FOSSASAT-1 v2 Test Specification

|  |  |  |
| --- | --- | --- |
| Date | Author(s) | Description |
| 22/07/2019 | Jan Gromeš | Initial release |
| 25/07/2019 | Jan Gromeš | Added non-communication test cases. |
| 04/08/2019 | Jan Gromeš | Updated low power mode. |

Contents

[Introduction 3](#_Toc15844330)

[Test Setup 3](#_Toc15844331)

[Main Program 4](#_Toc15844332)

[MAINPROGT1 – Compilation & Upload 4](#_Toc15844333)

[MAINPROGT2 – Modem Switching 5](#_Toc15844334)

[MAINPROGT3 – Watchdog Timer 6](#_Toc15844335)

[Persistent Storage 7](#_Toc15844336)

[PERSIST1 – Deployment Counter 7](#_Toc15844337)

[PERSIST2 – Power Control Configuration 8](#_Toc15844338)

[PERSIST3 – First Run Flag 9](#_Toc15844339)

[PERSIST4 – Restart Counter 10](#_Toc15844340)

[PERSIST5 – Callsign 11](#_Toc15844341)

[Deployment 12](#_Toc15844342)

[DEPLOYT1 – Deployment Sequence 12](#_Toc15844343)

[Power Control 13](#_Toc15844344)

[PWCTRLT1 – Battery Temperature 13](#_Toc15844345)

[PWCTRLT2 – Low Power Mode 14](#_Toc15844346)

[PWCTRLT3 – MPPT Keep Alive 15](#_Toc15844347)

[PWCTRLT4 – Variable Sleep Interval 16](#_Toc15844348)

[Pin Interface 17](#_Toc15844349)

[PININT1 – Pin Configuration 17](#_Toc15844350)

[PININT2 – Temperature Sensors 18](#_Toc15844351)

[Communication Subsystem 19](#_Toc15844352)

[COMMST1 – Ping/Pong Exchange 19](#_Toc15844353)

[COMMST2 – Relaying Messages 20](#_Toc15844354)

[COMMST3 – Relaying Messages with Custom Settings 21](#_Toc15844355)

[COMMST4 – System Info Exchange 22](#_Toc15844356)

[COMMST6 – Packet Info Exchange 23](#_Toc15844357)

[COMMST7 – Deployment command 24](#_Toc15844358)

[COMMST8 – Restart Command 25](#_Toc15844359)

[COMMST9 – EEPROM Wipe 26](#_Toc15844360)

[COMMST10 – Transmission enable 27](#_Toc15844361)

[COMMST11 – Callsign Configuration 28](#_Toc15844362)

[COMMST12 – Spreading Factor Configuration 29](#_Toc15844363)

[COMMST13 – MPPT Enable Configuration 30](#_Toc15844364)

[COMMST14 – MPPT Mode Configuration 31](#_Toc15844365)

[COMMST15 – Low Power Mode Configuration 32](#_Toc15844366)

[COMMST16 – Encryption And Password Protection 33](#_Toc15844367)

[COMMST17 – Memory Stress Test 34](#_Toc15844368)

[COMMST17 – Denial of Service Attack 35](#_Toc15844369)

[COMMST18 – RTTY 36](#_Toc15844370)

[References 37](#_Toc15844371)

# Introduction

The purpose of this document is to define test cases which verify functionality of communication subsystem of FOSSASAT-1. For specification of the communication protocol and frame types, see [1].

## Test Setup

When possible, full satellite (or functionally equivalent circuit) should be used for testing. However, due to the nature of communication subsystem, it is also possible to perform some of the test of communication subsystem with only ATmega328P and SX1268 radio module. In such case, the following tests must be skipped: COMMST4, COMMST7, COMMST8, COMMST13, COMMST14 and COMMST18. The reason for skipping the tests must also be stated in the section “Verdict”. All other subsystems must be tested with full satellite (or functionally equivalent circuit).

Ground station may be comprised of only ATmega328P and SX126x radio module.

Satellite shall be running the debug code. No other debug macros shall be defined, unless test specifically calls for it. All communication responses must be verified by reception on ground station and compared with debug console output. In case the test calls for changing modulation parameters, this change shall be verified by reception, as well as by observation using SDR.

Test case shall be considered failed if any step of test case fails. All results shall be recorded into a copy of this document, with additional media where appropriate.

