EXOTERRA System Controller Software Documentation

Installation and Setup

- Tested on Ubuntu 20.04.2 Python 3.8.5

```
  #Ensure python3 and python pip are installed installed on the system.
  sudo apt update
  sudo apt install python3 python3-pip

  #Install the other packages wheel.
  python3 -m pip install ./packages/python_can-4.0.11-py3-none-any.whl
  python3 -m pip install ./packages/canopen-1.2.4-py3-none-any.whl
  python3 -m pip install pyserial==3.5 wxpython==4.1.1

  #add the current user to the dialout group
  sudo usermod -a -G dialout $USER
  #logout of system and login
  #or run every command with sudo
```

Thruster Command Documentation.

Example Usage

```
python3 thruster_command.py 0x22 /dev/ttyUSB0
============= ExoTerra Thruster Command & Control =============
============= ExoTerra Thruster Command Help Menu =============
0 - Exit : [Exits the Program]
1 - Help : [Displays the help Menu]
2 - NMT STATE INIT : [Changes NMT STATE to INIT.]
3 - NMT STATE PRE-OP : [Changes NMT STATE to PRE-OP.]
4 - NMT STATE OPERATIONAL : [Changes NMT STATE to OPERATIONAL.]
5 - Run Ready Mode : [Writes a UINT-32 to the Thruster Ready Mode.]
6 - Run Steady State : [Writes a UINT-32 to the Thruster Steady State.]
7 - Thruster Shutdown : [Shutdown down the thruster.]
8 - Status : [Prints Status of Ready Mode, Steady State, and ThrusterStatus continuously.]
9 - Write Set Thrust : [Writes a throttle set point to the System Controller.]
10 - Condition : [Run the conditioning sequence.]
11 - Test : [Run the BIT sequence.]
Ready Mode: 0x0: Steady State: 0x0: ThrusterStatus:0x8 Condition Status:0x0
Thrust Point:0x1  Bit Status: 0x1fff5
System Controller Connected!
[rm:0:ss0:ts:0]>
```

System Controller Selectable Modes

Mode	Mode Description
2 - NMT STATE INIT	This state will reset the System Controller back to a default state.
3 - NMT STATE PRE-OPERATIONAL	This state sets the system controller in a low power mode. This is the default state on power up.
4 - NMT STATE OPERATIONAL	This state powers on the entire system and enables telemetry.

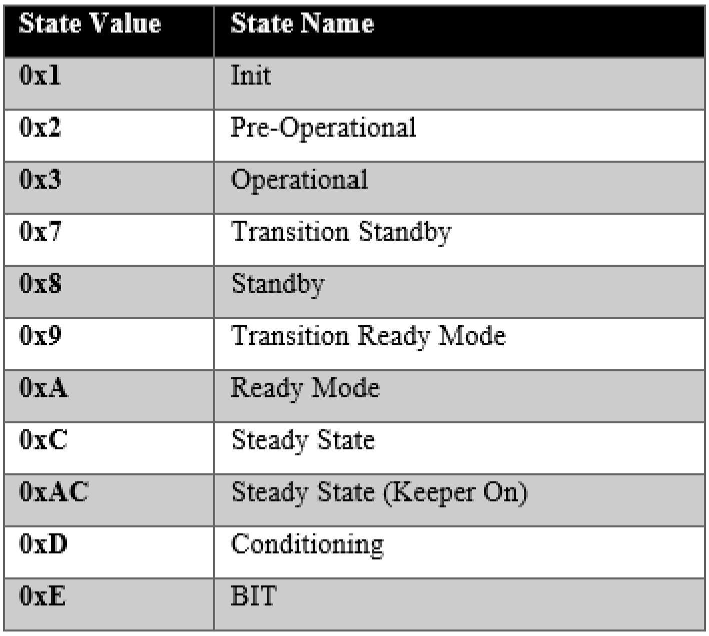
Thruster Command Prompt Breakdown

[<*ready mode*>:0:<*steady state*>:0:<***thruster state***>:0]>

```
NMT State INIT
[rm:0:ss:0:ts:2]>
NMT State PRE-OPERATIONAL
[rm:0:ss:0:ts:7]>
NMT State OPERATIONAL
[rm:0:ss:0:ts:8]>
```

