**Long Range Communication Test Procedure**

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| **Version Number** | **Date** | **Changes** | **Modified by:** |
| Version 1.0 | 2018/12/17 | Initial draft | Tharindu |
| Version 1.1 | 2018/12/17 | -First release draft  -Reviewed and improved initial draft  -Added title page | Adrian Salces |
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**Preparation**

Before going to Sarakura Mountain, make sure the following have been done:

1. Measure and confirm the following output power:

|  |  |
| --- | --- |
| Parameter | Measured Value (dBm) |
| BIRDS-2 CW TX output |  |
| BIRDS-2 command TX output |  |
| BIRDS-3 CW TX output |  |
| BIRDS-3 command TX output |  |
| IC-9100 output (set to 42 dBm) |  |
| IC-9100 output (set to 45 dBm) |  |
| SG-RF Amplifier configuration output (set to 42 dBm, SG = -11 dBm) |  |
| SG-RF Amplifier configuration output (set to 45 dBm, SG = -8 dBm) |  |

1. Measure the S11 of reference dipole antenna using VNA.

Center frequency (MHz):

S11 value:

1. Prepare and pack-up all equipment and materials:

Sarakura Mountain

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| Material/Equipment | Quantity | Check |
| BIRDS-3 EM satellite | 1 |  |
| BIRDS-3 FM satellite | 1 |  |
| BIRDS-3 UPD satellite | 1 |  |
| Pelican case/s | 1 or 2 |  |
| Spectrum analyzer | 1 |  |
| Portable AC power | 1 |  |
| Power banks | 1 or 2 |  |
| Dipole reference antenna | 1 |  |
| Gloves |  |  |
| BIRDS-2 laptop |  |  |
| BIRDS-3 laptop |  |  |

Kyutech GS

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| Material/Equipment | Quantity | Check |
| 30 dB attenuator, 30 W | 1 |  |
| 40 dB attenuator, 100 W | 1 |  |
| Attenuator set (low power) | 1 set |  |
| IC-9100 | 1 |  |
| RF Amplifier | 1 |  |
| Signal Generator | 1 |  |
| Spectrum analyzer | 1 |  |
| BIRDS GS UHF antenna | 1 |  |
| Horyu-4 GS UHF antenna | 1 |  |
| BIRDS GS PC | 1 |  |
| TNC for BIRDS-2 | 1 |  |
| TNC for BIRDS-3 | 1 |  |
| BIRDS-2 GS software | 1 |  |
| BIRDS-3 GS software | 1 |  |

**Test-1 Calibration**

1. Pointing BIRDS GS and Horyu-4 GS antennas towards Sarakura Mountain.
2. Measuring the effective downlink path attenuation from Sarakura Mountain to BIRDS GS using BIRDS-3 FM and BIRDS-2 UPD satellites transmitting CW beacon signal.
3. Measuring the effective downlink path attenuation from Sarakura Mountain to Horyu-4 GS using BIRDS-3 FM and BIRDS-2 UPD satellites transmitting CW beacon signal.
4. Measuring the effective uplink path attenuation from BIRDS GS to Sarakura Mountain using SG-RF Amplifier transmitting a single tone.
5. Measuring the effective uplink path attenuation from Horyu-4 GS to Sarakura Mountain using SG-RF Amplifier transmitting a single tone.

* **Step-1: Pointing the BIRDS GS antenna towards Sarakura Mountain**

In this test, BIRDS-3 FM satellite will transmit continuous beacon signal (20dBm) and BIRDS GS antenna will try to capture maximum power from Sarakura side.

1. Position BIRDS-3 FM satellite such that the UHF antenna is horizontal and facing towards the GS (Note: this will be BIRDS-3 FM satellite position all throughout this test).
2. Set the BIRDS-3 FM satellite to transmit continuous beacon signal.
3. Point the BIRDS GS antenna in the nominal direction (EL = 0°, AZ = 220°).
4. Measure the received power at the BIRDS GS antenna. Set channel power bandwidth of spectrum analyzer to 500Hz and center frequency 437.375MHz.
5. Adjust the BIRDS GS antenna direction about the nominal direction to find the direction with the maximum received power.
6. Fix the BIRDS GS antenna in this direction.

AZ direction:

Received signal power:

Note: When the maximum power is received antenna direction should be fixed and it should be kept until every test finish.

* **Step-2: Pointing the Horyu-4 GS antenna towards Sarakura Mountain**

Repeat the Step-1 but this time for Horyu-4 GS antenna.