# Main Program

## MAINPROGT1 – Compilation & Upload

#### Steps

1. Open software in Arduino IDE 1.8.9, set warning level to “All”, change board to some other than “Arduino Pro or Pro Mini” (e.g. “Arduino Mega ADK”) and compile software.
2. Change board to “Arduino Pro or Pro Mini” and compile software with warning level set to “All”.
3. Upload software and check debug console.

#### Expected result

1. Compiling for a different board will force Arduino IDE to rebuild core (including libraries) and show all warnings. It is irrelevant whether this compilation fails or succeeds.
2. Software shall compile successfully. No warnings originating from FOSSASAT code shall be reported.
3. Software shall be uploaded successfully. Debug console shall not report any warnings or errors.

#### Actual Result

#### Verdict

#### Notes

## MAINPROGT2 – Modem Switching

#### Steps

1. Restart satellite.
2. Keep satellite running for at least 10 minutes.

#### Expected result

1. All variables shall be set to default values.
2. Satellite shall correctly switch between modems.

#### Actual Result

#### Verdict

#### Notes

* Non-ISM LoRa modem is active for 8 seconds, ISM LoRa and FSK modems are active for 2 seconds.

## MAINPROGT3 – Watchdog Timer

#### Steps

1. Restart satellite.
2. Keep satellite running for at least 10 minutes.

#### Expected result

1. All variables shall be set to default values.
2. Satellite shall pet the watchdog every second when MCU is idle or sleeping. Watchdog shall not reset the satellite.

#### Actual Result

#### Verdict

#### Notes

# Persistent Storage

## PERSIST1 – Deployment Counter

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.
2. Reset satellite.
3. Repeat step 2 three times.
4. Repeat step 2 three more times.
5. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.

#### Expected result

1. Deployment counter shall be set to 0.
2. Deployment counter shall not increment on first reset.
3. Deployment counter shall increment for three consecutive resets.
4. Deployment counter shall not increment after more consecutive resets.
5. Deployment counter shall be set to 0.

#### Actual Result

#### Verdict

#### Notes

## PERSIST2 – Power Control Configuration

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.
2. Reset satellite.
3. Change one of the power control bits (e.g. low power mode enable bit by CMD\_SET\_LOW\_POWER\_ENABLE frame) and reset satellite.
4. Repeat step 3 for all power control bits.
5. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.

#### Expected result

1. Power control configuration shall be set to default values.
2. Debug console shall show the default power configuration values.
3. EEPROM variable shall be correctly updated. Debug console shall show the new power configuration values after the reset.
4. Satellite shall always retain power control configuration.
5. Power control configuration shall be set back to default values.

#### Actual Result

#### Verdict

#### Notes

* Default power configuration is: battery charging enabled, low power mode inactive, low power mode enabled, MPPT temperature switch enabled, MPPT keep alive enabled, transmissions enabled.

## PERSIST3 – First Run Flag

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.
2. Reset satellite.
3. Repeat step 2.
4. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.

#### Expected result

1. First run flag shall be set to 0.
2. First run flag shall be set to 1.
3. First run flag shall remain at 1.
4. First run flag shall be set back to 0.

#### Actual Result

#### Verdict

#### Notes

## PERSIST4 – Restart Counter

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.
2. Reset satellite.
3. Repeat step 2 for at least 10 times.
4. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.

#### Expected result

1. Restart counter shall be set to 0.
2. Restart counter shall increment by one.
3. Restart counter shall always increment by one.
4. Restart counter shall be set back to 0.

#### Actual Result

#### Verdict

#### Notes

## PERSIST5 – Callsign

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.
2. Reset satellite.
3. Change callsign.
4. Reset satellite.
5. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.

#### Expected result

1. Callsign shall be set to default value (FOSSASAT-1).
2. Callsign shall remain at the default value.
3. Callsign shall be updated correctly.
4. Callsign shall remain at the new value.
5. Callsign shall be set back to default value.

#### Actual Result

#### Verdict

#### Notes

# Deployment

## DEPLOYT1 – Deployment Sequence

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.
2. Reset satellite.
3. Repeat step 2 three times.
4. Repeat step 2 three more times.
5. Force deployment sequence using CMD\_DEPLOY frame.

#### Expected result

1. EEPROM variables shall be set to default values.
2. Deployment sequence shall not be run after first reset.
3. Deployment sequence shall be run correctly each time.
4. Deployment sequence shall no longer be run automatically after reset.
5. Deployment sequence shall be run (without sleeping interval).