Note - state is refreshed when enter is pressed

Thruster States



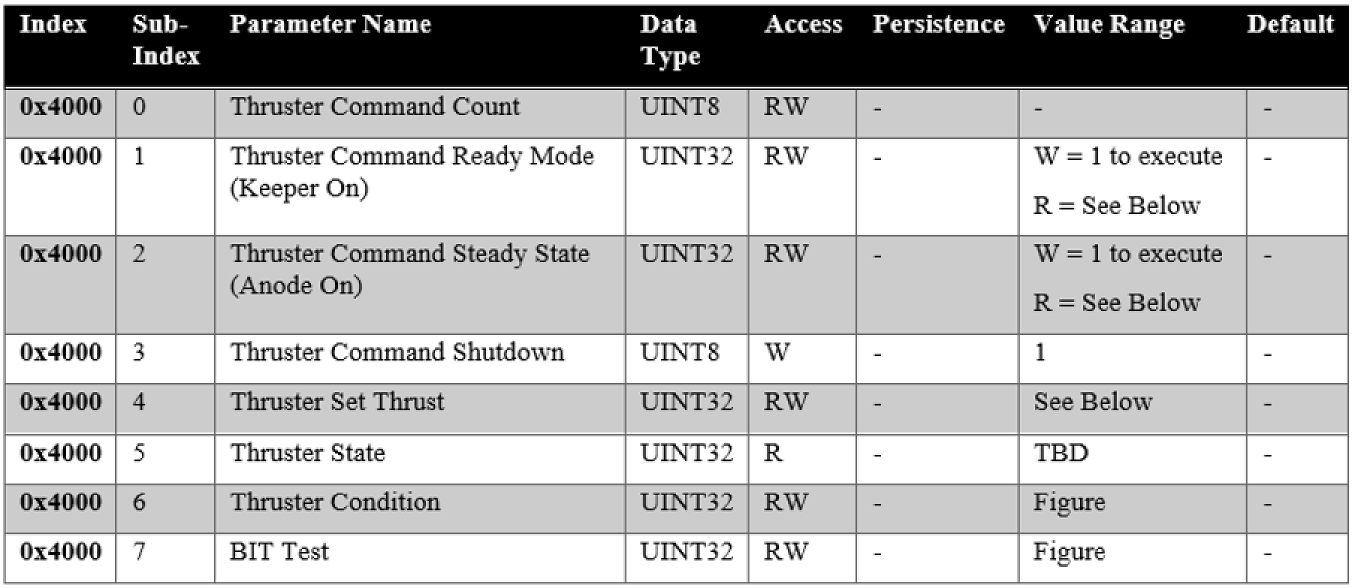
State Value	State Name
0x1	Init
0x2	Pre-Operational
0x3	Operational
0x7	Transition Standby
0x8	Standby
0x9	Transition Ready Mode
0xA	Ready Mode
0xC	Steady State
0xAC	Steady State (Keeper On)
0xD	Conditioning
0xE	BIT

Thruster Control Commands

Commands to the system are run shown as below. The index subindex and value associated with the command are echoed on the screen.

```
[rm:0:ss0:ts:0]> <menu selection>
{'Wrote:<index>-<subindex>: <value>'}

Example:
Thruster Shutdown
[rm:0:ss:0:ts:8]> 7
{'Wrote:0x4000-0x3: 0x01'}
```

Thruster Command Table



Index	Sub-Index	Parameter Name	Data Type	Access	Persistence	Value Range	Default
0x4000	0	Thruster Command Count	UINT8	RW	-	-	-
0x4000	1	Thruster Command Ready Mode (Keeper On)	UINT32	RW	-	W = 1 to execute R = See Below	-
0x4000	2	Thruster Command Steady State (Anode On)	UINT32	RW	-	W = 1 to execute R = See Below	-
0x4000	3	Thruster Command Shutdown	UINT8	W	-	1	-
0x4000	4	Thruster Set Thrust	UINT32	RW	-	See Below	-
0x4000	5	Thruster State	UINT32	R	-	TBD	-
0x4000	6	Thruster Condition	UINT32	RW	-	Figure	-
0x4000	7	BIT Test	UINT32	RW	-	Figure	-

BIT Tests

To run a BIT test make sure the Thruster Control State is Standby, select the bit menu item. Then when prompted select the bit number you want to run.