AZ direction:

Received signal power:

* **Step-3: Measuring effective downlink attenuation from Sarakura Mountain to GS.**

1. BIRDS-3 FM satellite will transmit continuous CW beacon. Carefully take note of this position.
2. Measure the received power by the BIRDS GS antenna and record in the table below.
3. Measure the received power by the Horyu-4 GS antenna and record in the table below.
4. BIRDS-2 UPD satellite will transmit continuous CW beacon (Note: UHF antenna horizontal and facing towards GS, UHF element upper, VHF element lower).
5. Measure the received power by the BIRDS GS antenna and record in the table below.
6. Measure the received power by the Horyu-4 GS antenna and record in the table below.

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| --- | --- | --- |
| Satellite name  (Transmitted from) | Received Power (dBm)  Using BIRDS GS Antenna | Effective downlink attenuation (dB)  (20 dBm – Received power) |
| BIRDS-3 FM |  |  |
| BIRDS-2 UPD |  |  |

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| --- | --- | --- |
| Satellite name  (Transmitted from) | Received Power (dBm)  Using Horyu-4 GS Antenna | Effective downlink attenuation (dB)  (20 dBm – Received power) |
| BIRDS-3 FM |  |  |
| BIRDS-2 UPD |  |  |

* **Step-4: Measuring effective uplink attenuation from GS to Sarakura Mountain**

This test is performed to check if effective downlink and uplink attenuations are the equal.

1. Set-up SG-RF Amplifier GS configuration such that TX output power is 45 dBm (SG = -8 dBm, single tone).

To antenna

Power out = 45 dBm

Frequency = 4xx.xxx MHz

Power out = -8 dBm





1. Connect BIRDS GS antenna to RF amplifier.

BIRDS-2 UPD

1. Setup the BIRDS-2 UPD satellite on the platform and *turn on the satellite*.

Load CW-disabled software (SKIP this if no time).

Record SA noise floor without any antenna connected (**25 kHz CH Power**).

SA Noise Floor w/o Antenna: \_\_\_\_\_\_ dBm

Record SA noise floor with BIRDS-2 UPD UHF antenna connected (**25 kHz CH Power**).

SA Noise Floor with BIRDS-2 UPD UHF Antenna: \_\_\_\_\_\_ dBm

1. Output single tone from SG.
2. Measure received RF power by BIRDS-2 UPD UHF antenna using spectrum analyzer. Record in the table below.
3. Connect Horyu-4 GS antenna to RF amplifier. Repeat 4-5.

BIRDS-3 EM

1. Setup the BIRDS-3 EM satellite on the platform.
2. Output single tone from SG.
3. Measure received RF power by BIRDS-3 EM UHF antenna using spectrum analyzer. Record in the table below.
4. Connect Horyu-4 GS antenna to RF amplifier. Repeat 8-9.

Reference Dipole Antenna

1. Setup the dipole reference antenna on the platform.
2. Output single tone from SG.
3. Measure received RF power by reference dipole antenna using spectrum analyzer. Record in the table below.
4. Connect Horyu-4 GS antenna to RF amplifier. Repeat 12-13.

Received uplink power for BIRDS-2 UPD UHF Antenna

|  |  |
| --- | --- |
| GS Transmitter Antenna | Effective uplink attenuation (dB)  (45 dBm – Received power) |
| BIRDS GS Antenna |  |
| Horyu-4 GS Antenna |  |

Received uplink power for BIRDS-3 EM UHF Antenna

|  |  |
| --- | --- |
| GS Transmitter Antenna | Effective uplink attenuation (dB)  (45 dBm – Received power) |
| BIRDS GS Antenna |  |
| Horyu-4 GS Antenna |  |

Received uplink power for Reference UHF Dipole Antenna

|  |  |
| --- | --- |
| GS Transmitter Antenna | Effective uplink attenuation (dB)  (45 dBm – Received power) |
| BIRDS GS Antenna |  |
| Horyu-4 GS Antenna |  |

**Test-2: Uplink Success Rate using SG-RF Amplifier GS Setup**

* The goal is to have a direct comparison of BIRDS-3 FM satellite uplink success rate to that of BIRDS-2 UPD uplink success rate. We assume that BIRDS-3 FM satellite will perform better than BIRDS-2 UPD satellite.
* BIRDS GS antenna will be used for sending uplink signal. It will be connected to RF amplifier output. Horyu-4 GS will be connected to ICOM radio for receiving ACK.
* First, BIRDS-2 uplink success rate will be determined by finding the maximum attenuator connected to RF amplifier wherein ACK can still be received (~75% success rate). Use simplified FM flight software but remove beacon.
* At this attenuator value, change to BIRDS-3 FM satellite and check its success rate (presumably, its success rate should still 100%). Increase the attenuator value and find the maximum value wherein ACK can still be received (~75% success rate). Use simplified FM flight software which has only ACK and no beacon.
* The increase in maximum attenuator value from that of BIRDS-2 UPD will determine the improvement of BIRDS-3 FM over BIRDS-2 UPD.