#### Actual Result

#### Verdict

#### Notes

* Deployment sequence consist of the following: sleeping for three minutes, setting both deployment MOSFETS to HIGH for one second, then setting both to LOW.

# Power Control

## PWCTRLT1 – Battery Temperature

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame and reset satellite.
2. Disable MPPT keep alive and enable MPPT temperature switch.
3. Use battery with voltage level more than 3.3 V and temperature sensor in ambient temperature.
4. Keep satellite running for at least 5 minutes.
5. Check debug console output.
6. Repeat steps 4 – 5 with temperature sensor value less than 0 °C.

#### Expected result

1. All variables shall be set to default values.
2. MPPT keep alive shall be disabled, temperature switch shall be enabled.
3. Charging will be enabled, and low power mode will not activate.
4. Battery shall be checked once every 5 minutes
5. Battery temperature shall be checked. Battery charging shall be enabled.
6. Battery charging shall be disabled due to low temperature.

#### Actual Result

#### Verdict

#### Notes

## PWCTRLT2 – Low Power Mode

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame and reset satellite.
2. Disable MPPT keep alive and enable low power mode.
3. Use battery with voltage level more than 3.3 V and temperature sensor in ambient temperature.
4. Keep satellite running for at least 5 minutes.
5. Check debug console output.
6. Repeat steps 4 – 5 with battery voltage less than 3.3 V.
7. Send any frame that requires satellite response (e.g. CMD\_PING).
8. Wait for at least 3 minutes.
9. Repeat steps 6 – 8 with battery voltage more than 3.3 V.
10. Disable low power mode and repeat steps 6 – 8.

#### Expected result

1. All variables shall be set to default values.
2. MPPT keep alive shall be disabled, low power mode shall be enabled.
3. Charging will be enabled, and low power mode will not activate.
4. Battery shall be checked once every 5 minutes
5. Battery temperature shall be checked. Battery charging shall be enabled, low power mode shall not be activated.
6. Low power mode shall be activated.
7. Satellite shall respond.
8. Satellite shall not send any automated messages (neither LoRa, nor RTTY).
9. Low power mode shall be deactivated. Satellite shall resume sending automated messages.
10. Low power shall be disabled and shall not activate when battery voltage drops. Satellite shall always respond and send automated messages.

#### Actual Result

#### Verdict

#### Notes

## PWCTRLT3 – MPPT Keep Alive

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame and reset satellite.
2. Disable MPPT keep alive and enable MPPT temperature switch.
3. Set battery temperature sensor to temperature lower than 0 °C.
4. Keep satellite running for at least 5 minutes.
5. Check debug console output.
6. Enable MPPT keep alive and repeat steps 3 – 5.
7. Disable MPPT keep alive.
8. Force battery voltage measurement (e.g. using CMD\_TRANSMIT\_SYSTEM\_INFO frame).
9. Enable MPPT keep alive and repeat step 8.

#### Expected result

1. All variables shall be set to default values.
2. MPPT keep alive shall be disabled, low power mode shall be enabled.
3. Charging will be disabled.
4. Battery shall be checked once every 5 minutes
5. Battery temperature shall be checked. Battery charging shall be disabled due to low temperature.
6. Battery charging shall be enabled regardless of temperature.
7. MPPT keep alive shall be disabled.
8. Battery charging shall be disabled when measuring battery voltage.
9. Battery charging shall always remain enabled, regardless of the measurement.

#### Actual Result

#### Verdict

#### Notes

## PWCTRLT4 – Variable Sleep Interval

#### Steps

1. Run satellite using battery with voltage level more than 3.7 V.
2. Repeat step 1 using battery with voltage level in range 3.6 – 3.7 V.
3. Repeat step 1 using battery with voltage level in range 3.5 – 3.6 V.
4. Repeat step 1 using battery with voltage level in range 3.4 – 3.5 V.
5. Repeat step 1 using battery with voltage level in range 3.3 – 3.4 V.
6. Repeat step 1 using battery with voltage level lower than 3.3 V.

#### Expected result

1. Sleep interval shall be set to 0 seconds.
2. Sleep interval shall be set to 5 seconds.
3. Sleep interval shall be set to 10 seconds.
4. Sleep interval shall be set to 20 seconds.
5. Sleep interval shall be set to 30 seconds.
6. Sleep interval shall be set to 40 seconds.

