

Jammertest 2024 Test Catalogue

Jammertest Consortium

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Statens vegvesen Norwegian Public Roads Administration













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Introduction

Jammertest is a Norwegian government initiative to create a testbed for industry, academia and other authorities to ensure robust and intelligent use of Global Navigation Satellite Systems (GNSS). A testbed is a controlled environment where activities that are not allowed under normal conditions can be carried out safely under control of the authorities. Jammertest is a specific type of testbed where six Norwegian authorities have come together to create an environment where GNSS jamming, spoofing and meaconing is present under controlled conditions in a real world outdoor environment.

This test catalogue describes all centrally planned test cases that can be executed at the Jammertest event at Andøya. For Jammertest, a selected number of tests from this plan will be included in a transmission plan. The transmission plan, which becomes available just before the Jammertest event starts, describes what tests will take place where and at what time. After the Jammertest event the organizers will publish an after the fact transmission log that contains all tests that were run and at what time they were run. The time schedule during the live event will be given in local time, UTC time + 2 (CEST).

A machine readable test catalogue is available in a JSON format, and this (PDF) document is built based on the machine readable test catalouge. The numbering of the tests are (as good as possible) persistant, and will over the years indicate the same tests. New variations of the tests will be given new numbers.

Tests are stacked together in larger test groups and test and varieties of tests are linked to test groups via a numbering system, in such a way that they fulfill this format: TestGroup.Test.TestVariation. Some tests have two numbers, test group and the specific test. Others may have three numbers due to the fact that a specific variation has been added. For example, if power is reduced, a new test variation is created and hence a variation number is added.

Naming of the jammers are linked to the jammer specifications document, that list all jammers with relevant information about the them. See the annexes for this.

This document is auto updated based on changes to the machine readable file, there is no version code apart from the time and date when the document is produced. In the Github repository all produced versions are stored in the history of this file.

Specifications of tests

Tests are grouped into test groups. Within a test group there is a logical connection between the tests that related to the use case. Hence each test group has a *Rationale* why this is test group is created, that also gives a hint about what to expect when subjected to the specific test. As many tests are on the bleeding edge of GNSS disturbances, the *Rationale* section may be updated between Jammertests based on new knowledge and experiences.

Technical details are stored in the *Test setup* section of the document. The *Areas* section of the document refer to where the test can be run. Here participants need to keep track of in which area they where and this also gives and indication of which areas where the organizers are capable of running the tests. There is also a location out at sea (not numbered) that can be used for maritime related test groups, and a location at the airport in Andenes, for aviation related test groups (only for air planes).



For each test group a set of tests and test varieties are listed with their unique identification number, a name and a text that describes the test and teh rationale. An approximate power number is also included. If the test is an automated ramp test then the power range is given. A time estimate of how long the test takes to conclude is given in minutes. Between tests there are also grace periods to allow systems to regain normal operation. Grace times are not given exact as they are dependent on equipment and needs to be discussed with participants beforehand. They also depend on operational concerns. The actual grace time will be calculated from the transmission log after the fact. The location of the transmitter equipment is also given in the test, this is a coarse human readable description of where the transmitting antenna is located. All participants are encouraged to make their own notes on the location of the transmitting antenna if detailed information is needed. There is also a comment field that can be used to document any other relevant information related to the specific test.

For those wanting more information or have feedback about the test group a technical contact is provided for each test group.

0 Supplemental periods

0.0: Mandatory briefings

Rationale

In order for everyone to have a good time and ensure a safe event, there will be mandatory briefings.

Test description

These are the mandatory safety briefings. These briefings will also be used to go through the plan for the day and the afternoon brief will contain important observations from the day and a safety debrief.

Additional information

Mandatory!

Tests within this test group

0.0.1 Mandatory morning briefing

No RF interference expected.

Power or power range

'N/A'

Test bands/constellation

'N/A'

Transmitter equipment 'N/A'

0.0.2 Mandatory afternoon (de)briefing

No RF interference expected.

Power or power range 'N/A'

Test bands/constellation 'N/A'

Transmitter equipment

'N/A'

0.1: Grace period

Rationale

In order for equipment to return to normal operation after interference, a grace period is provided between tests.

Test description

This period can be used to make sure that equipment is ready for upcoming tests.

Tests within this test group

0.1.1 Grace period

No RF interference expected in this test.

Power or power range

'N/A'

Test bands/constellation

'N/A'

Transmitter equipment

'N/A'

0.2: Booking slots

Rationale

Some participants require more specialized ad-hoc tests. Tests in this test group will allow participants to book a time slot and equipment to perform their own tests.

Test description

Tests in this group are available for booking.

Tests within this test group

0.2.1 Jamming booking slot

This test require prebooking.

Power or power range

'N/A'

Test bands/constellation 'N/A'

Transmitter equipment

'N/A'

0.3: Ad hoc tests

Rationale

Some tests can not be planned for in advance. These tests may include new scenarios or altered tests based on observations during the event.

Test description

Tests in this group are created ad hoc during the event. Test comments will describe the setup.

Tests within this test group

0.3.1 Ad hoc test

See log comment for description.

Power or power range 'N/A'

Test bands/constellation 'N/A'

Transmitter equipment

'N/A'

1 Jamming

1.1: Continuous stationary low power jamming with commercially available jammers

Rationale

The main objective is to observe how the J/S signal affect the availability of PNT, and/or how it produces inaccurate PNT data, when the jamming signal (J) is generated by low-power jammers commercially available online. Additionally, as these types of jammers are the ones one is most likely to meet in the real world, capturing and storing the signals from these jammers for later use in labs could be useful.

Test description

All tests will be performed with the jammers place 1 to 1.5 meters above ground (like on top of a vehicle) or on a stand. Unless otherwise stated, jammers will be in "maximum" posistion, meaning all relevant antennas are switched on and power is set to as high as possible. Runtime and pauses between tests is set in the transmission plan document.

Additional information

Specification of jammers can be found in Appendix G. Jammer power levels are based on 2023/2024 measurements. "Test bands/constellation" refers to potentially afflicted signal types of the 4 GNSS constellations GPS, GLONASS, Galileo, and BeiDou, from the jammer in question. This information must be considered indicative only. The main principle for putting a signal type in the "Test bands/constellation" list for a given jammer or test, is that measurements done by NKOM indicate that the output signal of the jammer covers the center frequency of the given GNSS band(s).

Tests within this test group

1.1.1 Jammer S1.1

Test with jammer S1.1

Power or power range

Min: 0.01 W Max: 0.0316 W

Test bands/constellation

'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'S1.1'

1.1.2 Jammer S1.2

Test with jammer S1.2

Power or power range

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'S1.2'

1.1.3 Jammer S1.3

Test with jammer S1.3 $\,$

Power or power range

Min: 0.01 W Max: 0.0316 W

Test bands/constellation

'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'S1.3'

1.1.4 Jammer S2.1

Test with jammer S2.1

Power or power range

Min: 0.0316 W Max: 0.1 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'S2.1'

1.1.5 Jammer S2.2

Test with jammer S2.2 $\,$

Power or power range

Min: 0.0316 W Max: 0.1 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'S2.2'

1.1.6 Jammer S2.3

Test with jammer S2.3

Power or power range

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'S2.3'

1.1.7 Jammer S2.4

Test with jammer S2.4 $\,$

Power or power range

Min: 0.0316 W Max: 0.1 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'S2.4'

1.1.8 Jammer U1.1

Test with jammer U1.1

Power or power range 'N/A'

Test bands/constellation 'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment 'U1.1'

1.1.9 Jammer U1.2

Test with jammer U1.2

Power or power range 'N/A'

Test bands/constellation 'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment 'U1.2'

1.1.10 Jammer U1.3

Test with jammer U1.3

Power or power range 'N/A'

Test bands/constellation 'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment 'U1.3'

1.1.11 Jammer U1.4

Test with jammer U1.4

Power or power range

'N/A'

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'U1.4'

1.1.12 Jammer H1.1

Test with jammer H1.1 with function settings set at high power and GPS L1+L2 wideband modulation.

Power or power range

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1'

1.1.13 Jammer H1.2

Test with jammer H1.2

Power or power range

Min: 0.0631 WMax: 0.0631 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'H1.2'

1.1.14 Jammer H1.4

Test with jammer H1.4 with function settings set at high power and GPS L1+L2 wideband modulation.

Power or power range

Min: 0.0003 W Max: 0.1 W

Test bands/constellation

'L1', 'E1', 'B1C', 'B1I', 'L2'

Transmitter equipment

'H1.4'

1.1.15 Jammer H1.5

Test with jammer H1.5 with function settings set at high power and GPS L1+L2 wideband modulation.

Power or power range

Min: 0.0003 W Max: 0.1 W

Test bands/constellation

'L1', 'E1', 'B1C', 'B1I', 'L2'

Transmitter equipment

'H1.5'

1.1.16 Jammer H3.1

Test with jammer H3.1

Power or power range

Min: 0.1 W Max: 0.1 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'H3.1'

1.1.17 Jammer H3.2

Test with jammer H3.2

Power or power range

Min: 0.1 W Max: 0.1 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'H3.2'

1.1.18 Jammer H3.3

Test with jammer H3.3 $\,$

Power or power range

Min: 1 W Max: 1 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H3.3'

1.1.19 Jammer H4.1

Test with jammer H4.1

Power or power range

Min: 0.3981 W Max: 0.631 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H4.1'

1.1.20 Jammer H6.1

Test with jammer H6.1

Power or power range

Min: 0.631 W Max: 0.631 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C'

Transmitter equipment

'H6.1'

1.1.21 Jammer H6.2

TEst with jammer H6.2

Power or power range

Test bands/constellation

'L1', 'E1', 'B1C', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.2'

1.1.22 Jammer H6.3

Test with jammer H6.3

Power or power range

Test bands/constellation

'L1', 'E1', 'B1C', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.3'

1.1.23 Jammer H6.4

Test with jammer H6.4

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.4'

1.1.24 Jammer H6.5

Test with jammer H6.5

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.5'

1.1.25 Jammer H6.6

Test with jammer H6.6

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.6'

1.1.26 Jammer H8.1

Test with jammer H8.1

Power or power range

Min: 0.631 W Max: 0.631 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'H8.1'

1.1.27 Jammer F6.1

Test with jammer F6.1 (with function settings set at full power and antennas F2 to F6).

Power or power range

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

F6.1'

1.1.28 Jammer H1.3

Test with jammer H1.3

Power or power range

'N/A'

Test bands/constellation 'L1', 'E1', 'B1C'

Transmitter equipment 'H1.3'

1.1.29 Jammer H2.1

Test with jammer H2.1

Power or power range 'N/A'

Test bands/constellation 'L1', 'E1', 'B1C', 'L2'

Transmitter equipment 'H2.1'

1.1.30 Jammer H2.2

Test with jammer H2.2

Power or power range

 ${\rm 'N/A'}$

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H2.2'

1.2: Continuous stationary high-power jamming with CW

Rationale

The main objective is to observe how the Jammer signal to GNSS signal (J/S) ratio affect the availability of PNT, and/or how it produces inaccurate PNT data. Phase transitions, going from not being jammed to being jammed and vice versa, are especially interesting. Tests have shown that errors can vastly increase in these phases (before availability disappears entirely).

Test description

The use of continuous high-power jamming will block GNSS signals in a large area at the event. There will be transmitted with a continuous wave (CW) modulation (single frequency component) using Right Hand Circular Polarized (RHCP) antennas. The CW signals will be transmitted at the centre frequencies of the relevant test bands. Up to 50 W ERP jamming power will result in among the highest J/S ratios during the event. The attendees may vary their distance to the transmitter and observe the changes and try to identify the protection ratio for their GNSS receiving system.

Additional information

The jammer employed will be F8.1 "Porcus Major", see Appendix G.

Tests within this test group

1.2.1 Jammer F8.1 "Porcus Major": 50 W CW: L1

Jammer F8.1 "Porcus Major": 50 W CW: L1

Power or power range

Min: 1 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.2.2 Jammer F8.1 "Porcus Major": 50 W CW: L1, G1

Jammer F8.1 "Porcus Major": 50 W CW: L1, G1

Power or power range

Min: 1 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1'

Transmitter equipment

1.2.3 Jammer F8.1 "Porcus Major": 50 W CW: L1, G1, L2

Jammer F8.1 "Porcus Major": 50 W CW: L1, G1, L2

Power or power range

Min: 1 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1', 'L2'

Transmitter equipment

'F8.1'

1.2.4 Jammer F8.1 "Porcus Major": 50 W CW: L1, G1, L2, L5

Jammer F8.1 "Porcus Major": 50 W CW: L1, G1, L2, L5

Power or power range

Min: 1 W Max: 50 W

 $Test \ bands/constellation$

'L1', 'E1', 'B1C', 'G1', 'L2', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F8.1'

1.3: Continuous stationary high-power jamming with sweep

Rationale

The main objective is to observe how the Jammer signal to GNSS signal (J/S) ratio affect the availability of PNT, and/or how it produces inaccurate PNT data. Phase transitions, going from not being jammed to being jammed and vice versa, are especially interesting. Tests have shown that errors can vastly increase in these phases (before availability disappears entirely).

Test description

Continuous high-power jamming will block GNSS signals in a large area at the event. There will be transmitted linear sawtooth modulated signals sweeping over the selected frequency bands using Right Hand Circular Polarized (RHCP) antennas. This means that the frequency component will sweep back and forth inside the specific frequency band with a given sweep rate. The sweeping signal will have a sweeping rate of up to 100 kHz at selected bandwidths, centred at the centre frequency of the relevant test band. The attendees may vary their distance to the transmitter and observe the changes and try to identify the thresholds of their GNSS equipment.

Additional information

The jammer employed will be F8.1 "Porcus Major", see Appendix G.

Tests within this test group

1.3.1 Jammer F8.1 "Porcus Major": 50 W sweep: L1, 100 kHz

50 W sweep: L1, sweep rate: 100 kHz

Power or power range

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.3.2 Jammer F8.1 "Porcus Major": 50 W sweep: L1, G1, 100 kHz

Jammer F8.1 "Porcus Major": 50 W sweep: L1, G1, sweep rate: 100 kHz

Power or power range

Min: 1 W Max: 50 W

$Test \ bands/constellation$

'L1', 'E1', 'B1C', 'G1'

Transmitter equipment

'F8.1'

1.3.3 Jammer F8.1 "Porcus Major": 50 W sweep: L1, G1, L2, 100 kHz

Jammer F8.1 "Porcus Major": 50 W sweep: L1, G1, L2, sweep rate: 100 kHz

Power or power range

Min: 1 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1', 'L2'

Transmitter equipment

1.3.4 Jammer F8.1 "Porcus Major": 50 W sweep: L1, G1, L2, L5, 100 kHz

Jammer F8.1 "Porcus Major": 50 W sweep: L1, G1, L2, L5, sweep rate: 100 kHz

Power or power range

Min: 1 W Max: 50 W

Test bands/constellation 'L1', 'E1', 'B1C', 'G1', 'L2', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F8.1'

1.3.5 Jammer F8.1 "Porcus Major": 50 W sweep: L1, sweep rate: 1 kHz, BW: 6 MHz

Jammer F8.1 "Porcus Major": 50 W sweep: L1, sweep rate: 1 kHz

Power or power range

Min: 1 W Max: 50 W

Test bands/constellation 'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.3.6 Jammer F8.1 "Porcus Major": 50 W sweep: L1, G1, 1 kHz

Jammer F8.1 "Porcus Major": 50 W sweep: L1, G1, sweep rate: 1 kHz

Power or power range

Min: 1 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1'

Transmitter equipment

'F8.1'

1.3.7 Jammer F8.1 "Porcus Major": 1 W sweep: L1, G1, L2, 1 kHz

Jammer F8.1 "Porcus Major": 1 W sweep: L1, G1, L2, sweep rate: 1 kHz

Power or power range

Min: 1 W Max: 1 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1', 'L2'

Transmitter equipment

'F8.1'

1.3.8 Jammer F8.1 "Porcus Major": 50 W sweep: L1, G1, L2, L5, sweep rate: 1 kHz, BW: 6 MHz

Jammer F8.1 "Porcus Major": 50 W sweep: L1, G1, L2, L5, sweep rate: 1 kHz

Power or power range

Min: 1 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1', 'L2', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F8.1'

1.4: Continuous stationary high-power jamming with PRN

Rationale

The main objective is to observe how the Jammer signal to GNSS signal (J/S) ratio affect the availability of PNT, and/or how it produces inaccurate PNT data. Phase transitions, going from not being jammed to being jammed and vice versa, are especially interesting. Tests have shown that errors can vastly increase in these phases (before availability disappears entirely).

Test description

Continuous high-power jamming will block GNSS signals in a large area at the event. There will be transmitted signals with Pseudo Random Noise (PRN) modulation using Right Hand Circular Polarized (RHCP) antennas. PRN signals have the same spectral form as the true signals transmitted by the GNSS satellites but with different spreading codes. The spreading codes are Binary Phase Shift Keying (BPSK) modulated onto the centre frequency of the relevant test bands. The attendees may vary their distance to the transmitter and observe the behaviour of their GNSS equipment.

Additional information

The jammer employed will be F8.1 "Porcus Major", see Appendix G.

Tests within this test group

1.4.1 Jammer F8.1 "Porcus Major": 50 W PRN: L1, Chiprate: 3 MHz

Jammer F8.1 "Porcus Major": 50 W PRN: L1

Power or power range

Min: 1 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.4.2 Jammer F8.1 "Porcus Major": 50 W PRN: L1, G1

Jammer F8.1 "Porcus Major": 50 W PRN: L1, G1

Power or power range

Min: 1 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1'

Transmitter equipment

F8.1'

1.4.3 Jammer F8.1 "Porcus Major": 50 W PRN: L1, G1, L2

Jammer F8.1 "Porcus Major": 50 W PRN: L1, G1, L2

Power or power range

Min: 1 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1', 'L2'

Transmitter equipment

1.4.4 Jammer F8.1 "Porcus Major": 50 W PRN: L1, G1, L2, L5, Chiprate: 3 MHz

Jammer F8.1 "Porcus Major": 50 W PRN: L1, G1, L2, L5

Power or power range

Min: 1 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1', 'L2', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F8.1'

1.5: Continuous stationary high-power jamming with "real world" PRN

Rationale

The type of jamming employed in this test is the same as real world signals observed in Europe, where the jammer parameters were found after demodulating a captured baseband stream.

Test description

The tests will be performed with BPSK modulation with a pseudo random symbol rate of 3 Mbaud at GPS L1 and 10.23 Mbaud at GLONASS G1. The test cases refer to which centre frequency of the relevant test bands the signal will be centred at.

Additional information

The jammer employed will be F8.1 "Porcus Major", see Appendix G.

Tests within this test group

1.5.1 50 W: L1 PRN (Mbaud of 3)

50 W: L1 PRN (BPSK-modulated with Mbaud symbol rate of 3)

Power or power range

Min: 1 W Max: 50 W

Test bands/constellation

L1'

Transmitter equipment

50 W: G1 PRN (BPSK-modulated with Mbaud symbolrate of 10.23)

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'G1'

Transmitter equipment

'F8.1'

1.6: Stationary high-power jamming, ramp power with PRN

Rationale

The main objective is to observe how the J/S signal affect the loss of PNT, and/or how it produces inaccurate PNT data, and at which power level. This will allow for evaluation of the sensitivity thresholds for various systems and algorithms.

Test description

The transmitted power will be ramped up and down from a lower to a higher ERP for each test, with 10 seconds hold time for each power level, with ramping steps of 2 dB. The modulation will be PRN. The attendees should be at a stationary location with a known distance to the jammer, so they can observe how different levels will affect the PNT.

Additional information

The jammer employed will be F8.1 "Porcus Major", see Appendix G.

Tests within this test group

1.6.1 Power ramping with Jammer F8.1 "Porcus Major": 0.2 μW (-37dBm) to 50 W (47dBm) with 2 dB increments PRN: L1

PRN jamming with a power ramp from 0.2 μ W (-37dBm) to a maximum of 50 W (47dBm) with 2 dB increments, within the test band L1.

Power or power range

Min: 2e-07 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

1.6.2 Power ramping with Jammer F8.1 "Porcus Major": 0.2 μW (-37dBm) to 50 W (47dBm) with 2 dB increments PRN: L1, G1

PRN jamming with a power ramp from 0.2 μW (-37dBm) to a maximum of 50 W (47dBm) with 2 dB increments, within the test bands L1, G1.

Power or power range

Test bands/constellation

'L1', 'E1', 'B1C', 'G1'

Transmitter equipment

'F8.1'

1.6.3 Power ramping with Jammer F8.1 "Porcus Major": 0.2 μW (-37dBm) to 50 W (47dBm) with 2 dB increments PRN: L1, G1, L2

PRN jamming with a power ramp from 0.2 μW (-37dBm) to a maximum of 50 W (47dBm) with 2 dB increments, within the test bands L1, G1, L2.

Power or power range

Min: 2e-07 W Max: 50 W

$Test \ bands/constellation$

'L1', 'E1', 'B1C', 'G1', 'L2'

Transmitter equipment

'F8.1'

1.6.4 Power ramping with Jammer F8.1 "Porcus Major": 0.2 μ W (-37dBm) to 50 W (47dBm) with 2 dB increments PRN: L1, G1, L2, L5

PRN jamming with a power ramp from 0.2 μW (-37dBm) to a maximum of 50 W (47dBm) at 2 dB increments, within the test bands L1, G1, L2, L5.

Power or power range

Test bands/constellation

'L1', 'E1', 'B1C', 'G1', 'L2', 'L5', 'E5a', 'B2a'

Transmitter equipment

1.7: Stationary high-power jamming, ramp power with CW

Rationale

The main objective is to observe how the J/S signal affect the loss of PNT, and/or how it produces inaccurate PNT data, and at which power level. This will allow for evaluation of the sensitivity thresholds for various systems and algorithms.

Test description

The transmitted power will be ramped up and down from a lower to a higher ERP for each test, with 10 seconds hold time for each power level, with ramping steps 2 dB. The modulation will be CW. The attendees should be at a stationary location with a known distance to the jammer, so they can observe how different levels will affect the PNT.

Additional information

The jammer employed will be F8.1 "Porcus Major", see Appendix G.

Tests within this test group

1.7.1 0.2 μW (-37dBm) to 50 W (47dBm) at 2 dB increments CW: L1

CW jamming with a power ramp from 0.2 μW (-37dBm) to a maximum of 50 W (47dBm) at 2 dB increments, at the test bands L1.

Power or power range

Min: 2e-07 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.7.2 0.2 μ W (-37dBm) to 50 W (47dBm) at 2 dB increments CW: L1, G1

CW jamming with a power ramp from 0.2 μW (-37dBm) to a maximum of 50 W (47dBm) at 2 dB increments, at the test bands L1, G1.

Power or power range

Min: 2e-07 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1'

Transmitter equipment

$1.7.3~0.2~\mu W$ (-37dBm) to 50 W (47dBm) at 2 dB increments CW: L1, G1, L2

CW jamming with a power ramp from 0.2 μW (-37dBm) to a maximum of 50 W (47dBm) at 2 dB increments, at the test bands L1, G1, L2.

Power or power range

$Test \ bands/constellation$

'L1', 'E1', 'B1C', 'G1', 'L2'

Transmitter equipment

'F8.1'

$1.7.4~0.2~\mu W$ (-37dBm) to 50 W (47dBm) at 2 dB increments CW: L1, G1, L2, L5

CW jamming with a power ramp from 0.2 μW (-37dBm) to a maximum of 50 W (47dBm) at 2 dB increments, at the test bands L1, G1, L2, L5.

Power or power range

Test bands/constellation

'L1', 'E1', 'B1C', 'G1', 'L2', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F8.1'

1.8: Stationary pyramid jamming with PRN for all GNSS bands sequentially

Rationale

This "pyramid" is intended to test the potential fallback behaviour of modern multi-constellation, multi-frequency receivers.

Test description

A jamming pyramid test of GNSS bands. The jamming is performed with PRN modulation and a constant power level. Each pyramid step will lastfor 5 minutes, with first 3 minutes active jamming, and then two minutes off. The test will jam most GNSS bands, incrementally adding bands ("pyramid steps") to the list of jammed signals, then removing them in the reverse order.

Additional information

The jammer employed will be F8.1 "Porcus Major", see Appendix G.

1.8.1 Jammer F8.1 "Porcus Major": 50 W PRN pyramid: E6, E5b, L5, G2, L2, B1I, G1, L1

50 W PRN pyramid jamming, starting with only E6 and adding bands all the way up to E6, E5b, L5, G2, L2, B1I, G1, L1. The test then continues by removing bands one by one in reverse order, until ending up with only E6. In total, it will look this: E6 E6, E5b E6, E5b, L5 E6, E5b, L5, G2 E6, E5b, L5, G2, L2 E6, E5b, L5, G2, L2, B1I E6, E5b, L5, G2, L2, B1I, G1 E6, E5b, L5, G2, L2, B1I, G1, L1 E6, E5b, L5, G2, L2, B1I, G1 E6, E5b, L5, G2, L2, B1I E6, E5b, L5, G2, L2 E6, E5b, L5, G2 E6, E5b, L5 E6, E5b E6

Power or power range

Test bands/constellation

'E6', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a', 'G2', 'L2', 'B1I', 'G1', 'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.9: Stationary inverted pyramid jamming with PRN for all GNSS bands sequentially

Rationale

This 'inverted pyramid' is intended to test the potential fallback behaviour of modern multi-constellation, multi-frequency receivers, in an opposite way than a normal pyramid test.

Test description

An inverted jamming pyramid test of GNSS bands. The jamming is performed with PRN modulation and a constant power level. Each pyramid step will lastfor 5 minutes, with first 3 minutes active jamming, and then two minutes off. The tests will jam most GNSS bands, incrementally removing bands ("pyramid steps") from the list of jammed signals, then adding them in the reverse order.

Additional information

The jammer employed will be F8.1 "Porcus Major", see Appendix G.

1.9.1 50 W PRN inverted pyramid: E6, E5b, L5, G2, L2, B1I, G1, L1

50 W PRN inverted pyramid jamming, starting with E6, E5b, L5, G2, L2, B1I, G1, L1 and removing bands all the way down to only E6. The test then continues by adding bands one by one in reverse order, until ending back at the starting frequency bands. In total, it will look like this:

 $\begin{array}{l} {\rm E6,\ E5b,\ L5,\ G2,\ L2,\ B1I,\ G1,\ L1}\\ {\rm E6,\ E5b,\ L5,\ G2,\ L2,\ B1I,\ G1}\\ {\rm E6,\ E5b,\ L5,\ G2,\ L2,\ B1I}\\ {\rm E6,\ E5b,\ L5,\ G2,\ L2}\\ {\rm E6,\ E5b,\ L5,\ G2}\\ {\rm E6,\ E5b,\ L5,\ G2}\\ {\rm E6,\ E5b,\ L5,\ G2}\\ {\rm E6,\ E5b,\ L5,\ G2,\ L2}\\ {\rm E6,\ E5b,\ L5,\ G2,\ L2,\ B1I}\\ {\rm E6,\ E5b,\ L5,\ G2,\ L2,\ B1I}\\ {\rm E6,\ E5b,\ L5,\ G2,\ L2,\ B1I,\ G1}\\ {\rm E6,\ E5b,\ L5,\ G2,\ L2,\ B1I,\ G1}\\ {\rm E6,\ E5b,\ L5,\ G2,\ L2,\ B1I,\ G1,\ L1}\\ \end{array}$

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'E6', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a', 'G2', 'L2', 'B1I', 'G1', 'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.10: Motorcade with low-power commercially available jammers (placed on stationary vehicle)

Rationale

These tests explore the impact on systems in DUT vehicles caused by a jammer placed on a parked car.

Test description

Jammers used in these tests are commercially available jammers. The jammers are to be placed on the roof of a vehicle, and DUT vehicles can then do driving tests based around this stationary jammer.

Additional information

Specification of jammers can be found in Appendix G. Jammer power levels are based on 2023/2024 measurements. "Test bands/constellation" refers to potentially afflicted signal types of the 4 GNSS constellations GPS, GLONASS, Galileo, and BeiDou, from the jammer in question. This information must be considered indicative only. The main principle for putting a signal type in the "Test bands/constellation" list for a given jammer or test, is that measurements done by NKOM indicate that the output signal of the jammer covers the center frequency of the given GNSS band(s).

1.10.1 Driving while passing a parked car with dual-band jammer

Test performed with jammer S2.4. DUT vehicles will start at driving from a point where they are only marginally or not at all affected by the jammer.

Power or power range

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'S2.4'

1.10.2 Driving while passing a parked car with multi-band jammer

Test performed with jammer H6.5. DUT vehicles will start at driving from a point where they are only marginally or not at all affected by the jammer.

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.5'

1.10.3 Vehicle starting in dual-band denied environment

Test performed with jammer S2.4. DUT vehicles will start up close to the parked car with the jammer, and then drive away.

Power or power range

Min: 0.0316 W Max: 0.1 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'S2.4'

1.10.4 Vehicle starting in multi-band denied environment

Test performed jammer H6.5. DUT vehicles will start up close to the parked car with the jammer, and then drive away.

Power or power range

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.5'

1.10.5 Driving while passing three consecutive parked cars with dual-band jammer

All tests will be performed with the jammers placed at predetermined sites (map and coordinates in appendix A). Over 1 km between locations.

Power or power range

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'S2.4', 'S2.2', 'S2.3'

1.10.6 Driving while passing three consecutive parked cars with multi-band jammer

All tests will be performed with the jammers placed at predetermined sites (map and coordinates in appendix A). Over 1 km between locations.

Power or power range

Min: 0.3981 W Max: 1 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.1', 'H6.2', 'H6.3'

1.10.7 Driving while passing three consecutive parked cars with both dualand multi-band jammers (in order of number of bands)

All tests will be performed with the jammers placed at predetermined sites (map and coordinates in appendix A). Over 1 km between locations.

Power or power range

Min: 0.0316 W Max: 0.631 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'S2.4', 'H6.1', 'H8.1'

1.11: Motorcade with low-power commercially available jammers (placed inside mobile vehicle)

Rationale

These tests simulate meeting a vehicle on the road with a jammer inside of it, to explore the impact on systems in DUT vehicles.

Test description

Jammers used in these tests are commercially available jammers and will be placed inside the jammercarrying vehicle. DUT vehicles will act in motorcades during the tests and move as one unit relative to the jammer-carrying vehicle. In some specific tests, the jammer can be placed inside of a DUT vehicle, testing that one specific vehicle.

Additional information

Specification of jammers can be found in Appendix G. Jammer power levels are based on 2023/2024 measurements. "Test bands/constellation" refers to potentially afflicted signal types of the 4 GNSS constellations GPS, GLONASS, Galileo, and BeiDou, from the jammer in question. This information must be considered indicative only. The main principle for putting a signal type in the "Test bands/constellation" list for a given jammer or test, is that measurements done by NKOM indicate that the output signal of the jammer covers the center frequency of the given GNSS band(s).

Tests within this test group

1.11.1 (Deprecated - Not available) Driving with dual-band jammer in test vehicle

Test performed with jammer S2.4, where the jammer is placed inside the mobile DUT vehicle.

Power or power range

Min: 0.0316 W Max: 0.1 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'S2.4'

1.11.2 Driving with dual-band jammer in vehicle in front of the test vehicle

Test performed with jammer S2.4

Power or power range

Min: 0.0316 W Max: 0.1 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'S2.4'

1.11.3 Driving with dual-band jammer in vehicle behind the test vehicle

Test performed with jammer S2.4

Power or power range

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'S2.4'

1.11.4 (Deprecated - Not available due to safety) Driving with dual-band jammer in vehicle overtaking the test vehicle

Test performed with jammer S2.4

Power or power range

$Test \ bands/constellation$

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

'S2.4'

1.11.5 (Deprecated - Not available due to safety) Driving with dual-band jammer in vehicle being overtaken by the test vehicle

Test performed with jammer S2.4

Power or power range

Min: 0.0316 W Max: 0.1 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'S2.4'

1.11.6 (Deprecated - Not available) Driving with multi-band jammer in test vehicle

Test performed with jammer H6.5, where the jammer is placed inside the mobile DUT vehicle.

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.5'

1.11.7 Driving with multi-band jammer in vehicle in front of the test vehicle

Test performed with jammer H6.5

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

'H6.5'

1.11.8 Driving with multi-band jammer in vehicle behind the test vehicle

Test performed with jammer H6.5

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.5'

1.11.9 (Deprecated - Not available due to safety) Driving with multi-band jammer in vehicle overtaking the test vehicle

Test performed with jammer H6.5

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.5'

1.11.10 (Deprecated - Not available due to safety) Driving with multi-band jammer in vehicle being overtaken by the test vehicle

Test performed with jammer H6.5

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

'H6.5'

1.12: Low power jamming with three commercially available multi-band jammers in different placements in the terrain

Rationale

The main objective is to simulate meeting several "more dangerous" jammers, multi-band jammers.

Test description

The test will use three multiband jammers, spaced out in the terrain in different places (configurations A and B). Attendees can move around or station themselves so that they can experience the different constellation and observe how their equipment and systems behave in a complicated GNSS RFI environment.

Additional information

The precise positions for each jammer will have to be decided in field, to best accommodate participants wishes and practical concerns (like terrain). The coordinates for each position, X, Y and Z, will have to be written down in field to help later analysis of the test results. Specification of jammers can be found in Appendix G. Jammer power levels are based on 2023/2024 measurements. "Test bands/constellation" refers to potentially afflicted signal types of the 4 GNSS constellations GPS, GLONASS, Galileo, and BeiDou, from the jammer in question. This information must be considered indicative only. The main principle for putting a signal type in the "Test bands/constellation" list for a given jammer or test, is that measurements done by NKOM indicate that the output signal of the jammer covers the center frequency of the given GNSS band(s).

Tests within this test group

1.12.1 All jammers stationary in placement-configuration A, activate sequentially

Sequential activation of the three jammers, from first to last as listed in 'Transmitter equipment'. Max/min power does not account for multiple jammers being active at once.

Power or power range

Min: 0.5012 W Max: 6.31 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F6.1', 'H6.5', 'H3.3'

1.12.2 All jammers stationary in placement-configuration B; activate sequentially

Sequential activation of the three jammers, from first to last as listed in 'Transmitter equipment'. Max/min power does not account for multiple jammers being active at once.

Power or power range

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F6.1', 'H6.5', 'H3.3'

1.12.3 Two jammers stationary in placement-confinguration A, last jammer, activated simultaneously

First two jammers are stationary, last one is mobile (as counted from first to last as listed in 'Transmitter equipment'). All jammers are activated simultaneously. Max/min power does not account for multiple jammers being active at once.

Power or power range

Min: 0.5012 WMax: 6.31 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F6.1', 'H6.5', 'H3.3'

1.13: Jamming attacks with jammers on board a ship

Rationale

The objective is to simulate the conditions of which a jammer can appear on ships like ferries, to explore the impact on the ship's systems when the jammer is on board.

Test description

In general, some tests will be done with jammers on top of the car and some with the jammers inside the car, with variations of single-, dual-, or multi-band commercially available jammers. Other tests are with jammers held by people on other parts of the ship. More specific locations and test setups will have to be chosen on site according to layout of ship and available time schedule.

Additional information

Specification of jammers can be found in Appendix G. Jammer power levels are based on 2023/2024 measurements. "Test bands/constellation" refers to potentially afflicted signal types of the 4 GNSS constellations GPS, GLONASS, Galileo, and BeiDou, from the jammer in question. This information must be considered indicative only. The main principle for putting a signal type in the "Test bands/constellation" list for a given jammer or test, is that measurements done by NKOM indicate that the output signal of the jammer covers the center frequency of the given GNSS band(s).

Tests within this test group

1.13.1 Single-band jammer on the car deck outside car

Test performed with jammer H8.1

Power or power range

Min: 0.631 W Max: 0.631 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'H8.1'

1.13.2 Single-band jammer on the car deck inside car

Test performed with jammer H8.1

Power or power range

Min: 0.631 W Max: 0.631 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'H8.1'

1.13.3 Dual-band jammer on the car deck outside car

Test performed with jammer H6.6 (antennas 3 and 5 activated).

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I'

Transmitter equipment

'H6.6'

1.13.4 Dual-band jammer on the car deck inside car

Test performed with jammer H6.6 (antennas 3 and 5 activated).

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation 'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I'

Transmitter equipment

'H6.6'

1.13.5 Multi-band jammer on the car deck outside car

Test performed with jammer H6.6 (all relevant antennas activated).

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.6'

1.13.6 Multi-band jammer on the car deck inside car

Test performed with jammer H6.6 (all relevant antennas activated).

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

'H6.6'

1.13.7 Multi-band jammer on deck close to the ship's antennas (by the bridge)

Test performed with jammer H6.6 (all relevant antennas activated).

Power or power range

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.6'

1.13.8 Multi-band jammer inside public areas of boat (under the bridge)

Test performed with jammer H6.6 (all relevant antennas activated).

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I', 'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'L5', 'E5a', 'B2a'

Transmitter equipment

'H6.6'

1.14: Stationary very high-power jamming, ramp power with PRN

Rationale

The main objective is to observe how the J/S signal affect the loss of PNT, and/or how it produces inaccurate PNT data, and at which power level up to a very high power. This will allow for evaluation of the sensitivity thresholds for various systems and algorithms.

Test description

The transmitted power will be ramped up and down from a lower to a higher ERP for each test, where the max power is the highest power that will be experience during the Jammertest event. Each power level holds for 10 seconds, with ramping steps of a certain amount of dB. If the last step doesn't add up to a whole dB step (e.g. from [...] 48, 50, 52 dBm to 53.0103 dBm (200 W)), it will be the exact amount of dB to realise the max power (e.g. a 1.0103 dB increment, not a 2 dB increment). The modulation will be PRN. The attendees should be at a stationary location with a known distance to the jammer, so they can observe how different levels will affect the PNT.

Additional information

The jammer employed will be "Porcus Major" F8.1, see Appendix G.

Tests within this test group

1.14.1 0.1 μW to 200 W, 2 dB increments PRN: L1

PRN jamming with a power ramp from 0.1 μW to a maximum of 200 W at 2 dB increments, at the test band L1.

Power or power range

Min: 1e-07 W Max: 200 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.14.2 0.1 μW to 200 W, 2 dB increments PRN: L1, G1

PRN jamming with a power ramp from 0.1 μW to a maximum of 200 W at 2 dB increments, at the test bands L1, G1.

Power or power range

Min: 1e-07 W Max: 200 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.14.3 0.1 μW to 200 W, 2 dB increments PRN: L1, G1, L2

PRN jamming with a power ramp from 0.1 μW to a maximum of 200 W at 2 dB increments, at the test bands L1, G1, L2.

Min: 1e-07 W Max: 200 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F8.1'

1.14.4 0.1 µW to 200 W, 2 dB increments PRN: L1, G1, L2, L5

PRN jamming with a power ramp from 0.1 μ W to a maximum of 200 W at 2 dB increments, at the test bands L1, G1, L5.

Power or power range

Min: 1e-07 W Max: 200 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'L2', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F8.1'

1.15: Stationary WB power ramp jamming of L1 and G1

Rationale

The main objective is to test receivers' ability to change between using GPS and GLONASS when one or the other is denied.

Test description

A 20 MHz wideband (WB) white noise signal will be active on either L1 or G1. Signal power will be ramped up (in 10 dB steps) during the first test, and then kept at the achieved maximum power for the reminder of the tests.

Additional information

Each test will have a short break after it is completed. When L1-only and G1-only is combined in a test, the transmission will change from the first to the second instantly.

Tests within this test group

1.15.1 WB jamming: L1

Low-power WB jamming on only the L1 band,

Min: 0.1 W Max: 1 W

Test bands/constellation

'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'N/A'

1.15.2 WB jamming: G1

Low-power WB jamming on only the G1 band,

Power or power range

Min: 1 W Max: 1 W

Test bands/constellation

'G1'

Transmitter equipment

'N/A'

1.15.3 WB jamming: G1 then L1

Low-power jamming of first only the G1 band and after half of the test duration, the signal is without a break switched to L1-only.

Power or power range

Min: 1 W Max: 1 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'N/A'

1.15.4 WB jamming: L1 then G1

Low-power jamming of first only the L1 band and after half of the test duration, the signal is without a break switched to G1-only.

Min: 1 W Max: 1 W

Test bands/constellation 'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'N/A'

1.16: Continuous stationary very high-power jamming with PRN

Rationale

The main objective is to observe how the J/S signal affect the loss of PNT, and/or how it produces inaccurate PNT data, at very high power levels or at very long ranges. This will allow for evaluation of both system under extreme duress and allow for the use of a very large testing area, ecspecially suited for ships and airplanes.

Test description

The use of continuous very high-power jamming will block out a very large area at the event. There will be transmitted with a PseudoRandom Noise (PRN) modulation using Right Hand Circular Polarized (RHCP) antennas. PRN signals have the same spectral form as the true signals sent from the GNSS satellites but with different spreading codes. The spreading codes are Binary Phase Shift Keying (BPSK) modulated onto the centre frequency of the relevant test bands. For Mbaud rates, see Appendix G .

These tests will have the highest transmission power experienced during the Jammertest event.

Additional information

The jammer employed will be "Porcus Major" F8.1, see Appendix G.

Tests within this test group

1.16.1 High Power PRN jamming: L1

High Power PRN jamming: L1

Power or power range

Min: 50 W Max: 100 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

1.16.2 High Power PRN jamming:: L1, G1

High Power PRN jamming: L1, G1

Power or power range

Min: 50 W Max: 100 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1'

Transmitter equipment

'F8.1'

1.16.3 High Power PRN jamming: L1, G1, L2

High Power PRN jamming: L1, G1, L2

Power or power range

Min: 50 W Max: 100 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1', 'L2'

Transmitter equipment

'F8.1'

1.16.4 High Power PRN jamming: L1, G1, L2, L5

High Power PRN jamming: L1, G1, L2, L5

Power or power range

Min: 50 W Max: 100 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1', 'L2', 'L5', 'E5a', 'B2a'

Transmitter equipment

1.17: Continuous stationary jamming with PRN at airport

Rationale

For airplanes, it is often hard to test reactions to GNSS jamming in controlled environment, and especially hard to do so at during approach and departure at an airport. The main objective of these tests is to facilitate just that, so that airplanes can test their systems in full approach and departure modes, at with procedures for a real airport activated.

