6		54		102	
7		55		103	
8	Offboard Battery Current CANID	56		104	
9		57		105	
10		58		106	
11		59		107	
12	Onboard Battery Voltage CANID	60		108	
13		61		109	
14		62		110	
15		63		111	
16	Onboard Battery Current CANID	64		112	
17		65		113	
18		66		114	
19		67		115	
20	Helix Loop CW Voltage CANID	68		116	
21		69		117	
22		70		118	
23		71		119	
24	Helix Loop CW Current CANID	72		120	
25		73		121	
26		74		122	
27		75		123	
28	Helix Loop CCW Voltage CANID	76		124	
29		77		125	
30		78		126	
31		79		127	
32	Helix Loop CCW Current CANID	80			
33		81			
34		82			
35		83			
36		84			
37		85			
38		86			
39		87			
40		88			
41		89			
42		90			
43		91			
44		92			
45		93			
46		94			
47		95			

## 5 CAN IDs

### 5.1 CAN Bus Load Calculations

The current CAN Bus config requires between 32456 bits and 38945 bits to be sent on the CAN bus every second.

Frequency	Best Case	Worst Case
100KHz	32.0%	39.0%
250KHz	13.0%	16.0%
500KHz	6.0%	8.0%
1MHz	3.0%	4.0%

### 5.2 ID 0 - Primary Clock Sync

Frequency: 50Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False	0 to 4294967295	Milliseconds	Time since system start

### 5.3 ID 1 - OBC Clock Sync

Frequency: 50Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False	0 to 4294967295	Milliseconds	Time since system start

### 5.4 ID 10 - Emergency Signal

Frequency: 50Hz

Byte	Bit	Signed	Range	Units	Description
0		False			Status
	0-1				System Status

### 5.5 ID 50 - Transition Cone Status

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0		False			Status
	0				Armed

### 5.6 ID 60 - Arm Recovery

Frequency: 0Hz

Byte	Bit	Signed	Range	Units	Description
0		False			Status
	0				Arm Recovery

### 5.7 ID 61 - Detatch Second Stage

Frequency: 0Hz

Byte	Bit	Signed	Range	Units	Description
0		False			Status
	0				Detatch Second Stage

## 5.8 ID 100 - Helium Pressure PT Data

Frequency: 50Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		False		PSIG	Helium Pressure
6-7		False		ADC counts	Raw Helium Pressure Measurement

## 5.9 ID 101 - LOX Pressure PT Data

Frequency: 50Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		False		PSIG	LOX Pressure
6-7		False		ADC counts	Raw LOX Pressure Measurement

## 5.10 ID 102 - Ethanol Pressure PT Data

Frequency: 50Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		False		PSIG	Ethanol Pressure
6-7		False		ADC counts	Raw Ethanol Pressure Measurement

## 5.11 ID 103 - Chamber Pressure PT Data

Frequency: 50Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		False		PSIG	Chamber Pressure
6-7		False		ADC counts	Raw Chamber Pressure Measurement

## 5.12 ID 200 - Helium Fill Valve Hall Effect State

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4		False		Open/Closed	Helium Fill Valve Hall Effect State

## 5.13 ID 201 - LOX Fill Valve Hall Effect State

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4		False		Open/Closed	LOX Fill Valve Hall Effect State



### 5.14 ID 202 - Ethanol Fill Valve Hall Effect State

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4		False		Open/Closed	Ethanol Fill Valve Hall Effect State

### 5.15 ID 250 - LOX Tank Liquid Level Data

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4		False		Percent	LOX Tank Liquid Level
5-6		False		Femtofarads	Raw LOX Tank Liquid Level Measurement

### 5.16 ID 251 - Ethanol Tank Liquid Level Data

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4		False		Percent	Ethanol Tank Liquid Level
5-6		False		Femtofarads	Raw Ethanol Tank Liquid Level Measurement