The BITs are hard coded as followed:

1. RESERVED
2. sequence_bit_latch_valve_open
3. sequence_bit_latch_valve_close
4. sequence_bit_cathode_low_flow_check
5. sequence_bit_anode_valve_check
6. sequence_bit_pcv_drain
7. sequence_inner_coil_test
8. sequence_outer_coil_test
9. sequence_keeper_test
10. sequence_anode_test

```
============= ExoTerra Thruster Command & Control =============
============= ExoTerra Thruster Command Help Menu =============
0 - Exit : [Exits the Program]
1 - Help : [Displays the help Menu]
```

```
2 - NMT STATE INIT : [Changes NMT STATE to INIT.]
3 - NMT STATE PRE-OP : [Changes NMT STATE to PRE-OP.]
4 - NMT STATE OPERATIONAL : [Changes NMT STATE to OPERATIONAL.]
5 - Run Ready Mode : [Writes a UINT-32 to the Thruster Ready Mode.]
6 - Run Steady State : [Writes a UINT-32 to the Thruster Steady State.]
7 - Thruster Shutdown : [Shutdown down the thruster.]
8 - Status : [Prints Status of Ready Mode, Steady State, and ThrusterStatus
continuously.]
9 - Write Set Thrust : [Writes a throttle set point to the System
Controller.]
10 - Condition : [Run the conditioning sequence.]
11 - Test : [Run the BIT sequence.]
2Ready Mode: 0x0: Steady State: 0x0: ThrusterStatus:0x8 Condition
Status:0x0 Thrust Point:0x1  Bit Status: 0x1fff5
System Controller Connected!
[rm:0x0:ss:0x0:ts:0x2]> 11
Test
Enter hex value to send to ECP - or 'x' to return to previous menu.
write> 0x3
{'Wrote:0x4000-0x7: 0x03000000'}
8
Status
Ready Mode: 0x0: Steady State: 0x0: ThrusterStatus:0x8 Condition Status:0x0
Thrust Point:0x1  Bit Status: 0x1fff5
```

The most IMPORTANT part is the last digit which shows the status of the BIT running.

BIT tests can be aborted with menu item 11 and value 0 (write 0 to index - 0x4000, subindex - 0x7).

```
[rm:0x0:ss:0x0:ts:0x8]> 11
Test
Enter hex value to send to ECP - or 'x' to return to previous menu.
write> 0x0
{'Wrote:0x4000-0x7: 0x00000000'}
[rm:0x0:ss:0x0:ts:0xe]> 8
Status
Ready Mode: 0x0: Steady State: 0x0: ThrusterStatus:0x8 Condition Status:0x0
Thrust Point:0x1  Bit Status: 0x1fff4
```

This will result in an aborted code for Bit Status, which is shown by the last digit 4.

Mode Status

This applies to Ready Mode, Steady State, Conditioning, and BIT modes. These are read at index 0x4000, subindex 0x1,0x2,0x6, and 0x7 respectively.

Then menu item 8 which updates every second to poll mode statuses. This status is broken into a few parts as follows.