Test description

The transmissions will be done at aviation relevant frequencies with varying degrees of transmission power and jamming modulations. The jammer will be placed and directed (with a RHCP directional antenna) along the runway of the airport. There will be transmitted with a Pseudo Random Noise (PRN) modulation using a BPSK spreading codes modulated onto the centre frequency of the relevant test bands. For Mbaud rates, see Appendix G.

Additional information

The jammer employed will be "Porcus Major" F8.1, see Appendix G.

Tests within this test group

1.17.1 10 W PRN: L1

 $10 \ {\rm W}$ PRN: L1

Power or power range

Min: 1 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'APJ'

1.17.2 10 W PRN: L5

10 W PRN: L5

Power or power range

Min: 1 W Max: 10 W

Test bands/constellation

'L5', 'E5a', 'B2a'

Transmitter equipment

'APJ'

10 W CW: L1, L5

Power or power range

Min: 1 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L5', 'E5a', 'B2a'

Transmitter equipment

'APJ'

1.17.4 10 W sweep: L1, L5

 $10~\mathrm{W}$ sweep: L1, L5

Power or power range

Min: 1 W Max: 10 W

$Test \ bands/constellation$

'L1', 'E1', 'B1C', 'L5', 'E5a', 'B2a'

Transmitter equipment

 ${\rm 'APJ'}$

1.17.5 10 W PRN: L1, L5

10 W PRN: L1, L5

Power or power range

Min: 1 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L5', 'E5a', 'B2a'

Transmitter equipment

'APJ'

1.17.6 1 W PRN: L1, L5

1 W PRN: L1, L5

Min: 1 W Max: 1 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L5', 'E5a', 'B2a'

Transmitter equipment

'APJ'

$1.17.7 \ 0.1 \ W \ PRN: L1, \ L5$

 $0.1 \le PRN: L1, L5$

Power or power range

Min: 0.1 W Max: 0.1 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L5', 'E5a', 'B2a'

Transmitter equipment

'APJ'

1.18: Stationary unintentional RFI

Rationale

Although intentional GNSS interference (jamming, spoofing and meaconing) is the most known and mentioned type of GNSS interference, it is not the only one. Unintentional interference (casued either by faulty equipment or by other frequency usage) is much more common. These tests try to simulate such interference (specifically continous wave signals (CWs), self-oscillation events and frequency drifts), to provide participants the ability to see how it affects their eqipment and systems, as well as to compare to different types of intentional interference in other tests during the week.

Test description

The tests will simulate different very common types of unintentional GNSS interference. The transmission power might be higher than what is common, but this can be mitigated by adjusting your distance to the interference source. Some of the interference frequencies will be outside of the GNSS bands, this is to create out-of-band interference.

Additional information

The jammer employed will be "Porcus Major" F8.1, see Appendix G.

1.18.1 Jammer F8.1 "Porcus Major": 50 W CW: L1

 $50~\mathrm{W}$ CW: L1

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.18.2 Jammer F8.1 "Porcus Major": 50 W CW: L2

50 W CW: L2

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'L2'

Transmitter equipment 'F8.1'

1.18.3 Jammer F8.1 "Porcus Major": 50 W CW: L5

 $50~\mathrm{W}$ CW: L5

Power or power range

Test bands/constellation

'L5', 'E5a', 'B2a'

Transmitter equipment

1.18.4 Jammer F8.1 "Porcus Major": 50 W drift: 1545 to 1620 MHz, with CW and sweep time of 1 minute

50 W frequency drift from 1545 to 1620 MHz, with a CW signal and a sweep duration of 1 minute.

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'F8.1'

1.18.5 Jammer F8.1 "Porcus Major": 50 W drift: 1545 to 1620 MHz, with CW and sweep time of 15 minutes

 $50~\mathrm{W}$ frequency drift from 1545 to 1620 MHz, with a CW signal and a sweep duration of 15 minutes.

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

F8.1'

1.18.6 Jammer F8.1 "Porcus Major": 50 W drift: 1620 to 1545 MHz, with CW and sweep time of 1 minute

50 W frequency drift from 1620 to 1545 MHz, with a CW signal and a sweep duration of 1 minute.

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

1.18.7 Jammer F8.1 "Porcus Major": 50 W drift: 1620 to 1545 MHz, with CW and sweep time of 15 minutes

50 W frequency drift from 1620 to 1545 MHz, with a CW signal and a sweep duration of 15 minutes.

Power or power range

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'F8.1'

1.18.8 Jammer F8.1 "Porcus Major": 50 W drift: 1545 to 1620 MHz, gaussian noise with BW of 500 kHz and sweep time of 1 minute

 $50~{\rm W}$ frequency drift from 1545 to 1620 MHz, with a gaussian noise signal with bandwidth (BW) of 500 kHz and a sweep duration of 1 minute.

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'F8.1'

1.18.9 Jammer F8.1 "Porcus Major": 50 W drift: 1545 to 1620 MHz, gaussian noise with BW of 500 kHz and sweep time of 15 minutes

 $50~{\rm W}$ frequency drift from 1545 to 1620 MHz, with a gaussian noise signal with bandwidth (BW) of 500 kHz and a sweep duration of 15 minutes.

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

1.18.10 Jammer F8.1 "Porcus Major": 50 W drift: 1620 to 1545 MHz, gaussian noise with BW of 500 kHz and sweep time of 1 minute

 $50~{\rm W}$ frequency drift from 1620 to 1545 MHz, with a gaussian noise signal with bandwidth (BW) of 500 kHz and a sweep duration of 1 minute.

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'F8.1'

1.18.11 Jammer F8.1 "Porcus Major": 50 W drift: 1620 to 1545 MHz, gaussian noise with BW of 500 kHz and sweep time of 15 minutes

 $50~{\rm W}$ frequency drift from 1620 to 1545 MHz, with a gaussian noise signal width bandwidth (BW) of 500 kHz and a sweep duration of 15 minutes.

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'F8.1'

1.18.12 Jammer F8.1 "Porcus Major": 50 W drift: 1150 to 1300 MHz, with CW and sweep time of 1 minute

50 W frequency drift from 1150 to 1300 MHz, with a CW signal and a sweep duration of 1 minute.

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

1.18.13 Jammer F8.1 "Porcus Major": 50 W drift: 1150 to 1300 MHz, with CW and sweep time of 15 minutes

50 W frequency drift from 1150 to 1300 MHz, with a CW signal and a sweep duration of 15 minutes.

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F8.1'

1.18.14 Jammer F8.1 "Porcus Major": 50 W drift: 1300 to 1150 MHz, with CW and sweep time of 1 minute

50 W frequency drift from 1300 to 1150 MHz, with a CW signal and a sweep duration of 1 minute.

Power or power range

Min: 50 W Max: 50 W

$Test \ bands/constellation$

'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F8.1'

1.18.15 Jammer F8.1 "Porcus Major": 50 W drift: 1300 to 1150 MHz, with CW and sweep time of 15 minutes

50 W frequency drift from 1300 to 1150 MHz, with a CW signal and a sweep duration of 15 minutes.

Power or power range

Test bands/constellation

'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

1.18.16 Jammer F8.1 "Porcus Major": 50 W drift: 1150 to 1300 MHz, gaussian noise with BW of 500 kHz and sweep time of 1 minute

 $50~{\rm W}$ frequency drift from 1150 to 1300 MHz, with a gaussian noise signal with bandwidth (BW) of 500 kHz and a sweep duration of 1 minute.

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F8.1'

1.18.17 Jammer F8.1 "Porcus Major": 50 W drift: 1150 to 1300 MHz, gaussian noise with BW of 500 kHz and sweep time of 15 minutes

 $50~{\rm W}$ frequency drift from 1150 to 1300 MHz, with a gaussian noise signal with bandwidth (BW) of 500 kHz and a sweep duration of 15 minutes.

Power or power range

Min: 50 W Max: 50 W

$Test \ bands/constellation$

'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F8.1'

1.18.18 Jammer F8.1 "Porcus Major": 50 W drift: 1300 to 1150 MHz, gaussian noise with BW of 500 kHz and sweep time of 1 minute

 $50~{\rm W}$ frequency drift from 1300 to 1150 MHz, with a gaussian noise signal with bandwidth (BW) of 500 kHz and a sweep duration of 1 minute.

Power or power range

Min: 50 W Max: 50 W

Test bands/constellation

'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

1.18.19 Jammer F8.1 "Porcus Major": 50 W drift: 1300 to 1150 MHz, gaussian noise with BW of 500 kHz and sweep time of 15 minutes

 $50~{\rm W}$ frequency drift from 1300 to 1150 MHz, with a gaussian noise signal with bandwidth (BW) of 500 kHz and a sweep duration of 15 minutes.

Power or power range

Test bands/constellation

'E6', 'B3I', 'G2', 'L2', 'E5b', 'B2b', 'B2I', 'G3', 'L5', 'E5a', 'B2a'

Transmitter equipment

'F8.1'

1.19: Circular testing with 3 jammers

Rationale

The main objective is to observe how the J/S signal affect the availability of PNT, and/or how it produces inaccurate PNT data, when the jamming signal (J) is generated by low-power jammers. 3 jammers of the same type is placed in a cirle 120 degrees a part. Distance from center i alteterd between 50, 100 and 150 meters. This testgroup is relevant for CRPA antenna testing and TDOA detection equipment.

Test description

All tests will be performed with the jammers placed 1 to 1.5 meters above ground on a pole and will be turned on and kept active (for example for 12 minutes) before being turned off. A break (of for example 4 minutes) between tests.

Additional information

Specification of jammers can be found in Appendix G. Jammer power levels are based on 2023/2024 measurements. "Test bands/constellation" refers to potentially afflicted signal types of the 4 GNSS constellations GPS, GLONASS, Galileo, and BeiDou, from the jammer in question. This information must be considered indicative only. The main principle for putting a signal type in the "Test bands/constellation" list for a given jammer or test, is that measurements done by NKOM indicate that the output signal of the jammer covers the center frequency of the given GNSS band(s).

Tests within this test group

1.19.1 3 jammers at 50 meters from center S1.1, S1.2 and S1.3

3 jammers, S1.1, S1.2 and S1.3

Power or power range

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment 'S1.1', 'S1.2', 'S1.3'

1.19.2 3 jammers at 100 meters from center S1.1, S1.2 and S1.3

3 jammers, S1.1, S1.2 and S1.3

Power or power range

Min: 0.01 W Max: 0.171 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'S1.1', 'S1.2', 'S1.3'

1.19.3 3 jammers at 150 meters from center S1.1, S1.2 and S1.3

3 jammers, S1.1, S1.2 and S1.3

Power or power range

Min: 0.01 W Max: 0.171 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'S1.1', 'S1.2', 'S1.3'

1.19.4 3 jammers at 50 meters from center S2.1, S2.2 and S2.3

3 jammers, S2.1, S2.2 and S2.3

Power or power range

Min: 0.01 W Max: 1.26 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

'S2.1', 'S2.2', 'S2.3'

1.19.5 3 jammers at 100 meters from center S2.1, S2.2 and S2.3

3 jammers, S2.1, S2.2 and S2.3

Power or power range

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'S2.1', 'S2.2', 'S2.3'

1.19.6 3 jammers at 150 meters from center S2.1, S2.2 and S2.3

3 jammers, S2.1, S2.2 and S2.3

Power or power range

Min: 0.01 W Max: 1.26 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'S2.1', 'S2.2', 'S2.3'

1.19.7 3 jammers at 50 meters from center U1.1, U1.2 and U1.3

3 jammers, U1.1, U1.2 and U1.3

Power or power range

'N/A'

Test bands/constellation 'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'U1.1', 'U1.2', 'U1.3'

1.19.8 3 jammers at 100 meters from center U1.1, U1.2 and U1.3

3 jammers, U1.1, U1.2 and U1.3

Power or power range 'N/A'

Test bands/constellation 'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment 'U1.1', 'U1.2', 'U1.3'

1.19.9 3 jammers at 150 meters from center U1.1, U1.2 and U1.3

3 jammers, U1.1, U1.2 and U1.3

Power or power range

'N/A'

Test bands/constellation 'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment 'U1.1', 'U1.2', 'U1.3'

1.19.10 3 jammers at 50 meters from center H6.4, H6.5 and H6.6

3 jammers, H6.4, H6.5 and H6.6

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation 'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment 'H6.4', 'H6.5', 'H6.6'

1.19.11 3 jammers at 100 meters from center H6.4, H6.5 and H6.6

³ jammers, H6.4, H6.5 and H6.6

Power or power range Min: 1 W

Max: 1.58 W

Test bands/constellation 'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'H6.4', 'H6.5', 'H6.6'

1.19.12 3 jammers at 150 meters from center H6.4, H6.5 and H6.6

3 jammers, H6.4, H6.5 and H6.6

Power or power range

Min: 1 W Max: 1.58 W

Test bands/constellation

'G1', 'L1', 'E1', 'B1C', 'B1I'

Transmitter equipment

'H6.4', 'H6.5', 'H6.6'

1.19.13 3 jammers at 50 meters from center H1.1, H1.4 and H1.5

3 jammers, H1.1, H1.4 and H1.5 LOW PWR, L1 sweep, L2 sweep

Power or power range Min: 1 W

Max: 0.1 W

Test bands/constellation 'L1', 'E1', 'B1C', 'L2'

Transmitter equipment 'H1.1', 'H1.4', 'H1.5'

1.19.14 3 jammers at 100 meters from center H1.1, H1.4 and H1.5

3 jammers, H1.1, H1.4 and H1.5 LOW PWR, L1 sweep, L2 sweep

Power or power range

Min: 1 W Max: 0.1 W Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment 'H1.1', 'H1.4', 'H1.5'

1.19.15 3 jammers at 150 meters from center H1.1, H1.4 and H1.5

3 jammers, H1.1, H1.4 and H1.5 LOW PWR, L1 sweep, L2 sweep

Power or power range

Min: 1 W Max: 0.1 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

1.20: Drone testing, landing and take off in a circle of 3 Jammers

Rationale

The main objective is to observe how the J/S signal affect the availability of PNT, and/or how it produces inaccurate PNT data, when the jamming signal (J) is generated by the NEAT military jammers from Novatel. 3 jammers of the same type is placed in a cirle 120 degrees a part. Distance from center i alteterd between 50, 100 and 150 meters. The test is repeated with different modulation and power levels. The intent is to allow each drone land and do take off in the center. This testgroup is also relevant for CRPA antenna testing and TDOA detection equipment.

Test description

All tests will be performed with the NEAT military jammers from Novatel placed 1 to 1.5 meters above ground on a pole and be turned on and kept active for a given period (for example for 15 minutes) before being turned off. A break (of for example 6 minutes) is included between tests. The test will then be repeated with different modulation and power levels. For test 1 - 12 the jammers will be turned on simultaneous. For test 13 to 15 the jammers will be turned on sequentially (Example jammer A for 15 minutes, then Jammer A+B for 15 minutes, and then Jammer A+B+C for 15minutes). Overview of location 2 can be found in the Appendix A

Additional information

Specification of jammers can be found in Appendix G. Jammer power levels are based on 2023/2024 measurements. "Test bands/constellation" refers to potentially afflicted signal types of the 4 GNSS constellations GPS, GLONASS, Galileo, and BeiDou, from the jammer in question. This information must be considered indicative only. The main principle for putting a signal type in the "Test bands/constellation" list for a given jammer or test, is that measurements done by NKOM indicate that the output signal of the jammer covers the center frequency of the given GNSS band(s).

1.20.1 3 jammers at 50 meters from center H1.1, H1.4 and H1.5

HIGH PWR, L1 NB, L2 NB

Power or power range

Min: 0.1 W Max: 0.116 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

1.20.2 3 jammers at 100 meters from center H1.1, H1.4 and H1.5

HIGH PWR, L1 NB, L2 NB

Power or power range

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment 'H1.1', 'H1.4', 'H1.5'

1.20.3 3 jammers at 150 meters from center H1.1, H1.4 and H1.5

HIGH PWR, L1 NB, L2 NB

Power or power range

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

1.20.4 3 jammers at 50 meters from center H1.1, H1.4 and H1.5

HIGH PWR, L1 WB, L2 WB

Power or power range

Min: 0.1 W Max: 0.133 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

1.20.5 3 jammers at 100 meters from center H1.1, H1.4 and H1.5

HIGH PWR, L1 WB, L2 WB

Power or power range

Min: 0.1 W Max: 0.133 W

Test bands/constellation 'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

1.20.6 3 jammers at 150 meters from center H1.1, H1.4 and H1.5

HIGH PWR, L1 WB, L2 WB

Power or power range

Min: 0.1 W Max: 0.133 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

1.20.7 3 jammers at 50 meters from center H1.1, H1.4 and H1.5

HIGH PWR, L1 CW, L2 CW

Power or power range

Min: 0.1 W Max: 0.249 W

Test bands/constellation 'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

$1.20.8\ 3$ jammers at 100 meters from center H1.1, H1.4 and H1.5

HIGH PWR, L1 CW, L2 CW

Power or power range

Min: 0.1 W Max: 0.249 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

1.20.9 3 jammers at 150 meters from center H1.1, H1.4 and H1.5

HIGH PWR, L1 CW, L2 CW

Power or power range

Min: 0.1 W Max: 0.249 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

1.20.10 3 jammers at 50 meters from center H1.1, H1.4 and H1.5

HIGH PWR, L1 sweep, L2 sweep

Power or power range

Min: 0.0501 W Max: 0.0592 W $Test \ bands/constellation$

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment 'H1.1', 'H1.4', 'H1.5'

1.20.11 3 jammers at 100 meters from center H1.1, H1.4 and H1.5

HIGH PWR, L1 sweep, L2 sweep

Power or power range

Min: 0.0501 W Max: 0.0592 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

1.20.12 3 jammers at 150 meters from center H1.1, H1.4 and H1.5

HIGH PWR, L1 sweep, L2 sweep

Power or power range

Min: 0.0501 W Max: 0.0592 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

1.20.13 3 jammers at 150 meters from center H1.1, H1.4 and H1.5 turned on sequentially

HIGH PWR, L1 NB, L2 NB, JAMMER A are turned on

Power or power range

Min: 0.0501 WMax: 0.0592 W

$Test \ bands/constellation$

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

1.20.14 3 jammers at 150 meters from center H1.1, H1.4 and H1.5 turned on sequentially

HIGH PWR, L1 WB, L2 WB, JAMMER A + B are turned on

Power or power range

Min: 0.0501 W Max: 0.0592 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

$1.20.15\ 3$ jammers at 150 meters from center H1.1, H1.4 and H1.5 turned on sequentially

HIGH PWR, L1 CW, L2 CW, JAMMER A + B + C are turned on

Power or power range

Min: 0.0501 W Max: 0.0592 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'H1.1', 'H1.4', 'H1.5'

1.21: LEO jamming

Rationale

Exclusive high-power jamming tests for low earth orbit (LEO) satellites.

Test description

Exclusive high-power jamming tests for low earth orbit (LEO) satellites.

Tests within this test group

1.21.1 NB sweep jamming with periodic power ramp

Sweeping jamming signal with saw tooth modulation with sweep rate of 1 ms. Signal is narrow band (NB), with a bandwidth of 40 kHz. Power is ramp up in four steps; 10 %, 20 %, 50 % and 100 % of total power, each 250 ms. Meaning that the power is ramped through the power range each second and then repeated periodically.

Power or power range

Min: 200 W Max: 200 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.21.2 NB sweep jamming with constant power

Sweeping jamming signal with saw tooth modulation with sweep rate of 1 ms. Singal is narrow band (NB), with a bandwidth of 40 kHz. Power is kept constant at 100 % of total power.

Power or power range

Min: 200 W Max: 200 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.21.3 WB sweep jamming with periodic power ramp

Sweeping jamming signal with saw tooth modulation with sweep rate of 1 ms. Singal is narrow band (NB), with a bandwidth of 1.4 MHz. Power is ramp up in four steps; 10%, 20%, 50% and 100% of total power, each 250 ms. Meaning that the power is ramped through the power range each second and then repeated periodically.

Power or power range

Min: 200 W Max: 200 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.21.4 WB sweep jamming with constant power

Sweeping jamming signal with saw tooth modulation with sweep rate of 1 ms. Singal is narrow band (NB), with a bandwidth of 1.4 MHz. Power is kept constant at 100% of total power.

Power or power range

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.21.5 OFDM jamming with periodic power ramp

Jamming signal simulating a LTE TDD waveform with a bandwidth of 1.4 MHz. Power is ramp up in four steps; 10 %, 20 %, 50 % and 100 % of total power, each 250 ms. Meaning that the power is ramped through the power range each second and then repeated periodically.

Power or power range

Min: 200 W Max: 200 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

1.21.6 OFDM jamming with constant power

Jamming signal simulating a LTE TDD waveform with a bandwidth of 1.4 MHz. Power is kept constant at 100 % of total power.

Power or power range

Min: 200 W Max: 200 W

Test bands/constellation

'L1', 'E1', 'B1C'

Transmitter equipment

'F8.1'

2 Spoofing

2.1: Incoherent position spoofing from stationary spoofer using synthetic ephemerides

Rationale

The idea is to test equipment and systems when exposed to false and misleading GNSS-PNT information, with a focus on position. These are very basic attacks that can be performed with easily available software and hardware. These attacks can give an indication to the receivers' resiliency to spoofing attacks. Most receivers will probably see these attacks as noise initially, effectively working as a jamming signal.

Test description

Simulated signals will be transmitted from a stationary antenna. Generated spoofing scenarios will use satellite ephemerides different from live sky satellites. Simulated signals may use one or more constellations and one or more signal bands.

Initial positions are either False (e.g. 70 N, 10 E) or True (target location, normally close to the at transmitter antenna location). Initial time is either False (e.g. a jump in time) or True (less than 100 ns timing error for a receiver at target location). Some test scenarios may be started with jamming (lasting for 5 min, one or several test bands, before the spoofing transmission is activated). Some spoofing scenarios may be accompanied by continuous jamming (one or several test bands).

Static scenarios are a fixed position, while dynamic scenarios are a drive around the area. For each dynamic test, the motion is first spoofed to a fixed start position for 5 minutes before the dynamic motion starts.

There will be a break between each test to allow receivers to reacquire fix onto real satellite signals. When max and min powers are indicated, this refers to spoofing power.

Additional information

Expected (least) range/power of spoofing signals: A radius of approximately 1.5 kilometre from the transmitter, depending on terrain and building signal shielding.

Tests within this test group

2.1.1 Large position and time jump, with power ramp

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5
No jamming.
Simulated position: 70 N, 10 E. Simulated start time: 01.10.2024 12:00.
Power will be ramp up from -35 dBm to 25 dBm in 5 dB steps, with each step lasting 3 minutes.

Power or power range

Min: 3.16e-07 W Max: 0.316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.1.2 Large position and time jump. GPS L1 C/A only

Signals: GPS L1 C/A No jamming. Simulated position: 70 N, 10 E. Simulated start time: 01.10.2024 12:00.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1'

Transmitter equipment

 \mathbf{S}

2.1.3 Large position and time jump. Galileo E1 only

Signals: Galileo E1. No jamming. Simulated position: 70 N, 10 E. Simulated start time: 01.10.2024 12:00.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'E1'

Transmitter equipment 'S'

2.1.4 Large position and time jump. GPS L1 and Galileo E1 only

Signals: GPS L1 C/A. Galileo E1. No jamming. Simulated position: 70 N, 10 E. Simulated start time: 01.10.2024 12:00.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.1.5 Large position and time jump. GPS and Galileo.

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5a, E5b. No jamming. Simulated position: 70 N, 10 E. Simulated start time: 01.10.2024 12:00.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.1.6 Large position and time jump. GPS L1 only, with initial and continuous jamming

Signals: GPS L1 C/A.

5 minutes of initial jamming (L1, G1, B1I, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed. Simulated position: 70 N, 10 E. Simulated start time: 01.10.2024 12:00.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1'

Transmitter equipment

'S'

2.1.7 Large position and time jump. Galileo E1 only, with initial and continuous jamming

Simulated position: 70 N, 10 E. Simulated start time: 01.10.2024 12:00.

Signals: Galileo E1.

⁵ minutes of initial jamming (L1, G1, B1I, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Power or power range

 $Test \ bands/constellation$

'E1'

Transmitter equipment

 \mathbf{S}

$2.1.8~{\rm Large}$ position and time jump. GPS and Galileo , with initial and continuous jamming

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5a, E5b. 5 minutes of initial jamming (L1, G1, B1I, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed. Simulated position: 70 N, 10 E. Simulated start time: 01.10.2024 12:00.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.1.9 Simulated driving (route 1). GPS L1 C/A and Galileo E1, with initial jamming

Signals: GPS L1 C/A. Galileo E1.

5 minutes of initial jamming (L1, G1, B1I, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission. Simulated start position: Bleik community house parking lot. Simulated start time: 01.10.2024 12:00.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.1.10 Simulated driving (route 1), with initial jamming

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

5 minutes of initial jamming (L1, G1, B1I, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission. Simulated start position: Bleik community house parking lot. Simulated start time: 01.10.2024 12:00.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.1.11 Simulated driving, true reference time (route 1), with initial jamming

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

5 minutes of initial jamming (L1, G1, B1I, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission. Simulated start position: Bleik community house parking lot. Simulated start time: Referenced to live GPS-signals.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.1.12 Large position and time jump

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5 No jamming. Simulated position: 70 N, 10 E. Simulated start time: 01.10.2024 12:00.

Power or power range

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.2: Incoherent position spoofing from stationary spoofer using broadcast(true) ephemerides

Rationale

The idea is to test equipment and systems when exposed to false and misleading GNSS-PNT information, with a focus on position. These spoofing tests use ephemerides (navigation data) identical to those broadcasted by the actual satellites, but the transmitted spoofing signals do not align with those received from actual satellites (incoherent). Receivers using the spoofed signals will (most likely) generate jumps in the navigation solution, either in position, time and/or velocity.

Test description

Simulated signals will be transmitted from a stationary antenna. Generated spoofing scenarios will use broadcast satellite ephemeris data. Simulated signals may use one or more constellations and one or more test bands.

Initial positions are either False (e.g. 70 N, 10 E) or True (target location, normally close to the transmitter antenna location). Initial time is either False (e.g. a jump in time/date) or True (less than 100 ns timing error for a receiver at target location). Some test scenarios may be started with jamming (lasting for 5 min, one or several test bands, before the spoofing transmission is activated). Some spoofing scenarios may be accompanied by continuous jamming (one or several test bands). The indicated "Test bands / constellation" refers to which signals are spoofed.

Static scenarios are a fixed position, while dynamic scenarios are a simulated drive around the area. For each dynamic test, the motion is first spoofed to a fixed start position for 5 minutes before the dynamic motion starts.

There will be a break between each test to allow receivers to reacquire fix onto real satellite signals. When max and min powers are indicated, this refers to spoofing power.

Additional information

Expected (least) range/power of spoofing signals: A radius of approximately 1.5 kilometre from the transmitter, depending on terrain and building signal shielding.

Tests within this test group

2.2.1 Large position jump, with power ramp

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

No jamming. Simulated position: 70 N, 10 E. Simulated start time: Referenced to live GPS-signals. Power will be ramp up from -35 dBm to 25 dBm in 5 dB steps, with each step lasting 3 minutes.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.2.2 Small position jump, with initial and continuous jamming

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

5 minutes of initial jamming (L1, G1, B1I, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Simulated position: North end of the football field - 69.27701401, 15.969328354, 45 m hae (Height Above Ellipsoid). Simulated start time: Referenced to live GPS-signals.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.2.3 Position jump

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

No jamming. Simulated position: Cemetery - 69.2824699, 15.9906568, 48 m hae. Simulated start time: Referenced to live GPS-signals.

Power or power range

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.2.4 Large position jump #2

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. No jamming. Simulated position: 69.25 N, 14,9 E. Simulated start time: Referenced to live GPS-signals.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.3: Coherent position spoofing from stationary spoofer using broadcast(true) ephemerides

Rationale

The idea is to test equipment and systems when exposed to false and misleading GNSS-PNT information, with a focus on position. These spoofing tests use ephemerides (navigation data) identical to those broadcasted by the actual satellites. The transmitted spoofing signals are intended to align (to within a few 100 ns) with those received from actual satellites at the target location (coherent). Receivers using the spoofed signals at rest at the target location will initially generate no major changes in the navigation solution, either in position, time and/or velocity, compared to the solution estimated from actual satellite signals.

Test description

Simulated signals will be transmitted from a stationary antenna. Generated spoofing scenarios will use broadcast satellite ephemeris data. Simulated signals may use one or more constellations and one or more signal bands.

Initial positions are True (target location, normally close to the transmitter antenna location). Initial time is True (less than 100 ns timing error for a receiver at target location). Some test scenarios may be started with jamming (lasting for 5 min, one or several test bands, before the spoofing transmission is activated). Some spoofing scenarios may be accompanied by continuous jamming (one or several test bands). The indicated "Test bands / constellation" refers to which signals are spoofed.

Static scenarios are a fixed position, while dynamic scenarios are a simulated drive around the area. For each dynamic test, the motion is first spoofed to a fixed start position for 5 minutes before the dynamic motion starts.

There will be a break between each test to allow receivers to reacquire fix onto real satellite signals. For all tests in this group, spoofing transmission will be corrected for signal delay to simulated start position.

When max and min powers are indicated, this refers to spoofing power.

Additional information

Expected (least) range/power of spoofing signals: A radius of approximately 1.5 kilometre from the transmitter, depending on terrain and building signal shielding.

Tests within this test group

2.3.1 Coherent power ramp

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5a and E5b.

No jamming.

Simulated position: Bleik community house parking lot. Simulated start time: Referenced to live GPS-signals.

Power will be ramped up from -35 dBm to 25 dBm in 5 dB steps, with each step lasting 3 minutes.

Power or power range

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.3.2 Small position jump with initial and continuous jamming

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

5 minutes of initial jamming (L1, G1, B1I, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Simulated position: North end of the football field - 69.27701401, 15.969328354, 45 m hae (Height Above Ellipsoid). Simulated start time: Referenced to live GPS-signals.

Power or power range

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.3.3 Small position jump

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

No jamming. Simulated position: North end of the football field - 69.27701401, 15.96932835, 45 m hae. Simulated start time: Referenced to live GPS-signals.

Power or power range

$Test \ bands/constellation$

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.3.4 Simulated driving (route 1). GPS L1 C/A only

Signals: GPS L1 C/A. No jamming. Simulated start position: Bleik community house parking lot. Simulated start time: Referenced to live GPS-signals.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1'

Transmitter equipment

 \mathbf{S}

2.3.5 Simulated driving (route 1). GPS only

Signals: GPS L1 C/A, L2C, L5. No jamming. Simulated start position: Bleik community house parking lot. Simulated start time: Referenced to live GPS-signals.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1', 'L2', 'L5'

Transmitter equipment

 \mathbf{S}

2.3.6 Simulated driving (route 1). GPS L1 C/A only, with initial and continuous jamming.

Signals: GPS L1 C/A.

5 minutes of initial jamming (L1, G1, B1I, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Simulated start position: Bleik community house parking lot. Simulated start time: Referenced to live GPS-signals.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1'

Transmitter equipment

 \mathbf{S}

2.3.7 Simulated driving (route 1). GPS only, with initial and continuous jamming.

Signals: GPS L1 C/A, L2C, L5.

5 minutes of initial jamming (L1, G1, B1I, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Simulated start position: Bleik community house parking lot. Simulated start time: Referenced to live GPS-signals.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1', 'L2', 'L5'

Transmitter equipment

 \mathbf{S}

2.3.8 Simulated driving (route 1). Galileo only

Signals: Galileo E1, E5.

No jamming. Simulated start position: Bleik community house parking lot. Simulated start time: Referenced to live GPS-signals.

Power or power range

Min: 0.316 WMax: 0.316 W

Test bands/constellation

'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.3.9 Simulated driving (route 1). Galileo only, with initial and continuous jamming.

Signals: Galileo E1, E5

⁵ minutes of initial jamming (L1, G1, B1I, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Simulated start position: Bleik community house parking lot. Simulated start time: Referenced to live GPS-signals.

Power or power range

Test bands/constellation

'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.3.10 Simulated driving (route 1)

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. No jamming. Simulated start position: Bleik community house parking lot. Simulated start time: Referenced to

live GPS-signals.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.3.11 Simulated driving (route 1) with initial and continuous jamming.

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

5 minutes of initial jamming (L1, G1, B1I, E6, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Simulated start position: Bleik community house parking lot. Simulated start time: Referenced to live GPS-signals.

Power or power range

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.3.12 Flying (route 4) - "drone scenario" GPS L1 C/A only

Signals: GPS L1 C/A.
No jamming.
Simulated start position: 69.277014014, 15.969328354, 40 m hae. Simulated start time: Referenced to live GPS-signals.
Spoofing transmission will be corrected for signal delay to simulated start position. Drones at start position (victim position) should see coherent signals.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1'

Transmitter equipment

'S'

2.3.13 Flying (route 4) - "drone scenario"

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

No jamming.

Simulated start position: 69.277014014, 15.969328354, 40 m hae. Simulated start time: Referenced to live GPS-signals.

Spoofing transmission will be corrected for signal delay to simulated start position. Drones at start position (victim position) should see coherent signals.

Power or power range

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.3.14 Sailing (route 5) - "ship scenario"

No jamming.

Simulated start position: Bleik harbour. Simulated start time: Referenced to live GPS-signals. Spoofing transmission will be corrected for signal delay to simulated start position. Ships at start position (victim position) should see coherent signals.

Power or power range

Min: 0.316 W Max: 0.316 W

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.3.15 Flying (route 2) - "helicopter scenario"

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.
No jamming.
Simulated start position: Over the sea 1 km N (Midnattskjæran) at 200 m hae. Simulated start time: Referenced to live GPS-signals.
Spoofing transmission will be corrected for signal delay to simulated start position. Helicopter at start

Spoofing transmission will be corrected for signal delay to simulated start position. Helicopter at start position (victim position) should see coherent signals.

Power or power range

Min: 0.316 W Max: 0.316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.4: Incoherent time spoofing from stationary spoofer using synthetic ephemerides

Rationale

The idea is to test equipment and systems when exposed to false and misleading GNSS-PNT information, with a focus on timing. These are synchronized spoofing scenarios in the sense that the navigation solution (position, velocity and clock bias) should not initially change significantly for a receiver at the target location. The scenarios are incoherent in the sense that spoofing signals are different from (not aligned with) those received from the actual satellites.

Test description

Simulated signals will be transmitted from a stationary antenna. Generated spoofing scenarios will use satellite ephemerides different from live sky satellites. Simulated signals may use one or more constellations and one or more signal bands.

Initial positions are True (target location, normally close to the transmitter antenna location). Some test scenarios may be started with jamming (lasting for 5 min, one or several test bands). Some spoofing scenarios may be accompanied by continuous jamming (one or several test bands). The indicated "Test bands / constellation" refers to which signals are spoofed.

There will be a small break between each test and a larger break after the test group is over to allow receivers to reacquire fix onto real satellite signals.

When max and min powers are indicated, this refers to spoofing power.

Additional information

Expected (least) range/power of spoofing signals: A radius of approximately a few hundred metres from the transmitter, depending on terrain and building signal shielding.

Tests within this test group

2.4.1 Time offset 15 minutes from real time. GPS L1 and Galileo E1 only, with power ramp

Signals: GPS L1 C/A. Galileo E1.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time offset is + 15 minutes (900 seconds), so "into the future".

The spoofing power will be ramped from -35 dBm to +15 dBm in steps of 5 dB every two minutes.

Power or power range

Min: 3.16e-07 W Max: 0.0316 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.4.2 Time offset 15 minutes from real time, with power ramp

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time offset is + 15 minutes (900 seconds), so "into the future". Spoofing power ramp -35 dBm to +15 dBm in steps of 5 dB every two minutes.

Power or power range

Min: 3.16e-07 W Max: 0.0316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.4.3 Time offset -3 minutes from real time, with power jump

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time offset is - 3 minutes (180 seconds), so "back into the past". Spoofing power will start at -20 dBm and be stepped up to 15 dBm in one step after 10 minutes.

Power or power range

Min: 1e-05 W Max: 0.0316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.4.4 Static + Frequency step. GPS L1 only

Signals: GPS L1 C/A.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Frequency steps means here spoofing signal transmission rate change. Frequency steps are added (10 ns/s) and starts five minutes after the spoofing starts.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1'

Transmitter equipment

 \mathbf{S}

2.4.5 Static + Frequency step. GPS L1 and Galileo E1 only

Signals: GPS L1 C/A. Galileo E1.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Power or power range

Min: 0.001 W Max: 0.001 W

Frequency steps means here spoofing signal transmission rate change. Frequency steps are added (10 ns/s) and starts five minutes after the spoofing starts.

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

$2.4.6~{\rm Static}$ + Frequency step. GPS L1 and Galileo E1 only, with initial and continuous jamming

Signals: GPS L1 C/A. Galileo E1.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Frequency steps means here spoofing signal transmission rate change. Frequency steps are added (10 ns/s) and starts five minutes after the spoofing starts.

Power or power range

Min: 0.001 WMax: 0.001 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

 \mathbf{S}

2.4.7 Static + Frequency step

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Frequency steps means here spoofing signal transmission rate change. Frequency steps are added (10 ns/s) and starts five minutes after the spoofing starts.

Power or power range

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.4.8 Static + Frequency step, with initial and continous jamming

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Frequency steps means here spoofing signal transmission rate change. Frequency steps are added (10 ns/s) and starts five minutes after the spoofing starts.

Power or power range

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.4.9 Static + Pseudorange error. GPS L1 only

Signals: GPS L1 C/A. No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. The pseudorange error is applied to all satellites, starting five minutes after the spoofing starts. The applied pseudorange error should equal a drift of x ns/s.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1'

Transmitter equipment

 \mathbf{S}

2.4.10 Static + Pseudorange error. GPS L1 and Galileo E1 only

Signals: GPS L1 C/A. Galileo E1.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The pseudorange error is applied to all satellites, starting five minutes after the spoofing starts. The applied error should equal a drift of x ns/s.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

$2.4.11~{\rm Static}+{\rm Pseudorange~error}.~{\rm GPS}~{\rm L1}$ and Galileo E1 only, with initial and continuous jamming

Signals: GPS L1 C/A. Galileo E1.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The pseudorange error is applied to all satellites, starting five minutes after the spoofing starts. The applied error should equal a drift of x ns/s.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

 \mathbf{S}

2.4.12 Static + Pseudorange error

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The pseudorange error is applied to all satellites, starting five minutes after the spoofing starts. The applied error should equal a drift of x ns/s.

Power or power range

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.4.13 Static + Pseudorange error, with initial and continous jamming

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The pseudorange error is applied to all satellites, starting five minutes after the spoofing starts. The applied error should equal a drift of x ns/s.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.5: Coherent time spoofing from stationary spoofer using broadcast(true) ephemerides

Rationale

The idea is to test equipment and systems when exposed to false and misleading GNSS-PNT information, with a focus on timing. These are synchronized spoofing scenarios in the sense that the navigation solution (position, velocity and clock bias) should not initially change significantly for a receiver at the target location. The scenarios are coherent in the sense that spoofing signals are similar (aligned with) those received from the actual satellites. Scenarios in these tests are intended to not alter the navigation solution at all for receivers at the target position for position and velocity estimates. Clock bias estimates should be affected by the frequency step in test 1 - 3, but not in 4 - 7.

Test description

Simulated signals will be transmitted from a stationary antenna. Generated spoofing scenarios will use broadcast satellite ephemeris data. Simulated signals may use one or more constellations and one or more signal bands.

Initial positions are True (target location, normally close to the transmitter antenna location). Initial time is True (less than 100 ns timing error for a receiver at target location). Some test scenarios may be started with jamming (lasting for 5 min, one or several test bands). Some spoofing scenarios may be accompanied by continuous jamming (one or several test bands). The indicated "Test bands / constellation" refers to which signals are spoofed.

There will be a short break between each test and a larger break after the test group is over to allow receivers to reacquire fix onto real satellite signals.

When max and min powers are indicated, this refers to spoofing power.

Additional information

Expected (least) range/power of spoofing signals: A radius of approximately a few hundred metres from the transmitter, depending on terrain and building signal shielding.

Tests within this test group

2.5.1 Time offset 15 minutes from real time. GPS L1 and Galileo E1 only, with power ramp

Signals: GPS L1 C/A. Galileo E1.
No jamming.
Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time offset is + 15 minutes (900 seconds), so "into the future".
The spoofing power will be ramped from -35 dBm to +15 dBm in steps of 5 dB every two minutes.

Power or power range

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.5.2 Time offset 15 minutes from real time, with power ramp

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.
No jamming.
Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time offset is + 15 minutes (900 seconds), so "into the future".
Spoofing power ramp -35 dBm to +15 dBm in steps of 5 dB every two minutes.

Power or power range

Min: 3.16e-07 W Max: 0.0316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.5.3 Time offset -3 minutes from real time, with power jump

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time offset is - 3 minutes (180 seconds), so "back into the past".

Spoofing power will start at -20 dBm and be stepped up to 15 dBm in one step after 10 minutes.

Power or power range

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.5.4 Time offset 15 minutes from real time. GPS L1 C/A

Signals: GPS L1 C/A. No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time offset is + 15 minutes (900 seconds), so "into the future".

Power or power range

Min: 3.16e-07 W Max: 0.0316 W

Test bands/constellation

'L1'

Transmitter equipment

'S'

2.5.5 Time offset 15 minutes from real time. Galileo E1

Signals: Galileo E1. No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time offset is + 15 minutes (900 seconds), so "into the future".