Signal Generator

RF Amplifier

RF out

RF in

To BIRDS GS antenna

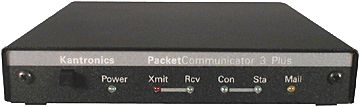
Variable

Attenuators

-8dBm

MOD in

TNC 9600bps



GS PC

* Variable attenuator should have below arrangement

To BIRDS antenna

From RF amp

Lower power

Rated attenuators

30dB

50Watt attenuators

* **Step-0: Setup the BIRDS-3 EM satellite nearby to monitor the received power during uplink success rate determination.**
* **Step-1: Measuring uplink success rate for BIRDS-2 UPD satellite.**

Send uplink commands to BIRDS-2 UPD satellite for a given attenuation value. If satellite sends back acknowledgment, it is taken as success. Repeat this procedure 10 times (not finalized) for a given attenuation value and record the success rate.

Sarakura side BIRDS-3 EM satellite will be used to measure receiving power. Measurement of RX power will be done independently but simultaneously by another person.

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| --- | --- | --- | --- |
| Variable attenuator Value (dB) | Success rate ( /10) | Total attenuation (dB) | Measured power (dBm) at sarakura |
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Total attenuation = Effective attenuation + Variable attenuator value.

* **Step-2: Measuring uplink success rate for BIRDS-3 FM satellite.**

Send uplink commands to BIRDS-3 FM satellite for a given attenuation value. If satellite sends back acknowledgment, it is taken as success. Repeat this procedure 10 times (not finalized) for a given attenuation value and record the success rate. Change TNC data rate from 9600bps to 4800bps. Change GS operating software for BIRDS-3 satellite (use 14byte uplink software).

Sarakura side BIRDS-3 EM satellite will be used to measure receiving power. Measurement of RX power will be done independently but simultaneously by another person.

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| Variable attenuator Value (dB) | Success rate ( /10) | Total attenuation (dB) | Measured power (dBm) at sarakura |
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Total attenuation = Effective attenuation + Variable attenuator value.

**Test-3: Uplink Success Rate using ICOM-9100 GS Setup**

* In this test, we do the same test as in Test-2 but use IC-9100 GS setup.
* BIRDS GS antenna will be connected to IC-9100 to transmit command signal (45 dBm) and receive ACK, as shown below:

To BIRDS GS antenna

Variable

Attenuators



Pout = 45dBm

* **Step-1: Measuring uplink success rate for BIRDS-2 UPD satellite.**

Send uplink commands to BIRDS-2 UPD satellite for a given attenuation value. If satellite sends back acknowledgment, it is taken as success. Repeat this procedure 10 times (not finalized) for a given attenuation value and record the success rate.

Sarakura side BIRDS-3 EM satellite will be used to measure receiving power. Measurement of RX power will be done independently but simultaneously by another person.

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| Variable attenuator Value (dB) | Success rate ( /10) | Total attenuation (dB) | Measured power (dBm) at Sarakura |
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Total attenuation = Effective attenuation + Variable attenuator value.

* **Step-2: Measuring uplink success rate for BIRDS-3 FM satellite.**

Send uplink commands to BIRDS-3 FM satellite for a given attenuation value. If satellite sends back acknowledgment, it is taken as success. Repeat this procedure 10 times (not finalized) for a given attenuation value and record the success rate. Change TNC data rate from 9600bps to 4800bps. Change GS operating software for BIRDS-3 satellite (use 14byte uplink software).

Sarakura side BIRDS-3 EM satellite will be used to measure receiving power. Measurement of RX power will be done independently but simultaneously by another person.

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| Variable attenuator Value (dB) | Success rate ( /10) | Total attenuation (dB) | Measured power (dBm) at Sarakura |
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Total attenuation = Effective attenuation + Variable attenuator value.