#### Actual Result

#### Verdict

#### Notes

# Pin Interface

## PININT1 – Pin Configuration

#### Steps

1. Check pin configuration in software matches hardware.

#### Expected result

1. All pins defined in software shall match the hardware.

#### Actual Result

#### Verdict

#### Notes

## PININT2 – Temperature Sensors

#### Steps

1. Check both temperature sensor values (e.g. by using CMD\_TRANSMIT\_SYSTEM\_INFO frame).
2. Repeat step 1 with both temperature sensors in different environments.

#### Expected result

1. Both sensors shall report accurate temperature values.
2. Both sensors shall always report accurate temperature values.

#### Actual Result

#### Verdict

#### Notes

# Communication Subsystem

## COMMST1 – Ping/Pong Exchange

#### Steps

1. Send valid CMD\_PING frame from ground station using non-ISM LoRa modem.
2. Repeat step 1 using ISM LoRa modem and FSK modem.
3. Add valid optional data to CMD\_PING frame and send it using non-ISM LoRa modem.
4. Repeat step 3 using CMD\_PING frame with invalid optional data field (optDataLen field does not match number of bytes in optData field).

#### Expected result

1. Satellite shall respond with RESP\_PONG frame using non-ISM LoRa modem.
2. Satellite shall respond with RESP\_PONG frame, always using non-ISM LoRa modem.
3. Satellite shall ignore optional data and respond with valid RESP\_PONG frame.
4. Satellite shall ignore optional data and respond with valid RESP\_PONG frame. Mismatch between optDataLen and actual length of optData field shall be reported in debug console.

#### Actual Result

#### Verdict

#### Notes

* CMD\_PING frame is considered valid when no optional data are present, or when optDataLen field matches length of optional data. In the latter case, optional data field is ignored.

## COMMST2 – Relaying Messages

#### Steps

1. Send valid CMD\_RETRANSMIT frame from ground station using non-ISM LoRa modem.
2. Repeat step 1 using ISM LoRa modem and FSK modem.
3. Send CMD\_ RETRANSMIT frame with invalid optional data field (optDataLen field does not match number of bytes in optData field).

#### Expected result

1. Satellite shall respond with RESP\_REPEATED\_MESSAGE frame using non-ISM LoRa modem.
2. Satellite shall respond with RESP\_REPEATED\_MESSAGE frame, always using non-ISM LoRa modem.
3. Satellite shall not respond with any frame. Mismatch between optDataLen and actual length of optData field shall be reported in debug console.

#### Actual Result

#### Verdict

#### Notes

* CMD\_RETRANSMIT frame is considered valid when it contains some optional data, when optDataLen field value is between 1 and 64 (inclusive) and when length of optional data matches value in field optDataLen.

## COMMST3 – Relaying Messages with Custom Settings

#### Steps

1. Send valid CMD\_RETRANSMIT\_CUSTOM frame from ground station using non-ISM LoRa modem. Set modulation parameters to any non-default settings.
2. Wait for any transmission from the satellite.
3. Repeat steps 1 – 2 for settings with lowest possible data rate (bandwidth 7.8 kHz, SF12).
4. Repeat steps 1 – 2 for multiple different settings.
5. Send invalid CMD\_TRANSMIT\_CALLSIGN\_ALT\_SF frame with one of the modulation parameters outside accepted range.
6. Repeat step 4 for all modulation parameters.

#### Expected result

1. Satellite shall respond with RESP\_REPEATED\_MESSAGE\_CUSTOM frame using non-ISM LoRa modem with the correct settings.
2. Further transmissions from the satellite shall use the default modem configuration.
3. Satellite shall always respond using correct settings. Satellite shall not reset when responding with very low data rates.
4. Satellite shall always respond using correct settings.
5. Satellite shall ignore this frame. Incorrect modulation parameter value shall be reported in debug console.
6. Satellite shall always ignore the invalid frame.

#### Actual Result

#### Verdict

#### Notes

* CMD\_RETRANSMIT\_CUSTOM is considered valid when all modulation parameters are within accepted range and when message length is between 1 and 64 (inclusive).