Power or power range

Test bands/constellation

'E1'

Transmitter equipment

'S'

2.5.6 Time offset 15 minutes from real time

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time offset is + 15 minutes (900 seconds), so "into the future".

Power or power range

Min: 3.16e-07 W Max: 0.0316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.5.7 Time offset -3 minutes from real time

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time offset is - 3 minutes (180 seconds), so "back into the past".

Power or power range

Min: 1e-05 W Max: 0.0316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.5.8 Static + Frequency step. GPS L1 and Galileo E1 only

Signals: GPS L1 C/A. Galileo E1.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Frequency steps means here spoofing signal transmission rate change. Frequency steps are added (10 ns/s) and starts five minutes after the spoofing starts.

Power or power range

Min: 1e-05 W Max: 1e-05 W

Test bands/constellation

'L1', 'E1'

2 Spoofing

 \mathbf{S}

$2.5.9~{\rm Static}$ + Frequency step. GPS L1 and Galileo E1 only, with initial and continuous jamming

Signals: GPS L1 C/A. Galileo E1.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Frequency steps means here spoofing signal transmission rate change. Frequency steps are added (10 ns/s) and starts five minutes after the spoofing starts.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.5.10 Static + Frequency step

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Frequency steps means here spoofing signal transmission rate change. Frequency steps are added (10 ns/s) and starts five minutes after the spoofing starts.

Power or power range

Min: 1e-05 W Max: 1e-05 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.5.11 Static + Frequency step, with initial and continuous jamming

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Frequency steps means here spoofing signal transmission rate change. Frequency steps are added (10 ns/s) and starts five minutes after the spoofing starts.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.5.12 Static + Frequency step, with power ramp

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Frequency steps means here spoofing signal transmission rate change. Frequency steps are added (10 ns/s) and starts five minutes after the spoofing starts.

Spoofing power ramp -35 dBm to +15 dBm in steps of 5 dB every two minutes.

Power or power range

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.5.13 Static + Pseudorange error. GPS L1 and Galileo E1 only

Signals: GPS L1 C/A. Galileo E1.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The pseudorange error is applied to all satellites, starting five minutes after the spoofing starts. The applied error should equal a drift of x ns/s.

Power or power range

Test bands/constellation

'L1', 'E1'

2.5.14 Static + Pseudorange error. GPS L1 and Galileo E1 only, with initial and continuous jamming

Signals: GPS L1 C/A. Galileo E1.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The pseudorange error is applied to all satellites, starting five minutes after the spoofing starts. The applied error should equal a drift of x ns/s.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.5.15 Static + Pseudorange error

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.
No jamming.
Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.
The pseudorange error is applied to all satellites, starting five minutes after the spoofing starts. The applied error should equal a drift of x ns/s.

Power or power range

Min: 1e-05 W Max: 1e-05 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.5.16 Static + Pseudorange error, with initial and continuous jamming

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The pseudorange error is applied to all satellites, starting five minutes after the spoofing starts. The applied error should equal a drift of x ns/s.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.5.17 Static + Pseudorange error, with power ramp

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The pseudorange error is applied to all satellites, starting five minutes after the spoofing starts. The applied error should equal a drift of x ns/s.

Spoofing power ramp -35 dBm to +15 dBm in steps of 5 dB every two minutes.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.5.18 Static + Nav data manipulation (clock/frequency related). GPS L1 and Galileo E1 only

Signals: GPS L1 C/A. Galileo E1.No jamming.Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.The navigation data manipulation starts five minutes after the spoofing starts.

Power or power range

Test bands/constellation

'L1', 'E1'

2.5.19 Static + Nav data manipulation (clock/frequency related). GPS L1 and Galileo E1 only, with initial and continuous jamming

Signals: GPS L1 C/A. Galileo E1.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Spoofing power wil be ramped -35 dBm to +15 dBm in steps of 5 dB every two minutes. The navigation data manipulation starts five minutes after the spoofing starts.

Power or power range

Min: 3.16e-07 W Max: 0.0316 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.5.20 Static + Nav data manipulation (clock/frequency related). GPS L1 and Galileo E1 only, with power ramp

Signals: GPS L1 C/A. Galileo E1.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Spoofing power will be ramped -35 dBm to +15 dBm in steps of 5 dB every two minutes. The navigation data manipulation starts five minutes after the spoofing starts.

Power or power range

Min: 3.16e-07 W Max: 0.0316 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.5.21 Static + Nav data manipulation (clock/frequency related)

Signals: Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. The navigation data manipulation starts five minutes after the spoofing starts.

Power or power range

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

$2.5.22~{\rm Static}$ + Nav data manipulation (clock/frequency related), with initial and continuous jamming.

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.
5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.
Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.
The navigation data manipulation starts five minutes after the spoofing starts.

Power or power range

Min: 3.16e-07 W Max: 0.0316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

$2.5.23~{\rm Static}$ + Nav data manipulation (clock/frequency related), with power ramp

Signals: GPS L1 C/A. Galileo E1.
No jamming.
Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.
Spoofing power wil be ramped -35 dBm to +15 dBm in steps of 5 dB every two minutes.
The navigation data manipulation starts five minutes after the spoofing starts.

Power or power range

Min: 3.16e-07 W Max: 0.0316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.5.24 Static + UTC-parameter nav. data manipulation (adding leap seconds)

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. The UTC-paramter nav. data manipulation consists of the spoofing signal saying that back in 2016, there was 19 leap seconds instead of 18.

Power or power range

Min: 1e-05 W Max: 1e-05 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.5.25 Static + UTC-parameter nav. data manipulation (adding leap seconds), with initial and continuous jamming

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The UTC-paramter nav. data manipulation consists of the spoofing signal saying that back in 2016, there was 19 leap seconds instead of 18.

Power or power range

$Test \ bands/constellation$

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.5.26 Static + UTC-parameter nav. data manipulation (removing leap seconds). GPS L1 C/A

Signals: GPS L1 C/A

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The UTC-paramter nav. data manipulation consists of the spoofing signal saying that back in 2016, there was counter-factual extra amount of -127 leap seconds, which in total means that there is removed -145 leap seconds.

Power or power range

Test bands/constellation

L1'

Transmitter equipment

 \mathbf{S}

2.5.27 Static + UTC-parameter nav. data manipulation (removing leap seconds)

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The UTC-paramter nav. data manipulation consists of the spoofing signal saying that back in 2016, there was counter-factual extra amount of -127 leap seconds, which in total means that there is removed -145 leap seconds.

Power or power range

Min: 1e-05 W Max: 1e-05 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

$2.5.28~{\rm Static}$ + UTC-parameter nav. data manipulation (removing leap seconds), with initial and continuous jamming

Power or power range

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

⁵ minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The UTC-paramter nav. data manipulation consists of the spoofing signal saying that back in 2016, there was counter-factual extra amount of -127 leap seconds, which in total means that there is removed -145 leap seconds.

Transmitter equipment

 \mathbf{S}

2.5.29 Time offset 15 minutes from real time - "harbour scenario"

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. No jamming. Fixed spoofed position: Bleik harbour. Time offset is + 15 minutes (900 seconds), so "into the future".

Power or power range

Min: 0.316 WMax: 0.316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.5.30 Time offset 15 minutes from real time - "helicopter scenario"

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. No jamming.

Simulated start position: Over the sea 1 km N (Midnattskjæran) at 200 m hae. Time offset is + 15 minutes (900 seconds), so "into the future".

Power or power range

Min: 1 W Max: 1 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.6: Incoherent GPS position and time spoofing from mobile spoofer

Rationale

The objective is to simulate a vehicle-borne spoofing device "out in the wild", so that attendees can experience how a mobile spoofing source affects their (stationary or mobile) equipment and systems.

Test description

A SDR spoofer will be employed in different ways in and around vehicles. The spoofed signals will be on GPS L1 only. All spoofing tests will be combined with jamming on GLONASS G1. Both jamming and spoofing will be done with 10 dBm. The indicated "Test bands / constellation" refers to which signals are spoofed.

There will be a break between each test to allow receivers to reacquire fix onto real satellite signals.

Additional information

Starting position will be approximately 69.212409N,15.858314E (Stave community house) in all scenarios (might change due to operational requests). Spoofed time will be approximately true (depends on the latest update of satellite data), usually within a few hours

Tests within this test group

2.6.1 Spoofer (in vehicle with roof mounted antenna) stationary with dynamic spoofed position.

Spoofer placed inside of a stationary vehicle with the transmitting antenna on the roof. The spoofed position starts static (at starting position) and at approximately true time. After 10 minutes, the spoofed position starts to move south with constant speed (40 km/h), while spoofer stays stationary.

Power or power range

Test bands/constellation 'L1'

Transmitter equipment

'F1.2'

2.6.2 Spoofer (in vehicle with roof mounted antenna) stationary and then moving with fixed spoofed position.

Spoofer antenna placed on the roof of a vehicle that starts out stationary for 10 minutes, before the vehicle begins to drive south along Stavedalsveien (FV7702) at 40 km/h. The spoofed position remains fixed and approximately as the true position from starting point throughout the test.

Power or power range

Min: 0.01 W Max: 0.01 W

Test bands/constellation

'L1'

Transmitter equipment

'F1.2'

2.6.3 Spoofer (in vehicle with roof mounted antenna) moving with fixed spoofed position.

Spoofer placed on the roof of a vehicle that moves south along Stavedalsveien (FV7702) at 40 km/h from the starting point. 10 seconds after the vehicle begins to move, the spoofing is activated, spoofing to a fixed position at 70 N, 10 E.

Power or power range

Min: 0.01 W Max: 0.01 W

Test bands/constellation

'L1'

Transmitter equipment

'F1.2'

2.6.4 Spoofer (in vehicle with roof mounted antenna) stationary and then moving with first fixed and then dynamic spoofed position.

Spoofer placed on the roof of a vehicle that starts out stationary for 10 minutes, then the vehicle begins to drive south along Stavedalsveien (FV7702) at 40 km/h. Spoofed position is approximately true for the first 10 minutes, then starts to move directly south with constant speed (40 km/h) (which in effect is a slightly different direction than the vehicle is moving in).

Power or power range

Min: 0.01 W Max: 0.01 W

Test bands/constellation

'L1'

Transmitter equipment

'F1.2'

2.7: Stationary coherent spoofing with extreme timeshifts (+/-years)

Rationale

Some equipment will use GNSS to provide time or to synchronize time dependent systems. The equipment and subsystems being fed this timing information can use this time for for example checking validity of licences, certificates, etc. This test can be used to check for unintended effects of large time shifts on equipment and subsystems.

Test description

Providing a date 2 years back in time or 2 years ahead can cause denial of service for some downstream services. The test will move the date 2 years back or forth from the day that the test is being executed at.

Additional information

The effect on subsystems is not known and hence care should be taken to limit the range of the transmission to include (as best as possible) only DUT eqipment and systems.

Tests within this test group

$2.7.1 \; {\rm Static} + {\rm Time \; manipulation} \; (2 \; {\rm years \; backwards}). \; {\rm GPS \; L1} \; {\rm and \; Galileo \; E1 \; only}$

Signals: GPS L1 C/A. Galileo E1.No jamming.Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.Time jumps 2 years into the past.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.7.2 Static + Time manipulation (2 years backwards). GPS L1 and Galileo E1 only, with initial and continuous jamming

Signals: GPS L1 C/A. Galileo E1.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Time jumps 2 years into the past.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.7.3 Static + Time manipulation (2 years backwards). GPS L1 and Galileo E1 only, with power ramp

Signals: GPS L1 C/A. Galileo E1.

No jamming. Spoofing power wil be ramped -35 dBm to +15 dBm in steps of 5 dB every two minutes. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time jumps 2 years into the past.

Power or power range

Min: 0.0316 W Max: 0.0316 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.7.4 Static + Time manipulation (2 years backwards)

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.
No jamming.
Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.
Time jumps 2 years into the past.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.7.5 Static + Time manipulation (2 years backwards), with initial and continuous jamming

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Power or power range

Min: 0.001 W Max: 0.001 W

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Time jumps 2 years into the past.

$Test \ bands/constellation$

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.7.6 Static + Time manipulation (2 years backwards), with power ramp

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. No jamming. Spoofing power wil be ramped -35 dBm to +15 dBm in steps of 5 dB every two minutes. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time jumps 2 years into the past.

Power or power range

Min: 0.0316 W Max: 0.0316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

$2.7.7~\mathrm{Static}$ + Time manipulation (2 years forwards). GPS L1 and Galileo E1 only

Signals: GPS L1 C/A. Galileo E1. No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time jumps 2 years into the future.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

 \mathbf{S}

2.7.8 Static + Time manipulation (2 years forwards). GPS L1 and Galileo E1 only, with initial and continuous jamming

Signals: GPS L1 C/A. Galileo E1.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Time jumps 2 years into the future.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

 \mathbf{S}

2.7.9 Static + Time manipulation (2 years forwards). GPS L1 and Galileo E1 only, with power ramp

Signals: GPS L1 C/A. Galileo E1. No jamming. Spoofing power wil be ramped -35 dBm to +15 dBm in steps of 5 dB every two minutes. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time jumps 2 years into the future.

Power or power range

Min: 0.0316 W Max: 0.0316 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.7.10 Static + Time manipulation (2 years forwards)

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time jumps 2 years into the future.

Power or power range

Min: 0.001 W Max: 0.001 W

$Test \ bands/constellation$

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

$2.7.11~{\rm Static}$ + Time manipulation (2 years forwards), with initial and continuous jamming

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Time jumps 2 years into the future.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.7.12 Static + Time manipulation (2 years forwards), with power ramp

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. No jamming. Spoofing power wil be ramped -35 dBm to +15 dBm in steps of 5 dB every two minutes. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Time jumps 2 years into the future.

Power or power range

Min: 0.0316 W Max: 0.0316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.7.13 Static + Time manipulation (April 2019). GPS L1 and Galileo E1 only

Signals: GPS L1 C/A. Galileo E1. No jamming. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Start time: 01.04.2019 12:00. This takes us back before the 2019 GPS week rollover.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.7.14 Static + Time manipulation (April 2019). GPS L1 and Galileo E1 only, with initial and continuous jamming

Signals: GPS L1 C/A. Galileo E1.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

Start time: 01.04.2019 12:00. This takes us back before the 2019 GPS week rollover.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.7.15 Static + Time manipulation (April 2019)

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.
No jamming.
Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.
Start time: 01.04.2019 12:00. This takes us back before the 2019 GPS week rollover.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

$2.7.16~\mathrm{Static}+\mathrm{Time}$ manipulation (April 2019), with initial and continuous jamming

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5. 5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae. Start time: 01.04.2019 12:00. This takes us back before the 2019 GPS week rollover.

Power or power range

Min: 0.001 W Max: 0.001 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.8: Stationary SBAS spoofing with "Do Not Use GPS" commands

Rationale

On the 9th of October 2023, the European SBAS system EGNOS erroneously made the satellites broadcast a GIC-information that declared all GPS satellites as unusable, which caused a lot of problems for EGNOS users, ranging from no effect at all to rapid fluctuations in GPS availability to no GPS service at all (variations probably caused by different impelemtations in user equipment). This test is to replicate that EGNOS phenomenon. For more information on this event, see EGNOS Service Notice Number: 028 (10/10/2023).

Test description

The test will only transmit EGNOS signals, that should be as close to real signals as possible, only with a different GIC information, that now tells the EGNOS boradcasted signal recipient to not use GPS.

Tests within this test group

2.8.1 EGNOS with "Do Not Use GPS" commands

Power or power range Min: 1 W Max: 1 W

Test bands/constellation

'L1'

Transmitter equipment

 \mathbf{S}

2.8.2 EGNOS with "Do Not Use GPS" commands and normali spoofing

Signals: EGNOS L1.

No jamming.

The transmission of false SBAS signals will start immediately upon test start. Test will also include coherent spoofing of GPS L1 C/A, L2, L5, E1 and E5 to ensure compliance between SBAS corrections and the GNSS signals. This spoofing will be coherent and the sppofed position will be in front of the HQ.

Power or power range

Min: 1 W Max: 1 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.9: Stationary coherent spoofing with invalid ephemerids

Rationale

Additional information

The effect on subsystems is not known and hence care should be taken to limit the range of the transmission to include (as best as possible) only DUT eqipment and systems.

Tests within this test group

2.9.1 Static + Nav. data manipulation (invalid ephemerids). GPS L1 and Galileo E1 only

Signals: GPS L1 C/A. Galileo E1.

No jamming.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The data manipulation starts five minutes after the spoofing starts, which will introduce an invalid ephemerids parameter.

Power or power range

Test bands/constellation

'L1', 'E1'

Transmitter equipment

 \mathbf{S}

2.9.2 Static + Nav. data manipulation (invalid ephemerids). GPS L1 and Galileo E1 only, with initial and continuous jamming

Signals: GPS L1 C/A. Galileo E1.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The data manipulation starts five minutes after the spoofing starts, which will introduce an invalid ephemerids parameter.

Power or power range

Test bands/constellation

'L1', 'E1'

Transmitter equipment

 \mathbf{S}

$2.9.3~{\rm Static}$ + Nav. data manipulation (invalid ephemerids). GPS L1 and Galileo E1 only, power ramp

Signals: GPS L1 C/A. Galileo E1.

No jamming.

Spoofing power wil be ramped -35 dBm to +15 dBm in steps of 5 dB every two minutes.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The data manipulation starts five minutes after the spoofing starts, which will introduce an invalid ephemerids parameter.

Power or power range

Min: 0.0316 WMax: 0.0316 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

 \mathbf{S}

2.9.4 Static + Nav. data manipulation (invalid ephemerids)

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.
No jamming.
Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.
The data manipulation starts five minutes after the spoofing starts, which will introduce an invalid ephemerids parameter.

Power or power range

Min: 0.1 W Max: 0.1 W

$Test \ bands/constellation$

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

2.9.5 Static + Nav. data manipulation (invalid ephemerids), with initial and continuous jamming

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

5 minutes of initial jamming (L1, G1, B1I, L2, E5b, L5 with 2 W) prior to spoofing transmission, then continuous on other bands than the ones spoofed.

Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The data manipulation starts five minutes after the spoofing starts, which will introduce an invalid ephemerids parameter.

Power or power range

Min: 0.1 W Max: 0.1 W

$Test \ bands/constellation$

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

'S'

2.9.6 Static + Nav. data manipulation (invalid ephemerids), with power ramp

No jamming.

Signals: GPS L1 C/A, L2C, L5. Galileo E1, E5.

Spoofing power wil be ramped -35 dBm to +15 dBm in steps of 5 dB every two minutes. Fixed spoofed position: 69.27547832, 15.96832496, 35 m hae.

The data manipulation starts five minutes after the spoofing starts, which will introduce an invalid ephemerids parameter.

Power or power range

Min: 0.0316 W Max: 0.0316 W

Test bands/constellation

'L1', 'L2', 'L5', 'E1', 'E5a', 'E5b'

Transmitter equipment

 \mathbf{S}

3 Meaconing

3.1: Stationary measoning from single receiver

Rationale

Meaconing is to record live navigation signals and rebroadcast them with higher power to deceive GNSS receivers to take the position of the meaconing system. The objective of these tests is to observe how equipment and systems behave under meaconing from a single receiver, with and without initial jamming. Attendees may observe PNT changes and/or loss of PNT, and monitor the changes when their equipment and systems are exposed to different power levels. It might be interesting to move around to see how your equipment behave when receiving the (static) meaconed position. If your equipment has countermeasures against jamming/spoofing a meaconed signal can be a challenging test. Some tests might be repeated to allow for e.g. comparison of static vs dynamic positioning of your equipment.

Test description

GNSS retransmission of real live sky signals from one receiver, where the goal is that GNSS user equipment calculates a wrong position using real satellite data, only slightly time delayed. The test will retransmit on the L1 and L2 bands, where the employed antennas for the receivers RX1 and RX2 have cut-off frequencies at 1562 - 1588 MHz (L1) & 1216 - 1240 MHz (L2) and 1564 - 1586 MHz (L1) & 1218 - 1238 MHz (L2), respectively. This means that GPS L1 and L2, Galileo E1, and BeiDou B1C should be visible in the retransmitted data stream, that GLONASS G1 should not be visible, and that B1I signals from some BeiDou satellites might be visible, especially on RX1. There is also a possibility that G2 signals from some GLONASS satellites might be visible. Please note that the filter's frequency cut-offs are not perfect, so some other signals might "leak" through.

The tests are performed with constant transmission power, some with initial jamming and some without. A 10-minute break between each test is planned. The meaconed position is for RX1: (TBD1) and for RX2: (TBD2).

Additional information

The meaconing setup employed is F1.1 "Porcellus". The jammer employed is F8.1 "Porcus Major", see Appendix G for more information about the equipment.

Tests within this test group

3.1.1 Meacon F1.1 "Porcellus": RX1 at 1 W

1 W meaconing from receiver RX1

Power or power range

Min: 1 W Max: 1 W Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment 'F1.1'

3.1.2 Meacon F1.1 "Porcellus": RX1 at 1 W with initial jamming

1 W meaconing from receiver RX1 preceded by 5 min. jamming: PRN L1, L2, L5 and G1 at 50 W)

Power or power range

Min: 1 W Max: 1 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1 and F8.1'

3.1.3 Meacon F1.1 "Porcellus": RX1 at 10 W

 $10~\mathrm{W}$ meaconing from receiver RX1

Power or power range

Min: 10 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

3.1.4 Meacon F1.1 "Porcellus": RX1 at 10 W with initial jamming

10 W meaconing from receiver RX1 preceded by 5 min. jamming (PRN L1, L2, L5 and G1 at 50 W)

Power or power range

Min: 10 W Max: 10 W

$Test \ bands/constellation$

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1 and F8.1'

3.1.5 Meacon F1.1 "Porcellus": RX2 at 10 W

10 W meaconing from receiver RX2

Power or power range

Min: 10 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

3.2: Stationary meaconing from two receivers

Rationale

Meaconing is to record live navigation signals and rebroadcast them with higher power to deceive GNSS receivers to take the position of the meaconing system. The objective of these tests is to observe how equipment and systems behave under meaconing from two receivers, with and without initial jamming. Attendees should try to observe PNT changes and/or loss of PNT, and monitor the changes when their equipment and systems are exposed to two different meaconed signals. If your equipment has countermeasures against jamming/spoofing a meaconed signal can be a challenging test. Some tests might be repeated to allow for e.g. comparison of static vs dynamic positioning of your equipment. When RX1 and RX2 are transmitting simultaneously, you should pay attention to the uncertainty of your equipment's position estimates.

Test description

GNSS re-transmission of real live sky signals from one receiver, where the goal is that GNSS user equipment calculates a wrong position using real satellite data, only slightly time delayed. The test will re-transmit on the L1 and L2 bands, where the employed antennas for the receivers RX1 and RX2 have cut-off frequencies at 1562 – 1588 MHz (L1) & 1216 – 1240 MHz (L2) and 1564 – 1586 MHz (L1) & 1218 – 1238 MHz (L2), respectively. This means that GPS L1 and L2, Galileo E1, and BeiDou B1C should be visible in the retransmitted data stream, that GLONASS G1 should not be visible, and that B1I signals from some BeiDou satellites might be visible, especially on RX1. There is also a possibility that G2 signals from some GLONASS satellites might be visible. Please note that the filter's frequency cut-offs are not perfect, so some other signals might "leak" through.

The tests are performed with constant power outputs, some with initial jamming and some without. A 10-minute break between each test is planned.

Additional information

The meaconing setup employed is F1.1 "Porcellus". The jammer employed is F8.1 "Porcus Major", see Appendix G for more information about the equipment.

Tests within this test group

3.2.1 Meacon F1.1 "Porcellus": RX1 and RX2 at 10 W

10 W meaconing from receivers RX1 and RX2, activated at the same time.

Power or power range

Min: 10 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

3.2.2 Meacon F1.1 "Porcellus": RX1 and RX2 at 10 W with initial jamming

 $10~{\rm W}$ meaconing from receivers RX1 and RX2, activated at the same time, preceded by 5 min. jamming (PRN L1, L2, L5 and G1 at 50 W)

Power or power range

Min: 10 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1 and F8.1'

3.2.3 Meacon F1.1 "Porcellus": RX1 and RX2 at 10 W turned on and off at different times

10 W meaconing from receivers RX1 and RX2, activated at different times. RX2 is turned on 5 minutes after RX1 is activated. RX1 is turned off after another 10 minutes and RX2 is turned off after the test has lasted 20 minutes.

Power or power range

Min: 10 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

3.2.4 Meacon F1.1 "Porcellus": RX1 and RX2 at 10 W alternating

10 W meaconing from receivers RX1 and RX2, alternating continuously. RX1 is activated first, then turned off after 1 minute while RX2 is being turned on. RX2 is then turned off after 1 more minute and RX1 is turned on. The cycle is repeated for as long as the test is set up (for example 5 cycles).

Power or power range

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

3.2.5 Meacon F1.1 "Porcellus": RX1 and RX2 at 10 W alternating with breaks

10 W meaconing from receivers RX1 and RX2, alternating with breaks. RX1 is activated first and left on for 1 minute, before being turned off. Nothing is then transmitted for 1 minute (transmission break). After the minute, RX2 is turned on and left on for 1 minute before being turned off. After another transmission break of 1 minute, repeat the cycle. The cycle is repeated for as long as the test is set up (for example 5 cycles).

Power or power range

Min: 10 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

3.2.6 Meacon F1.1 "Porcellus": RX1 and RX2 at 10 W alternating with decreasing durations without breaks

10 W meaconing from receivers RX1 and RX2, alternating more and more rapidly. RX1 is activated first and left on for 4 minutes, before switching to RX2 for 4 minutes. Then, 2 minutes RX1, 2 minutes RX2, 1 minute RX1, 1 minute RX2 and continues with halving durations until approximately 16 minutes has passed.

Power or power range

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

3.2.7 Meacon F1.1 "Porcellus": RX1 and RX2 at 10 W alternating with different switching frequencies.

10 W meaconing from receivers RX1 and RX2. Test consists of sets of two minutes, with different switching frequencies between RX1 and RX2 for each session. Example: First session: switch after 1 minute, second session: switch every 30 seconds, third session: switch every 15 seconds, etc.

Power or power range

Min: 10 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

3.2.8 Meacon F1.1 "Porcellus": RX1 and RX2 at 10 W alternating with breaks and jamming in breaks

10 W meaconing from receivers RX1 and RX2, alternating with breaks. RX1 is activated first and left on for 1 minute, before being turned off. Jamming (PRN L1, L2, L5 and G1 at 50 W) is then transmitted for 1 minute (in the break from the meaconing). After the minute of jamming, RX2 is turned on and left on for 1 minute before being turned off. After another jamming break of 1 minute, repeat the cycle. The cycle is repeated for as long as the test is set up (for example 5 cycles).

Power or power range

Min: 10 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

3.2.9 Meacon F1.1 "Porcellus": RX1 and RX2 at 10 W alternating with decreasing durations without breaks and with G1 jamming

10 W meaconing from receivers RX1 and RX2, alternating more and more rapidly. RX1 is activated first and left on for 4 minutes, before switching to RX2 for 4 minutes. Then, 2 minutes RX1, 2 minutes RX2, 1 minute RX1, 1 minute RX2 and continues with halving durations until approximately 16 minutes has passed. All is done while jamming (PRN G1 at 50 W) is active continuously.

Power or power range

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

3.2.10 Meacon F1.1 "Porcellus": RX1 and RX2 at 10 W alternating with different switching frequencies and with G1 jamming

10 W meaconing from receivers RX1 and RX2. Test consists of sets of two minutes, with different switching frequencies between RX1 and RX2 for each session. Example: First session: switch after 1 minute, second session: switch every 30 seconds, third session: switch every 15 seconds, etc. All is done while jamming (PRN G1 at 50 W) is active continuously.

Power or power range

Min: 10 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

3.3: Stationary measoning from a single or two receivers with ramping power

Rationale

Meaconing is to record live navigation signals and rebroadcast them with higher power to deceive GNSS receivers to take the position of the meaconing system. The objective of these tests is to observe how equipment and systems behave under varying meaconing transmission power levels. It might be interesting to see when or if your device jumps from an existing PNT fix to a meaconed signal with a higher power level.

Test description

GNSS re-transmission of real live sky signals from one receiver, where the goal is that GNSS user equipment calculates a wrong position using real satellite data, only slightly time delayed. The test will re-transmit on the L1 and L2 bands, where the employed antennas for the receivers RX1 and RX2 have cut-off frequencies at 1562 - 1588 MHz (L1) & 1216 - 1240 MHz (L2) and 1564 - 1586MHz (L1) & 1218 - 1238 MHz (L2), respectively. This means that GPS L1 and L2, Galileo E1, and BeiDou B1C should be visible in the retransmitted data stream, that GLONASS G1 should not be visible, and that B1I signals from some BeiDou satellites might be visible, especially on RX1. There is also a possibility that G2 signals from some GLONASS satellites might be visible. Please note that the filter's frequency cut-offs are not perfect, so some other signals might "leak" through.

Additional information

The meaconing setup employed is F1.1 "Porcellus". The jammer employed is F8.1 "Porcus Major", see Appendix G for more information about the equipment.

Tests within this test group

3.3.1 Meacon F1.1 "Porcellus": RX1 with ramping power

Meaconing from receiver RX1, with ramping power. Power is ramped up from 0.001 W to 10 W and then back down again to 0.001 W in 5 dB steps, with each step lasting for 2 minutes.

Power or power range

Min: 0.001 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

3.3.2 Meacon F1.1 "Porcellus": RX1 at constant 5 W and RX2 with ramping power

1 W meaconing from receiver RX1, with receiver RX2 ramping power. Power for RX1 is kept constant, while power for RX2 is ramped up from 0.001 W to 10 W and then back down again to 0.001 W in 5 dB steps, with each step lasting for 2 minutes.

Power or power range

Min: 0.01 W Max: 10 W

Test bands/constellation

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

3.3.3 Meacon F1.1 "Porcellus": RX1 at less than 1 W, adding RX2 at 10 W after 5 minutes

Meaconing from receiver RX1 with low power for 5 minutes, then adding RX2 with more than 10dB higher power for 15 minutes

Power or power range

$Test \ bands/constellation$

'L1', 'E1', 'B1C', 'L2'

Transmitter equipment

'F1.1'

Appendices

Appendix A - Description of test areas at Andøya



Appendix A - Description of test areas at Andøya

RED	=	Official test area 1, Bleik
Green	=	Official test area 2 , Grunnvatn
Blue	=	Official test area 3 , Stave

Survey points

Notice: Geodetic reference frame is EUREF89. Differences between EUREF89 and WGS84 (from Appendix H):

N WGS84 epoch2024.7 = NEUREF89UTM33epoch1989.0 + ΔN where ΔN=0.64mE WGS84 epoch2024.7 = EEUREF89UTM33epoch1989.0 + ΔE where ΔE = 0.46m $\varphi WGS84 epoch2024.7 = \varphi EUREF89UTM33epoch1989.0 + ΔLat where ΔLat = 0.0000056^{\circ}$ $\lambda WGS84 epoch2024.7 = \lambda EUREF89UTM33epoch1989.0 + ΔLong where ΔLong = 0.0000119$ Seven significant decimal digits for latitude and longitude will ensure cm-precision.

Point ID	Latitude	Longitude	Ellipsoidal	Physical	Northing	Easting	Mark
			height	height	UTM33	UTM33	
							Foot
							antenna
SAMF	69.27560042	15.96812897	42.73	6.88	7685395.45	538232.98	at roof
MECONING	69.28000843	16.00593213	370.23	334.44	7685910.97	539717.71	rig
							Green
RX_1	69.28031078	16.01065010	352.50	316.72	7685947.75	539903.42	antenna
							White
RX_2	69.27876623	16.01691109	358.16	322.39	7685779.63	540153.46	antenna
SENDER	69.28007238	16.00643461	381.98	346.19	7685918.43	539737.43	rig
							Grey
							ant.
							yellow
REFANTENNA	69.27538406	15.96826115	41.01	5.16	7685371.41	538238.59	tripod
							Ericsson
							Right
E-BLEIK-RF	69.27560844	15.96881180	42.64	6.79	7685396.77	538259.93	Front
							Ericsson
							Left
E-BLEIK-LF	69.27560014	15.96882632	42.60	6.75	7685395.85	538260.52	Front
							Ericsson
							Left
E-BLEIK-LB	69.27560509	15.96884918	42.60	6.75	7685396.42	538261.42	Back
							Ericsson
							Right
E-BLEIK-RB	69.27561842	15.96885426	42.65	6.80	7685397.91	538261.59	Back
							Antenna
11	69.27548568	15.96814545	40.85	5.00	7685382.66	538233.84	rig

							Antenna
12	69.27549051	15.96816671	40.84	4.99	7685383.22	538234.67	rig
							Antenna
13	69.27549534	15.96818795	40.85	5.00	7685383.77	538235.50	rig
							Antenna
14	69.27550022	15.96820929	40.86	5.01	7685384.32	538236.33	rig
							Antenna
21	69.27549321	15.96813174	40.86	5.01	7685383.49	538233.28	rig
							Antenna
22	69.27549803	15.96815312	40.87	5.02	7685384.05	538234.12	rig
							Antenna
23	69.27550290	15.96817433	40.88	5.03	7685384.60	538234.95	rig
							Antenna
24	69.27550779	15.96819577	40.89	5.04	7685385.16	538235.79	rig
							Antenna
31	69.27550083	15.96811797	40.89	5.04	7685384.34	538232.73	rig
							Antenna
32	69.27550562	15.96813928	40.89	5.04	7685384.88	538233.56	rig
							Antenna
33	69.27551050	15.96816054	40.91	5.06	7685385.44	538234.39	rig
		45 00040400	40.00	5.07		500005.00	Antenna
34	69.27551533	15.96818190	40.92	5.07	7685385.99	538235.22	rig
		45 00040477	40.00	5.07		500000 40	Antenna
41	69.27550813	15.96810477	40.92	5.07	7685385.14	538232.19	rig
12	60 07554007	45.00042500	40.00	5.00	7005005 00	520222.02	Antenna
42	69.27551297	15.96812596	40.93	5.08	7685385.69	538233.02	rig
42	C0 27554702	15 0001 4720	40.04	F 00	7005200 25	F20222 0F	Antenna
43	69.27551782	15.96814729	40.94	5.09	7685386.25	538233.85	rig
44	69.27552264	15.96816853	40.96	5.11	7685386.80	538234.68	Antenna
44	09.27552204	12.90010022	40.90	5.11	7085580.80	556254.06	rig
1	69.27553403	15.96883049	39.86	4.01	7685388.48	538260.80	Asphalt nail
1	09.27555405	13.90883049	39.80	4.01	7085588.48	558200.80	Asphalt
2	69.27523091	15.96674688	40.48	4.63	7685353.39	538179.06	nail
-	05.27525051	13.30074000	+0.40	05	1000000000	3301/3.00	Tree
							stick,
							Height
							ref:
LOK2-ORIG	69.22249871	15.93303984	66.92	31.04	7679453.28	536937.52	terrain
	55122275071		50.52	51.57			Tree
			1	1	1		

							Height
							ref: top
							Tree
							stick,
							Height
A100	69.22336709	15.93366659	65.76	29.87	7679550.48	536960.86	ref: top
							Tree
							stick,
							Height
A150	69.22380127	15.93398000	65.64	29.75	7679599.08	536972.52	ref: top
							Tree
							stick,
							Height
B50	69.22218526	15.93394222	65.80	29.91	7679418.87	536973.77	ref: top
							Tree
							stick,
							Height
B100	69.22187181	15.93484460	66.76	30.88	7679384.47	537010.03	ref: top
							Tree
							stick,
							Height
B150	69.22155835	15.93574693	67.95	32.07	7679350.07	537046.28	ref: top
							Tree
							stick,
							Height
C50	69.22237796	15.93182408	64.44	28.55	7679439.08	536889.60	ref: top
							Tree
							stick,
							Height
C100	69.22225721	15.93060834	63.97	28.08	7679424.89	536841.68	ref: top
							Tree
							stick,
							Height
C150	69.22213644	15.92939261	63.64	27.75	7679410.69	536793.75	ref: top

Description of site 1

Overview of survey points

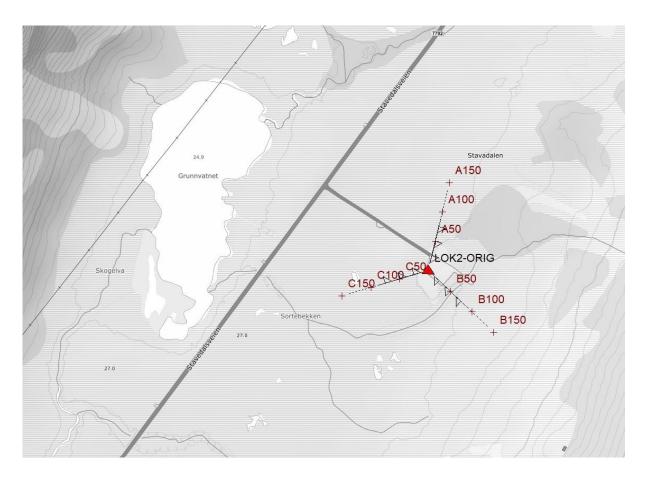


More detailed view of surveyed points.

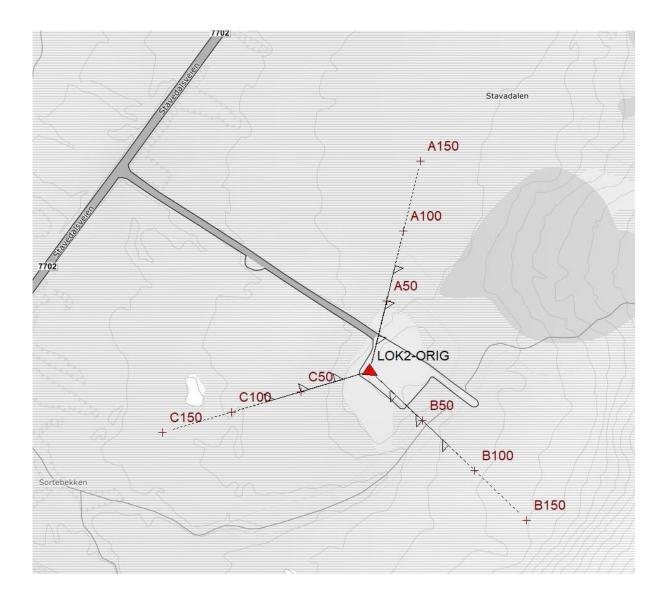
7700

Description of site 2

Location 2 is the parking lot at the end of a dirt road. Position N 69.2225°, Ø 15.9335° Most of the testing will be conducted at the parking lot, or the surrounding area.



There will be certain marked position surrounding the area. 120 degrees apart, at 50, 100 and 150 meter in distance. Those positions can be found on the picture below:



Description of motorcade route(s) on Andøya, site 3

The start is as Stave commynity house (69.212187 North ,15.858559 East), the small jammers can be used the intersection between county road 7702 and communal road "Oklveien" (69.14409 North, 15.75847 East). The picture below shows the stretch of road that can be used for the motorcade (Red line).



The road is quite narrow 5.1 meters with a speed limit of 80 km/h. The traffic volume is low with about 1000 vehicles per day. For some tests where reduced speed is need there will be a NPRA vehicle in front and at the back of motorcade. Communication to the vehicles will be via FM radio.

Appendix B - GNSS systems overview with signal notation and frequency

Appendix B - GNSS systems overview with signal notation and frequency

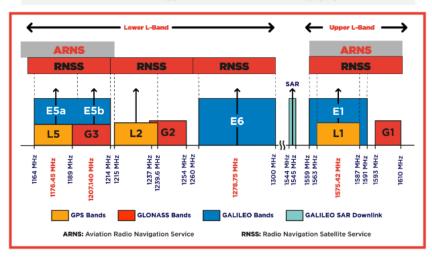
GNSS band acronym	Frequency band
L1 = GPS band L1,	1563 – 1587 MHz
L2 = GPS band L2,	1215 – 1240 MHz
L5 = GPS band L5,	1164 – 1189 MHz
G1 = GLONASS band G1	1593 – 1610 MHz
G2 = GLONASS band G2	1237 – 1254 MHz
G3 = GLONASS band G3	1189 – 1214 MHz
B1I = BeiDou legacy band B1I	1559 – 1563 MHz
B1C = BeiDou band B1C	1559 – 1592 MHz
B2a = BeiDou band B2a	1166 – 1187 MHz
B2b = BeiDou band B2b	1197 – 1217 MHz
B3I = BeiDou band B3	1258 – 1279 MHz
E5a = Galileo band E5a	1164 – 1189 MHz
E5b = Galileo band E5b	1189 – 1214 MHz
E1 = Galileo band E1	1559 – 1591 MHz
E6 = Galileo band E6	1260 – 1300 MHz

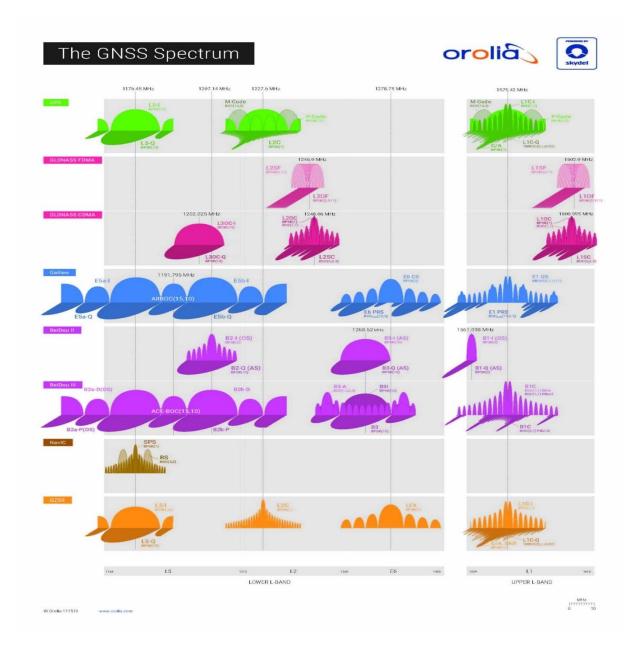
Disclaimers:

When GNSS bands are proclaimed in a given test, the transmissions will be somewhere in the abovementioned frequency bandwidth.