Mode Status Breakdown

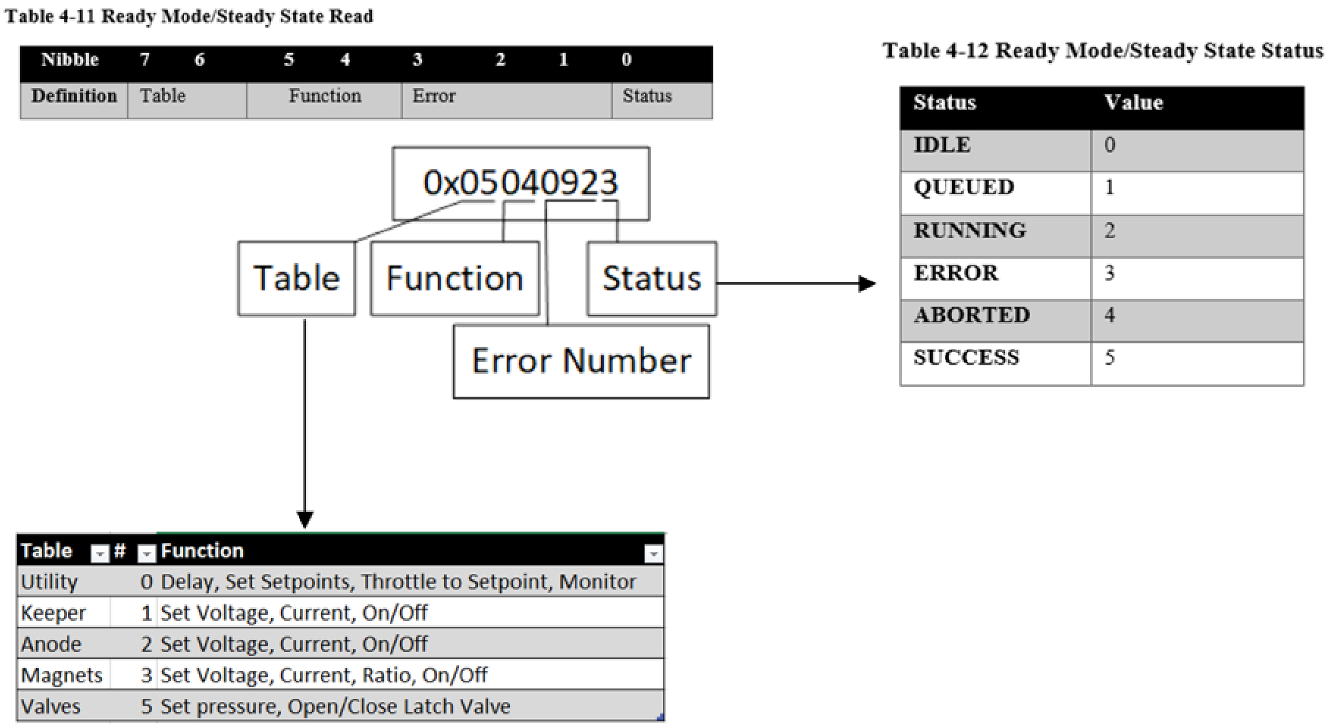


Table 4-11 Ready Mode/Steady State Read

Nibble	7	6	5	4	3	2	1	0
Definition	Table		Function		Error			Status

Table 4-12 Ready Mode/Steady State Status

Status	Value
IDLE	0
QUEUED	1
RUNNING	2
ERROR	3
ABORTED	4
SUCCESS	5

Table	#	Function
Utility	0	Delay, Set Setpoints, Throttle to Setpoint, Monitor
Keeper	1	Set Voltage, Current, On/Off
Anode	2	Set Voltage, Current, On/Off
Magnets	3	Set Voltage, Current, Ratio, On/Off
Valves	5	Set pressure, Open/Close Latch Valve