COMMST4 – System Info Exchange

#### Steps

1. Send valid CMD\_TRANSMIT\_SYSTEM\_INFO frame from ground station using non-ISM LoRa modem.
2. Repeat step 1 using ISM LoRa modem and FSK modem.
3. On the satellite, change as many reported variables as possible and repeat step 1.

#### Expected result

1. Satellite shall respond with RESP\_ SYSTEM\_INFO frame using non-ISM LoRa modem. All received values shall reflect the current satellite state.
2. Satellite shall respond with RESP\_ SYSTEM\_INFO frame, always using non-ISM LoRa modem.
3. Satellite shall respond with RESP\_ SYSTEM\_INFO frame using non-ISM LoRa modem. All received values shall reflect the current satellite state.

#### Actual Result

#### Verdict

#### Notes

* CMD\_TRANSMIT\_SYSTEM\_INFO frame is considered valid when no optional data are present, or when optDataLen field matches length of optional data. In the latter case, optional data field is ignored.

## COMMST6 – Packet Info Exchange

#### Steps

1. Send valid CMD\_GET\_LAST\_PACKET\_INFO frame from ground station using non-ISM LoRa modem.
2. Repeat step 1 using ISM LoRa modem and FSK modem.

#### Expected result

1. Satellite shall respond with RESP\_LAST\_PACKET\_INFO frame using non-ISM LoRa modem. The response shall contain correct values for SNR and RSSI.
2. Satellite shall respond with RESP\_LAST\_PACKET\_INFO frame, always using non-ISM LoRa modem.

#### Actual Result

#### Verdict

#### Notes

* CMD\_GET\_LAST\_PACKET\_INFO frame is considered valid when no optional data are present, or when optDataLen field matches length of optional data. In the latter case, optional data field is ignored.

## COMMST7 – Deployment command

#### Steps

1. Upload satellite code undefined macro ENABLE\_DEPLOYMENT\_SEQUENCE.
2. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.
3. Send valid CMD\_DEPLOY frame from ground station using non-ISM LoRa modem.
4. Repeat step 3 at least 2 more times.
5. Reset satellite.
6. Repeat step 3 at least 2 more times

#### Expected result

1. Satellite shall not perform automated deployment on start.
2. Satellite EEPROM shall be reset to default state.
3. Encrypted response shall contain the correct number of deployment attempts (1 attempt).
4. Satellite shall always perform deployment sequence. Encrypted response shall contain the correct number of deployment attempts.
5. Satellite shall reset.
6. Satellite shall always perform deployment sequence. Encrypted response shall contain the correct number of deployment attempts.

#### Actual Result

#### Verdict

#### Notes

* CMD\_GET\_LAST\_PACKET\_INFO frame is considered valid when it contains correct password and is encrypted using correct key. Optional data field is ignored when present.

## COMMST8 – Restart Command

#### Steps

1. Send valid CMD\_RESTART frame from ground station using non-ISM LoRa modem.
2. Repeat step 1 using ISM LoRa modem and FSK modem.

#### Expected result

1. Satellite shall restart.
2. Satellite shall always restart correctly.

#### Actual Result

#### Verdict

#### Notes

* CMD\_RESTART frame is considered valid when it contains correct password and is encrypted using correct key. Optional data field is ignored when present.

## COMMST9 – EEPROM Wipe

#### Steps

1. Change all satellite EEPROM variables using appropriate command frames (callsign, deployment counter etc.).
2. Send valid CMD\_WIPE\_EEPROM frame.
3. Check EEPROM variables changed in step 1.

#### Expected result

1. Some EEPROM variables shall have non-default values.
2. Satellite EEPROM shall be reset to default state.
3. All EEPROM variables shall be changed back to their default state.

#### Actual Result

#### Verdict

#### Notes

* CMD\_WIPE\_EEPROM frame is considered valid when it contains correct password and is encrypted using correct key. Optional data field is ignored when present.

## COMMST10 – Transmission enable

#### Steps

1. Send any frame that will make satellite respond (e.g. CMD\_PING).
2. Send valid CMD\_SET\_TRANSMIT\_ENABLE frame with optional data byte set to 0 from ground station using non-ISM LoRa modem.
3. Repeat step 1 using all available modems.
4. Wait for at least 5 minutes.
5. Send valid CMD\_SET\_TRANSMIT\_ENABLE frame with optional data byte set to 1.
6. Repeat step 1 using all available modems.
7. Wait for at least 5 minutes.