We annotate a GNSS band as affected by GNSS RFI, if the jammer, spoofer or meaconing signal covers the centre frequency of the given GNSS band. Whether the GNSS band reception is affected is largely dependent on reception conditions, and the receiver equipment itself.

GNSS System	Signal Notation	Signal Frequency (MHz)
	L1 C/A	1575.42
	L1C	1575.42
GPS	L2 C	1227.6
	L2 P	1227.6
	L5	1176.45
	L1 C/A	1598.0625-1609.3125
GLONASS	L2 C	1242.9375-1251.6875
GLUNASS	L2 P	1242.9375-1251.6875
	L3 OC	1202.025
	E1	1575.42
	E5a	1176.45
Galileo	E5b	1207.14
	E5 AltBOC	1191.795
	E6	1278.75
	B1I	1561.098
	B2I	1207.14
BeiDou	B3I	1268.52
BeiDou	B1C	1575.42
	B2a	1176.45
	B2b	1207.14
NAVIC	L5	1176.45
	L1	1575.42
SBAS	L5	1176.45
	L1 C/A	1575.42
	L1 C	1575.42
0755	L1S	1575.42
QZSS	L2C	1227.6
	L5	1176.45
	L6	1278.75

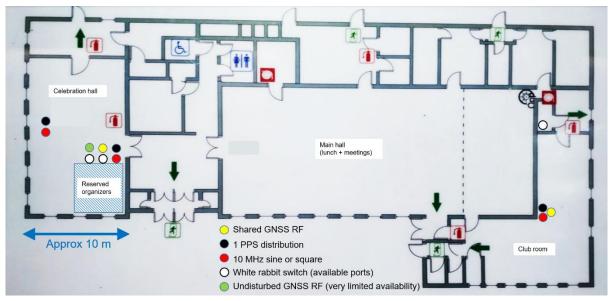




Appendix C - Timing and RF signal distribution at Bleik community house

Appendix C – Timing and RF signal distribution at Bleik community house

Updated 2024-08-26



Reference timing signals will be available in the 'Celebration hall' and 'Club room' at Bleik community house. RF signals from a shared antenna

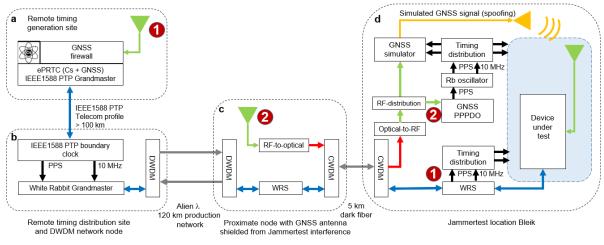
GNSS RF distribution

Reference antenna: Novatel GNSS-750 positioned outside the community house (exact position TBD). The antenna gain is approx. 41 dB. Cable loss is approx. 5-6 dB (dependent on antenna location).

The distribution system consists of a Tallysman 4 port active splitter, with a net gain of 0 dB on each port. The RF signal is further split into 4 16-port passive splitters, with a net loss of 12 dB per port. Net gain per port will be approximately 24 dB from the Novatel antenna in 'celebration hall'. In 'club room' the gain will be reduced a few dB more from cable loss (TBD).

There will be 38 ports available in 'celebration hall', and 16 ports available in 'club room'. All unused ports will be terminated with a 50 ohm dummy load. The splitter connector is of type N female. TNC and SMA adapters could be provided if critical. All ports available are DC blocked, and terminated internally with a 200 ohm resistor to simulate a GNSS antenna preamplifier load.

Timing sources



There are two sources of timing available at Bleik community house:

(1) ePRTC class timing over a combination of standard IEEE1588 and White Rabbit PTP. The timing source is a Cs-clock backed ePRTC made available by Telenor. Timing is transported over standard PTP in Telenor's sync backbone and over White Rabbit PTP in the Norwegian national research DWDM network (Sikt) and finally over a dedicated CWDM bidirectional channel to Bleik community house. Anticipated ePRTC performance is within +/- 30 ns from UTC (after calibration). Performance in 2023 was likely within +/- 10 ns (albeit without a careful calibration).

(2) GNSS timing using RF signals over optical fiber from an antenna at a nearby location shielded from Jammertest RF interference. The remote GNSS signal is fed to a prototype disciplined OCXO using the Fugro AtomiChron PPP timing service. Anticipated timing performance is within +/-5 ns from UTC after calibration.

Timing signal distribution

Timing signals will be distributed as electrical signals: pulse-per-second, 10 MHz sine and 10 MHz square. There are also opportunities to connect to available ports on White Rabbit switches.

Physical signal distribution characteristics

Distribution amplifiers: Microsemi 9611 Connectors: BNC female PPS: 0 – 2 V into 50 Ohm with a rise time of approx 20 ns 10 MHz square: 0 – 2 V into 50 Ohm with a rise time of approx 20 ns 10 MHz sine: 3 Vp-p into 50 Ohm

This appendix will be updated with pulse delay calibration values for the rising edge of PPS signals for the distribution amplifiers deployed.

Connection to White Rabbit switches

There is opportunity to connect PTP devices (standard or White Rabbit) to available ports on White Rabbit switches in the Celebration Hall and the Club room. The organizers cannot offer extensive support for this, but we will do our best. Please bring your own SFPs and (rugged) fiber cables, preferable something already known to work. Consult the list of tested SFPs and fiber types here: https://ohwr.org/project/white-rabbit/-/wikis/sfp.

'Celebration Hall' - timing signal availability

- Two or three racks with physical timing signal distribution with a total of 84 outputs configurable in blocks of 12.
- PPS from ePRTC and Fugro AtomiChron
- 10 MHz sine
- 10 MHz square
- Available ports on White Rabbit switch(es)

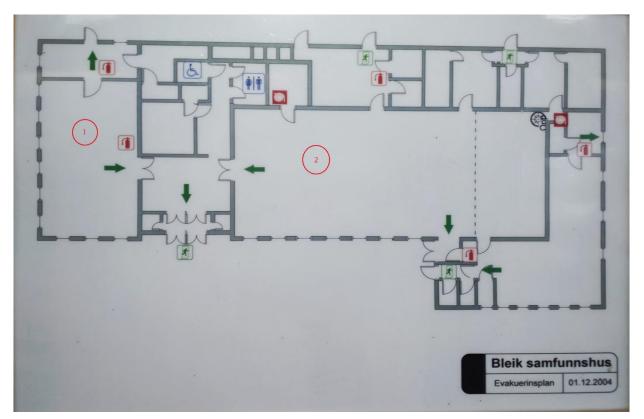
'Club room' - timing signal availability

- One rack (possibly two) with physical timing signal distribution with a total of 48 outputs configurable in blocks of 12
- PPS from White Rabbit switch (following either ePRTC or AtomiChron timing source)
- 10 MHz square from White Rabbit switch ((following either ePRTC or AtomiChron timing source)
- Available ports on the White Rabbit switch

Appendix D - Overview of inside of Bleik community house

Appendix D - Overview of inside of Bleik community house

Figure D 1 gives an overview of the layout of Bleik community house with evacuation exits indicated.

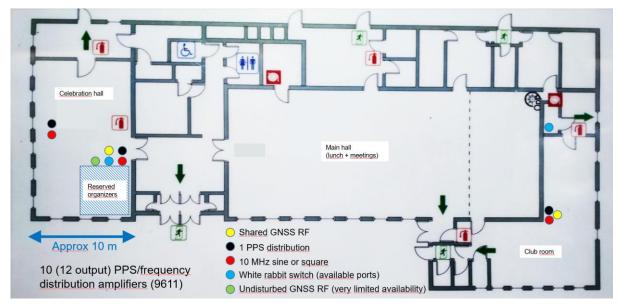


D 1: Floor plan of Bleik samfunnshus ('Bleik community house').

The organizers will set up a shared WiFi network in the building that the participants will be able to use. In addition wired access is possible but the one has to bring cable to hook into our switches (RJ45 Ethernet). The uplink from the community house is shared hence download/upload speeds are dependant on other users. For EU residents Norway is part of EU Roam-at-home hence you should be able to use data on your phone without extra cost (but do check)

There are three rooms that we used in the house, the kitchen room (to the left, with number 1). The mess hall (in the middle, number 2). And the youth club the invers L shaped room to the right.

Figure D 2 gives an overview of RF and timing distribution points indicated.



D 2: Floor plan of Bleik community house with RF and timing distribution points indicated.

Appendix E - Overview of Bleik and HQ

Appendix E - Overview of Bleik and HQ

Figure E 1 gives a bird eye view Bleik community house ('HQ') and the close surrounding areas, with the areas intended use indicated. E.g. where to park test vehicles when used in a test (in front of the HQ) and where to place antennas (in front of and ENE of HQ).

Note that parking is strictly enforced. Note also that indications of where to set up antennas and where to land/control UAVs are suggestive.



E 1: Bleik community house ('HQ') and the close surrounding areas, with intended use indicated. Aerial photo from norgeskart.no



Figure E 2 gives a bird eye view of the village of Bleik with important locations indicated.

E 2: The village of Bleik and the surrounding areas, with useful locations indicated. Aerial photo from norgeskart.no

Figure E 3 and E 4 shows the areas from figures E 1 and E 2, respectively, without indications.



E 3: Overview of Bleik HQ and close surrounding areas. Aerial photo from norgeskart.no



E 4: Overview of Bleik village and surrounding areas. Aerial photo from norgeskart.no

Appendix F - Overview of spoofed routes

Appendix F - Overview of spoofed routes

Route 1



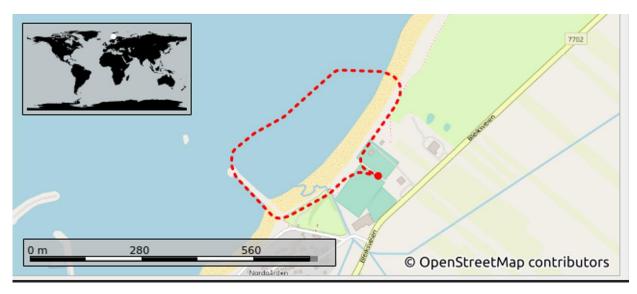
Route 2

TBD

Route 3



Route 4



Route 5

TBD

Appendix G - Technical details on jammer equipment

Appendix G - Technical details on jammer equipment

1 st Letter (Norwegian / English)	1 st digit	2 nd digit
S = Sigarett / Cigarette		
H = Håndholdt / Handheld	Number of	# jammer within same
U = USB / USB stick	antennas	category
F = Fastmontert / Permanently installed		
(Fixed)		

The nomenclature for naming of the jammer equipment is as follows:

Exempli gratia:

S1.2, is a cigarette type jammer, that has 1 antenna, and is unit nr.2 in this category.

Additional information:

- Each chapter gives an overview of each jammer brought to Jammertest. As far as possible, it gives information on
 - Centre frequency [MHz]
 - Bandwidth [MHz]
 - Power Spectral Density (PSD) [dBm/MHz] for the entire bandwidth
 - Total output power (TX total) [dBm] for the entire bandwidth
 - CF max [dBm] (maxhold power at the centre frequency)
 - Sweep rate [µs] (if applicable)
 - o Modulation
- Indicators such as "L1, L2, L5" etc. are used to indicate main bands of attack, used for convenience to distinguish between jammers' modus operandi
- 2023 measurements
 - Technical details on low power jammers given in this appendix are from uncalibrated measurements. They are rough estimates given for both the frequency and time domain. Power levels are not correctly displayed on the chart, because of external attenuators used during measurements with a signal analyser. There may also have been some constraints in the measurement device, causing fast frequency components to not be correctly displayed.
- 2024 measurements
 - Measurements done with a R&S FSW. All measurements were performed connected directly to the jammers' antenna port, with the other antennas disconnected and (if applicable) DIP switches for the other antenna ports disabled. Powe levels etc. should be as close to reality as possible for output power at the antenna port.
 - Throughout the measurements, bandwidth is defined as 3 dB from local (identifiable) maxima along the maxhold's descent.
 - TX power is measured within said bandwidth. Note that TX total is measured over the entire bandwidth, so that peak output power is not equal to TX total.

Technical details on low-power jammer "S1.1"

The jammer S1.1 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are intended to cover the car, and a given radius around the car.

S1.1 is an one-antenna, so-called "L1-only", jammer, disrupting only the upper L-band.

MultiView 📲	Spectrum	× An	alog Demod	×R	eal-Time S	pectrum	×		
Ref Level 15.00			1 MHz						
	15 dB SWT 1.	.01 ms VBW	1 MHz Mode	Auto Sweep					
ACLR			1	1				-	Clrw ●2Pk Ma>
LO dBm					мз			M3[2]	7.89 dE
io doni		M1			T*1		02		1,5774005 G
		Ť I					1 A	M1[2]	3.73 dE
) dBm									1,562 421 5 G
-10 dBm									-
-20 dBm									
20 0011									
	<u> </u>		i ili ili.						
-30 dBm	/							+	
40.dBm									\
HU UBIN / INC									∇
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150 dBm	▋┧。								
	III KALI UUTA								Aller Ar Ar Aller A
CF 1.577 400 5 G	iHz		1001 p	ts		6.09 MHz/			Span 60.9 M
Result Summa	ry				None			P	ower Max Ho
Channel Tx1 (Ref)		Bandwidth		Offset		Power 7.58 dBm/			
Tx Total		29.957 MHz				22.34	dBm		
Marker Table						22.54			
Type Ref	Trc	X-Value		Y-Value		Function		Function R	esult
M1		62 421 5 G		3.73 dBm		rancaon		- ancion K	Court
D2 M1	2	29.957 M	Hz	1.54 dB					
M3	2 1.5	77 400 5 G	Hz	7.89 dBm					
							- Measuring		2024-07- 11:38:
									11:30:

Technical characteristics of S1.1 (2024 measurements)

PSD

[dBm/MHz]

7,58

TX total

[dBm]

22,34

CF

max

[dBm]

7,89

Sweep

rate [µs]

37,1

Bandwidth

[MHz]

29,96

Centre

frequency

[MHz]

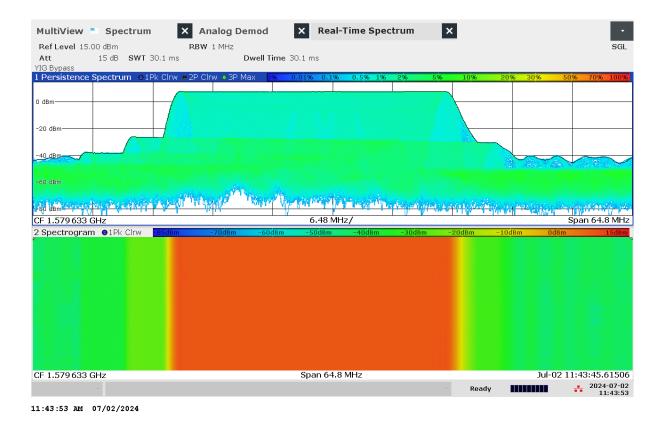
1577,40

G 1: Frequency and power measurement of jammer S1.1



Modulation

Sawtooth



G 2: Real-time persistence and spectrogram measurement of jammer S1.1

Att	15 dB AQ	T 100 µs DBW 40	MHz Freq 1.57	9633 GHz					
Bypass M Time D	omain							OIAP CIN	v DC Ref:0⊢
								D2[1] -108.	080 000 000 1
MHz									37.1000
MIF12								M1[1] 12.	590 382 000 M
									38,1000
MHz			M1				D2		
MHz									
						- All And			
Hz									
z									
MHz									and the second se
				and the second second	1				
MHz-				ALA MARKAN					
and the second s									
MHa				and the second se				and the second se	
MHz									-
1.579633	3 GHz			100	1 pts		1		10.0 μ
esult Sun	nmary								
		r Power 8.12 dB					Offset -1.75		
M	+Peak 12.701 MHz	-Peak -16.8 MHz	±Peak/2 14.751 MHz	RMS		od. Freq 26.87539 kHz	SINAD	DISTORT	THD
IVI	12.701 MHZ	-10.8 MHZ	14.751 MHZ	8.8025	MHZ	20.87339 KHZ	Ready		2024-07

G 3: Time domain (analog demod) measurement of jammer S1.1

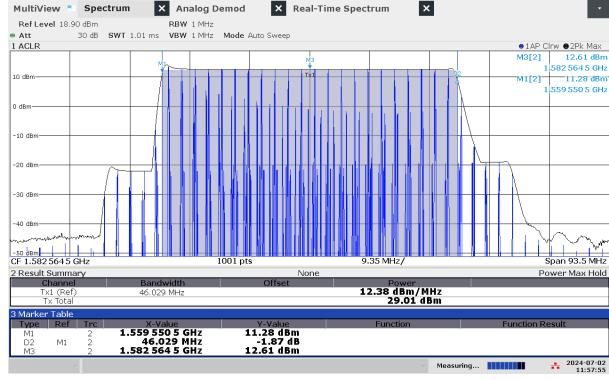
Technical details on low-power jammer "S1.2"

The jammer S1.2 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are intended to cover the car, and a given radius around the car.

S1.2 is an one-antenna, so-called "L1-only", jammer, disrupting only the upper L-band.

Technical characteristics of S1.2 (2024 measurements)

Centre Bandwidth PSD TX total CF Sweep Modulation frequency [dBm/MHz] rate [µs] [MHz] [dBm] max [MHz] [dBm] 1582,56 40.03 12,38 29,01 12,61 21,56 Sawtooth



11:57:55 AM 07/02/2024

G 4: Frequency and power measurement of jammer S1.2



MultiView 📒 Spectru		od X Real-Time	Spectrum X		•
Att 30 dB SWT	RBW 1 MHz 30.1 ms Dwg	ell Time 30 ms			
YIG Bypass					
1 Persistence Spectrum 0	1Pk Clrw • 2P Clrw • 3P Max	0% 0.01% 0.1% 0.5	% 1% 2% 5%	10% 20% 30%	50% 70% 100%
0 dBm					
-20 dBm					
-40 dBm					
-60 dBm					
in an		ALL PROPERTY AND A STREET	haite shake the second of		ale Rindbard and a state of the latter
CF 1.582 564 5 GHz	a and a state of the	9.35 MHz/	in the later of the later of the second s	l sa haindh aite ait dhan na dha dhan i	Span 93.5 MHz
		2.00 1411/2/			
2 Spectrogram A1 D/ Clow	-01 1dBm -70dBm -60dB	m -50dBm -40dBm	- 20dBm - 20dBm	-10dBm 0dBm	
2 Spectrogram O1Pk Clrw	-81.1dBm -70dBm -60dB	m −50dBm ~40dBm	-30dBm -20dBn	-10dBm OdBm	10dBm 18.9dBm
2 Spectrogram O1Pk Clrw	-81.1dBm -70dBm -60dE	m -50dBm -40dBm	-30dBm -20dBn	n –10dBm OdBm	
2 Spectrogram ●1Pk Clrw	-60di	m -50dBm -40dBm	-30dBm -20dBn	ı –10dBm Od <mark>Bm</mark>	
2 Spectrogram	81.1dBm -70dBm -60dE	m -50d8m -40d8m	-30dBm -20dBn	1 –10dBm Od <u>B</u> m	
2 Spectrogram ●1Pk Clrw	81.1dBm -70dBm -60dE	m -SOdBm -40dBm	-30dBm -20dBn	n –10dBm OdBm	
2 Spectrogram •1Pk Clrw	81.1dB m -70dBm -60dE	m -SOdBm -40dBm	-30dBm -20dBn	n –10dBm OdBm	
2 Spectrogram •1Pk Clrw	81.1dBm -70dBm -60dE	m -SOdBm -40dBm	-30dBm -20dBn	n -10dBm OdBm	
2 Spectrogram •1Pk Clrw	81.1dBm -70dBm -60dE	m -SOdBm -40dBm	-30dBm -20dBn	n -10dBm OdBm	
2 Spectrogram •1Pk Clrw	81.1dBm -70dBm -60dB	im -SOdBm -40dBm	-30dBm -20dBn	n -10dBm OdBm	
2 Spectrogram •1Pk Clrw	81.1dBm -70dBm -60dB	im -SOdBm -40dBm	-30dBm -20dBn	n -10dBm OdBm	
2 Spectrogram • 1Pk Clrw CF 1.582 564 5 GHz	81.1dBm - 70dBm -60dB	<u>т -sodBm -40dBm</u> Span 93.5 MHz	-30dBm -20dBn		

12:08:01 PM 07/02/2024

G 5: Real-time persistence and spectrogram measurement of jammer S1.2



12:05:23 PM 07/02/2024

G 6: Time domain (analog demod) measurement of jammer S1.2

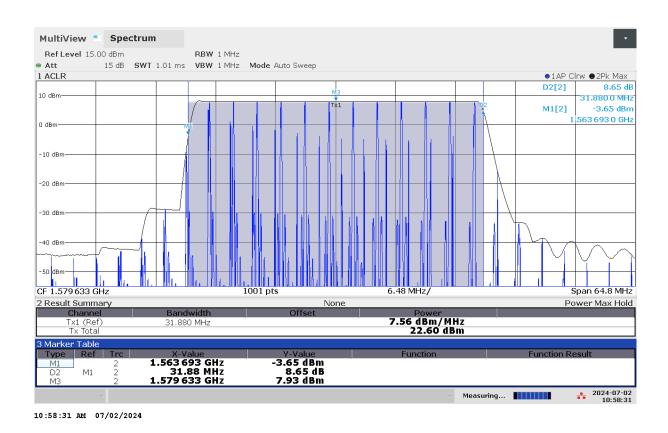
Technical details on low-power jammer "S1.3"

The jammer S1.3 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are intended to cover the car, and a given radius around the car.

S1.3 is an one-antenna, so-called "L1-only", jammer, disrupting only the upper L-band.

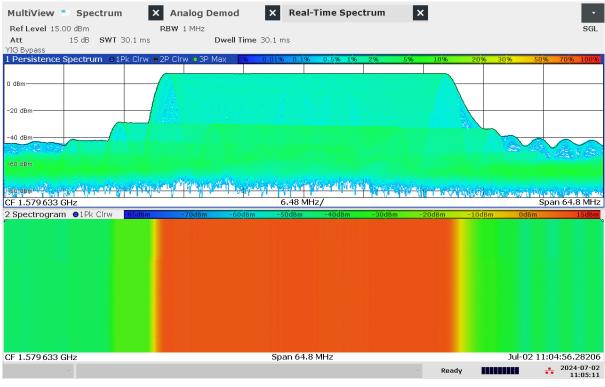
Technical characteristics of S1.3 (2024 measurements)

Centre Bandwidth **PSD** TX total CF Sweep Modulation frequency [MHz] [dBm/MHz] rate [µs] [dBm] max [MHz] [dBm] 1579,63 31,88 7,56 22,60 7,93 37,5 Sawtooth



G 7: Frequency and power measurement of jammer S1.3





11:05:12 AM 07/02/2024

G 8: Real-time persistence and spectrogram measurement of jammer S1.3



G 9: Time domain (analog demod) measurement of jammer S1.3

Technical details on low-power jammer "S2.1"

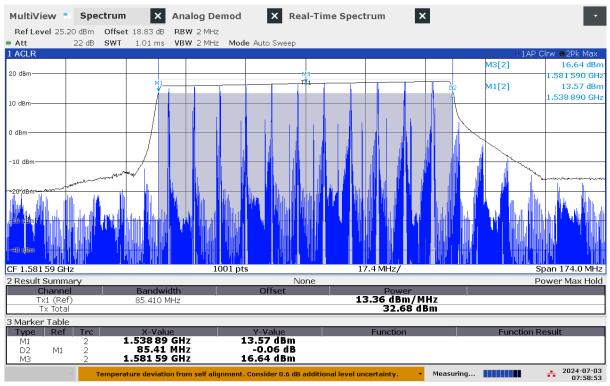
The jammer S2.1 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are intended to cover the car, and a given radius around the car.

S2.1 is a two-antenna, so-called "L1+L2", jammer, disrupting both the upper and lower L-band.



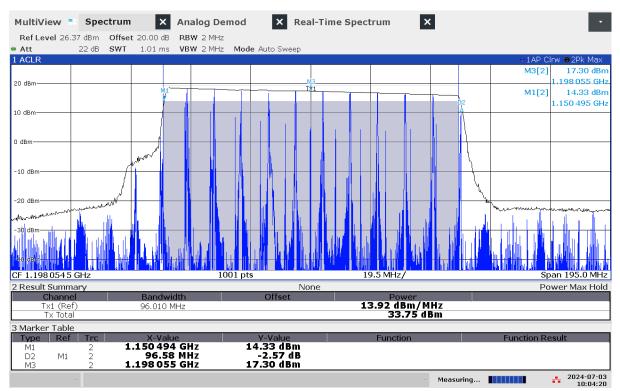
Technical characteristics of S2.1 (2024 measurements)

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"L1"	1581,59	85,41	13,36	32,68	16,64	40,63	Sawtooth+burst
"L2"	1198,05	96,58	13,92	33,75	17,30	42,1	Sawtooth+burst



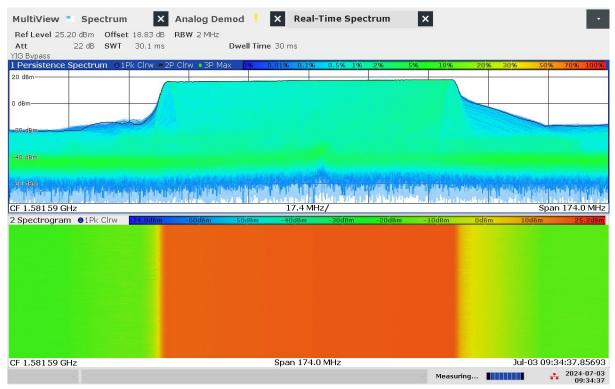
^{07:58:54} AM 07/03/2024

G 10: Frequency and power measurement of jammer S2.1 on antenna "L1"



10:04:20 AM 07/03/2024

G 11: Frequency and power measurement of jammer S2.1 on antenna "L2"



09:34:37 AM 07/03/2024

G 12: Real-time persistence and spectrogram measurement of jammer S2.1 on antenna "L1"

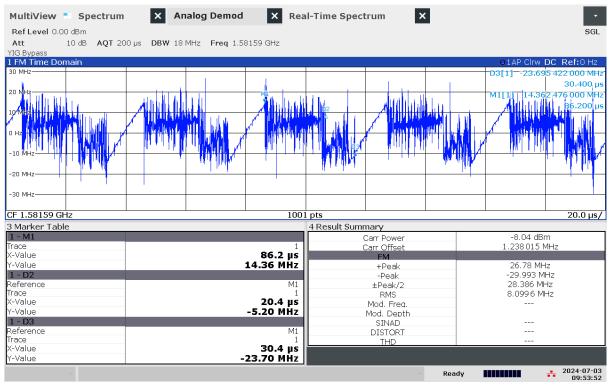
MultiView	Spe	ctrum	×	Anal	og De	mod	×	< Rea	I-Time S	Spect	trum	×						-
Ref Level 26.	37 dBm	Offset	20.00 dB	RB₩	2 MHz													
Att	22 dB	SWT	30 ms			Dwell	Time 3	30 ms										
YIG Bypass						51515	_					11 M 12			AT MEN HOUSE ALL PROPERTY AND	and the second	-	
1 Persistence	Spectru	m olp	K CIrw 🖷 Z	P Clrw	© 3P_Ma	ax <mark>09</mark>	6 0.0	1% 0.1	% 0.5%	1%	2%	5%	10%	209	6 <u>30</u> %	509	6 70%	100%
20 dBm																		
0 dBm	-													F				
	1	\sim													1			
-20 dBm	had																	
															~~~~			
-40 dBm																		_
NO GOM																		
A CONTRACTOR OF A CONTRACTOR A											A.A		<b>BURNER</b>					d male adde
-60 dBm	Landard .	in the later	Martin Like	AUT	Land	in the	11 Aug	ALLA		1.14	1.044	in the state	64LEM	1 Law	( Hils II	Litt	d. Lade	a Jahata
The state of the state of the	the life of the	10000																THE REAL PROPERTY.
CE 1 108 054 5	CHZ			11.1				17.4	4Hz/				4			Sn	an 174	0 MHz
CF 1.1980545		Clow	70.62dBm	-604	0 m	-E0d0		17.4			20.d0 m	-10	d at	OdBm	100	201	an 174.	
CF 1.1980545 2 Spectrogram		Clrw	-73,63dBm	-60d	Bm	-SOdBn	n -	17.4 M	1Hz/ -30dBm		-20dBm	-10	ldBm	OdBm	100	201		.0 MHz .37dBm
		Clrw	-73,63dBm	-60d	Bm	-S0dBn	n –				-20dBm	-10	ldBm	OdBm	100	201		
		Clrw	73,63dBm	-60d	Bm	-SOdBr	n –				-20dBm	-10	JdBm	OdBm	100	201		
		Clrw	-73.63dBm	-60d	Bm	- 50dBn	n –				-20dBm	-10	JdBm	OdBm	100	201		
		Clrw	-73.63dBm	-604	Bm	- SOdBri	n –				-20dBm	-10	dBm	OdBm	100	201		
		Clrw	.73.63dBm	-60d	Bm	-SOdBr	n				-20dBm	-10	dBm	OdBm	100	201		
		Clrw	73,63dBm	-60d	Bm	- 50dBn	n –				-20dBm	-10	dBm	OdBm	100	201		
		Clrw	-73.63dBm	-60d	Bm	-S0dBr	n -				-20dBm	-10	dBm	OdBm	100	201		
		Clrw	73,63d8m	-60d	Bm	-S0dBn	1           				-20dBm	-10	dBm	OdBm	100	201		
		Clrw	73,63d8m	-604	Bm	-50dBn	n -				-20dBm	-10	idBm	OdBm	100	201		
		Clrw	73,63dBm	-60đ	Bm	-50dBn					-20dBm	-10	idBm	OdBm	100	201		
	n ●1Pk	Clrw	73.63d9m	-60d	Bm	-S0dBn		40dBm			-20tiBm	-10	id Bm	OdBm		Bm		37dBm
2 Spectrogran	n ●1Pk	Clrw	<b>73,63d0m</b>	-60d	Bm	- 50dBr		40dBm	-30dBm		-20dBm	-10	Measur			Bm	26 :21:12. • 202	37dBm

10:21:12 AM 07/03/2024

G 13: Real-time persistence and spectrogram measurement of jammer S2.1 on antenna "L2"

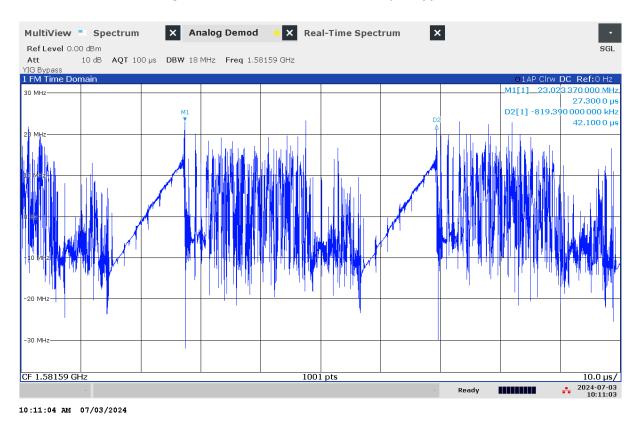


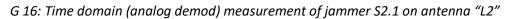
G 14: Time domain (analog demod) measurement of jammer S2.1 on antenna "L1"



09:53:52 AM 07/03/2024

G 15: Time domain (analog demod) measurement with wider span of jammer S2.1 on antenna "L1"





# Technical details on low-power jammer "S2.2"

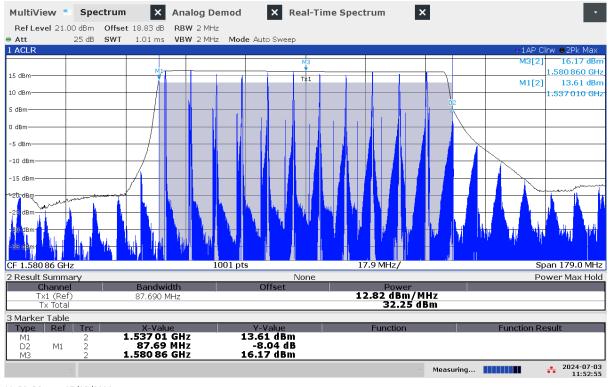
The jammer S2.2 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are intended to cover the car, and a given radius around the car.

S2.2 is a two-antenna, so-called "L1+L2", jammer, disrupting both the upper and lower L-band.



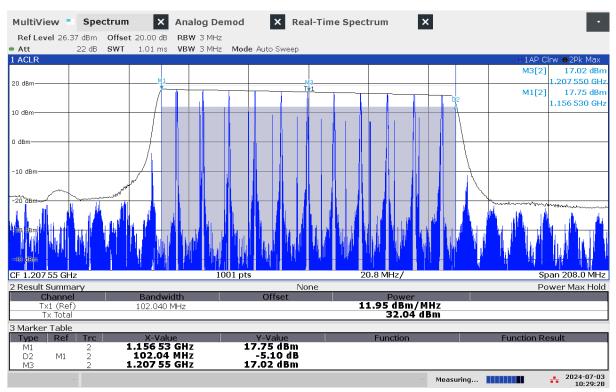
# Technical characteristics of S2.2 (2024 measurements)

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"L1"	1580,86	87,69	12,82	32,25	16,17	40,7	Sawtooth+burst
"L2"	1207,55	102,04	11,95	32,04	17,02	41,0	Sawtooth+burst



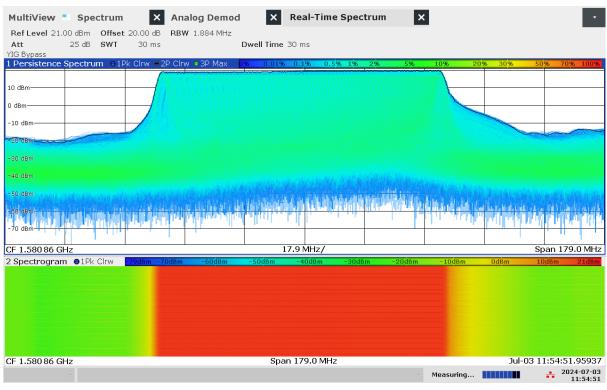
11:52:56 AM 07/03/2024

G 17: Frequency and power measurement of jammer S2.2 on antenna "L1"



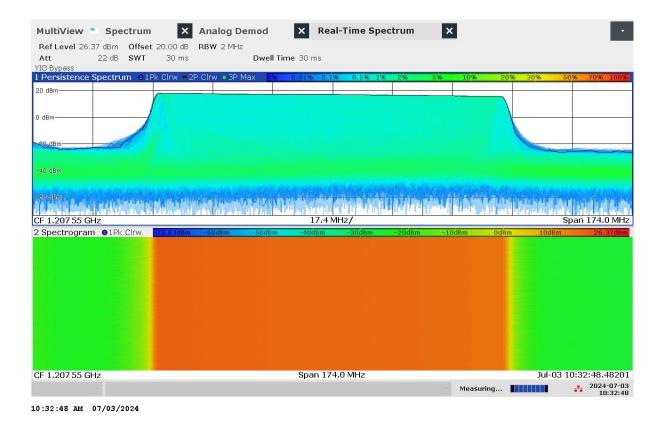
10:29:29 AM 07/03/2024

#### G 18: Frequency and power measurement of jammer S2.2 on antenna "L2"

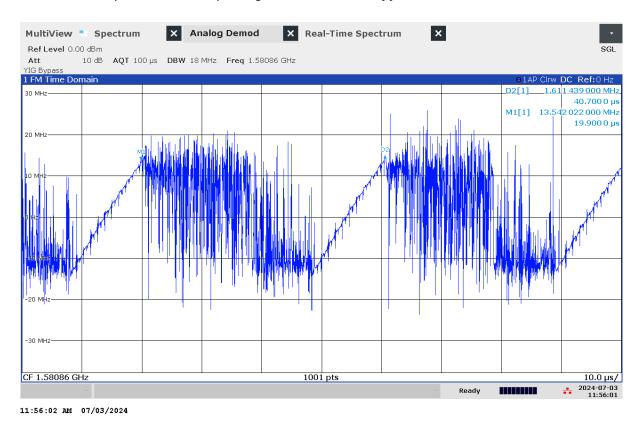


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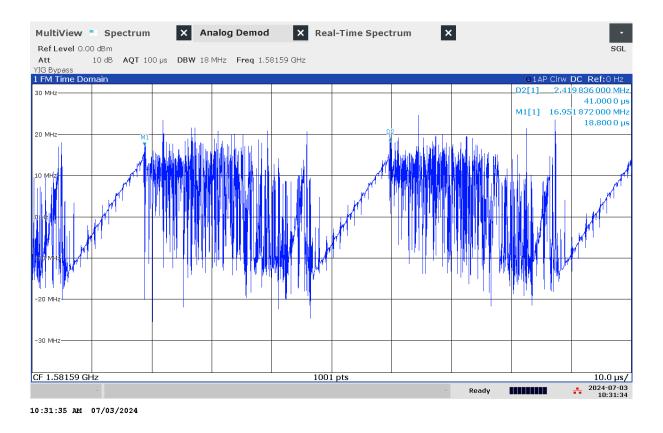
G 19: Real-time persistence and spectrogram measurement of jammer S2.2 on antenna "L1"



G 20: Real-time persistence and spectrogram measurement of jammer S2.2 on antenna "L2"



G 21: Time domain (analog demod) measurement of jammer S2.2 on antenna "L1"



G 22: Time domain (analog demod) measurement of jammer S2.2 on antenna "L2"



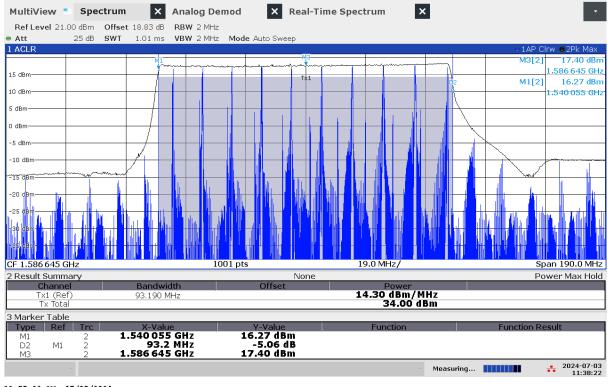
# Technical details on low-power jammer "S2.3"

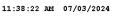
The jammer S2.3 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are intended to cover the car, and a given radius around the car.

S2.3 is a two-antenna, so-called "L1+L2", jammer, disrupting both the upper and lower L-band.