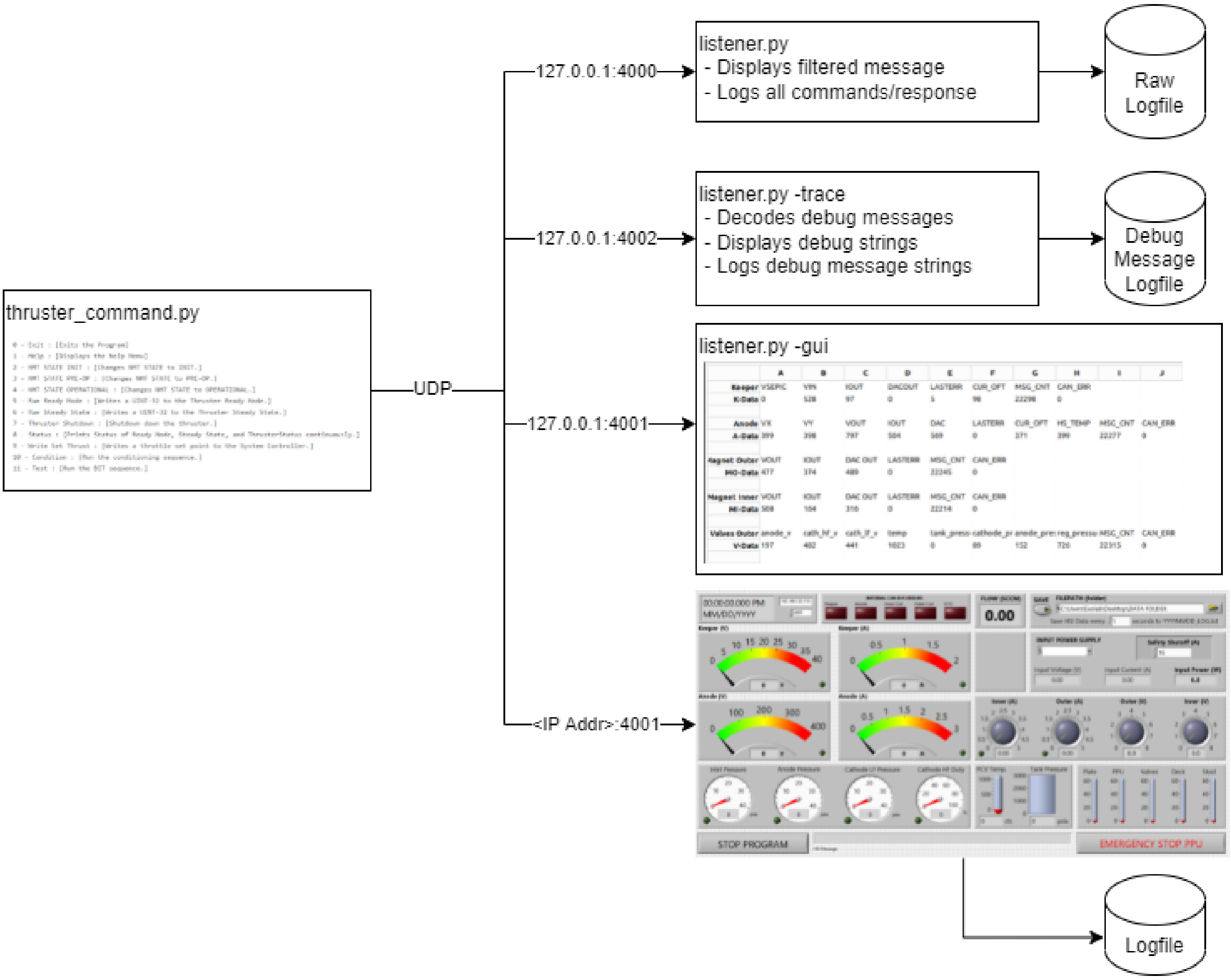
The Listener Script

The listener.py script allows for viewing and capturing of raw serial messages, trace, and telemetry messages. Thruster Command forwards msg traffic over UDP to the listener script on 3 ports, one for raw serial msgs, one for debug messages, and one for telemetry messages. The UDP ports are 4000, 4002, 4001 respectively.

```
python .\listener.py -h
usage: listener.py [-h] [-trace] [-hsi] [-gui] [-socket SOCKET] [-port
PORT]

Listens for exoserial data on the local network (udp).

optional arguments:
  -h, --help      show this help message and exit
  -trace          Enables Trace Mode.
  -hsi            Enables HSI Mode.
  -gui            Enables Gui.
  -socket SOCKET  The Network host to bind to.
  -port PORT      The port to listen on.


#Listening to trace msgs
python .\listener.py -trace

#Listening to hsi msgs
python .\listener.py -hsi

#Listening to hsi msgs with gui
```

```
python .\listener.py -gui

#Listening to raw msgs
python .\listener.py
```

Script Message Diagram



```
0 - Exit : [Exits the Program]
1 - Help : [Displays the help Menu]
2 - HMT STATE INIT : [Changes HMT STATE to INIT.]
3 - HMT STATE PRE-OP : [Changes HMT STATE to PRE-OP.]
4 - HMT STATE OPERATIONAL : [Changes HMT STATE to OPERATIONAL.]
5 - Raw Ready Mode : [Writes a UINT-32 to the Thruster Ready Mode.]
6 - Raw Steady State : [Writes a UINT-32 to the Thruster Steady State.]
7 - Thruster Shutdown : [Shutdown down the thruster.]
8 - Status : [Prints Status of Ready Mode, Steady State, and ThrusterStatus continuously.]
9 - Write Set Thrust : [Writes a throttle set point to the System Controller.]
10 - Condition : [Run the conditioning sequence.]
11 - Test : [Run the BIT sequence.]
```