### 5.17 ID 300 - LOX Tank Temperature Data

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		Celcius	LOX Tank Temperature
6-7		False		ADC counts	Raw LOX Tank Temperature Measurement

### 5.18 ID 301 - Ethanol Tank Temperature Data

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		Celcius	Ethanol Tank Temperature
6-7		False		ADC counts	Raw Ethanol Tank Temperature Measurement

### 5.19 ID 302 - Nozzle Temperature Data

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		Celcius	Nozzle Temperature
6-7		False		ADC counts	Raw Nozzle Temperature Measurement

## 5.20 ID 303 - Upper Air Frame Temperature Data

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		Celcius	Upper Air Frame Temperature
6-7		False		ADC counts	Raw Upper Air Frame Temperature Measurement

## 5.21 ID 304 - ITC Temperature Data

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		Celcius	ITC Temperature
6-7		False		ADC counts	Raw ITC Temperature Measurement

## 5.22 ID 305 - Lower Air Frame Temperature Data

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		Celcius	Lower Air Frame Temperature
6-7		False		ADC counts	Raw Lower Air Frame Temperature Measurement

## 5.23 ID 400 - Helium Pressure PT Current

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		milliamps	Helium Pressure PT Current
6-7		False		ADC counts	Raw Helium Pressure PT Current Measurement

## 5.24 ID 401 - LOX Pressure PT Current

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		milliamps	LOX Pressure PT Current
6-7		False		ADC counts	Raw LOX Pressure PT Current Measurement

## 5.25 ID 402 - Ethanol Pressure PT Current

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		milliamps	Ethanol Pressure PT Current
6-7		False		ADC counts	Raw Ethanol Pressure PT Current Measurement

### 5.26 ID 403 - Chamber Pressure PT Current

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		milliamps	Chamber Pressure PT Current
6-7		False		ADC counts	Raw Chamber Pressure PT Current Measurement

### 5.27 ID 404 - Helium Fill Valve Hall Effect Current

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		milliamps	Helium Fill Valve Hall Effect Current
6-7		False		ADC counts	Raw Helium Fill Valve Hall Effect Current Measurement

### 5.28 ID 405 - LOX Fill Valve Hall Effect Current

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		milliamps	LOX Fill Valve Hall Effect Current
6-7		False		ADC counts	Raw LOX Fill Valve Hall Effect Current Measurement

### 5.29 ID 406 - Ethanol Fill Valve Hall Effect Current

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		milliamps	Ethanol Fill Valve Hall Effect Current
6-7		False		ADC counts	Raw Ethanol Fill Valve Hall Effect Current Measurement

### 5.30 ID 407 - Upper Air Frame VIN Current

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		Milliamps	Upper Air Frame Board Current
6-7		False		ADC counts	Raw Upper Air Frame Board Current Measurement

### 5.31 ID 408 - ITC VIN Current

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		Milliamps	ITC Board Current
6-7		False		ADC counts	Raw ITC Board Current Measurement

### 5.32 ID 409 - Lower Air Frame VIN Current

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		Milliamps	Lower Air Frame Board Current
6-7		False		ADC counts	Raw Lower Air Frame Board Current Measurement

### 5.33 ID 500 - Upper Air Frame VIN Voltage

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		Millivolts	Upper Air Frame Board VIN Voltage
6-7		False		ADC counts	Raw Upper Air Frame Board VIN Voltage Measurement

### 5.34 ID 501 - ITC VIN Voltage

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		Millivolts	ITC Board VIN Voltage
6-7		False		ADC counts	Raw ITC Board VIN Voltage Measurement

### 5.35 ID 502 - Lower Air Frame VIN Voltage

Frequency: 10Hz

Byte	Bit	Signed	Range	Units	Description
0-3		False		Milliseconds	Time since system start
4-5		True		Millivolts	Lower Air Frame Board VIN Voltage
6-7		False		ADC counts	Raw Lower Air Frame Board VIN Voltage Measurement