Technical characteristics of S2.3 (2024 measurements)

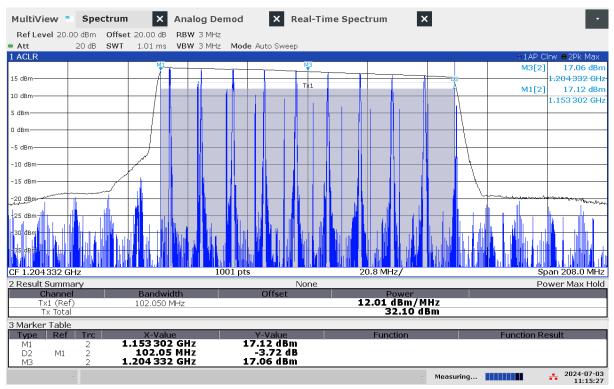
Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"L1"	1586,65	93,19	14,30	34,0	17,40	46,7	Sawtooth+burst
"L2"	1204,33	102,05	12,01	32,1	17,06	50,5	Sawtooth+burst





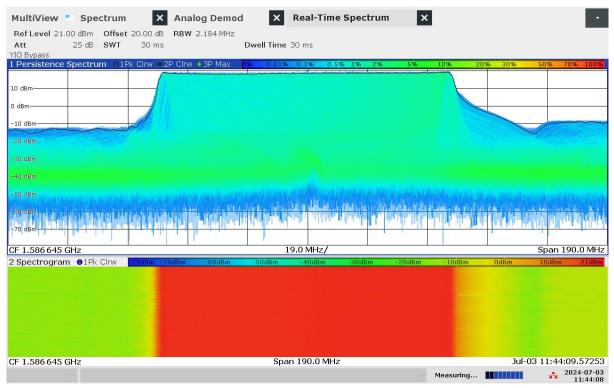
G 23: Frequency and power measurement of jammer S2.3 on antenna "L1"





11:15:27 AM 07/03/2024

G 24: Frequency and power measurement of jammer S2.3 on antenna "L2"

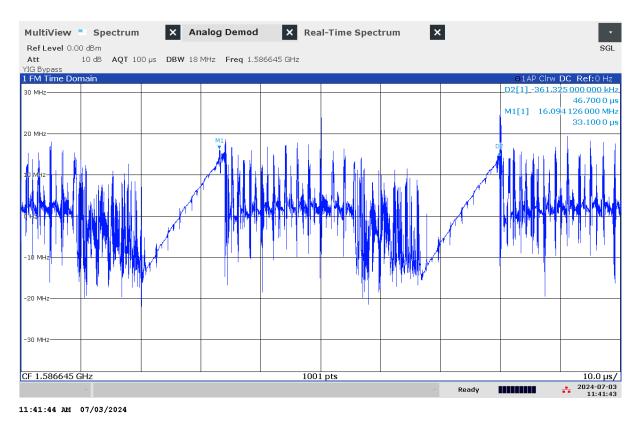


11:44:09 AM 07/03/2024

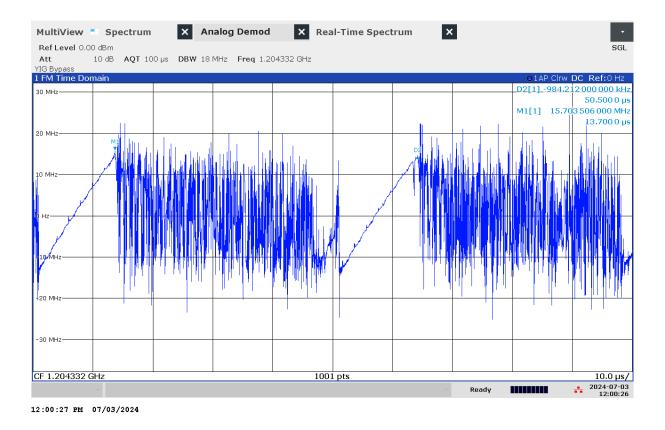
G 25: Real-time persistence and spectrogram measurement of jammer S2.3 on antenna "L1"

IltiView <b>Spectrum</b> If Level 26.37 dBm Offset		W 2 MHz						
t 22 dB SWT	30 ms	Dwe	<b>ell Time</b> 30 ms					
Bypass ersistence Spectrum 01F		nw o 3D May	0% 0.01% 0.1%	0.5% 1%	2% 5	6 10%	20% 30%	50% 70%
dBm	K CITW @ZP CIT		0.010 0.12	0.370 170	2.70 3.	0 10,0	2010 3010	30% 70%
		1			L			
um	1						N N	
sm-	1							
dBm								
dBm								
The strength of the second strength of the window we	and and a state of the state of		and an in a little way		and a bank of the			a Republic and the state of the state of
	and the states	A like and and a like		ue balloni		l al Canton II a	Period Western	a a substantia a substantia a sub
		ann air an Ar		WY CAPADA			enter etter på enter	Ener 174.0
dBm 1.204332 GHz	ny proprio		17.4 M		-2048m		9d8m 10d	Span 174.0
	173.63dBm -0	Distance (M 60dBm -50d		Hz/	-20dBm	-10dBm	OdBm 10d	
1.204332 GHz	1444)  A  lahas 73.63dBm -c	<b>Managar</b> M			-20dBm	-10dBm	OdBm 10d	
1.204332 GHz	173.63d8m -C	Monasti (K 60dBm -50d			-20dBm	-10dBm	Oděm 10d	
1.204332 GHz	73.63dBm -6	50dBm -50d			-20dBm	-10dBm	Oděm 10d	
1.204332 GHz	73.63dBm e	an a			-20dBm	-10dBm	Oděm 10d	
1.204332 GHz	73.63d8m -c	oden -sod			-20dBm	-10dBm	Odğım 10d	
1.204332 GHz	rya.cad8m -c	sodem -sod			-20dBm	– 10dBm	Odğım 10d	
1.204332 GHz	73.63d8m -c	sadem -sad			-20dBm	– 10dBm	Odğm 10d	
1.204332 GHz	73.63dBm c	SOCIEM - SOCI			-20ġBm	-10dBm	Odğm 10d	
1.204332 GHz	73.63d8m c	odan - sod			-20ġBm	-10dBm	OdBm 10d	
1.204332 GHz	73.63dBm -0	odan - sod			-20ġBm	-10dBm	OdBm 10d	
1.204332 GHz	73.63d8m —€	addam - 50d		-30dBm	-20dBm	-10 <u>48</u> m		

G 26: Real-time persistence and spectrogram measurement of jammer S2.3 on antenna "L2"



G 27: Time domain (analog demod) measurement of jammer S2.3 on antenna "L1"



G 28: Time domain (analog demod) measurement of jammer S2.3 on antenna "L2"

# Technical details on low-power jammer "S2.4"

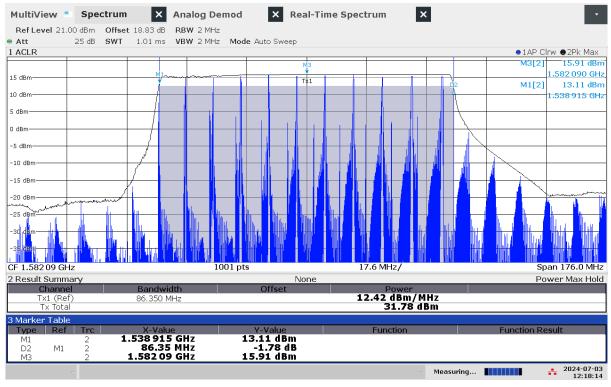
The jammer S2.4 belongs to the 'Cigarette jammer' category of jammers. Such jammers are often installed in the cigarette lighter outlet in cars. They are intended to cover the car, and a given radius around the car.

S2.4 is a two-antenna, so-called "L1+L2", jammer, disrupting both the upper and lower L-band.



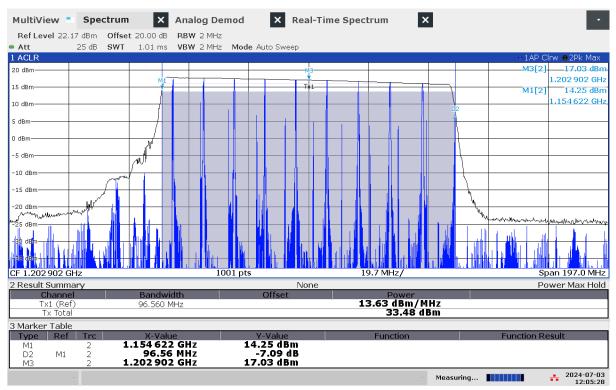
## Technical characteristics of S2.4 (2024 measurements)

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"L1"	1582,09	86,35	12,42	31,78	15,91	43,5	Sawtooth+burst
"L2"	1202,90	96,56	13,63	33,48	17,03	47,3	Sawtooth+burst



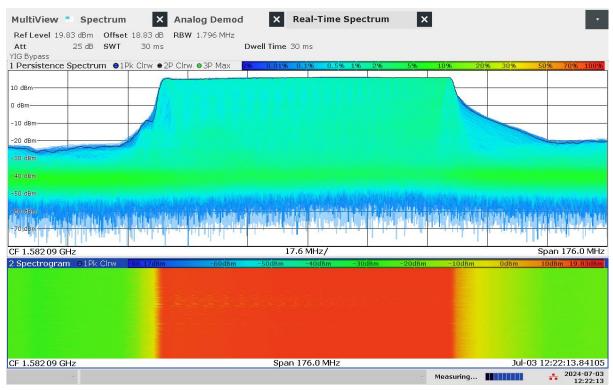
12:18:14 PM 07/03/2024

G 29: Frequency and power measurement of jammer S2.4 on antenna "L1"



12:05:29 PM 07/03/2024

#### G 30: Frequency and power measurement of jammer S2.4 on antenna "L2"

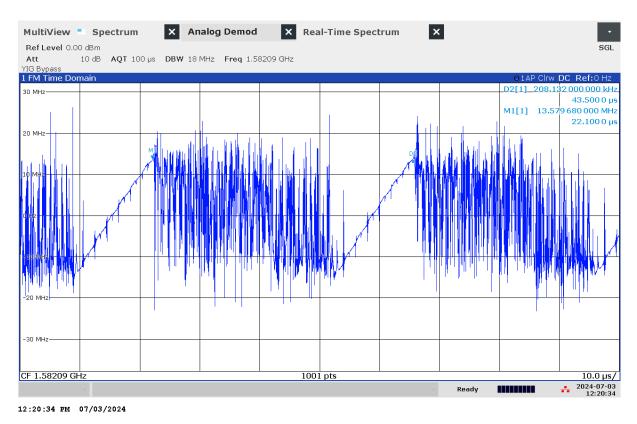


12:22:13 PM 07/03/2024

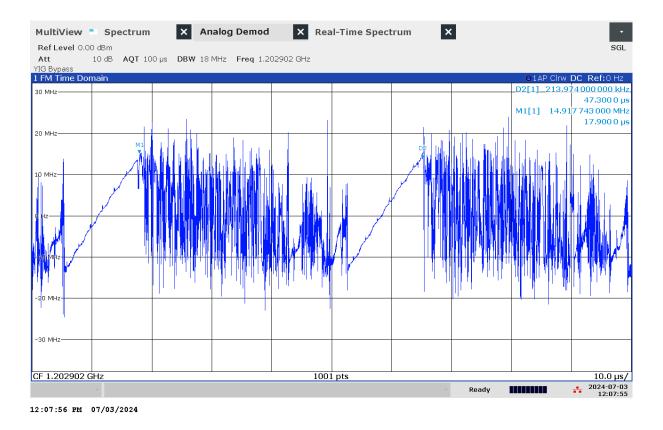
G 31: Real-time persistence and spectrogram measurement of jammer S2.4 on antenna "L1"

MultiView 📲 Spectrum 🗙 Ana	alog Demod × Real-Time Spectrum	×
	/ 2 MHz	
Att 25 dB SWT 30.1 ms	Dwell Time 30.1 ms	
YIG Bypass 1 Persistence Spectrum ●1Pk Clrw ●2P Clrw	/ ● 3P Max 11% 0.01% 0.1% 0.5% 1% 2% 5%	<b>10%</b> 20% 30% 50% 70% <b>100%</b>
20 dBm-		
10 dBm		
0 dBm		
-10 dBm		
-20 dBm		
-30 dBm		
-se abii		
-40 dBm		
-50 dBm		an Manakina na kata na kata na manana na kata na kata na kata na manana na manana na manana na kata na
60 d8m -70 d8m CF 1.202 902 GHz	19.6 MHz/	Span 196.0 MHz
2 Spectrogram 01Pk Clrw -77.83dBm	-60dBm -50dBm -40dBm -30dBm -20dBm	-10dBm 0dBm 10dBm 22.17dBm
z oposi ogram e znasni		
and the second		
and the second		
and the second		
and the second		
CF 1.202 902 GHz	Span 196.0 MHz	Jul-03 12:09:33.72153
		Measuring 2024-07-03 12:09:32
12:09:33 FM 07/03/2024		

## G 32: Real-time persistence and spectrogram measurement of jammer S2.4 on antenna "L2"



G 33: Time domain (analog demod) measurement of jammer S2.4 on antenna "L1"



G 34: Time domain (analog demod) measurement of jammer S2.4 on antenna "L2"

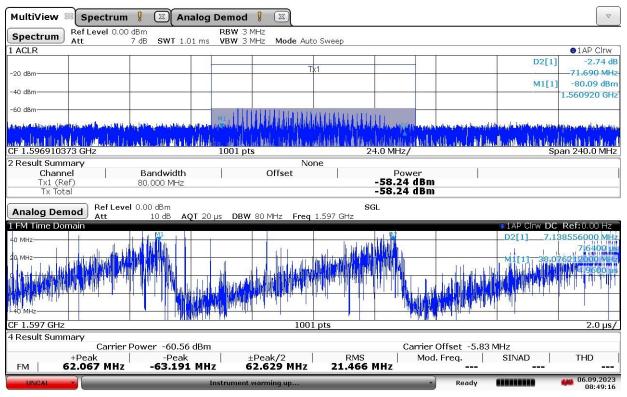
# Technical details on low-power jammer "U1.1 to U1.4"

USB jammers is category of jammers that is often installed in the USB outlet. The are intended to cover a small radius. These particular jammers suggest in the LED screen that they jam two bands, although this is not the case (see below).



## Technical characteristics of U1.1 to U1.4 (2023 measurements)

Centre frequency	Bandwidth	PSD	TX total	CF max	Sweep	Modulation
[MHz]	[MHz]	[dBm/MHz]	[dBm]	[dBm]	rate [µs]	
1590 - 1600	70 - 80	N/A	N/A	N/A	5 - 8	Sawtooth



08:49:17 06.09.2023

G 35: Example measurement of a U1.1 – U1.4 jammer

## Technical details on low-power jammer "H1.1"

The jammer H1.1 belongs to the 'Handheld category' of jammers. It is a medium weight battery driven jammer with a configuration panel for operation: multi-frequency and multi-modulation for both low and high output power. Its commercially available for military training purposes as Novatel's NEAT-jammer. Antenna has TNC-connector.

H1.1 is an one-antenna, yet multi-frequency, jammer, therefore a so-called "L1+L2", disrupting parts of both the upper and lower L-band.

Configuration choices are (as provided by the producer):

- Centre frequency: 1575.42 MHz and 1227.6 MHz
- Estimated output power: low power -5 dBm, high power 20 dBm
- Type of modulation: narrow band (NB), wide band (WB), continuous wave (CW), chirp/sweep and other (optional to program)

In the 2024 measurements below, bandwidth is defined as

- main lobe in PRN signal
- 3 dB from local (identifiable) maxima

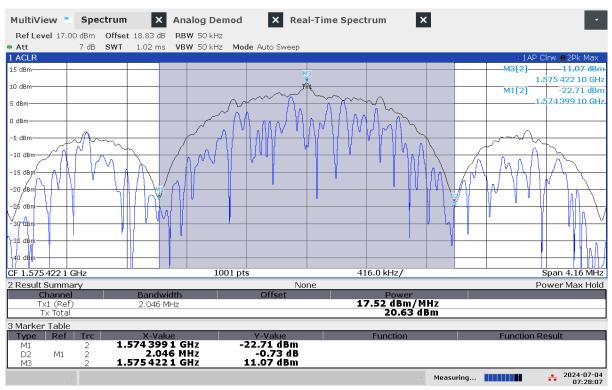
### Technical characteristics of H1.1 (2024 measurements)

Antenna configuration	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
L1, NB, HIGH PWR	1575,42	2,05	17,52	20,63	11,07	N/A	PRN (spreading code of 1 MHz)
L1, WB, HIGH PWR	1575,40	20,03	8,20	21,25	11,43	N/A	PRN (spreading code of 10 MHz)
L1, CW, HIGH PWR	1575,42	0,103	22,50	12,62	13,67	N/A	CW
L1, CHIRP, HIGH PWR	1575,60	18,75	3,10	15,83	-5,73	10,42	Sawtooth
L1, NB, LOW PWR	1575,42	2,05	-12,84	-9,73	-19,35	N/A	PRN (spreading code of 1 MHz)
L1, WB, LOW PWR	1575,40	19,93	-21,66	-8,66	-17,91	N/A	PRN (spreading



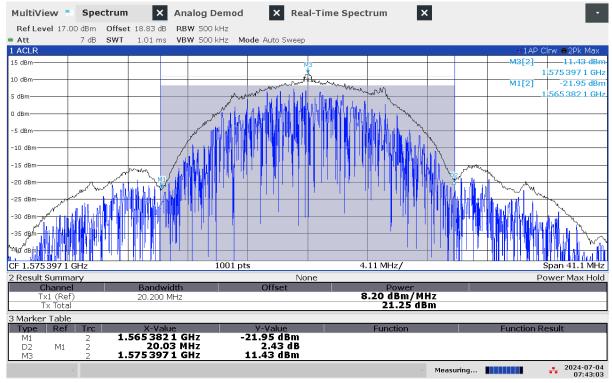
							code of 10 MHz)
L1, CW, LOW PWR	1575,42	0,10	-7,55	-17,46	-16,37	N/A	CW
L1, CHIRP, LOW PWR	1575,60	18,75	-27,03	-14,31	-35,65	10,46	Sawtooth
L2, NB, HIGH PWR	1227,42	2,049	18,73	21,84	12,17	N/A	PRN (spreading code of 1 MHz)
L2, WB, HIGH PWR	1227,36	20,30	9,27	22,34	12,09	N/A	PRN (spreading code of 10 MHz)
L2, CW, HIGH PWR	1227,42	0,10	23,96	14,13	15,17	N/A	CW
L2, CHIRP, HIGH PWR	1227,22	18,79	4,98	17,72	-4,11	10,4	Sawtooth
L2, NB, LOW PWR	1227,42	2,05	-11,20	-8,09	-17,79	N/A	PRN (spreading code of 1 MHz)
L2, WB, LOW PWR	1227,36	20,30	-20,39	-7,32	-17,41	N/A	PRN (spreading code of 10 MHz)
L2, CW, LOW PWR	1227,42	0,10	-5,98	-15,81	-14,77	N/A	CW
L2, CHIRP, LOW PWR	1227,22	18,76	-24,97	-12,23	-33,98	10,4	Sawtooth

Measurements given below are for 'High power' configurations only.



07:28:07 AM 07/04/2024

G 36: Frequency and power measurement of jammer H1.1 with antenna configuration L1 Narrow band High Power (NB HIGH PWR)



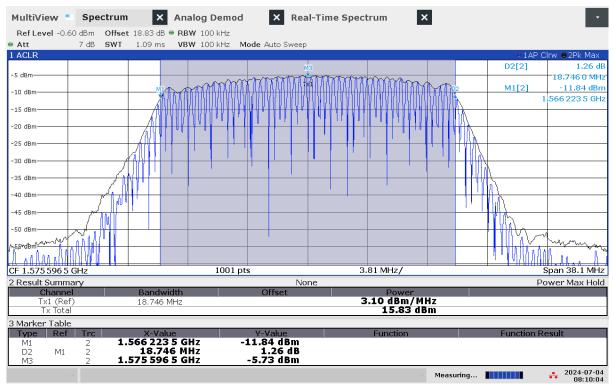
07:43:03 AM 07/04/2024

G 37: Frequency and power measurement of jammer H1.1 with antenna configuration L1 Wide band High Power (WB HIGH PWR)

MultiView - Spec	trum X Analo	g Demod X Rea	al-Time Spectrum	×	
	Offset 18.83 dB • RBW			-	
		100 kHz Mode Auto Sweep	<b>b</b>		
1 ACLR				014	P Clrw 😑 2Pk Max
15 dBm			<b>1</b> 3	D2[2]-	0,00 dB-
		M1	02		102.900 kHz
10 dBm			*1	M1[2]	10.64 dBm
5 dBm					1.575372120 GHz
0 dBm					
-5 dBm-					
-10 dBm					
-15 dBm					
	fst				
-20 dBm	F			- W	
-25 dBm					
- IN				Vig	W.C.
-30 dBm					$\mathcal{H}$
ASydBm Martin					n www.
Marchanni I					Malle March
-40,dBm					
CF 1.575 423 55 GHz		1001 pts	50.0 kHz/		Span 500.0 kHz
2 Result Summary		•	ne		Power Max Hold
Channel	Bandwidth	Offset	Power		T OWER MUXTICIA
Tx1 (Ref)	102.900 kHz		22.50 dBm	/MHz	
Tx Total			12.62	dBm	
3 Marker Table					
Type Ref Trc	X-Value	Y-Value	Function	Function	n Result
M1 2 D2 M1 2	1.575 372 12 GH 102.9 kH	z 10.64 dBm z -0.00 dB			
M3 2	1.575 423 55 GH	z 13.67 dBm			
				🗸 Measuring	2024-07-04

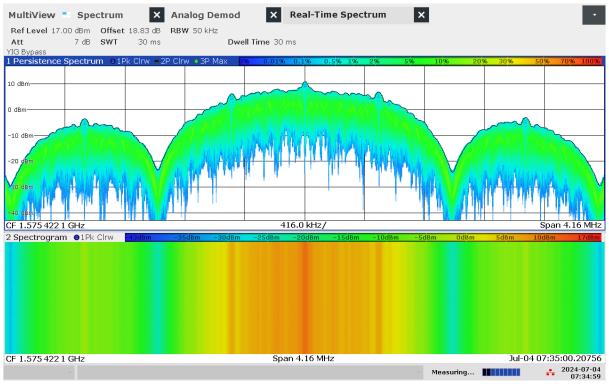
07:56:38 AM 07/04/2024

*G 38: Frequency and power measurement of jammer H1.1 with antenna configuration L1 Continuous Wave band High Power (CW HIGH PWR)* 



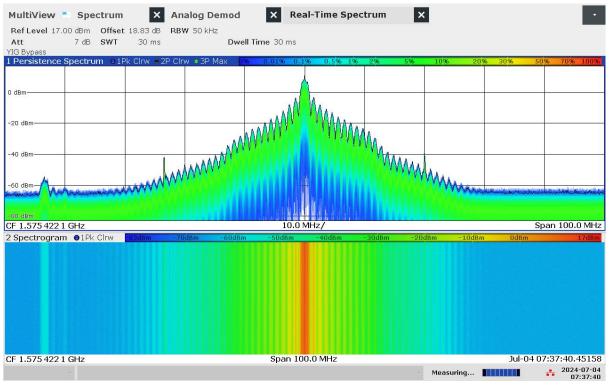
08:10:05 AM 07/04/2024

*G* 39: Frequency and power measurement of jammer H1.1 with antenna configuration L1 Chirp High Power (CHIRP HIGH PWR)



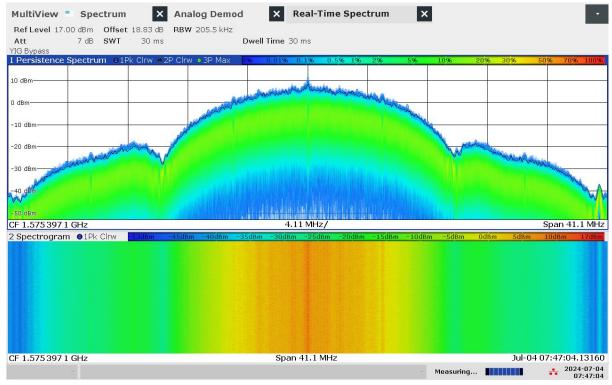
07:35:00 AM 07/04/2024

*G* 40: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L1 Narrow band High Power (NB HIGH PWR)



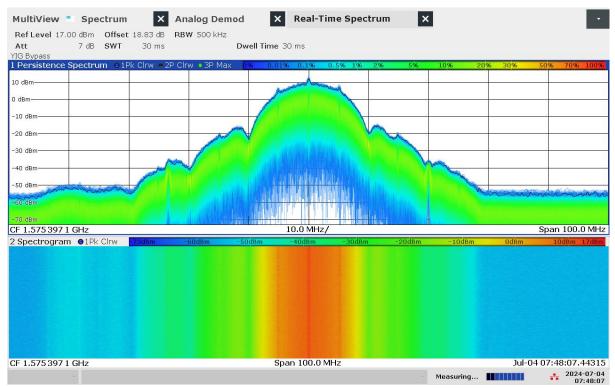
07:37:40 AM 07/04/2024

# G 41: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L1 Narrow band High Power (NB HIGH PWR)



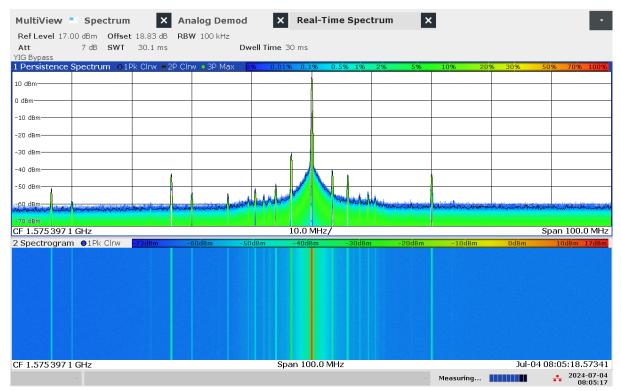
07:47:04 AM 07/04/2024

*G* 42: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L1 Wide band High Power (WB HIGH PWR)



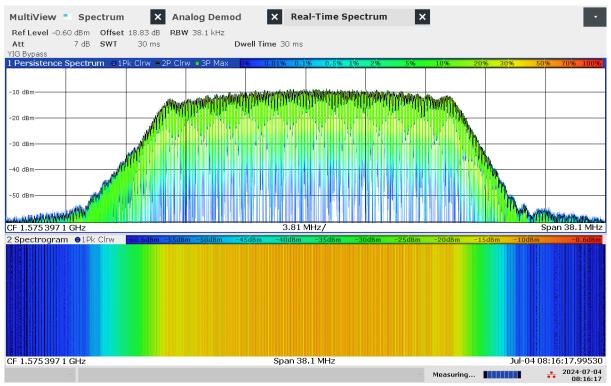
07:48:07 AM 07/04/2024

*G* 43: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L1 Wide band High Power (WB HIGH PWR)



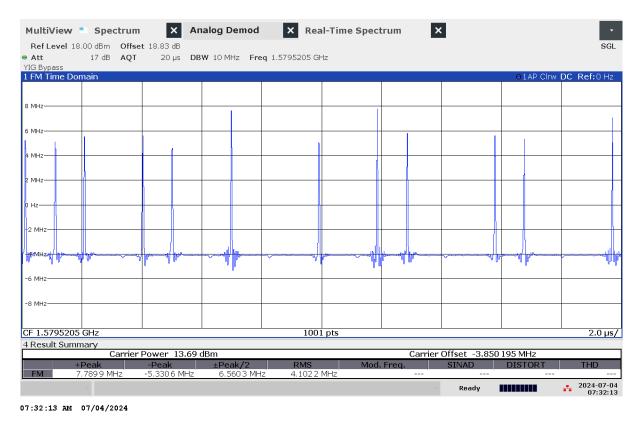
08:05:18 AM 07/04/2024

*G* 44: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L1 Continuous Wave band High Power (CW HIGH PWR)

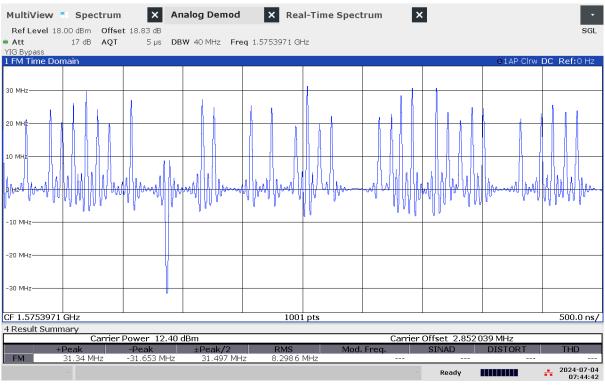


08:16:18 AM 07/04/2024

*G* 45: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L1 Chirp High Power (CHIRP HIGH PWR)



G 46: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L1 Narrow band High Power (NB HIGH PWR)



07:44:42 AM 07/04/2024

G 47: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L1 Wide band High Power (WB HIGH PWR)

MultiView	- Spec	trum	×	Analo	g Demod	×	Real-1	ime Spect	rum	×		•
Ref Level 1	8.00 dBm	Offset	: 18.83 dB									
	17 dB	AQT	5 ms	DBW 8	00 kHz 🛛 Fi	req 1.57542	2355 GH:	z				
YIG Bypass 1 FM Time Do											O LAD Churr	DC Ref:0 Hz
I FM TIME DO	orriain					1						DC REI:UHZ
400 kHz												
300 kHz												
200 kHz												
100 kHz												
-0-Hz						· · · · · · · · · · · · · · · · · · ·						
-100 kHz												
-200 kHz												
-300 kHz												
-400 kHz												
L												
CF 1.575423							1001 pt	S				500.0 μs/
4 Result Sum		reciper D	Power 13.	64 dPm					Corrio	Offset 224.22	70 710 Ц-	
	+Peak		-Peak		Peak/2	R	٧S	Mod	Freq.	SINAD	DISTORT	THD
FM	2.284 kH	z	-2.6173 kH		2.596 4 kH		01.37 H					
	T.								~	Measuring		2024-07-04 08:01:42

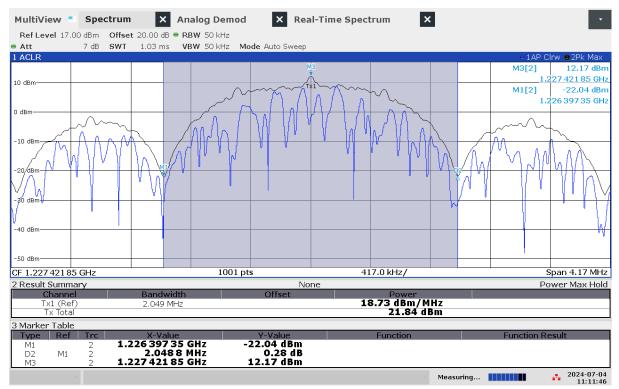
08:01:43 AM 07/04/2024

*G 48: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L1 Continuous Wave band High Power (CW HIGH PWR)* 



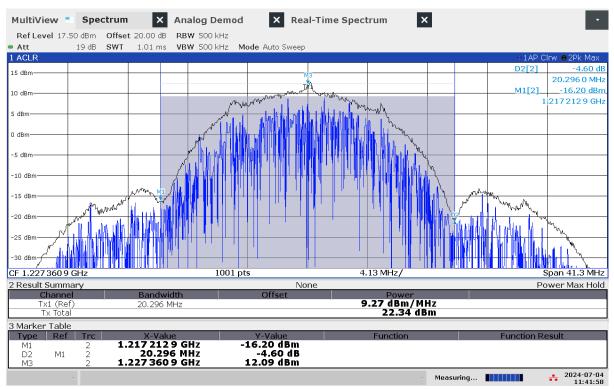
08:14:03 AM 07/04/2024

*G* 49: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L1 Chirp High Power (CHIRP HIGH PWR)



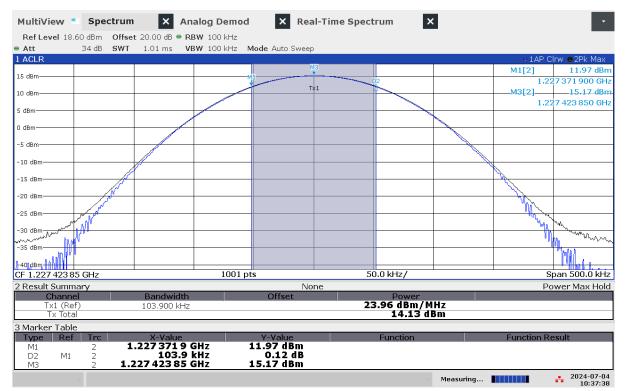
11:11:47 AM 07/04/2024

# G 50: Frequency and power measurement of jammer H1.1 with antenna configuration L2 Narrow band High Power (NB HIGH PWR)



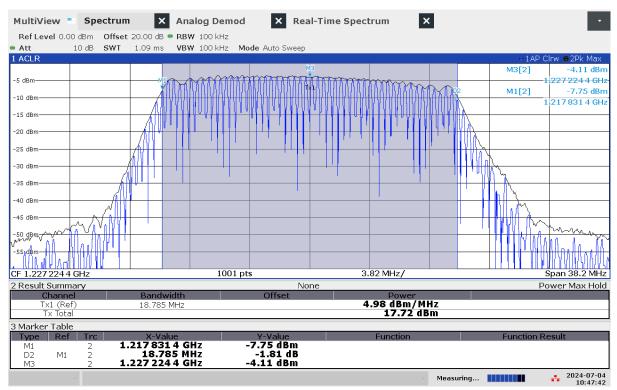
^{11:41:59} AM 07/04/2024

G 51: Frequency and power measurement of jammer H1.1 with antenna configuration L2 Wide band High Power (WB HIGH PWR)



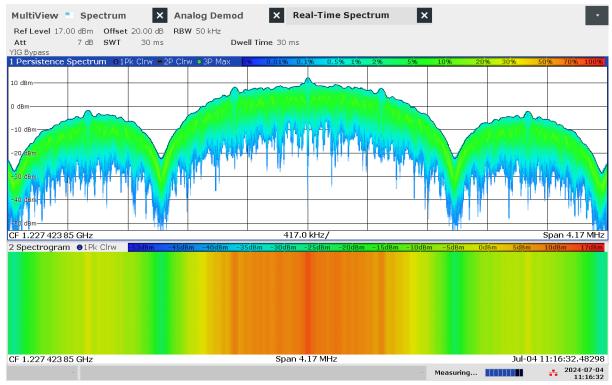
10:37:39 AM 07/04/2024

G 52: Frequency and power measurement of jammer H1.1 with antenna configuration L2 Continuous Wave band High Power (CW HIGH PWR)



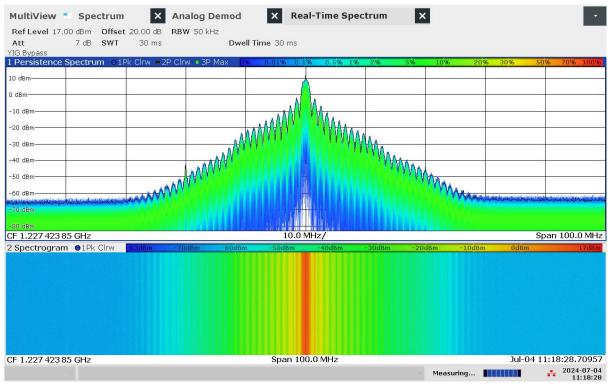
^{10:47:43} AM 07/04/2024

*G* 53: Frequency and power measurement of jammer H1.1 with antenna configuration L2 Chirp High Power (CHIRP HIGH PWR)



11:16:32 AM 07/04/2024

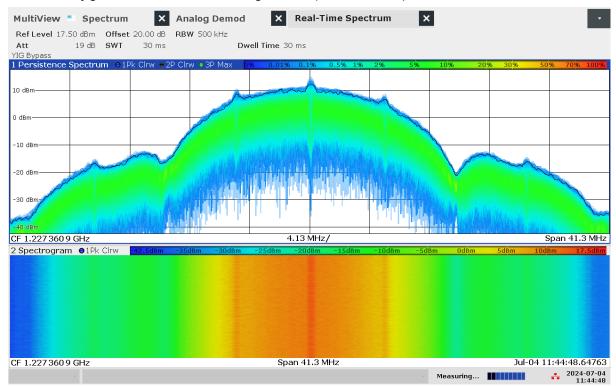
*G* 54: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L2 Narrow band High Power (NB HIGH PWR)



11:18:28 AM 07/04/2024

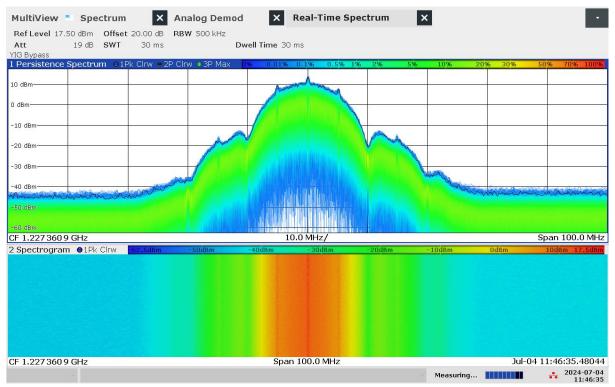
G 55: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with

antenna configuration L2 Narrow band High Power (NB HIGH PWR)



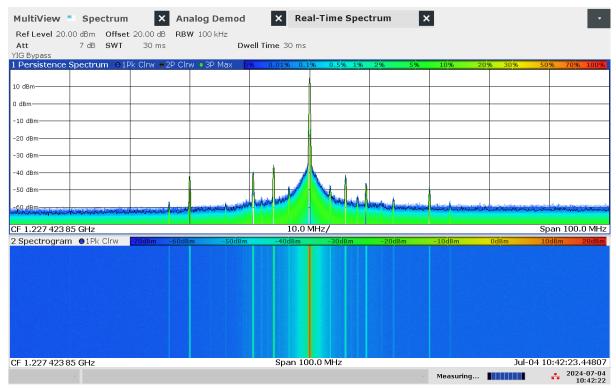
11:44:48 AM 07/04/2024

*G* 56: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L2 Wide band High Power (WB HIGH PWR)



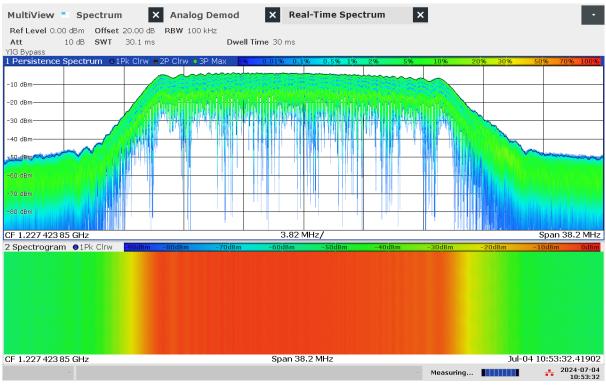
11:46:35 AM 07/04/2024

G 57: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L2 Wide band High Power (WB HIGH PWR)



10:42:23 AM 07/04/2024

*G* 58: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L2 Continuous Wave band High Power (CW HIGH PWR)



10:53:32 AM 07/04/2024

# G 59: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L2 Chirp High Power (CHIRP HIGH PWR)



11:15:22 AM 07/04/2024

G 60: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L2 Narrow band High Power (NB HIGH PWR)



11:43:37 AM 07/04/2024

G 61: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L2 Wide band High Power (WB HIGH PWR)

MultiView	v 🍨 Spectru	ım 🗙 Ar	nalog Demod	× Rea	I-Time Spect	trum ×	1		
	19.17 dBm Of			1 007 10005	~				
<ul> <li>Att</li> <li>YIG Bypass</li> </ul>	17 dB AQ	2T 5ms DB	W SUUKHZ Fr	eq 1.22742385	GHZ				
1 FM Time I	Domain							●1AP Clrw	DC Ref:0 Hz
00 1411-									
30 MHz									
20 MHz									
20 MIN2									
10 MHz									
-0-Hz									
-10 MHz									
-20 MHz									
-30 MHz									
CF 1.22742				1001	   nts				500.0 µs/
4 Result Su				1001	r pta				56010 µ37
T Result Su		er Power 15.10	dBm			Carrier	Offset 656.03	2674 Hz	
	+Peak	-Peak	±Peak/2	RMS	Mod.	Freq.	SINAD	DISTORT	THD
FM	3.0851 kHz	-1.4406 kHz	2.614 k⊢	lz 935.4	3 Hz	`			
	Ŧ						Measuring		2024-07-04 10:39:55

10:39:56 AM 07/04/2024

*G* 62: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L2 Continuous Wave band High Power (CW HIGH PWR)

	<b>w 📑 Spec</b> I 19.17 dBm			-			al-Time Spec		×	-		SGL
Att	17 dB			DBW 40 MHz	Freq 1.	22742385 0	GHz					302
/IG Bypass FM Time	Domoin	-	·		-							DC Ref:0 Hz
	Domain											21 000 000 kH
L5 MHz	P	41									DZ[1] -935.5	21 000 000 кн 10,400 0 µ
5 MH2		T T						D	2		M1[1] 14.10	0.4000 H
									Ē		MILI] 14.10	3,1800 μ
												3.18001
.0 MHz	e al la							and				
	and all and a second							muummumm				
لمعهد	www.colum						- ward	www.	Į –			
5 MH2 ~~~~							March Carl					
<b>.</b>							wowwww					
						للمسم سميرية	]					
) Hz					_	Martin						- martin
		{			m							- Martin
				The second second							Breereward	
-5 MHz				and the mean land							- Ladon Dallag Addrew	
5 14112			polarin manufician	iww]						wywatate water and	him.	
			a data Mana							1000000 MUNUN		
		LUN NOV	ANO.						had	m har War		
10 MHz		our .							1			
									1			
			[									
15 MHz												
	2385 GHz					100	l pts					2.0 µs
Result Su												
		arrier	Power 14.2						ier	Offset 1.0121		
514	+Peak		-Peak	±Peak/2		RMS		Freq.		SINAD	DISTORT	THD
FM	14.109 Mł	ΠZ	-11.568 MH	z 12.838	MHŻ	5.7411	MHZ 9t	5.11937 kHz				2024-07-04

10:51:40 AM 07/04/2024

*G* 63: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L2 Chirp High Power (CHIRP HIGH PWR)

## Technical details on low-power jammer "H1.2"

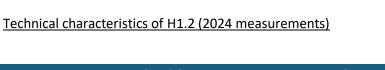
The jammer H1.2 belongs to the 'Handheld category' of jammers. It is a small and light battery driven jammer with an easy operation, just an on/off-button with a LED-light to indicate activation.

H1.2 is an one-antenna, so-called "L1-only", jammer, disrupting only the upper L-band.