	A	B	C	D	E	F	G	H	I	J
Keeper	VSEPIC	VIN	IOUT	DACOUT	LASTERR	CUR_OFT	MSG_CNT	CAN_ERR		
K-Data	0	528	97	0	5	98	22298	0		
Anode	VX	VY	VOUT	IOUT	DAC	LASTERR	CUR_OFT	HS_TEMP	MSG_CNT	CAN_ERR
A-Data	399	398	797	504	569	0	371	399	22277	0
Magnet Outer	VOUT	IOUT	DAC OUT	LASTERR	MSG_CNT	CAN_ERR				
MO-Data	477	374	489	0	22345	0				
Magnet Inner	VOUT	IOUT	DAC OUT	LASTERR	MSG_CNT	CAN_ERR				
MI-Data	508	104	316	0	22214	0				
Valves Outer	anode_v	cath_hf_v	cath_lf_v	temp	tank_press	cathode_p	anode_pre	reg_pressu	MSG_CNT	CAN_ERR
V-Data	197	402	441	1023	0	89	152	726	22315	0

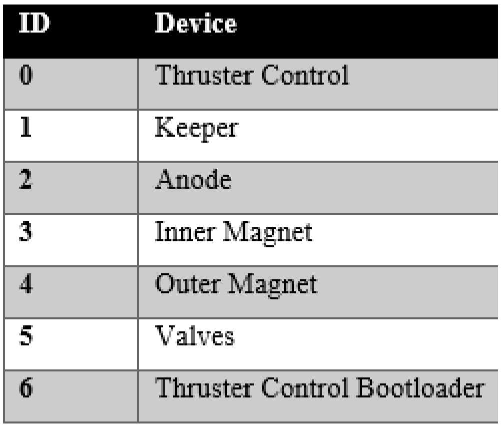
Msg Type	Description
Trace Msg	A print message from the system controller for more insight into debugging.
HSI Msg	A health and status message from the system controller for direct viewing of status and state.
Raw Msg	These messages are raw serial messages in a structure as shown in the ICD.

Versions.py

versions.py dumps the firmware from versions from the System Controller and writes them to a local file as well as displays them to the current terminal. The versions script creates a log file with a timestamp in the local directory every time it runs, with the format shown below.

```
python3 versions.py /dev/ttyUSB0
Id: Version  :gitsha    :git sha 1 :Exec V 1  :git sha 2 :Exec V 2  :git
sha 3 :Exec V 3
0 : 00010300 : 770c450c : 770c450c : 00010300 : 770c450c : 00010300 :
770c450c : 00010300
1 : 00000101 : 7b4af855 : 7b4af855 : 00000101 : 7b4af855 : 00000101 :
7b4af855 : 00000101
2 : 00000202 : fdf28164 : fdf28164 : 00000202 : fdf28164 : 00000202 :
fdf28164 : 00000202
3 : 00000101 : c7430617 : c7430617 : 00000101 : c7430617 : 00000101 :
c7430617 : 00000101
4 : 00000101 : c7430617 : c7430617 : 00000101 : c7430617 : 00000101 :
c7430617 : 00000101
5 : 00000200 : fbac9d86 : fbac9d86 : 00000200 : fbac9d86 : 00000200 :
fbac9d86 : 00000200
6 : 00000100 : 770c450c : 770c450c : 00000100 : 770c450c : 00000100 :
770c450c : 00000100
```

Version IDs



ID	Device
0	Thruster Control
1	Keeper
2	Anode
3	Inner Magnet
4	Outer Magnet
5	Valves
6	Thruster Control Bootloader

Errors and Explanations

Error Code	Error Description	Possible Solutions
Code 0x06010002	Attempt to write a read only object	Make sure the System Controller is flashed to the correct firmware with versions.py or check to make sure it is in Operational Mode.
Code 0x08000020	Data cannot be transferred or stored to the application	Make sure the System Controller is in Operational Mode.

version 0.0.6