#### Expected result

1. Satellite shall respond with the correct response frame.
2. Satellite shall no longer send any transmissions.
3. Satellite shall not send any response frames.
4. Satellite shall not send any automated frames.
5. Satellite shall resume sending transmissions.
6. Satellite shall always respond with the correct response frame.
7. Satellite shall send automated system info frames using LoRa and RTTY.

#### Actual Result

#### Verdict

#### Notes

* CMD\_SET\_TRANSMIT\_ENABLE frame is considered valid when it contains correct password, is encrypted using correct key and has exactly one byte of optional data.

## COMMST11 – Callsign Configuration

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.
2. Send CMD\_PING with callsign “FOSSASAT-1”.
3. Send valid CMD\_SET\_CALLSIGN frame with callsign set to some other string (e.g. “NEWCALLSIGN-4”).
4. Send CMD\_PING with callsign “FOSSASAT-1”.
5. Send CMD\_PING with the new callsign.
6. Send CMD\_SET\_CALLSIGN frame with new callsign longer than 32 bytes.

#### Expected result

1. Satellite callsign shall be set to default value (“FOSSASAT-1”).
2. Satellite shall respond using the default callsign.
3. Satellite shall set its callsign to the new value.
4. Satellite shall not respond to frame with incorrect callsign. Callsign mismatch shall be reported in debug console.
5. Satellite shall respond using the new callsign.
6. Satellite shall not update its callsign. Callsign length error shall be reported in debug console.

#### Actual Result

#### Verdict

#### Notes

* CMD\_WIPE\_EEPROM frame is considered valid when it contains correct password and is encrypted using correct key. Optional data field contains the new callsign, which may not be longer than 32 bytes.

## COMMST12 – Spreading Factor Configuration

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.
2. Send any frame that will make satellite respond (e.g. CMD\_PING).
3. Send valid CMD\_SET\_SF\_MODE frame with optional data byte set to 1 from ground station using non-ISM LoRa modem.
4. Repeat step 2 using non-ISM and ISM LoRa modem with standard spreading factor.
5. Repeat step 2 using non-ISM and ISM LoRa modem with alternative spreading factor.
6. Send valid CMD\_SET\_SF\_MODE frame with optional data byte set to 0 from ground station using non-ISM LoRa modem.
7. Repeat steps 4 – 5.

#### Expected result

1. All EEPROM variables shall be set to default values.
2. Satellite shall respond using standard spreading factor.
3. Satellite shall use alternative spreading factor for both ISM and non-ISM LoRa modems.
4. Satellite shall not be able to receive transmissions with standard spreading factor.
5. Satellite shall correctly respond using alternative spreading factor.
6. Spreading factor shall be set back to standard mode.
7. Satellite shall only respond to transmissions with standard spreading factor.

#### Actual Result

#### Verdict

#### Notes

* CMD\_SET\_SF\_MODE frame is considered valid when it contains correct password, is encrypted using correct key and has exactly one byte of optional data.

## COMMST13 – MPPT Enable Configuration

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.
2. Send valid CMD\_SET\_MPPT\_ENABLE frame with optional data byte set to 0 from ground station using non-ISM LoRa modem.
3. Request system info using CMD\_TRANSMIT\_SYSTEM\_INFO frame.
4. Send valid CMD\_SET\_MPPT\_ENABLE frame with optional data byte set to 1 from ground station using non-ISM LoRa modem.
5. Repeat step 3.

#### Expected result

1. All EEPROM variables shall be set to default values.
2. MPPT shall be disabled.
3. System info frame shall show MPPT is disabled.
4. MPPT shall be enabled.
5. System info frame shall show MPPT is enabled.

#### Actual Result

#### Verdict

#### Notes

* CMD\_SET\_MPPT\_ENABLE frame is considered valid when it contains correct password, is encrypted using correct key and has exactly one byte of optional data.

## COMMST14 – MPPT Mode Configuration

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.
2. Send valid CMD\_SET\_MPPT\_MODE frame with disabled temperature switch and disabled keep-alive.
3. Request system info using CMD\_TRANSMIT\_SYSTEM\_INFO frame.
4. Repeat steps 2 – 3.

#### Expected result

1. All EEPROM variables shall be set to default values.
2. MPPT temperature switch and keep-alive shall be disabled.
3. System info frame shall show correct MPPT configuration.
4. MPPT mode in system info frame shall always correspond to with the last MPPT configuration frame sent.