Bandwidth Antenna Centre PSD TX total CF max Sweep Modulation [dBm/MHz] frequency [MHz] [dBm] [dBm] rate [MHz] [µs] "L1" 1575,22 21,99 14,35 27,78 9,36 6,08 Sawtooth

× Real-Time Spectrum

x



× Analog Demod

PILITUATEAA	opectru		alog Delliou		Frime Spece				
Ref Level 18.9			500 kHz						
Att	46 dB <b>SW</b>	T 1.01 ms VBW	500 kHz Mode	Auto Sweep					
LACLR									lrw ⊜2Pk Ma
		M1						M3[2]	9.36 dE
10 dBm			111 m		3 1		1102		.575 221 0 G 13.23 dE
						ALLA LLA MAR		M1[2]	5642240 G
								1	30422400
) dBm									
			HALAN BARREN						
-10 dBm						ALLA ALLA MAL			
20 0000				T PL LIFTUR ANALA	ANUNNAMI I I I I I				
-20 dBm		1							
-30 dBm									
00 00.0								li i Ven	l.
		. /					V NY NY NY N	illikin –	
440\dBhr <del>y4~4~4</del>	And the second starting the second starting the second starting starting starting starting starting starting st	₩¶							- Wildman
	. հ. ստենս	- Install		'	'I I II			UNU ADALA I	
so Idem - 11 1	h Mh Mh M	LANDAN CHU VELL		ч <u> </u>					
CF 1.575221 G	Hz		1001 pts		4.	47 MHz/		ę	Span 44.7 Mi
2 Result Summa				No	ne			Po	wer Max Ho
Channe Tx1 (Ref		Bandwidth		Offset	14	Power	U 7		
Tx Total		21.994 MHz			14	.35 dBm/M 27.78 d	8m		
3 Marker Table									
Type Ref	Trc	X-Value		Y-Value		Function		Function Re	esult
M1		1.564 224 G		3.23 dBm					
D2 M1 M3	2	21.994 M 1.575 221 G		-3.41 dB 9.36 dBm					
CIVI	2	1.575221 6	112	5.50 abii					. 2024-07-
							Measuring		2024-07-0

12:29:15 PM 07/02/2024

MultiView Spectrum

G 64: Frequency and power measurement of jammer H1.2



MultiView	Spec	trum	×	Analog	g Demod	×	Real-Tim	e Spec	trum	×					-
RefLevel 18.9	90 dBm			RBW 500	<hz< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></hz<>										
Att	46 dB	SWT 3	0.1 ms		Dwe	Il Time 30.	1 ms								
YIG Bypass		the second second			WALLAN MARKAN SALW		1.221.222 21								
1 Persistence S	Spectrur	n <b>o</b> 1P	kClrw 🖷	2P Clrw 🧿	3PMax 🛛	<b>%</b> 0.01%	0.1% 0.	5% 1%	2%	5%	10%	20%	30%	50% 7	0% 100%
0 dBm						1	-								
-40 dBm	in the second	anend		ed					- Calado	ieren		window,	ch-carlain	wana	20mm
-60 dBm								ANA ILIN							
and the set of the second					in a barrier										THUS MAD DIVISION
CF 1.582 564 5	GHz		FRUIT	the stall		il - Maria c	9.35 MHz/	(dis dit an			ht: 现现上 由	<b>地</b> 和海口	And the second second	Span	93.5 MHz
CF 1.5825645 2 Spectrogram		Clrw	-81.1dBm	-70dBm	-60dBm	-50dBm		-3	OdBm	-20dBn	n -10	dBm	OdBm		93.5 MHz 18.9dBm
2 Spectrogram	● ●1Pk(	Cirw	81.1dBm	-70dBm	-60dBm	-50dBm	-40dBm		0dBm	-20dBn	n –10	dBm		10dBm	<u>18.9dBm</u>
Contractor and Contractor	● ●1Pk(	Cirw	91,1dBm	-70dBm	-60dBm	-50dBm			OdBm	-20dBn	n –10	dBm		10d8m 2 12:36:	

12:36:23 PM 07/02/2024

G 65: Real-time persistence and spectrogram measurement of jammer H1.2



G 66: Time domain (analog demod) measurement of jammer H1.2

# Technical details on low-power jammer "H1.3"

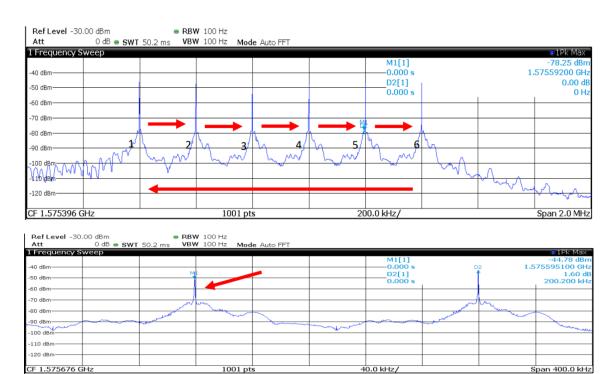
H1.3 is a small, handheld and battery driven jammer using frequency hopping (normally commercially available jammers employ chirp signals, making this jammer an oddity).

H1.3 is an one-antenna, so-called "L1-only", jammer, disrupting only the upper L-band.

## Technical characteristics of H1.3 (2023 measurements)

Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
1575	1	N/A	N/A	N/A	5 - 8	Frequency hopping

- Type of modulation: frequency hopping
  - Jumping between 6 separated frequencies. Every 50 ms the frequency increases 200 kHz, starting with 1574.62 MHz. After approximately 1 MHz the frequency jumps back to the start frequency at 1574.62 MHz.



G 67: Example measurement of H1.3 jammer



# Technical details on low-power jammer "H1.4"

Jammer H1.4 is assumed more or less identical to jammer H1.1 (originating from the same source and built by the same producer).

# Technical details on low-power jammer "H1.5"

Jammer H1.5 is assumed more or less identical to jammer H1.1 (originating from the same source and built by the same producer).

# Technical details on low-power jammer "H2.1 and H2.2"

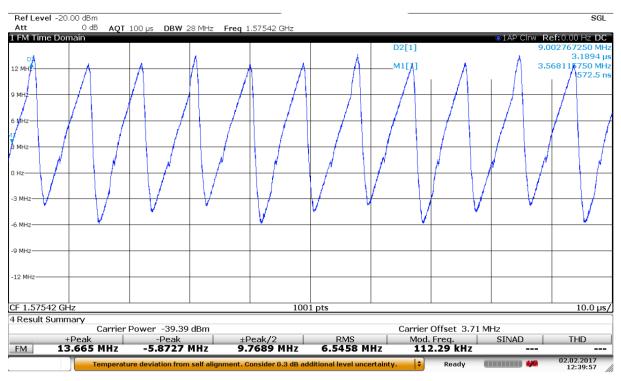
H2.1 and H2.2 are small and light handheld, battery driven jammers with built-in antennas.

They are two-antenna, so-called "L1+L2", jammers, disrupting both the upper and lower L-band.

## Technical characteristics of H2.1 and H2.2 (2023 measurements)



Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
1580	20	N/A	N/A	N/A	9	Sawtooth
1227	20	N/A	N/A	N/A	9	Sawtooth



G 68: Example measurement of H2.1 and H2.2 jammer

## Technical details on low-power jammer "H3.1"

The jammer H3.1 belongs to the 'Handheld category' of jammers. It is a small and light battery driven jammer with an easy operation, just an on/off-button with a LED-light to indicate activation.

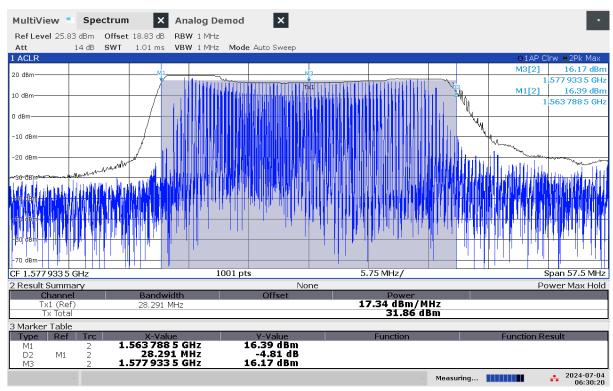
H3.1 is a three-antenna, so-called "multi-frequency", jammer, but not a "multi-GNSS-jammer". It jams three different bands, but only one channel is relevant for GNSS bands ("L1-only"), so disrupting only the upper L-band.

Relevant GNSS antenna is marked: "GPS"

### Technical characteristics of H3.1 (2024 measurements)



Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"GPS"	1577,93	28,29	17,34	31,86	16,17	6,16	Sawtooth



^{06:30:21} AM 07/04/2024

G 69: Frequency and power measurement of jammer H3.1 on antenna "GPS"

MultiView 📑 Spectru	m 🗙 Analog Demod 🗙 Real-Time Spectrum 🗙
Ref Level 25.83 dBm Offs	set 18.83 dB RBW 1 MHz
Att 14 dB SWT	T 30.1 ms Dwell Time 30 ms
YIG Bypass	n a the second
	01Pk Clrw ● 2P Clrw ● 3P Max 0% 0.01% 0.1% 0.5% 1% 2% 5% 10% 20% 30% 50% 70% 100%
20 dBm	
0 dBm	
-20 dBm	
-40 dBm	
and the second second in the second second	
-60 dBm	
CF 1.577 933 5 GHz	5.75 MHz/ Span 57.5 MHz
2 Spectrogram O1Pk Clrw	
	- <mark>74.17dBm -60dBm -50dBm -40dBm -30dBm -20dBm -10dBm 0dBm 10dBm 25.83dBm</mark>
	<mark>-74.17dBm -60dBm -50dBm -40dBm -30dBm -20dBm -10dBm 0dBm 10dBm 25.83dBm</mark>
	<mark>-74,17dBm -60dBm -50dBm -40dBm -30dBm -20dBm -10dBm OdBm 10dBm 25.83dBm</mark>
	<mark>-74,17dBm -60dBm -50dBm -40dBm -30dBm -20dBm -10dBm OdBm 10dBm 25.83dBm</mark>
	<mark>-74,17dBm -60dBm -50dBm -40dBm -30dBm -20dBm -10dBm OdBm 10dBm 25.83dBm</mark>
	74.17dBm -60dBm -50dBm -40dBm -30dBm -20dBm -10dBm 0dBm 10dBm 25.83dBm
	74.17dBm ==60dBm ==50dBm ==40dBm ==30dBm ==20dBm ==10dBm 0dBm 0dBm 10dBm 25.83dBm
	74.17dBm ==60dBm ==50dBm ==40dBm ==30dBm ==20dBm ==10dBm 0dBm 0dBm 10dBm 25.83dBm
	74.17dBm ==60dBm ==50dBm ==40dBm ==30dBm ==20dBm ==10dBm 0dBm 0dBm 10dBm 25.83dBm
	74.17dBm ==60dBm ==50dBm ==40dBm ==30dBm ==20dBm ==10dBm OdBm OdBm 10dBm 25,83dBm
	"74.17dBm ≥60dBm -50dBm -40dBm -30dBm -20dBm -10dBm 0dBm 10dBm 25,83dBm
CF 1.5779335 GHz	74.17dBm       -60dBm       -50dBm       -40dBm       -30dBm       -20dBm       -10dBm       0dBm       10dBm       25,83dBm         Span 57.5 MHz       Jul-04 06:36:29.11118         Measuring       2024-07-00       06:36:29.11118

06:36:29 AM 07/04/2024

G 70: Real-time persistence and spectrogram measurement of jammer H3.1 on antenna "GPS"



G 71: Time domain (analog demod) measurement of jammer H3.1 on antenna "GPS"

## Technical details on low-power jammer "H3.2"

The jammer H3.2 belongs to the 'Handheld category' of jammers. It is a small and light battery driven jammer with an easy operation, just an on/off-button with a LED-light to indicate activation.

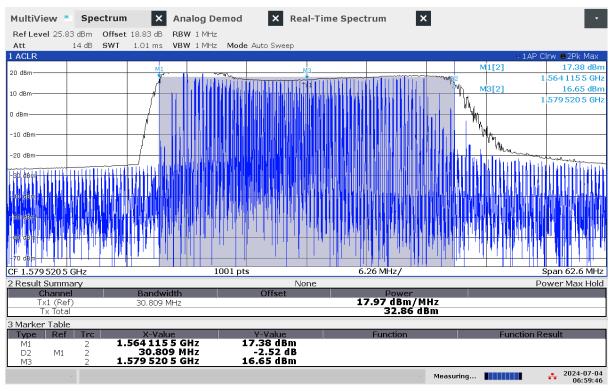
H3.2 is a three-antenna, so-called "multi-frequency", jammer, but not a "multi-GNSS-jammer". It jams three different bands, but only one channel is relevant for GNSS bands ("L1-only"), so disrupting only the upper L-band.

Relevant GNSS antenna is marked: "GPS"

### Technical characteristics of H3.2 (2024 measurements)



Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"GPS"	1579,52	30,81	17,97	32,86	16,65	6,44	Sawtooth



06:59:46 AM 07/04/2024

G 72: Frequency and power measurement of jammer H3.2 on antenna "GPS"

IultiView 🎫 Spectrum	× Ana	alog Demod	× Real-	Time Spec	ctrum	×			
<b>Ref Level</b> 25.83 dBm Offset Att 14 dB SWT G Bypass	: 18.83 dB <b>RBW</b> 30 ms	/ 1.089 MHz Dw	<b>vell Time</b> 30 ms						
Persistence Spectrum 01F	Pk Clrw 🛛 2P Clrv	v o 3P Max 🛛 🕬	0.01% 0.1%	0.5% 1%	2%	5% 1	0% 20%	6 30%	50% 70% 100
dBm									
dBm							1 th		
0 dBm									
0 dBm		<i>X</i> 1							
		4 P. 3 B.							
	and the second second			424.0	PALANA				
		HAD I.		A. Care		ALM BU	Land Har	di ana an	
• 1.579 520 5 GHz Spectrogram ●1Pk Clrw	The state of the s	n in	6.26 MH	-30dBm	-20dBm	10.10	n OdBm	10 10-	Span 62.6 M
	-74.17dBm -6	OdBm -50dBm	-40UBM	-30ubm	-2006m	-10dB	n UUBM	10dBn	25.830
apart of the offer									
1.579 520 5 GHz			Span 62.6	MHz			easuring		07:08:03.650 2024-07- 2024-07-09-09-09-09-09-09-09-09-09-09-09-09-09-

07:08:03 AM 07/04/2024

G 73: Real-time persistence and spectrogram measurement of jammer H3.2 on antenna "GPS"

MultiView	/ 📒 Spectrum	1 × AI	nalog Demod	× Rea	I-Time Spect	rum ×			•
	18.00 dBm Offse						-		SGL
<ul> <li>Att</li> <li>YIG Bypass</li> </ul>	17 dB AQT	20 µs DE	3W 18 MHz Fre	<b>q</b> 1.5795205 Gł	lz				
1 FM Time I	Domain								DC Ref:0 Hz
								D2[1] -611.10	51 000 000 kHz
20 MHz									6.4400 µs
20 MHz								M1[1] 12.60	3 440 000 MHz
									5.380 0 µs
15 MHz		M1							
					D2				
10 MHz								/	η
5 MHz		weet			w in			W	
5 MH2	M			/		l		- Mar	
						1			
0 Hz									
-5 MHz			N.						
-10 MHz			$\backslash$						
-10 MHz									
-15 MHz									
-20 MHz									
CF 1.57952				100					2.0 µs/
4 Result Su				100.	i pis				2.0 µs/
4 Kesult Su		Power 19.98	dBm			Carrier	Offset -889.3	89 98 kHz	
	+Peak	-Peak	±Peak/2	RMS	Mod.	Freq.	SINAD	DISTORT	THD
FM	12.603 MHz	-13.185 MHz	12.894 MH	z 7.8792		3.701 4 kHz	`		
	$\nabla$					$\nabla$	Ready		2024-07-04 07:05:52

07:05:53 AM 07/04/2024

## G 74: Time domain (analog demod) measurement of jammer H3.2 on antenna "GPS"

## Technical details on low-power jammer "H3.3"

The jammer H3.3 belongs to the 'Handheld category' of jammers. It is a small and relatively light battery driven jammer with an easy operation, just an on/off-button with a LED-light to indicate activation.

H3.3 is a three-antenna, so-called "L1+L2+L5", jammer, disrupting both the upper and lower L-band.

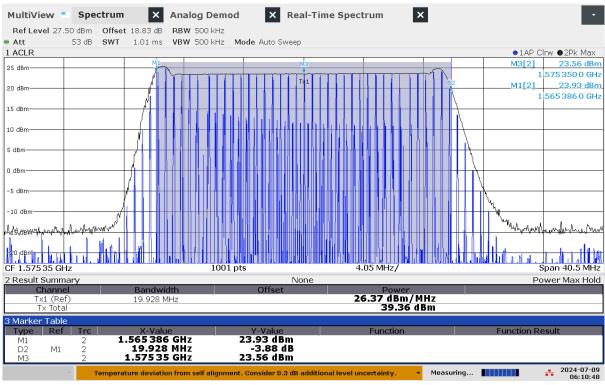
The three antennas are marked with white lines of different length: short=L1, medium=L2, long=L5

The jammer has additional noise in several other (non GNSS) frequency bands, but with significant lower power.



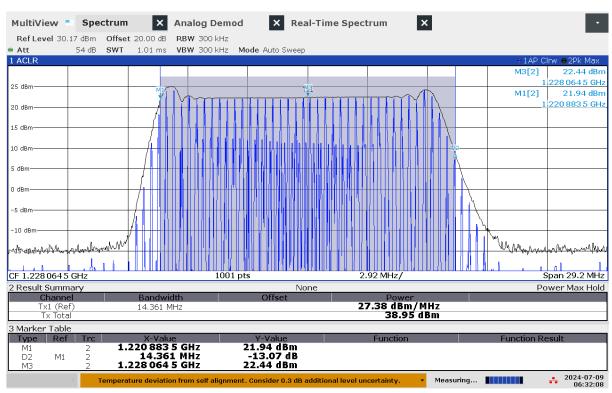
## Technical characteristics of H3.3 (2024 measurements)

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"short" (L1)	1575,35	19,93	26,37	39,36	23,56	12,96	Sawtooth
"medium" (L2)	1228,06	14,36	27,38	38,95	22,44	12,51	Sawtooth
"long" (L5)	1176,24	17,45	28,62	41,04	25,83	12,51	Sawtooth



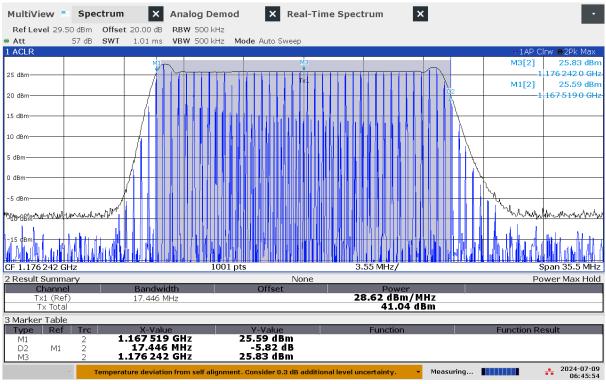
06:10:49 AM 07/09/2024

### G 75: Frequency and power measurement of jammer H3.3 on antenna "short" (L1)



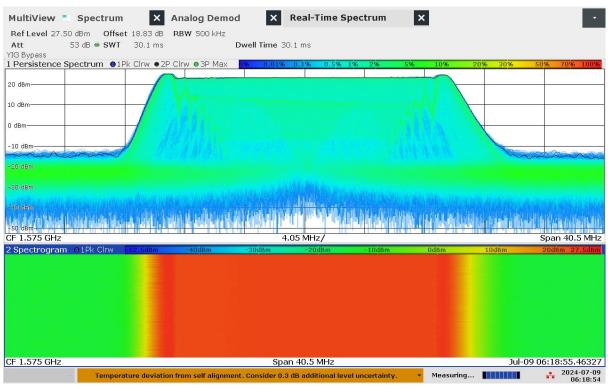
06:32:08 AM 07/09/2024

G 76: Frequency and power measurement of jammer H3.3 on antenna "medium" (L2)



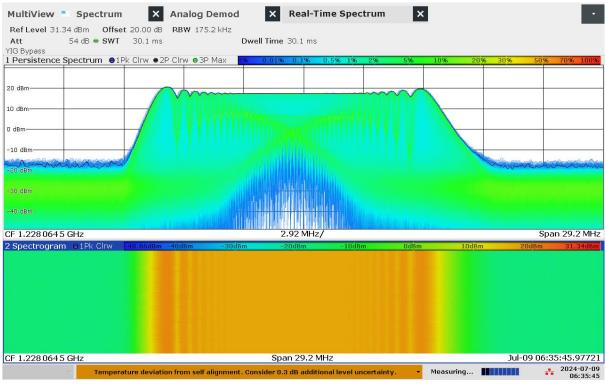
06:45:55 AM 07/09/2024

G 77: Frequency and power measurement of jammer H3.3 on antenna "long" (L5)



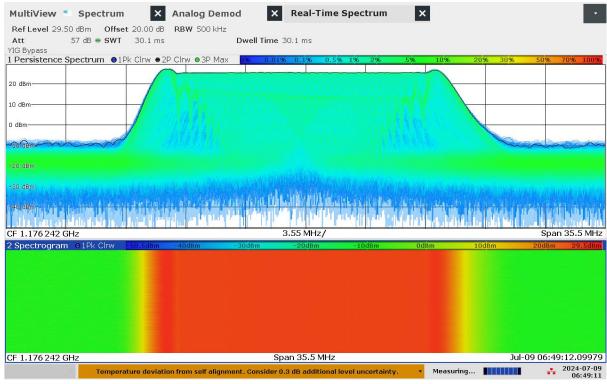
06:18:55 AM 07/09/2024

G 78: Real-time persistence and spectrogram measurement of jammer H3.3 on antenna "short" (L1)



06:35:46 AM 07/09/2024

*G* 79: Real-time persistence and spectrogram measurement of jammer H3.3 on antenna "medium" (L2)



06:49:12 AM 07/09/2024

G 80: Real-time persistence and spectrogram measurement of jammer H3.3 on antenna "long" (L5)

MultiVie	w 🎫 Spectru	im 🗙 A	nalog Demod	× Rea	I-Time Spec	trum >	۲.		-
Ref Leve	l 18.00 dBm Of								SGL
<ul> <li>Att</li> <li>YIG Bypass</li> </ul>	26 dB 🗛	2T 30 µs DE	3W 28 MHz Fre	<b>q</b> 1.57535 GHz					
1 FM Time	Domain							O1AP Clrw	DC Ref:0 Hz
14 MHz								D2[1]_154.6	70 000 000 kHz
10.15									12.960 0 µs
12 MHz			M1					M1[1] 9.62	4 425 000 MHz
10 MHz			X				D2		9.2100 μs
8 MHz			1						
6 MHz									
4 MHz									
2 MHz									
0 Hz									
-2 MHz	4								
-4 MHz									
-6 MHz				/					
-8 MHz			+	•			+		
-10 MHz									
-12 MHz									
-14 MHz CF 1.5753	5 GHz			1001	nte				3.0 µs/
4 Result Su				1001	i pia				5.0 µs/
		er Power 28.30	dBm			Carrier	Offset -653.5	5547 kHz	
	+Peak	-Peak	±Peak/2	RMS		. Freq.	SINAD	DISTORT	THD
FM	9.7791 MHz	-10.087 MHz	9.932.9 MH:	z 5.9189	MHz 7	7.063.96 kHz			
	- Temp	erature deviation fr	om self alignment.	Consider 0.3 dB a	ndditional level ur	ncertainty. 🔹 🔻	Ready		2024-07-09 06:17:55

06:17:56 AM 07/09/2024

#### G 81: Time domain (analog demod) measurement of jammer H3.3 on antenna "short" (L1)



06:34:25 AM 07/09/2024

G 82: Time domain (analog demod) measurement of jammer H3.3 on antenna "medium" (L2)



06:48:05 AM 07/09/2024

G 83: Time domain (analog demod) measurement of jammer H3.3 on antenna "long" (L5)

### Technical details on low-power jammer H4.1

The jammer H4.1 belongs to the 'Handheld category' of jammers. It is a small and relatively light battery driven jammer with a relatively easy operation, just an on/off-button with a LED-light to indicate activation and DIP switches to change between channels.

H4.1 is a four-antenna, so-called "L1+L2+L5+E6", jammer, disrupting both the upper and lower L-band.

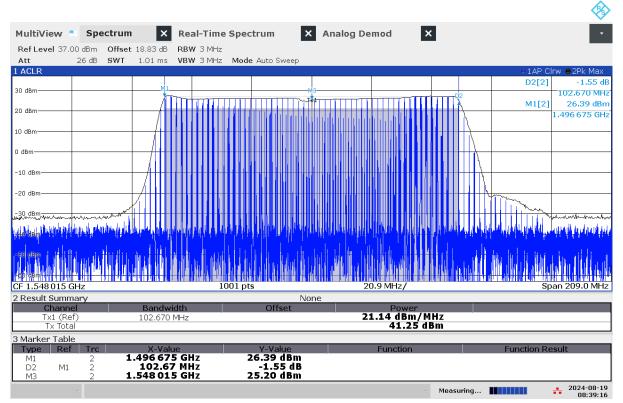
The four antennas are marked with numbers: "1" (L1), "2" (E6), "3" (L2) and "4" (L5)

The jammer has additional noise (harmonics) in several other (non GNSS) frequency bands.

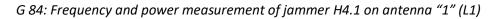


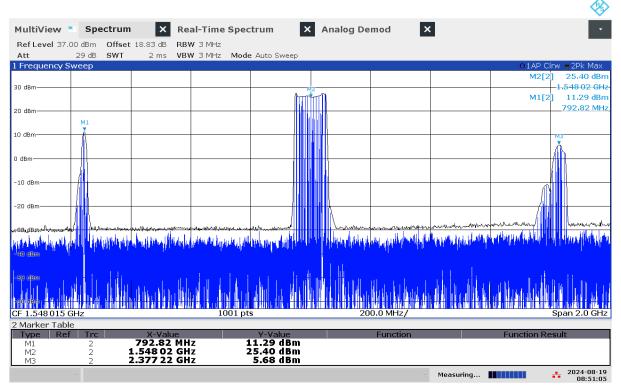
Technical characteristics of H4.1 (2024 measurements)
-------------------------------------------------------

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"1" (L1)	1548,02	102,67	21,14	41,25	25,20	8,82	Sawtooth- modulated
"2" (E6)	1261,92	48,80	22,38	39,26	22,33	8,86	Sawtooth
"3" (L2)	1220,34	47,88	21,08	37,88	20,29	8,82	Sawtooth
"4" (L5)	1182,32	39,66	22,87	38,85	22,83	8,84	Sawtooth



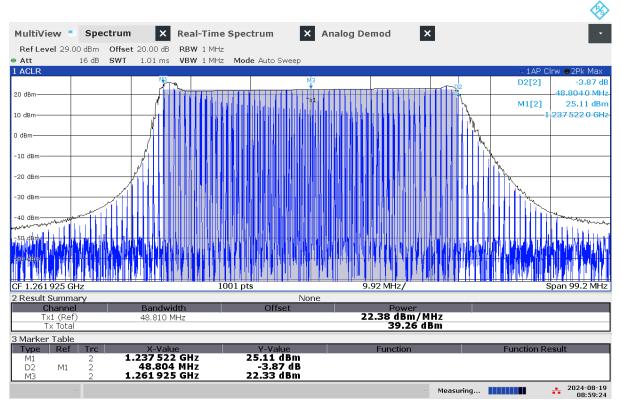
08:39:16 AM 08/19/2024



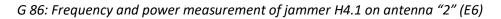


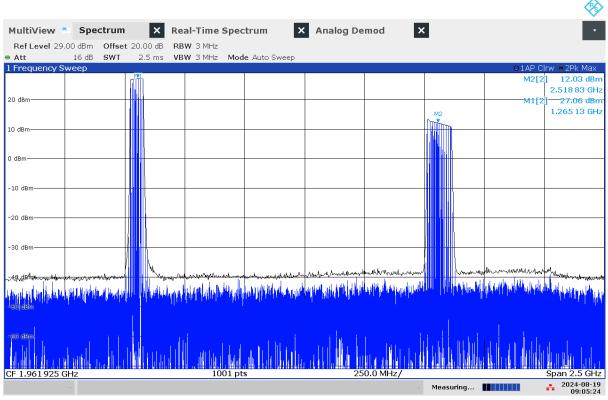
08:51:06 AM 08/19/2024

G 85: Frequency and power measurement with wider span of jammer H4.1 on antenna "1" (L1)



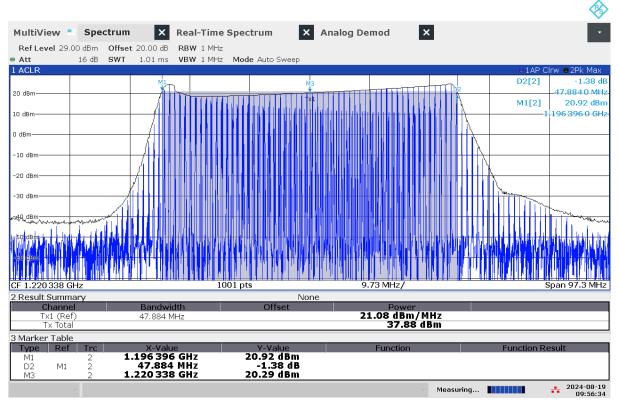
08:59:25 AM 08/19/2024



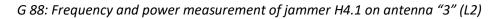


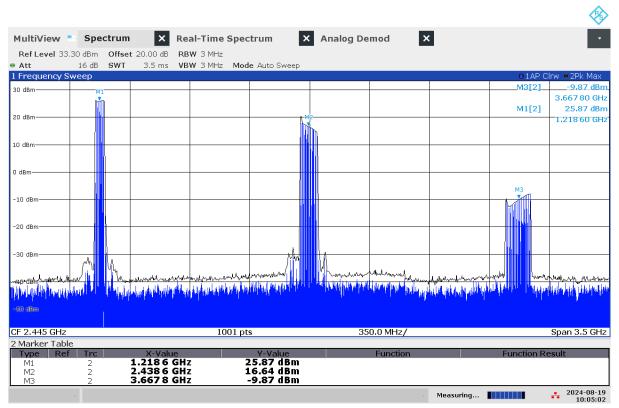
09:05:24 AM 08/19/2024

G 87: Frequency and power measurement with wider span of jammer H4.1 on antenna "2" (E6)



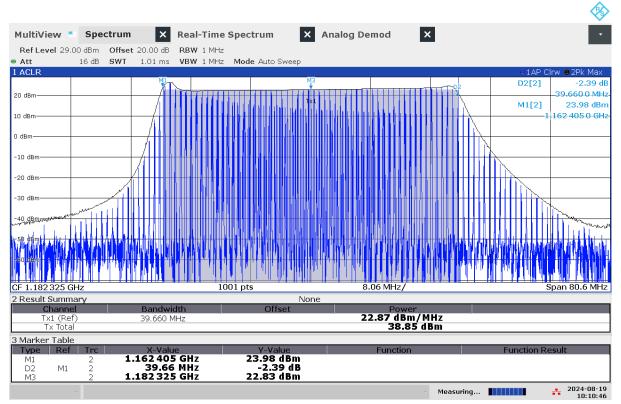
09:56:35 AM 08/19/2024





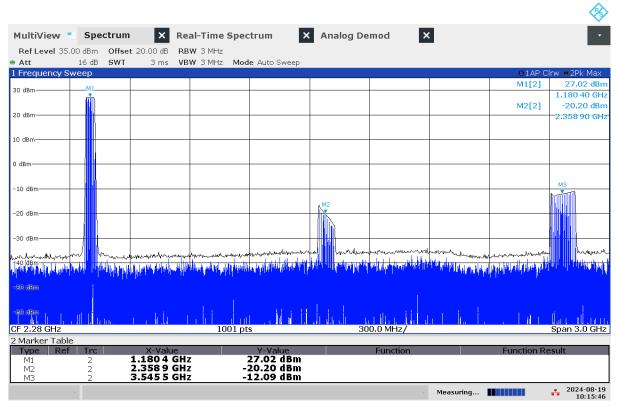
10:05:03 AM 08/19/2024

G 89: Frequency and power measurement with wider span of jammer H4.1 on antenna "3" (L2)



10:10:46 AM 08/19/2024

G 90: Frequency and power measurement of jammer H4.1 on antenna "4" (L5)



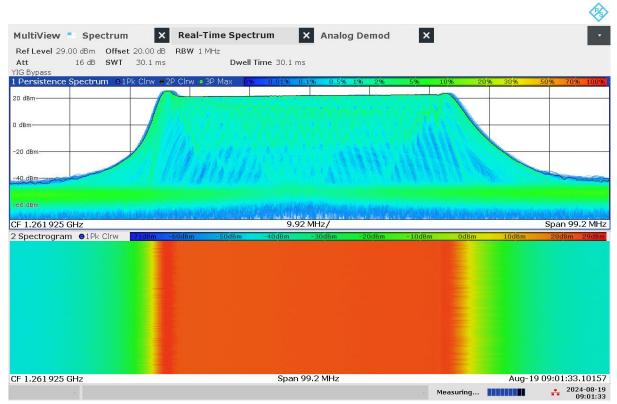
^{10:15:47} AM 08/19/2024

G 91: Frequency and power measurement with wider span of jammer H4.1 on antenna "4" (L5)

MultiView	- Spe	ctrum	×	Real-Time	e Spectrui	m 🗙	Analog De	emod	×			-
Ref Level 37.	00 dBm	Offset	18.83 dB	RBW 3.1351	MHz							
Att	26 dB	SWT	30 ms		Dwell	Time 30 ms						
YIG Bypass 1 Persistence	Spectru	m oiP	k Clow 😐 2		ax 1%	0.01% 0.1%	0.5% 1%	2%	5% 10%	20%	30% 5	0% 70% 100%
I T GI SISCONCE	opeed a		K ONW 02				01010 110			2010	0010 0	
20 dBm				-					V			
0 dBm	2			[								
											ē.	
-20 dBm		_		1 Ann							6	
anian		~~										
-40 dBm												
Constant Printers												lacando ante acente das
-60 dBm CF 1.541 GHz	I EF LATH	Nicion M	an internet		ALC: NOT THE OWNER.	20.9 M	CAN BE AN A LOSS OF A REAL OF		a is all the s	and the second second second		pan 209.0 MHz
2 Spectrogram		Clow	-63dBm	-50dBm	-40dBm	-30dBm	-20dBm	-10dBm	OdBm	10dBm	20dBm	37dBm
2 op ood og, di												
CE 1 541 GHz						Spap 200	0 MHz				Aug-19 (	18:48:06 79617
CF 1.541 GHz	-					Span 209	0 MHz		- Meas	suring 🚺	Aug-19 (	08:48:06.79617 2024-08-19 08:48:06

08:48:06 AM 08/19/2024

G 92: Real-time persistence and spectrogram measurement of jammer H4.1 on antenna "1" (L1)



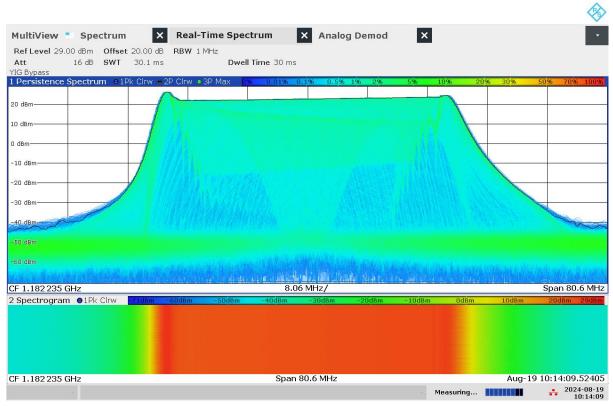
09:01:33 AM 08/19/2024

G 93: Real-time persistence and spectrogram measurement of jammer H4.1 on antenna "2" (E6)

												Ś
MultiView	Spe	ctrum	×	Rea	l-Time Spec	trum	× Analo	g Demod	×			
Ref Level 29.	00 dBm	Offset	t 20.00 dB	RBW	980.847 kHz							
Att	16 dB	SWT	30 ms			Dwell Time	30 ms					
YIG Bypass 1 Persistence	Spectru	m 01	Pk Clow @2	P Clow	• 3P Max	6 0.01%	0.1% 0.5%	1% 2%	5%	10% 2	0% 30%	50% 70% 100%
					h							
20 dBm				4								
10 dBm	2											
										1		
0 dBm												
-10 dBm	-									1		
-20 dBm											1	
-30 dBm		1	1	新祥								
-40 dBm	na											- Carrier
-50 dBm												
-60 dBm								GALERA AND			in the store particular mark	Continues of the Annual Contacts
ANTE AND DES	straid all							a k a h a h a h a .	ni. N.e.	Carrie .		
CF 1.220 388 (		-					73 MHz/					Span 97.3 MHz
2 Spectrogram	n OlPk	Cirw	-71dBm	-60dBm	-50dBm	-40dBm	-30dBm	-20dBm	-10dBm	OdBm	10dBm	20dBm 29dBm
CF 1.220 388 (	GHz					Spar	97.3 MHz				Aua-1	9 10:03:04.22461
	-					- 1201				Measuring		2024-08-19 10:03:04
										-		10:03:04

10:03:04 AM 08/19/2024

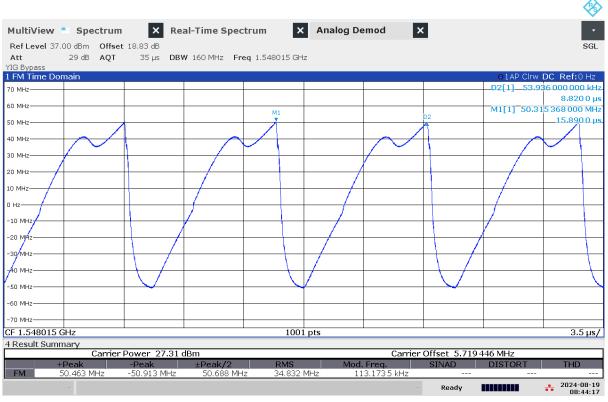
G 94: Real-time persistence and spectrogram measurement of jammer H4.1 on antenna "3" (L2)



10:14:09 AM 08/19/2024

G 95: Real-time persistence and spectrogram measurement of jammer H4.1 on antenna "4" (L5)

~



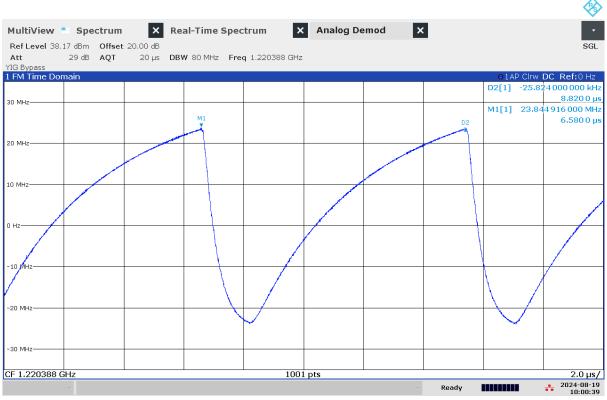
^{08:44:17} AM 08/19/2024

G 96: Time domain (analog demod) measurement of jammer H4.1 on antenna "1" (L1)

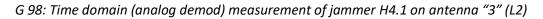


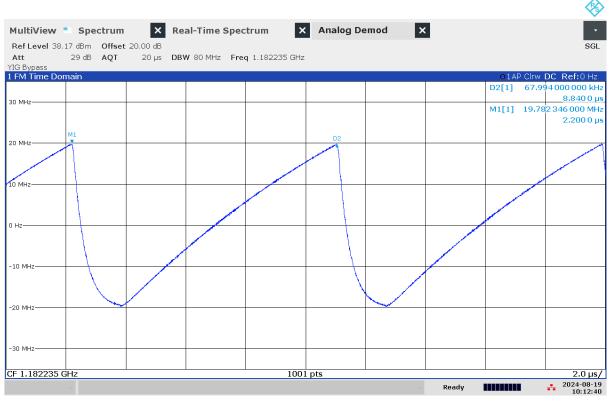
09:03:27 AM 08/19/2024

G 97: Time domain (analog demod) measurement of jammer H4.1 on antenna "2" (E6)



10:00:40 AM 08/19/2024





10:12:41 AM 08/19/2024

G 99: Time domain (analog demod) measurement of jammer H4.1 on antenna "4" (L5)

# Technical details on low-power jammer "H6.1"

The jammer H6.1 belongs to the 'Handheld category' of jammers. It is a larger but relatively light battery driven jammer with a relatively easy operation, just an on/off-button with a LED-light to indicate activation and DIP switches to change between channels.

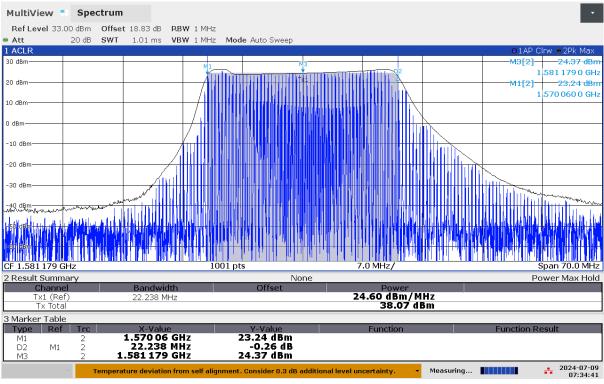
H6.1 is a six-antenna, so-called "multi-frequency", jammer, but technically not a "multi-GNSS-jammer". It jams six different bands, but only two channels are relevant for GNSS bands, both in the upper L-band (so "L1-only"), thus only disrupting the upper L-band.



The most relevant GNSS antenna is marked "6". The periphery antenna is marked "4". To avoid disrupting non-GNSS services, use only antenna "6".

