Avionics Reference Document

David Knight

August 15, 2020

Contents

List of Tables

List of Figures

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 refered to as The Helix System. It consists of multiple circuit boards called Extention Boards which can read data from sensors through the rocket or interact with actuators throughout the rocket. These Extention boards are all connected together in a ring topology which allows new Extention Boards to be added or removed from the system without impacting performace of the rest of the system. These Extention 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 onbaord 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, it's 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	Link
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	Link
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	Link
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	Link
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	Link
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	Link
Sensing Units	mT
Output Type	Push-Pull
Trip	±4.4mT
Release	±0.9mT
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

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

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

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

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

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