#### Actual Result

#### Verdict

#### Notes

* CMD\_SET\_MPPT\_MODE frame is considered valid when it contains correct password, is encrypted using correct key and has exactly two bytes of optional data.

## COMMST15 – Low Power Mode Configuration

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.
2. Send valid CMD\_SET\_LOW\_POWER\_ENABLE frame with optional data byte set to 0 from ground station using non-ISM LoRa modem.
3. Request system info using CMD\_TRANSMIT\_SYSTEM\_INFO frame.
4. Send valid CMD\_SET\_LOW\_POWER\_ENABLE frame with optional data byte set to 1 from ground station using non-ISM LoRa modem.
5. Repeat step 3.

#### Expected result

1. All EEPROM variables shall be set to default values.
2. Low power mode shall be disabled.
3. System info frame shall show low power is disabled.
4. Low power mode shall be enabled.
5. System info frame shall show low power is enabled.

#### Actual Result

#### Verdict

#### Notes

* CMD\_SET\_LOW\_POWER\_ENABLE frame is considered valid when it contains correct password, is encrypted using correct key and has exactly one byte of optional data.

## COMMST16 – Encryption And Password Protection

#### Steps

1. Send any valid private command without optional data (e.g. CMD\_DEPLOY).
2. Repeat step 1 using incorrect password.
3. Repeat step 1 using incorrect encryption key.
4. Repeat steps 1 – 3 using private command with optional data (e.g. CMD\_SET\_MPPT\_ENABLE).

#### Expected result

1. Satellite shall perform the correct action (based on frame type).
2. Satellite shall successfully decode frame and detect incorrect password. Password mismatch shall be reported in the debug console and transmitted to ground station.
3. Satellite shall fail in decoding the frame. Password mismatch shall be reported in the debug console and transmitted to ground station.
4. Satellite shall correctly check password and report any mismatch.

#### Actual Result

#### Verdict

#### Notes

## COMMST17 – Memory Stress Test

#### Steps

1. Send valid public frame without optional data (e.g. CMD\_PING).
2. Send valid public frame with optional data (e.g. CMD\_RETRANSMIT).
3. Send valid private frame without optional data (e.g. CMD\_DEPLOY).
4. Send valid private frame with optional data (e.g. CMD\_DEPLOY).
5. Set satellite callsign to 32 characters.
6. Send CMD\_RETRANSMIT with the longest possible message (32 bytes).
7. Repeat steps 1 – 6 for at least 8 hours.

#### Expected result

1. Satellite shall respond correctly.
2. Satellite shall respond correctly.
3. Satellite shall respond correctly.
4. Satellite shall respond correctly.
5. Satellite callsign shall be updated correctly.
6. Satellite response shall contain the correct data.
7. Satellite shall not restart or freeze for the duration of the test. Satellite shall also transmit automated frames. All commands shall be executed correctly

#### Actual Result

#### Verdict

#### Notes

* It is recommended to use multiple different callsigns and retransmission messages, to ensure satellite code is free of memory leaks.

## COMMST17 – Denial of Service Attack

#### Steps

1. Send valid public frame without optional data (e.g. CMD\_PING).
2. Send valid public frame with optional data (e.g. CMD\_RETRANSMIT).
3. Repeat steps 1 – 2 as quickly as possible for at least 8 hours.

#### Expected result

1. Satellite shall respond correctly.
2. Satellite shall respond correctly.
3. Satellite shall not restart or freeze for the duration of the test.

#### Actual Result

#### Verdict

#### Notes

## COMMST18 – RTTY

#### Steps

1. Wipe EEPROM using CMD\_WIPE\_EEPROM frame.
2. Wait for satellite to transmit RTTY system info frame.
3. Decode RTTY system frame using SDR.
4. Change all possible values reported in system info frame.
5. Repeat steps 2 – 3.

#### Expected result

1. All EEPROM variables shall be set to default values.
2. Satellite shall automatically transmit system info frame using RTTY.
3. All decoded values shall match values reported in debug console.
4. System info frame shall contain new values.
5. All decoded values shall match values reported in debug console.

#### Actual Result

#### Verdict

#### Notes

* Multiple different SDR setups should be used to receive the RTTY data, for the purposes of independent verification.

# References

[1] Communication Protocol. *FOSSA Systems.* June 2019.