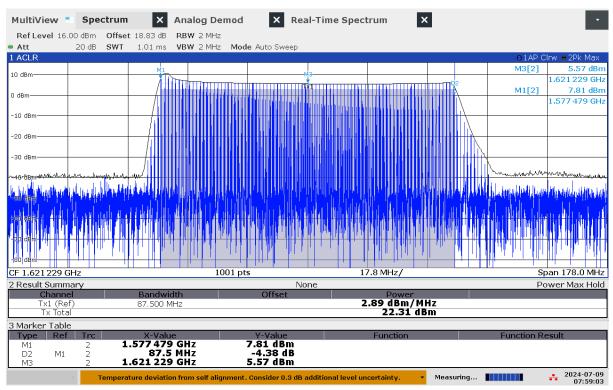
#### Technical characteristics of H6.1 (2024 measurements)

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"4"	1621,23	87,50	2,89	22,31	5,57	5,9	Sawtooth
"6" (L1)	1581,18	22,24	24,60	38,07	24,37	5,86	Sawtooth



07:34:41 AM 07/09/2024

G 100: Frequency and power measurement of jammer H6.1 on antenna "6" (L1)



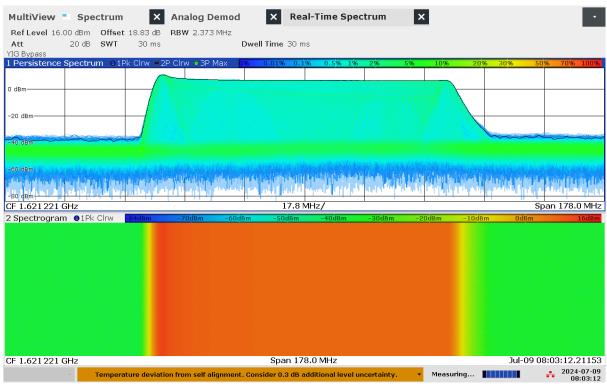
07:59:04 AM 07/09/2024

G 101: Frequency and power measurement of jammer H6.1 on antenna "4"

MultiView 🍍 Spectru	m 🗙 Analog Dem	od 🛛 🗙 Real-Time Spectr	um 🗙	*
Ref Level 33.00 dBm Offs	et 18.83 dB RBW 1 MHz			
Att 20 dB SWT	- 30.1 ms E	well Time 30.1 ms		
YIG Bypass				
1 Persistence Spectrum O	IPK CINW • 2P CINW • 3P Max	0% 0.01% 0.1% 0.5% 1% 2	2% 5% 10%	20% 30% 50% 70% 100%
20 dBm				
0 dBm-				
o ubii				
-20 dBm				
-20 uBm-				
-40rdBm		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		
		The second s		
-60 dBm	a second a second second	an a		和我们是一些没有是没有了。"杨云云是是是是这些话的问题。
CF 1.581 179 GHz		7.0 MHz/		Span 70.0 MHz
2 Spectrogram O1Pk Clrw	-67dBm -50dBm	-40dBm -30dBm -20dBm	-10dBm OdBm	10dBm 20dBm 33dBm
CF 1.581 179 GHz		Span 70.0 MHz		Jul-09 07:39:31.68450 • 2024-07-09

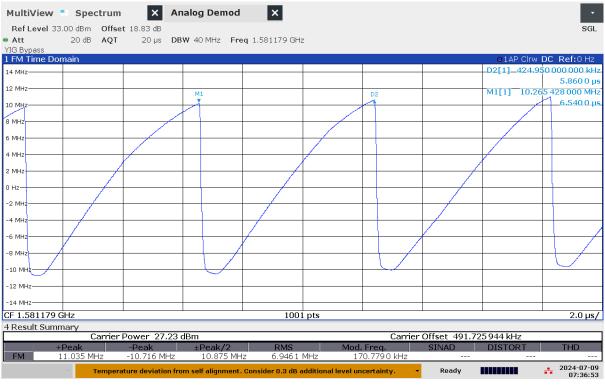
07:39:31 AM 07/09/2024

G 102: Real-time persistence and spectrogram measurement of jammer H6.1 on antenna "6" (L1)



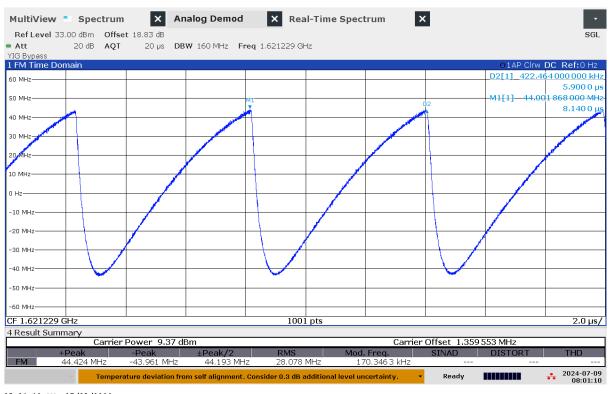
08:03:12 AM 07/09/2024

G 103: Real-time persistence and spectrogram measurement of jammer H6.1 on antenna "4"



07:36:53 AM 07/09/2024

#### G 104: Time domain (analog demod) measurement of jammer H6.1 on antenna "6" (L1)



08:01:10 AM 07/09/2024

G 105: Time domain (analog demod) measurement of jammer H6.1 on antenna "4"

## Technical details on low-power jammer "H6.2"

The jammer H6.2 belongs to the 'Handheld category' of jammers. It is a larger but relatively light battery driven jammer with a relatively easy operation, just an on/off-button with a LED-light to indicate activation and DIP switches to change between channels.

H6.2 is a six-antenna, so-called "multi-frequency", jammer. It jams six different bands, but only three channels are relevant for GNSS bands ("L1+L2+L5"), thus disrupting the upper and lower L-band.

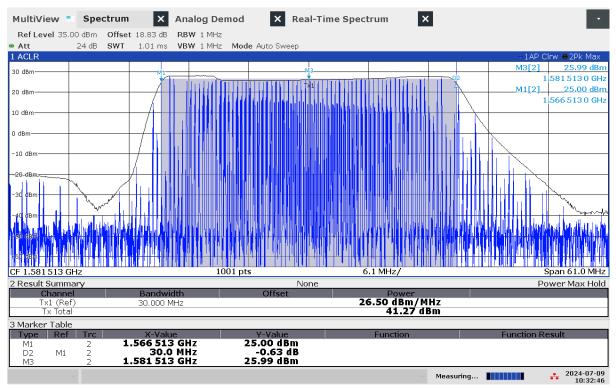


The relevant antennas are marked with numbers: "4" (L1), "5" (L5) and "6" (L2).

The jammer has additional noise in several other (non GNSS) frequency bands, but with significant lower power.

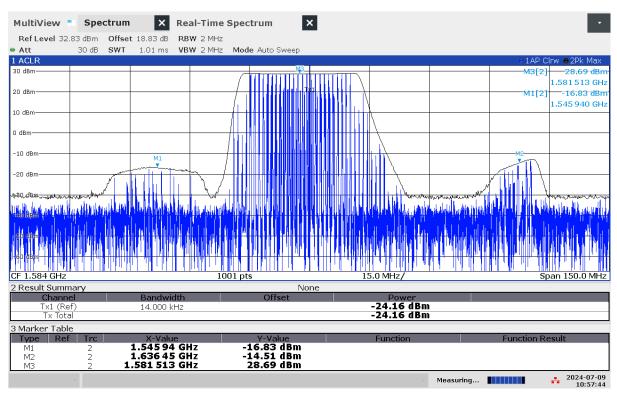
### Technical characteristics of H6.2 (2024 measurements)

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"4" (L1)	1581,51	30,00	26,50	41,27	25,99	7,0 / 28,2	Sawtooth modulated unto sinus
"5" (L5)	1154,62	110,77	19,98	40,42	24,57	7,14	Sawtooth
"6" (L2)	1247,94	113,14	21,85	42,39	26,78	7,1	Sawtooth



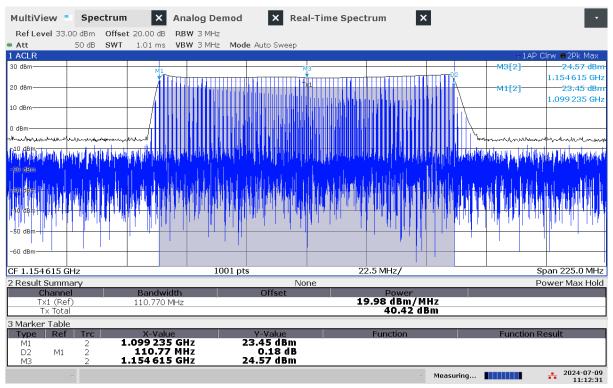
10:32:47 AM 07/09/2024

G 106: Frequency and power measurement of jammer H6.2 on antenna "4" (L1)



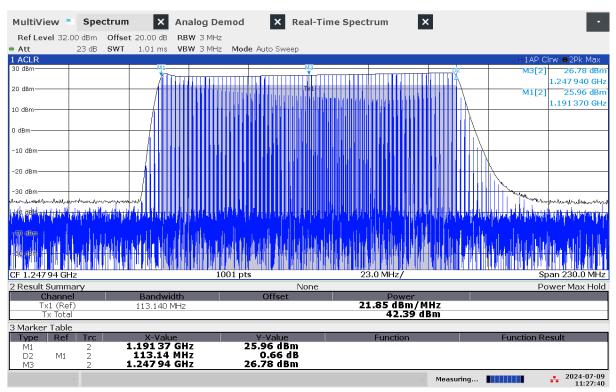
10:57:45 AM 07/09/2024

G 107: Frequency and power measurement with wider band of jammer H6.2 on antenna "4" (L1)



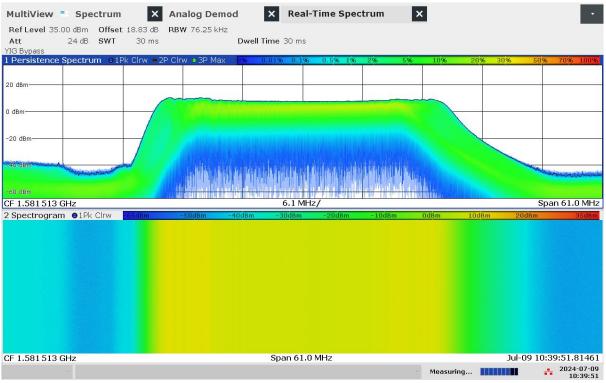
11:12:32 AM 07/09/2024

G 108: Frequency and power measurement of jammer H6.2 on antenna "5" (L5)



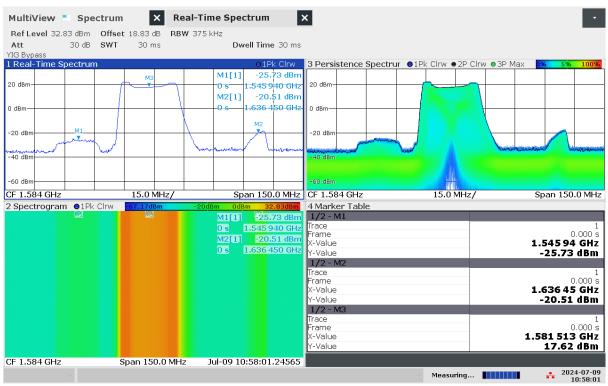
11:27:41 AM 07/09/2024

G 109: Frequency and power measurement of jammer H6.2 on antenna "6" (L2)



10:39:51 AM 07/09/2024

G 110: Real-time persistence and spectrogram measurement of jammer H6.2 on antenna "4" (L1)



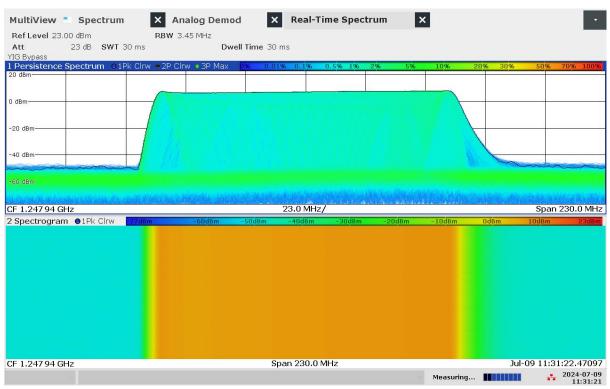
10:58:01 AM 07/09/2024

*G* 111: Real-time persistence and spectrogram measurement with wider span of jammer H6.2 on antenna "4" (L1)

MultiView 📒 Spectrur	n 🗙 Analog Demod	× Real-T	ime Spect	rum 🗙			•
Ref Level 28.00 dBm	RBW 3 MHz						
Att 50 dB SWT YIG Bypass	30.1 ms Dwell Tir	<b>ne</b> 30 ms					
1 Persistence Spectrum o	1Pk Clrw ⊜2P Clrw ⊙3P Max 🛛 🛛 🛛 🛛 🛛	0.01% 0.1%	0.5% 1%	2% 5%	10% 20	<mark>% 30</mark> % 5	0% 70% 100%
20 dBm							
0 dBm							
-20 dBm						han	
-40 dBm							
							A MARKAGA ANA
-69 dBm	an an in saindhin saint Chaodhlaintean Thuan an taona ann an taonachta						
the start of the least sails	The second s	a tak	1	1.1.1.		of the second se	1 1 1 1
CE 1 154615 GHz		22.5 MHz	• /			S	nan 225.0 MHz
CF 1.154615 GHz 2 Spectrogram •1Pk Clrw	<mark>-72dBm -</mark> 60dBm -50dBm	22.5 MHz		JdBm -10dE	3m OdBm	10dBm	Span 225.0 MHz 20dBm 28dBm
	<b>-72dBm -</b> 60dBm -50dBm		•	DdBm -10dE	3m OdBm		
	<b>-72dBm -</b> 60dBm -50dBm		•	JdBm −10dE	3m OdBm		
	72dBm -60dBm -50dBm		•	DdBm -10df	3m Odķm		
	72dBm -60dBm -50dBm		•	dBm -10dt	3m Od <u>k</u> m		
	-72dBm -60dBm -50dBm		•	DdBm -10d8	3m Odğm		
	<mark>-72dBm -60dBm -50dBm</mark>		•	<mark>∂dBm -10di</mark>	8m Odğm		
	-72dBm -60dBm -50dBm		•	<mark>0dBm −10</mark> db	8m Odëm		
	72dBm -60dBm -50dBm		•	adam −10di	8m Odëm		
2 Spectrogram ●1Pk Clrw	72dBm -60dBm -50dBm	-40 <u>d8m -3</u>	0d8m -20	ldBm −10df	8m Odëm	10dBm	20dim <b>20dBm</b>
	72dbm -60dbm -50dbm		0d8m -20	ldBm −10df	Am OdBm	10dBm	

11:17:35 AM 07/09/2024

G 112: Real-time persistence and spectrogram measurement of jammer H6.2 on antenna "5" (L5)



11:31:22 AM 07/09/2024

G 113: Real-time persistence and spectrogram measurement of jammer H6.2 on antenna "6" (L2)



^{10:37:46} AM 07/09/2024

*G* 114: Time domain (analog demod) measurement with wider sweep of jammer H6.2 on antenna "4" (L1)



G 115: Time domain (analog demod) measurement of jammer H6.2 on antenna "5" (L5)



11:28:53 AM 07/09/2024

G 116: Time domain (analog demod) measurement of jammer H6.2 on antenna "6" (L2)

### Technical details on low-power jammer "H6.3"

The jammer H6.3 belongs to the 'Handheld category' of jammers. It is a larger but relatively light battery driven jammer with a relatively easy operation, just an on/off-button with a LED-light to indicate activation and DIP switches to change between channels.

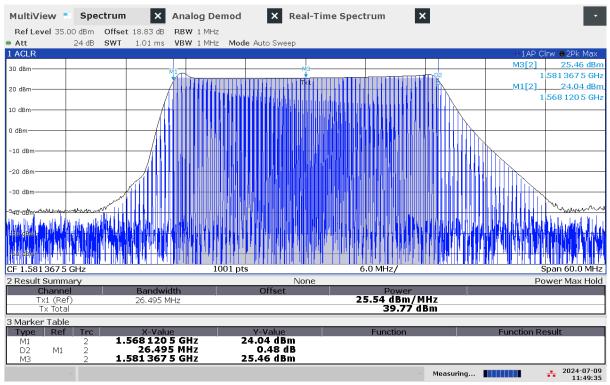
H6.3 is a six-antenna, so-called "multi-frequency", jammer. It jams six different bands, but only three channels are relevant for GNSS bands ("L1+L2+L5"), thus disrupting the upper and lower L-band.



The relevant antennas are marked with numbers: "4" (L1), "5" (L5) and "6" (L2).

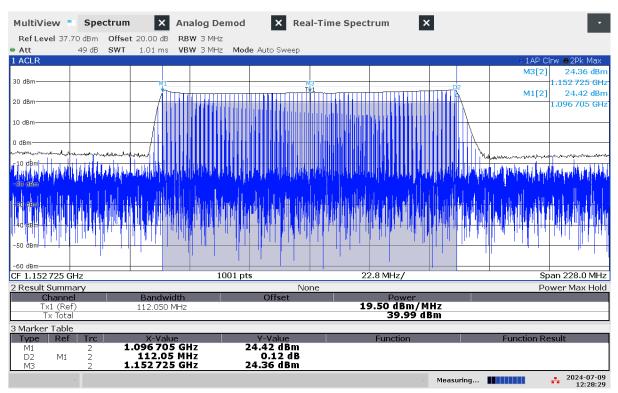
### Technical characteristics of H6.3 (2024 measurements)

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"4" (L1)	1581,37	26,50	25,54	39,77	25,46	7,1	Sawtooth
"5" (L5)	1152,73	112,05	19,50	39,99	24,36	7,06	Sawtooth
"6" (L2)	1248,65	111,06	21,80	42,25	26,65	7,08	Sawtooth



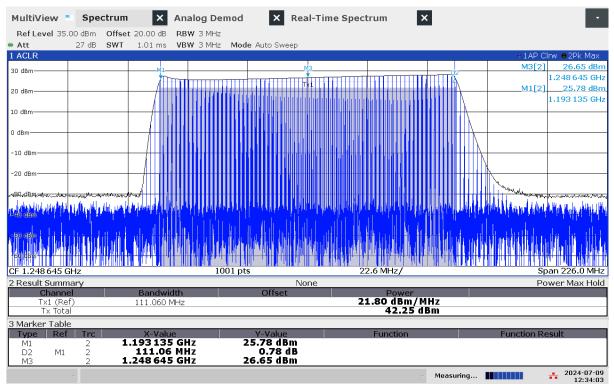
11:49:35 AM 07/09/2024

G 117: Frequency and power measurement of jammer H6.3 on antenna "4" (L1)



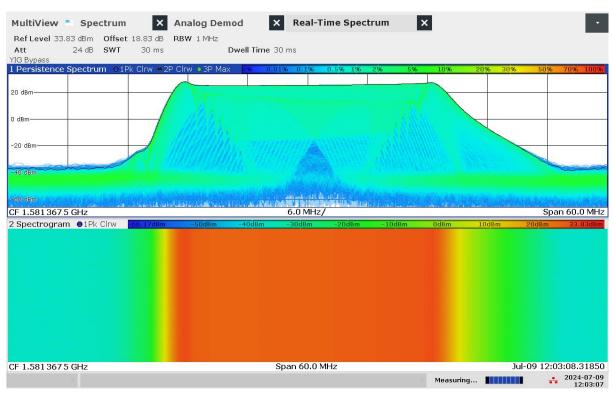
12:28:29 PM 07/09/2024

G 118: Frequency and power measurement of jammer H6.3 on antenna "5" (L5)



12:34:04 PM 07/09/2024

G 119: Frequency and power measurement of jammer H6.3 on antenna "6" (L2)



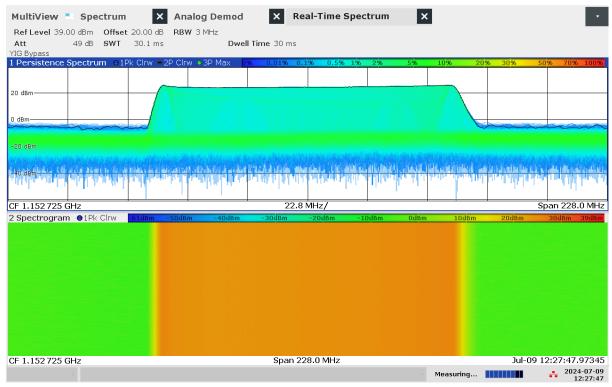
12:03:08 PM 07/09/2024

G 120: Real-time persistence and spectrogram measurement of jammer H6.3 on antenna "4" (L1)

MultiView	Spec	ctrum	×	Anal	log Den	nod	X Real-	Time Spe	ctrum	×				-
Ref Level 33.8				RBW	3.333 MH									
Att YIG Bypass	24 dB	SWT	30 ms			Dwell 1	f <b>ime</b> 30 ms							
1 Persistence	Spectru	m <mark>⊙</mark> 1P	kClrw ⊜2	P Clrw	• 3P Max	( <mark>0%</mark> 0	.01% 0.1%	0.5% 1%	2%	5%	10%	2096 3	0 <mark>% 50</mark>	<mark>% 70% 100%</mark>
20 dBm														
20 0811														
0 dBm						-+			N					
-20 dBm														
			~~~~	~	~~				1000	~~~			~	
-40 dBm														
-60 dBm		Le Astrony	al alternated				a such and shales	al and set of the			in the second			
-60 dBm CF 1.581 367 5		a civiliti i	ni, ya ƙasara ƙ	alle kanta	iti di Uni	L. VALLER	20.0 MH	interaction de la Iz/	in de Villes	ini ka ji	LOR WALL		S	oan 200.0 MH:
CF 1.581 367 5 2 Spectrogram	6 GHz		-66.17dBm		50dBm	-40dBm	20.0 MH -30dBm	liz/ -20dBm			OdBm	10dBm	Sj 20dBr	Jan 200.0 Min.
CF 1.581 367 5	6 GHz				50dBm		20.0 191	127					3	Jan 200.0 Min.
CF 1.581 367 5	6 GHz				50dBm		20.0 191	127					3	Jan 200.0 Min.
CF 1.581 367 5	6 GHz				50dBm		20.0 191	127					3	Jan 200.0 Min.
CF 1.581 367 5	6 GHz				50dBm		20.0 191	127					3	Jan 200.0 Min.
CF 1.581 367 5	6 GHz				50dBm		20.0 191	127					3	Jan 200.0 Min.
CF 1.581 367 5	6 GHz				50dBm		20.0 191	127					3	Jan 200.0 Min.
CF 1.581 367 5	6 GHz				50dBm		20.0 191	127					3	Jan 200.0 Min.
CF 1.581 367 5	6 GHz				50dBm		20.0 191	127					3	Jan 200.0 Min.
CF 1.581 367 5	GHz ●1Pk				SDdBm		20.0 191	-20dBm					20dBr	Jan 200.0 Min.

12:03:49 PM 07/09/2024

G 121: Real-time persistence and spectrogram measurement with wider span of jammer H6.3 on antenna "4" (L1)



12:27:48 PM 07/09/2024

G 122: Real-time persistence and spectrogram measurement of jammer H6.3 on antenna "5" (L5)

MultiView 🍍 Spectrum		× Real-Time Spectr	um ×	*
Ref Level 35.00 dBm Offset				
Att 27 dB SWT YIG Bypass	30.1 ms Dwell Tim	e 30 ms		
1 Persistence Spectrum 01	Pk Clrw 🖷 2P Clrw 🔍 3P Max 🛛 💵	0.01% 0.1% 0.5% 1% 2	2% 5% 10% 2	0% 30% 50% 70% 100%
20 dBm				
0 dBm				
-20 dBm				
-40 dBm		an an Artan Anton a character a seathle and		
internation of the classific	the terminal states in the states at some the se	in a star of the street of the star	date the area a distance test of a	illen Stoten an aller i false flands fil
-60 dBm - million parts a second state				
		17 3 MHz/		Spap 173 0 MHz
CF 1.248 755 GHz	-65dBm -50dBm -40dBm	17.3 MHz/	-10dBm 0dBm 10	Span 173.0 MHz
CF 1.248755 GHz 2 Spectrogram ●1Pk Clrw	65dBm -50dBm -40dBm		-10dBm 0dBm 10	Span 173.0 MHz dBm 20dBm 35dBm
	65dBm -50dBm -40dBm		-10dBm 0dBm 10	
	65dBm -50dBm -40dBm		-10dBm Od Bm 10	
	65dBm -50dBm -40dBm		<mark>-10d8m Od8</mark> m 10	
	65dBm -50dBm -40dBm		-10d9m 0d8m <u>1</u> 0	
	<mark>65dBm -50dBm -40d</mark> Bm		<mark>-10d9m 0d8</mark> m 10	
	<mark>65dBm -50d</mark> Bm -40dBm		<mark>-10d8m 0d8</mark> m 10	
	<mark>65dBm -50dBm -40dBm</mark>		<mark>-10dBm OdB</mark> m 10	
	65dBm -50dBm -40dBm		<mark>-10d8m 0d8</mark> m 10	
	65dBm -50dBm -40dBm		<mark>-10d8m 0d8</mark> m 10	
	65dBm -50dBm -40dBm		<mark>-10d8m 0d8</mark> m 10	

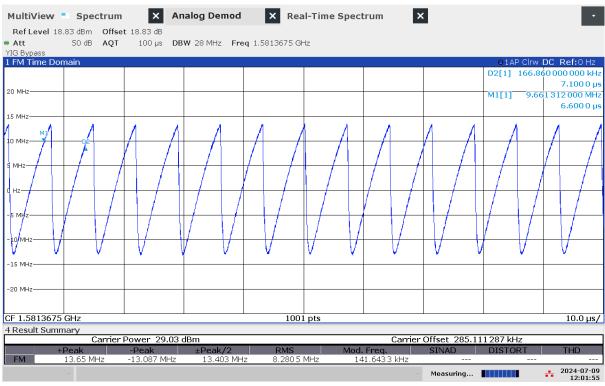
12:39:49 PM 07/09/2024

G 123: Real-time persistence and spectrogram measurement of jammer H6.3 on antenna "6" (L2)



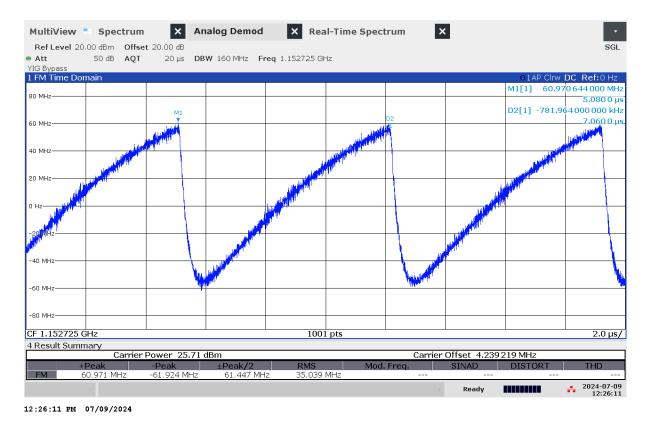
12:01:20 PM 07/09/2024

G 124: Time domain (analog demod) measurement of jammer H6.3 on antenna "4" (L1)

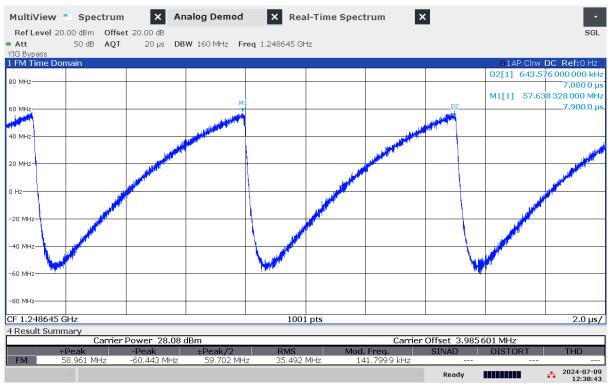


12:01:55 PM 07/09/2024

G 125: Time domain (analog demod) measurement with wider sweep of jammer H6.3 on antenna "4" (L1)



G 126: Time domain (analog demod) measurement of jammer H6.3 on antenna "5" (L5)



12:38:44 PM 07/09/2024

G 127: Time domain (analog demod) measurement of jammer H6.3 on antenna "6" (L2)

Technical details on low-power jammer "H6.4"

The jammer H6.4 belongs to the 'Handheld category' of jammers. It is a larger but relatively light battery driven jammer with a relatively easy operation, just an on/off-button with a LED-light to indicate activation and DIP switches to change between channels.

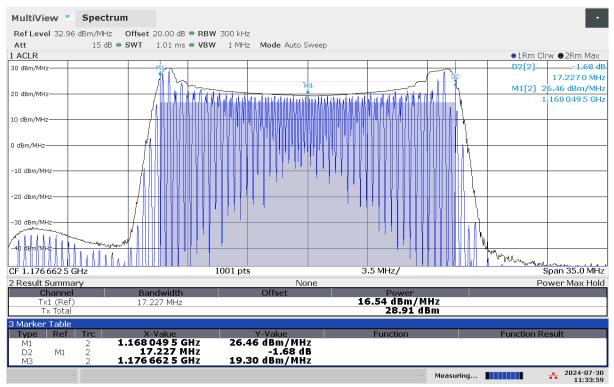
H6.4 is a six-antenna, so-called "multi-frequency", jammer. It jams six different bands, but only three channels are relevant for GNSS bands ("L1+L2+L5"), thus disrupting the upper and lower L-band.

The relevant antennas are marked with numbers: "1" (L5), "3" (L2) and "5" (L1)

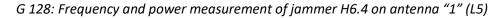
Technical characteristics of H6.4 (2024 measurements)

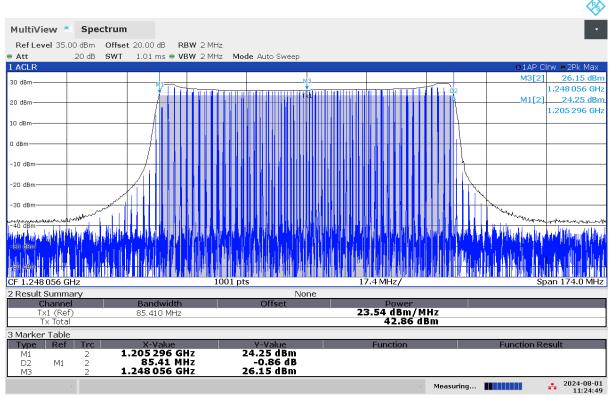
Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"1" (L5)	1176,66	17,23	16,54	28,91	19,30	10,62	Triangle
"3" (L2)	1248,01	85,41	23,54	42,86	26,15	10,3	Triangle
"5" (L1)	1593,36	81,28	22,82	41,92	25,63	11	Triangle





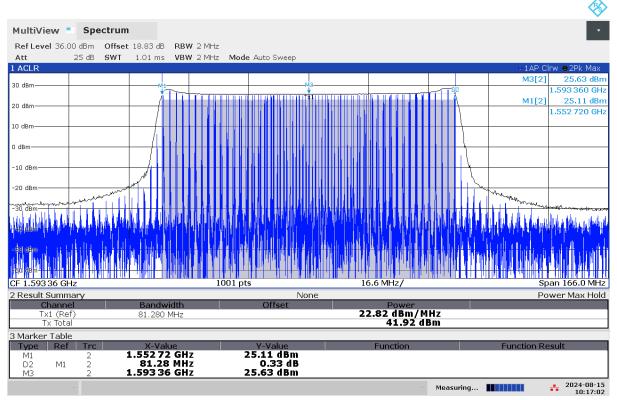
11:33:59 AM 07/30/2024



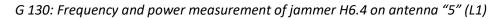


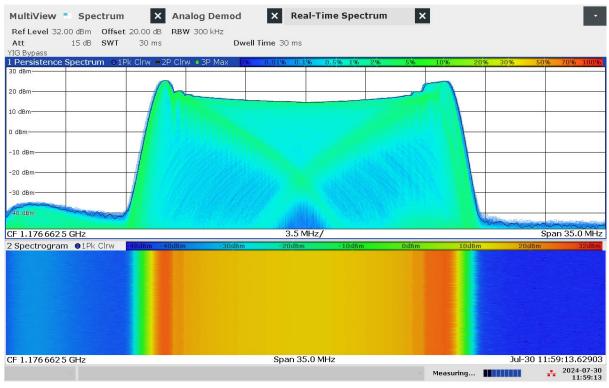
11:24:50 AM 08/01/2024

G 129: Frequency and power measurement of jammer H6.4 on antenna "3" (L2)



10:17:02 AM 08/15/2024





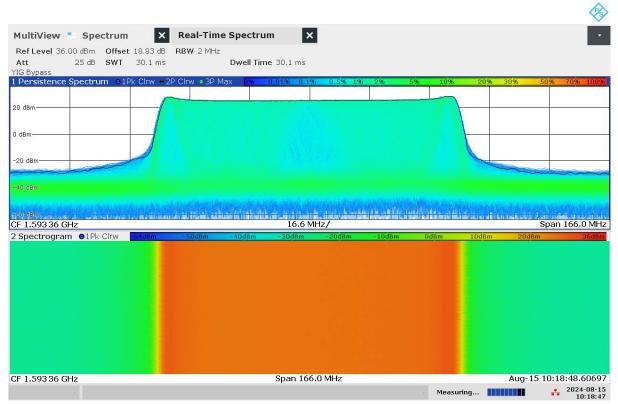
11:59:13 AM 07/30/2024

G 131: Real-time persistence and spectrogram measurement of jammer H6.4 on antenna "1" (L5)

MultiView 🔹 Spectrum	× Analog Demod	Real-Time Spectrum	×	
Ref Level 35.00 dBm Offset 2	20.00 dB RBW 500 kHz			
	30.1 ms Dwell Time	• 30 ms		
YIG Bypass				
1 Persistence Spectrum 01Pk	Cirw Cirw	11% 0.1% 0.5% 1% 2% 5	5 <mark>% 10% 20% 30%</mark>	50% 70% 100%
30 dBm				
20 dBm				
10 dBm				
0 dBm				
-10 dBm				
-20 dBm	-			
-30 dBm	1			
-40.dBm			mintin	a minimum and a summer
-50 dBm				
-60 dBm				
CF 1.248 056 GHz		17.4 MHz/		Span 174.0 MHz
2 Spectrogram O1Pk Clrw 🔤	65dBm -50dBm -40dBm	-30dBm -20dBm -10dBm	OdBm 10dBm 200	dBm 35dBm
CF 1.248 056 GHz		Span 174.0 MHz	Aug-0	01 11:30:23.56904
			Measuring	
			measuring	2024-08-01 11:30:23

11:30:23 AM 08/01/2024

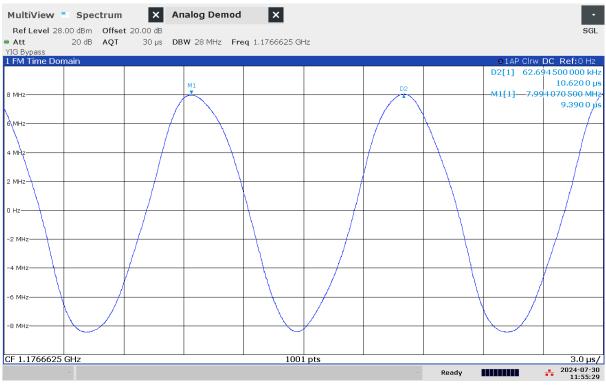
G 132: Real-time persistence and spectrogram measurement of jammer H6.4 on antenna "3" (L2)



10:18:48 AM 08/15/2024

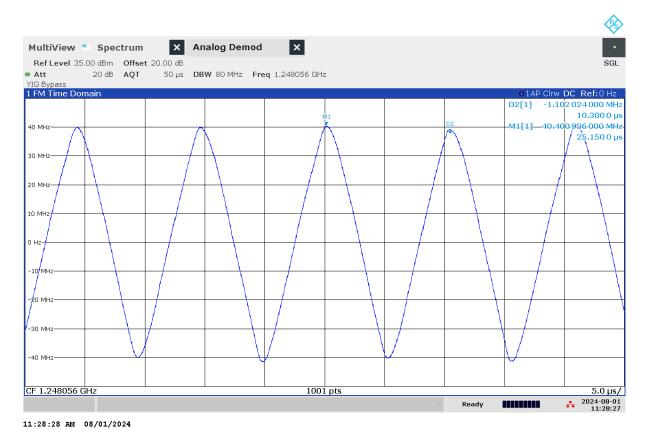
G 133: Real-time persistence and spectrogram measurement of jammer H6.4 on antenna "5" (L1)

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11:55:30 AM 07/30/2024

G 134: Time domain (analog demod) measurement of jammer H6.4 on antenna "1" (L5)



G 135: Time domain (analog demod) measurement of jammer H6.4 on antenna "3" (L2)



10:24:04 AM 08/15/2024

G 136: Time domain (analog demod) measurement of jammer H6.4 on antenna "5" (L1)

Technical details on low-power jammer "H6.5"

The jammer H6.5 belongs to the 'Handheld category' of jammers. It is a larger but relatively light battery driven jammer with a relatively easy operation, just an on/off-button with a LED-light to indicate activation and DIP switches to change between channels.

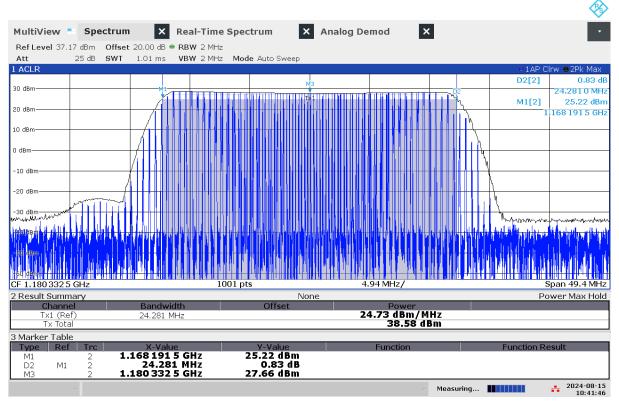
H6.5 is a six-antenna, so-called "multi-frequency", jammer. It jams six different bands, but only three channels are relevant for GNSS bands ("L1+L2+L5"), thus disrupting the upper and lower L-band.

The relevant antennas are marked with numbers: "1" (L5), "3" (L2) and "5" (L1)

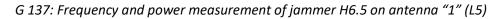
Technical characteristics of H6.5 (2024 measurements)

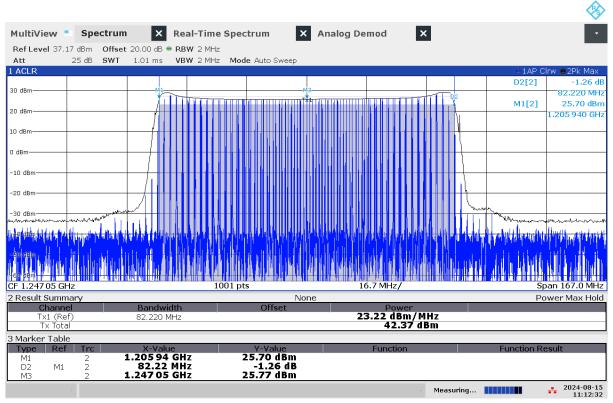
Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"1" (L5)	1180,33	24,28	24,73	38,58	27,66	10,26	Triangle
"3" (L2)	1247,05	82,22	23,22	42,37	25,77	10,32	Triangle
"5" (L1)	1595,6	80,12	22,62	41,65	25,41	10,3	Triangle





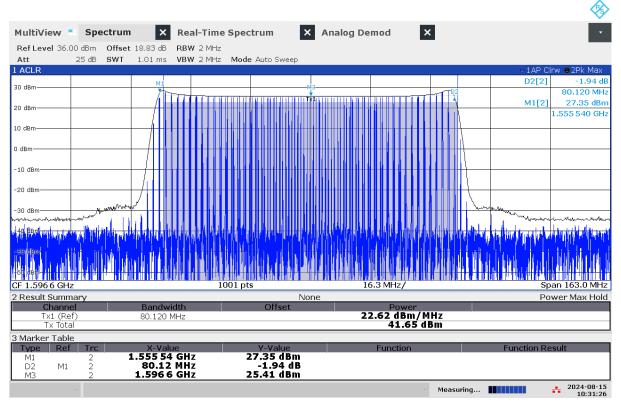
10:41:46 AM 08/15/2024



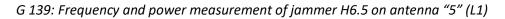


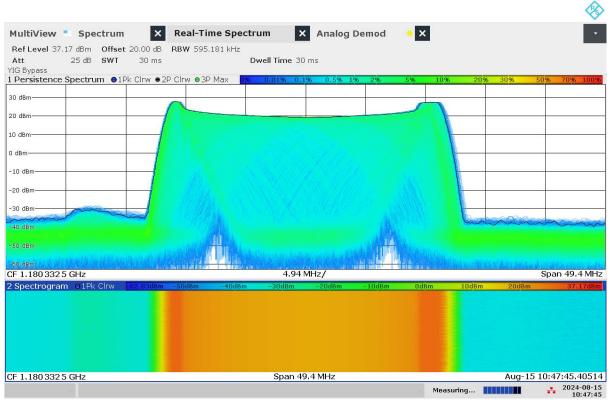
^{11:12:33} AM 08/15/2024

G 138: Frequency and power measurement of jammer H6.5 on antenna "3" (L2)



10:31:27 AM 08/15/2024





10:47:45 AM 08/15/2024

G 140: Real-time persistence and spectrogram measurement of jammer H6.5 on antenna "1" (L5)

MultiView Spectrum	Real-Time Spectrum	Analog Demod	×	-
Ref Level 37.17 dBm Offset 20.00 d	B RBW 2 MHz			
Att 25 dB SWT 30.1 m	s Dwell Time 30.1 ms			
YIG Bypass 1 Persistence Spectrum •1Pk Clrw •	2P Clrw ● 3P Max 0% 0.01% 0.	1% 0.5% 1% 2% 5	% 10% 20% 30 %	50% 70% 100%
TPErsistence spectrum • TPR CIW		170 0.370 170 270 3	70 1070 2070 3070	50% 70% 100%
30 dBm				
20 dBm				
10 dBm				
0 dBm				
-10 dBm				
-20 dBm-				
-30 dBm			1 hours	Actor and
-40 dBm				
-50 dBm	a search and the faith dealers a strate in the search and and	a construction of the station of the		arka mantu an ang ditantu i Roma Suranan
-60 dBm	and the second states a	in and the fille of the different t	neda I. d. M. S	
CF 1.247 05 GHz	16.7	MHz/		Span 167.0 MHz
2 Spectrogram O1Pk Clrw -62.83dB	m -50dBm -40dBm -30dBm	-20dBm -10dBm	OdBm 10dBm 20)dBm 37.17dBm
CF 1.247 05 GHz	Span 16	57.0 MHz		ig-15 11:17:56.08001
			 Measuring 	2024-08-15 11:17:56

11:17:56 AM 08/15/2024

G 141: Real-time persistence and spectrogram measurement of jammer H6.5 on antenna "3" (L2)

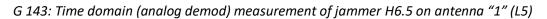
MultiView	Spe	ctrum	×	Rea	al-Time	Spec	trum	×	Analog	Demod		×				-
Ref Level 36.	00 dBm	Offset	18.83 dB	RBW	/ 2 MHz											3
Att	25 dB	SWT	30.1 ms			Dwell	Time 30.	1 ms								
YIG Bypass 1 Persistence	Spectru	m 01F	k Clrw 😑	2P Clrv	v o 3P Ma	ax 09	6 0.019	6 0.1%	0.5%	196 296	5%	10%	20%	30%	50%	70% 100%
30 dBm																_
												-				
20 dBm			1									T				
10 dBm												1				
0 dBm																
-10 dBm			_													
-20 dBm																
-30 dBm		~	9										Las	0.000	_	- Contractor
-40 dBm																
-50 dBm	alabelet, racia na															
-60 dBm	dia Di		Ind Same	ni in	anab thi				. in a include	an chairte an Talainn Machailte	ai pinisi	Line, it is	Man L	Manna I	ing ins	Acard, white
CF 1.596 6 GH		Clau	2 4 dB		DdBm	-40dBr		16.6 M DdBm	-20dBm	-10d	0	OdBm	10dBm	and an		166.0 MHz
2 Spectrogran		CITW	-64dBm	-51	UUBM	-40081	n -3	JUBM	-200Bm	-100	BM	UUBM	TUGBM	20dE	m	36dBm
CF 1.596 6 GH	Z						Spa	an 166	.0 MHz					Aug-1		5:05.18961
												Measu	iring 📕		**	2024-08-15 10:35:04

10:35:05 AM 08/15/2024

G 142: Real-time persistence and spectrogram measurement of jammer H6.5 on antenna "5" (L1)

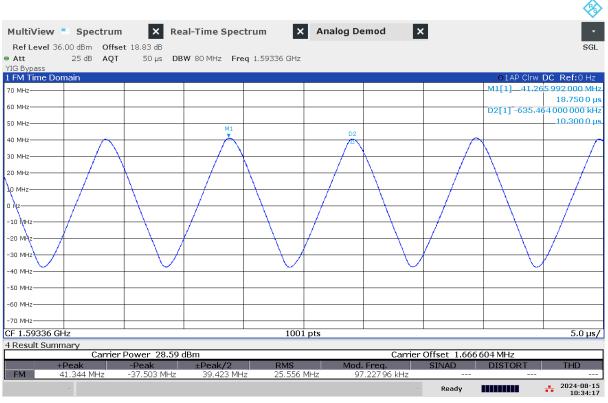
MultiView	Spectrum	×	Real-Time Spec	trum 🗙	Analog De	emod 🛛 🔶 🗙		-
	.17 dBm Offse							SGL
Att IG Bypass	25 dB AQT	20 µs	DBW 80 MHz Fre	q 1.1803325 G⊦	łz			
FM Time Dor	main							DC Ref:0 Hz
							D2[1] -829.9	
								10.2600
0 MHz							M1[1]-10.94	3 438 000 MF 5.860 0 µ
								0.0000
5 MHz								
			M1					
0 MHz							 D2	
MHz		1						
	/	ſ		N				
Hz				<u> </u>		/		
5 MHz								
10 MHz						-		
15 MHz								
20 MHz								
F 1.1803325	GHz			1001	pts			2.0 µs

10:47:03 AM 08/15/2024





G 144: Time domain (analog demod) measurement of jammer H6.5 on antenna "3" (L2)



10:34:17 AM 08/15/2024

G 145: Time domain (analog demod) measurement of jammer H6.5 on antenna "5" (L1)

Appendices

Technical details on low-power jammer "H6.6"

The jammer H6.6 belongs to the 'Handheld category' of jammers. It is a larger but relatively light battery driven jammer with a relatively easy operation, just an on/off-button with a LED-light to indicate activation and DIP switches to change between channels.

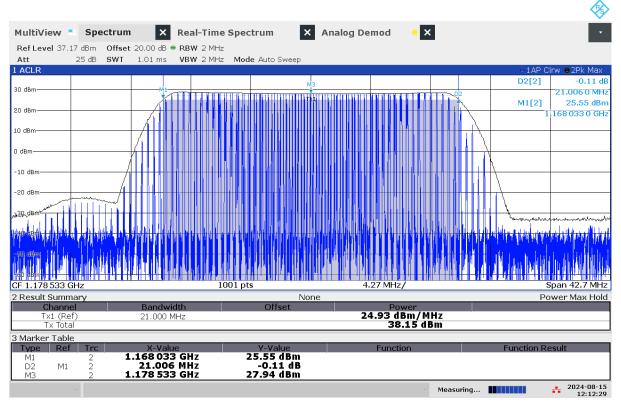
H6.6 is a six-antenna, so-called "multi-frequency", jammer. It jams six different bands, but only three channels are relevant for GNSS bands ("L1+L2+L5"), thus disrupting the upper and lower L-band.

The relevant antennas are marked with numbers: "1" (L5), "3" (L2) and "5" (L1)

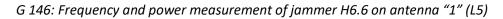
Technical characteristics of H6.6 (2024 measurements)

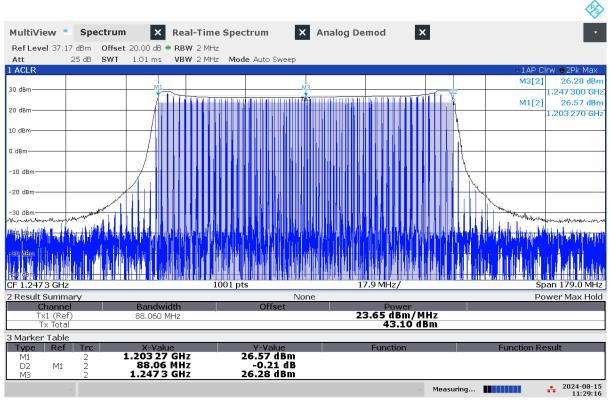
Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"1" (L5)	1178,53	21,01	24,93	38,15	27,94	10,00	Triangle
"3" (L2)	1247,30	88,06	23,65	43,10	26,28	9,92	Triangle
"5" (L1)	1592,48	73,60	22,84	41,51	25,60	10,46	Triangle





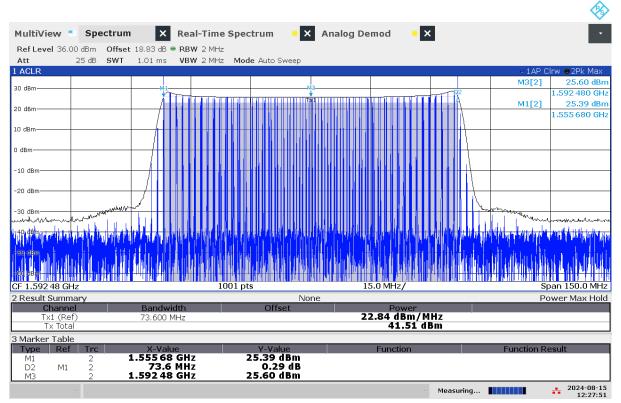
12:12:29 PM 08/15/2024



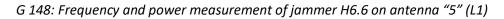


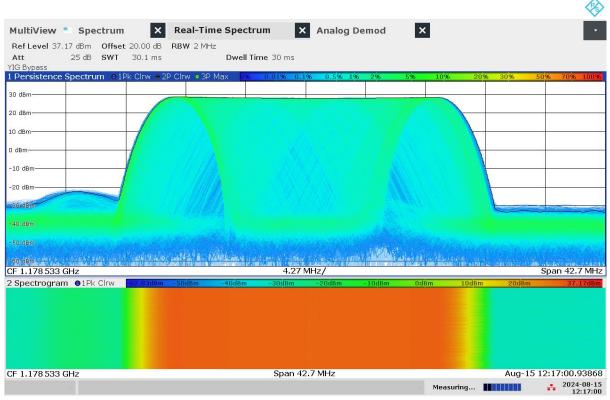
^{11:29:17} AM 08/15/2024

G 147: Frequency and power measurement of jammer H6.6 on antenna "3" (L2)



12:27:52 PM 08/15/2024





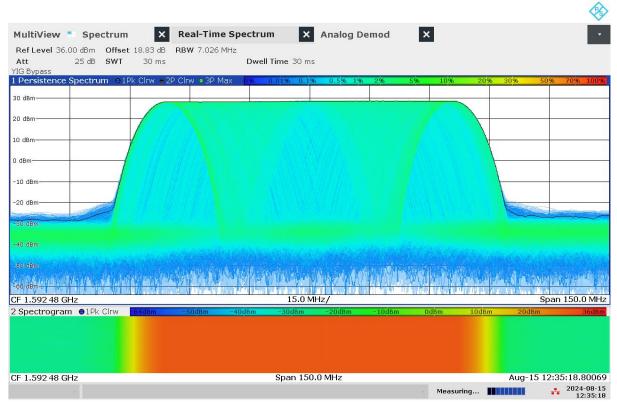
12:17:01 PM 08/15/2024

G 149: Real-time persistence and spectrogram measurement of jammer H6.6 on antenna "1" (L5)

																		Ś
MultiView	Spe	ctrum	×	Rea	al-Time	Spect	rum	×	Analog	Demo	d	×						•
Ref Level 37.	17 dBm	Offset	20.00 dB	RBW	2.144 M	1Hz		_										
Att	25 dB	SWT	30 ms			Dw	ell Time	30 ms										
YIG Bypass 1 Persistence	Cootuu	- 1 D					0.010	0.10/	0.5%	10/ 00/		~	100	0.00	30%	50%	70%	10000
1 Persistence	spectru		K UHW 🛡 🛛		OP M	ax <mark>u</mark> so	0.01%	0.1%	0.5%	1% 2%	5	96	10%	20%	30%	50%	70%	100%
30 dBm			6															
20 dBm			$ \longrightarrow $										+					
10 dBm													ł			_		
0 dBm																		
-10 dBm																		
-20 dBm																		
-30 dBm															how		7	
-40 dBm																	~~~	~~~~
-50 dBm																U.M. A.		144.43
160 dBm	i È i		i badi avli	1.1100	1 45 H H + 1	till i silen		ara bi bi t				i ini		46.46	inne ar bas		Bat an	
CF 1.2473 GH 2 Spectrogram		Cleve	62.83dBm	-50d	Daw	-40dBm	-30dE	17.9 Mł	-20dBm	-10dF	2	OdBm		10dBm	20dB	100	an 179.	17dBm
2 Spectrogram	I UIPK	CIIW	62.83UBM	-500	BW -	-40UBm	-3048	me	-20UBm	-1008	m	UUBM		TOUBIN	ZUUB	п	37.	17ubm
CF 1.2473 GH	7						Spa	ın 179.	0 MHz						Aug-	15 11	31:49.4	47107
G 1.247 3 GH	2	_	_				эра						loacurie		Aug-	13 11	2024	-08-15
												~ P	reasurir	ig 🔳			11	1:31:49

11:31:49 AM 08/15/2024

G 150: Real-time persistence and spectrogram measurement of jammer H6.6 on antenna "3" (L2)

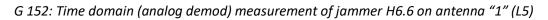


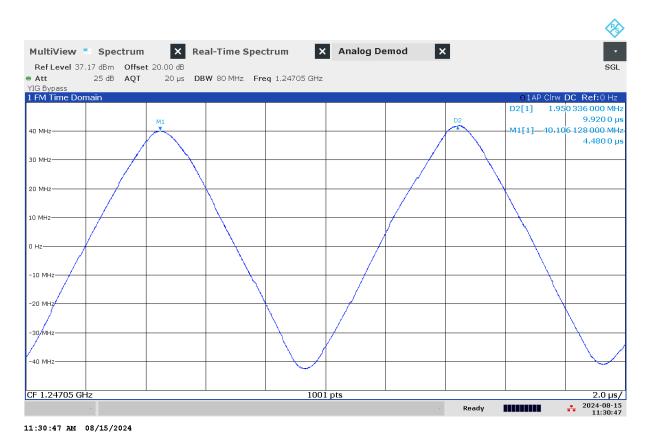
12:35:18 PM 08/15/2024

G 151: Real-time persistence and spectrogram measurement of jammer H6.6 on antenna "5" (L1)

	Spectrum		al-Time Spec	trum ×	Analog De	emod ×	1		
	17 dBm Offset 25 dB AQT		W 18 MHz Fre	q 1.178533 GH:	7				S
Bypass	-								
M Time Don	nain		1	1					DC Ref:0 ⊢
MHz								M1[1] 8.63	2,720 C
MHz								D2[1]_545.3	
VIH2								02[1]-040/0	10.000 0
/Hz	M1					D2			10.0000
	V V								
Hz					1				
-12							<u> </u>		
~ /		\mathbf{X}							
Hz									
Hz									
H2									
, 							$ \rangle \rangle$		
/Hz		$\langle \rangle$			/				
MHz								N	
4112			Ν					\mathbf{X}	
1Hz									
1Hz									
MHz-				[T
MHz-									
MHz									
MH2									

12:15:08 PM 08/15/2024





G 153: Time domain (analog demod) measurement of jammer H6.6 on antenna "3" (L2)



12:33:48 PM 08/15/2024

G 154: Time domain (analog demod) measurement of jammer H6.6 on antenna "5" (L1)

Technical details on low-power jammer "F6.1"

The jammer F6.1 belongs to the 'Permanently installed (Fixed)' of jammers. It is a large and heavy tabletop type of jammer, in need of constant power supply with a relatively easy operation, just an on/off-button with a LED-light to indicate activation and DIP switches to change between channels.

F6.1 is a six-antenna, so-called "multi-frequency", jammer. It jams six different bands, but only four channels are relevant for GNSS bands ("L1+L2+L5"), thus disrupting the upper and lower L-band.

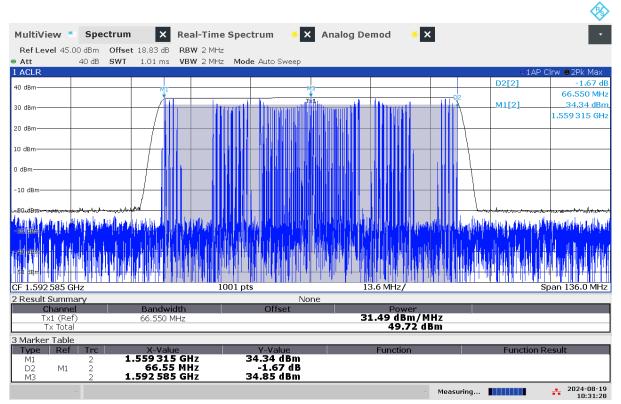
The relevant antennas are marked with letters and numbers: "F2" (L1), "F3" (L1), "F4" (L2) and "F6" (L5)



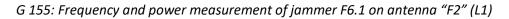
This jammer has the possibility to adjust the output power, with a power control knob for each antenna. The measurements below are all done at maximum power.

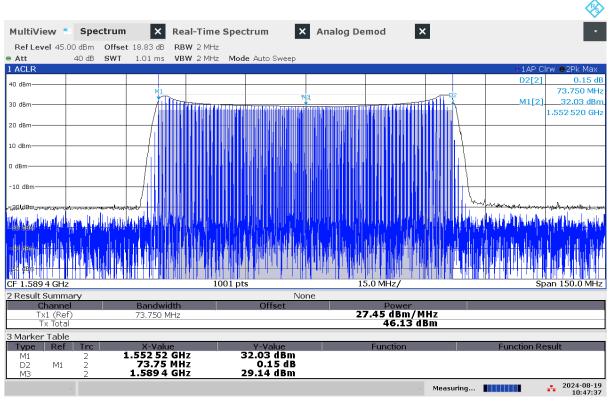
Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"F2" (L1)	1592,59	66,55	31,49	49,72	34,85	6,46 / 98,50	sinus / FM-modulert
"F3" (L1)	1589,40	73,75	27,45	46,13	29,14	6,24	sinus
"F4" (L2)	1243,65	76,22	25,42	44,24	26,94	6,20 / 155,00	sinus / FM-modulert
"F6" (L5)	1177,93	16,58	24,93	37,13	18,51	5,96	sinus

Technical characteristics of F6.1 (2024 measurements)



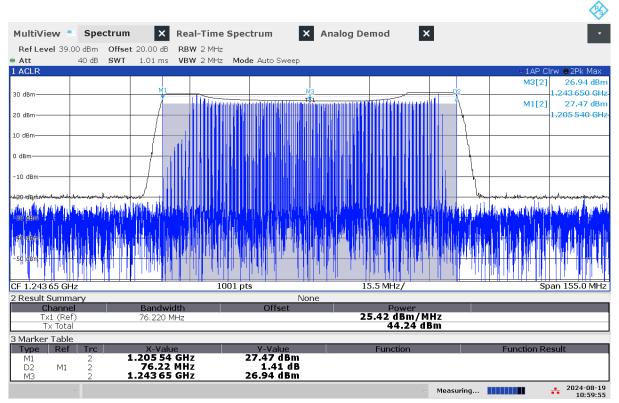
10:31:29 AM 08/19/2024



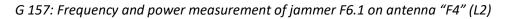


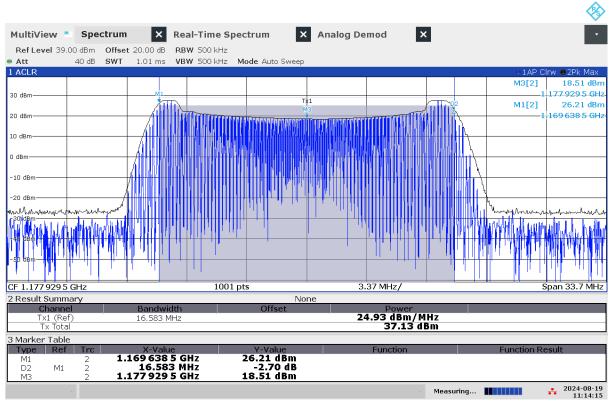
^{10:47:38} AM 08/19/2024

G 156: Frequency and power measurement of jammer F6.1 on antenna "F3" (L1)



10:59:56 AM 08/19/2024





^{11:14:16} AM 08/19/2024

G 158: Frequency and power measurement of jammer F6.1 on antenna "F6" (L5)

				I
MultiView 🔹 Spectrum 🗙	Real-Time Spectrum	Analog Demod	×	•
Ref Level 45.00 dBm Offset 18.83 dB Att 40 dB SWT 30 ms	RBW 3.375 MHz Dwell Time 30 ms			
YIG Bypass				
1 Persistence Spectrum O1Pk Clrw = 2	P Clrw • 3P Max 0% 0.01% 0.1%	5 0.5% 1% 2% 5 9	<u>6 10% 20%</u>	30% 50% 70% 100%
40 dBm			not in the	
30 dBm				
20 dBm				
10 dBm				
0 dBm				
-10 dBm				
-20 dBm				and the second second second
-30 dBm				
-40 dBm				
 International Control of the International Control of the Int	a dela Maria del Cristiano del Maria - Valenci (1946-1)	AT A MARKAN AND A DATA	LA MANUEL AND	A REAL PROPERTY AND A REAL PROPERTY.
-50'dBm	a tha an ta the shifts deals bit india a dia diab		in the first of a distance	
CF 1.592 585 GHz	13.6 M			Span 136.0 MHz
2 Spectrogram ●1Pk Clrw -55dBm	-40dBm -30dBm -20dBm	-10dBm OdBm	10dBm 20dBm	30dBm 45dBm
CF 1.592 585 GHz	Span 136	.0 MHz		Aug-19 10:42:21.33409
A			 Measuring 	2024-08-19 10:42:20

10:42:21 AM 08/19/2024

G 159: Real-time persistence and spectrogram measurement of jammer F6.1 on antenna "F2" (L1)

MultiView 📒 Spectrum 🗙	Real-Time Spectrum X Analog Demod	×
Ref Level 45.00 dBm Offset 18.83 dB	RBW 2.206 MHz	
Att 40 dB SWT 30 ms	Dwell Time 30 ms	
YIG Bypass 1 Persistence Spectrum 01Pk Clrw 02	PClrw o3PMax 03% 0.01% 0.1% 0.5% 1% 2% 5%	10% 20% 30% 50% 70% 100%
	P CI W C3P Max 0% 0.01% 0.1% 0.3% 1% 2% 3%	
40 dBm		
30 dBm		
20 dBm		
10 dBm		
0 dBm		
-10 dBm		
-20 dBm		the way have been a second
-30 dBm		
		A Martin Martin and a state of the second state of
-40 dBm	and the second	adapted a second se
-50 d8m-1		a Mahadalah bilah sari sin di Likebi pertama saka telahaka dar.
CF 1.589 4 GHz	15.0 MHz/	Span 150.0 MHz
2 Spectrogram O1Pk Clrw 55dBm	-40dBm -30dBm -20dBm -10dBm OdBm	10dBm 20dBm 30dBm 45dBm
CF 1.589 4 GHz	Span 150.0 MHz	Aug-19 10:53:35.93209
-		Measuring Measuring 2024-08-19 10:53:35

10:53:36 AM 08/19/2024

G 160: Real-time persistence and spectrogram measurement of jammer F6.1 on antenna "F3" (L1)

				I
MultiView Spectrum X	Real-Time Spectrum	× Analog Demod	×	•
Ref Level 39.00 dBm Offset 20.00 dB	RBW 2 MHz			
Att 40 dB SWT 30.1 ms YIG Bypass	Dwell Time 30.1 ms	S		
1 Persistence Spectrum 01Pk Clrw e 2	P Clrw • 3P Max 0% 0.01% 0	.1% 0.5% 1% 2% 5	5 <mark>% 10% 20% 3</mark>	0% 50% 70% 100%
30 dBm				
20 dBm				
10 dBm				
0 dBm				
-10 dBm				
=20-dBm			-	mahan
-30 dBm	an da an		Accession and a second second	
-40 dBm	a la	A COLUMN 2 AND A DAMA OF		
-50 dBm		an a sa tan tani ni ta ta ta		
date - de stat - reals a transfer a la la	ellint, h.e. w. t.			of the design of the latter
CF 1.24365 GHz		5 MHz/		Span 155.0 MHz
2 Spectrogram 1Pk Clrw	50dBm -40dBm -30dBm	-20dBm -10dBm (OdBm 10dBm 2	OdBm 30dBm 39dBm
CF 1.24365 GHz	Span 1	55.0 MHz		Aug-19 11:01:15.30893 2024-08-19
			- Measuring	11:01:15

11:01:15 AM 08/19/2024

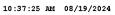
G 161: Real-time persistence and spectrogram measurement of jammer F6.1 on antenna "F4" (L2)

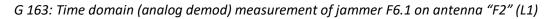
		♦
MultiView Spectrum 🗙	Real-Time Spectrum X Analog Demod X	•
Ref Level 39.00 dBm Offset 20.00 dB	RBW 500 kHz	
Att 40 dB SWT 30.1 ms	Dwell Time 30 ms	
YIG Bypass 1 Persistence Spectrum 0 1Pk Clrw • 2P	PC/rw o3PMax 0% 0.01% 0.1% 0.5% 1% 2% 5% 109	6 20% 30 <mark>% 50% 70% 100%</mark>
30 dBm		
20 dBm		
10 dBm		
0 dBm	A A A A A A A A A A A A A A A A A A A	
-10 dBm		
-20 dBm		
-30 dBm		him
-40 dBm		
-40 UBM		
-50 dBm		The second second second second second
erendentel a semiliterial all and think with a		and the latence of the second seco
CF 1.177 929 5 GHz	3.37 MHz/	Span 33.7 MHz
2 Spectrogram O1Pk Clrw -61dBm -5	50dBm -40dBm -30dBm -20dBm -10dBm 0dBm	10dBm 20dBm 30dBm 39dBm
CF 1.177 929 5 GHz	Span 33.7 MHz	Aug-19 11:15:23.74043

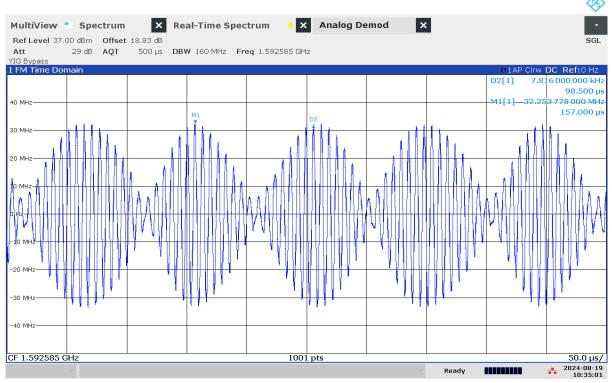
11:15:23 AM 08/19/2024

G 162: Real-time persistence and spectrogram measurement of jammer F6.1 on antenna "F6" (L5)

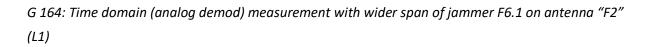


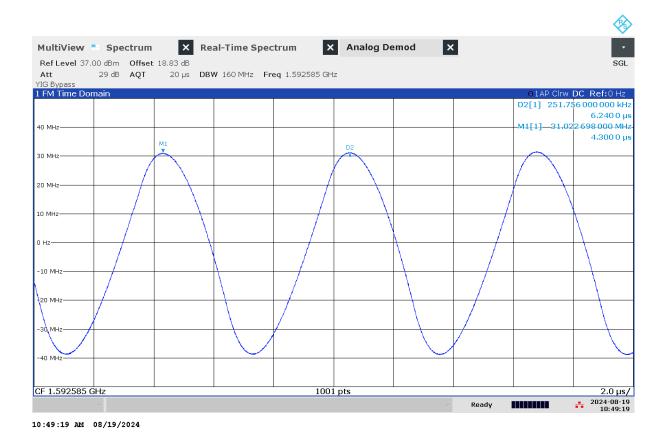


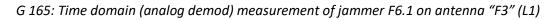


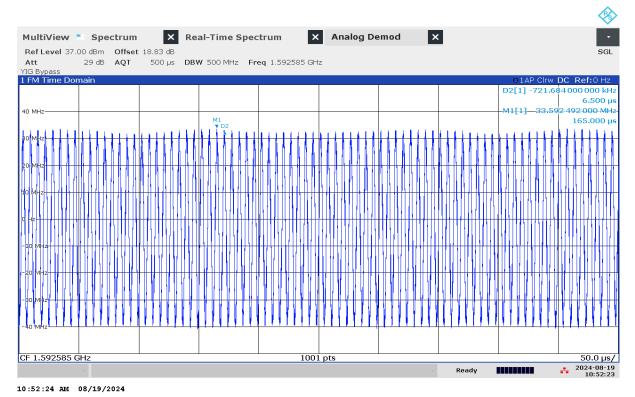


10:35:01 AM 08/19/2024

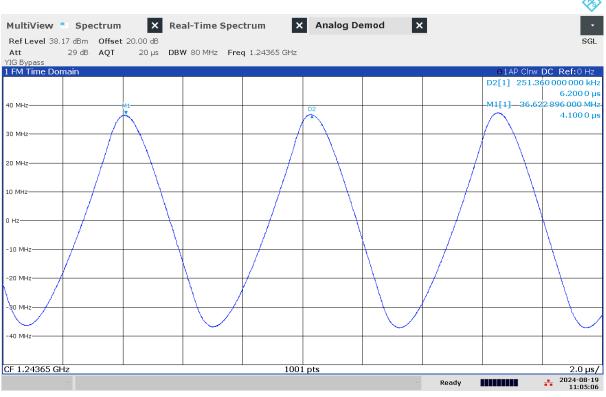


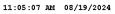


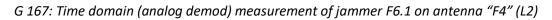


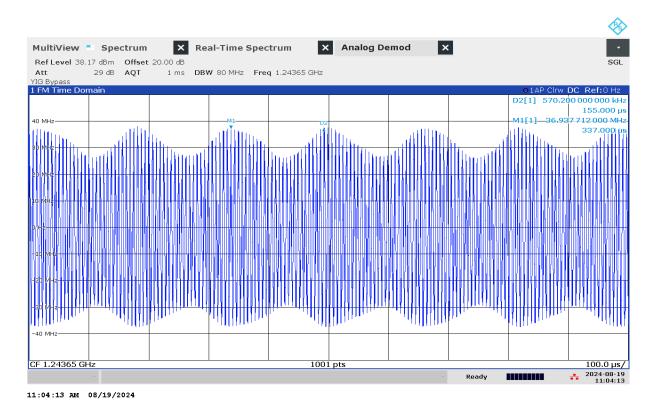


G 166: Time domain (analog demod) measurement with wider span of jammer F6.1 on antenna "F3" (L1)

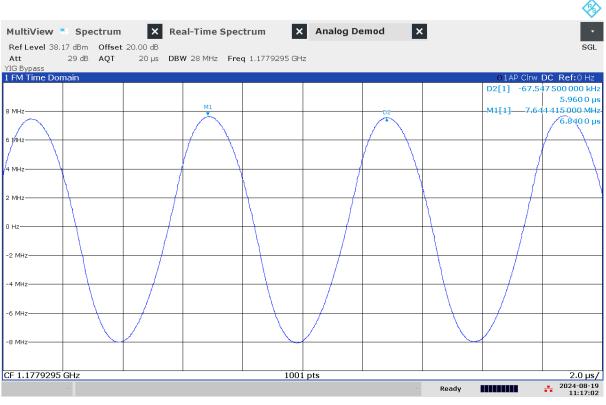




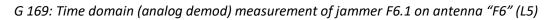


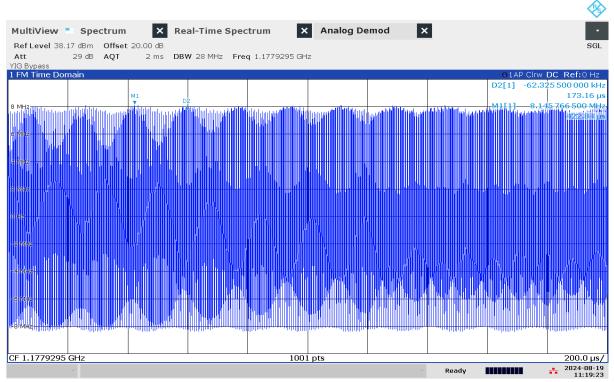


G 168: Time domain (analog demod) measurement with wider span of jammer F6.1 on antenna "F4" (L2)



11:17:03 AM 08/19/2024





11:19:24 AM 08/19/2024

G 170: Time domain (analog demod) measurement with wider span of jammer F6.1 on antenna "F6" (L5)

Technical details on low-power jammer H8.1

The jammer H8.1 belongs to the 'Handheld category' of jammers. It is a larger but relatively light battery driven jammer with a relatively easy operation, just an on/off-button with a LED-light to indicate activation and DIP switches to change between channels.

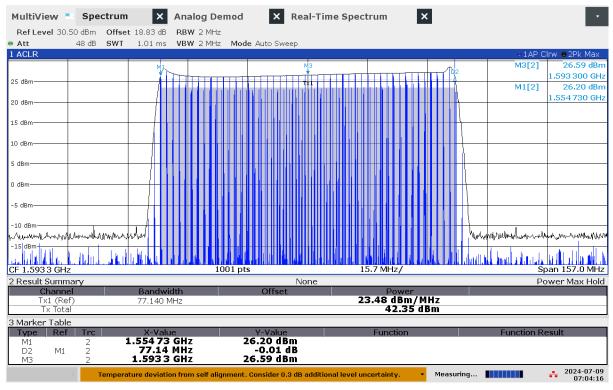
H8.1 is a eight-antenna, so-called "multi-frequency", jammer, but not a "multi-GNSS-jammer". It jams eight different bands, but only one GNSS-band ("L1-only"), so disrupting only the upper L-band.



Relevant GNSS antenna is marked: "6"

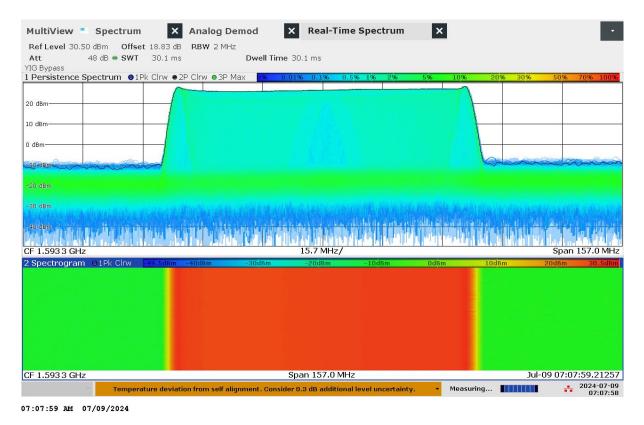
Technical characteristics of H8.1 (2024 measurements)

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
"6"	1593,30	77,14	23,48	42,35	26,59	10,47	Triangle



07:04:16 AM 07/09/2024

G 171: Frequency and power measurement of jammer H8.1 on antenna "6"



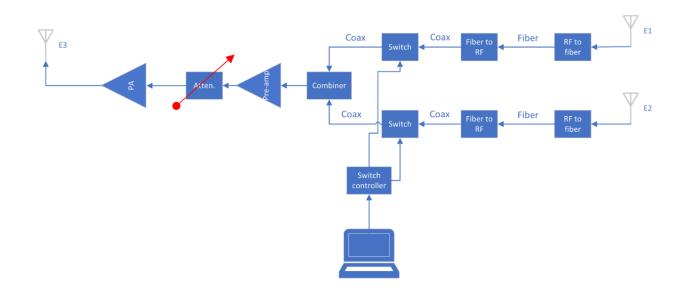
G 172: Real-time persistence and spectrogram measurement of jammer H8.1 on antenna "6"



G 173: Time domain (analog demod) measurement of jammer H8.1 on antenna "6"

Technical details on the meaconing setup "Porcellum" / "F1.1"

The meaconing setup consists of two GNSS antennas "E1" and "E2" at two respective locations some distance from the transmitting antenna. Real live sky signals from the receivers are (after travelling through long cables) retransmitted with a directional antenna "E3" pointing towards the community house in Bleik. The locations of the receiving antennas are outside of the line-of-sight to the transmitter antenna to avoid a feedback loop. The setup allows for switching between the two receiving antennas, ramping power and simultaneous transmission of both signals.



G 174: Diagram of the meaconing setup

Technical details on the high-power jammer "Porcus Major"/ "F8.1"

The high-power jammer provides jamming signals with up to 50 W EIRP simultaneously on eight GNSS bands, where the maximum available power depends on the signal modulations. Figure G 176 is a block diagram of the high-power jammer that shows how it works in pniciple. The jammer uses two USRP X410 SDR from Ettus Research as exciters. Each SDR have four output channels covering the frequency range of 1 MHz to 7.2 GHz, with maximum 400 MHz instantaneous bandwidth. The SDRs have an internal gain range of 60 dB in 1 dB steps. Each of the exciter output signals are fed to the corresponding channel of the programmable step-attenuator. The jammer can also utilize other signal generators. The attenuator has an attenuation range of 95 dB in 0.25 dB steps. The output signal from the attenuators is then fed to the power amplifiers. The amplifiers connect to eight individual antennas via a 10 m coax. The antennas are directional helical antennas with right hand circular polarization (RHCP) and 10 dB gain.

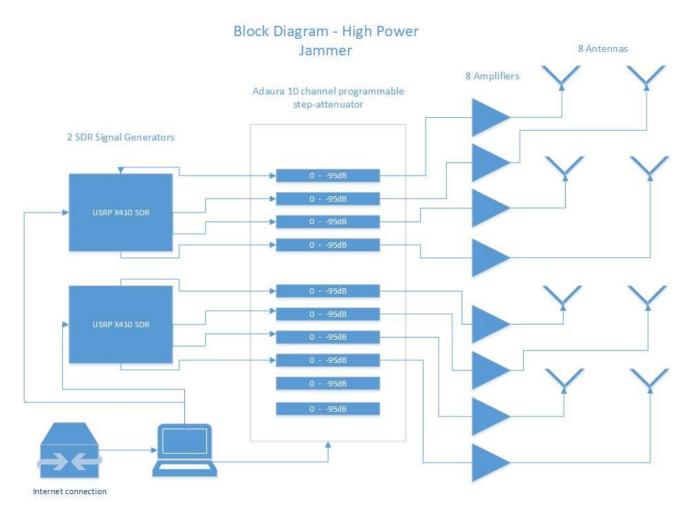
	CW		RN	Frequency sweep			
Frequency band name	Frequency (MHz)	Center frequency (MHz)	BPSK chiprate (MHz)	Center frequency (MHz)	Sweep rates (kHz)	Frequency bandwidth (MHz)	
L1	1575.42	1575.42	3	1575.42	1-100	6	
L2	1227.6	1227.6	3	1227.6	1-100	6	
L5	1176.45	1176.45	3	1176.45	1-100	6	
G1	1602	1602	3	1602	1-100	6	
G2	1246	1246	3	1246	1-100	6	
E5b	1207.14	1207.14	3	1207.14	1-100	6	
E6	1278.75	1278.75	3	1278.75	1-100	6	
B1I	1561.098	1561.098	3	1561.098	1-100	6	

An overview of the jammer signal modulations is given in G 175.

G 175: Overview of the signal modulations employed by 'Porcus Major'

A PC controls the high-power jammer, that is both exciters and the step-attenuators. Software allows for the jammer to automatically execute individual tests described for the high-power jammer and supports all jamming signals described therein.

The high-power jammer is connected to Internet and time synchronized using Network Time Protocol (NTP). After a jamming activity, it can upload the activity log to the central server.



G 176: Diagram of the high-power jammer

Technical details on software defined radio mobile SDR spoofer "F1.2"

A software defined radio (SDR) of type BladeRF x115 from Nuand is used for the mobile spoofing tests. The output signal is amplified 45 dB through an AA MCS 800 – 2200MHz amplifier, so that the maximum total EIRP is about 10 dBm. This signal is transmitted by a dipole antenna on the top of the vehicle, see <u>ds1036-080410.pdf (european-antennas.co.uk)</u>.



G 177: Picture of the SDR without casing

The spoofed signals are GPS C/A only and may be combined with Glonass jamming (G1).

Appendix H - Andøya ground truth

Appendix H

Reference frame offsets for ground truth markers at Jammertest 2024

1. Introduction

Based on requests received at Jammertest 2023, the Norwegian Public Roads Administration and the Norwegian Mapping Authority plan to establish some ground truth markers for use at Jammertest 2024. Ground Truth (GT) markers are well marked points on ground (or tied to ground), for which accurate coordinates have been computed. We provide this document to inform the Jammertest participants about the differences between the most commonly used geodetic reference frames in Norway. The document also provides the necessary information to perform simple horizontal transformations between these reference frames, and some information about the differences between ellipsoidal heights ("GNSS heights") and physical heights ("heights above mean sea level") in the test areas.

2. Geodetic reference systems and reference frames

The terms "reference system" and "reference frame" are often used somewhat interchangeably, which might be confusing. The difference between these terms is that a reference **system** is the theoretical definition of a coordinate system and its relation to a geophysical or geometrical model of the earth, whereas a reference **frame** consists of a set of physical points with computed coordinates that indirectly defines the "invisible" reference system. Therefore, a reference frame is called a realization of a reference system. For example, ETRF89 (European Terrestrial Reference Frame 1989) is a realization of ETRS89 (European Terrestrial Reference System 1989).

3. EUREF89

EUREF89 is a Norwegian densification of ETRF89 and is the official reference frame for Norwegian maps. EUREF89 is considered a static 3D reference frame with reference epoch 1989 Jan. 1st. The term "static" means that the reference frame is tied to the stable part of the Eurasian tectonic plate, so that the horizontal coordinates of a point do not change with time (as a general rule). This differs from dynamic reference frames, ref. section 5.

The GT will be given as coordinates for a set of physically marked points, given in the reference frame EUREF89 (ETRF89) and coordinate differences to WGS84, known as the "GPS reference frame".

To ensure correctness of the GT, measurements and calculations will be performed independently by geodesists both at The Norwegian Mapping Authority (NMA) and The Norwegian Public Road Administration (NPRA).

4. Some coordinate forms in a reference frame

Coordinates for a point P at the surface of the Earth can be given in various forms, e.g.

- Cartesian coordinates X, Y, Z
- Ellipsoidal coordinates φ (latitude), λ (longitude), h (height above ellipsoid) (Figure 1)
- In a map projection, e.g. UTM33 as North, East and height (above ellipsoid) (Figure 2)

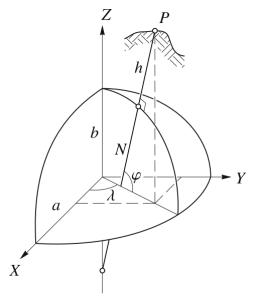


Figure 1: From [1] GNSS – Global Navigation Satellite Systems

Equations to convert between the coordinate forms, see e.g. [1].

The NMA operates a nationwide Network RTK service which is named CPOS. Coordinates for the permanent GNSS stations in CPOS refer to EUREF89.

Note: Coordinates computed by measurements to a GNSS rover unit refer to EUREF89 when using corrections from CPOS. More information in the NMA report [3]: *Norwegian reference frames and transformations.*

Approximate coordinates for one point representing the test area in EUREF89 UTM zone 33 is North N=7,690,000 and East E=540,000 or Latitude: 69.316631093° and Longitude: 16.014796031°.



Figure 2: The UTM33 grid nearby Andøya

(Figure 1)

5. Dynamic or global 4D reference frames

In a global or a dynamic reference frame, the coordinates of a point change as a function of time, as the continents move mainly due to the plate tectonics. To achieve unambiguity in such a frame, the time (epoch) to which the data refer must be specified. ITRF2014, IGS14 and WGS84 are all dynamic and very similar reference frames.

Note: A single GPS unit without any corrections will refer to WGS84, current epoch of time (the moment of measurement).

6. Reference frame differences at Andøya, September 2024

A transformation with the NMA software SkTrans from EUREF89 to ITRF2014 (very similar to WGS84) UTM33 epoch 2024.69 (2024 Sep.) gives N= 7,690,000.6355, E= 540,000.4579 or Lat = 69.316636723° and Long = 16.014807912°.

Transformation equations from EUREF89 epoch 1989.00 to ITRF2014≈WGS84 epoch 2024.69 for all points the test area around Andøya around 2024 September 10th then become:

$N_{WGS84\ epoch2024.7} = N_{EUREF89UTM33_{epoch1989.0}} + \Delta N$	where	ΔN=0.64m
$E_{WGS84 epoch2024.7} = E_{EUREF89UTM33_{epoch1989.0}} + \Delta E$	where	∆E = 0.46m
·		
$\varphi_{WGS84\ epoch2024.7} = \varphi_{EUREF89UTM33_{epoch1989.0}} + \Delta Lat$	where	$\Delta Lat = 0.0000056^{\circ}$
$\lambda_{WGS84 epoch2024.7} = \lambda_{EUREF89UTM33_{epoch1989.0}} + \Delta Long$	where	$\Delta Long$ = 0.0000119

Seven significant decimal digits for latitude and longitude will ensure cm-precision.

7. Vertical coordinates (heights)

Vertical coordinates (heights) computed by GNSS receivers refer to a rotational ellipsoid which is a simplified model of the earth. These heights are called ellipsoidal heights, or heights above ellipsoid. On the other hand, the mean sea level roughly aligns to the geoid, which is an equipotential surface in the earth's gravity field. In order to translate ellipsoidal heights into physical heights (heights above mean sea level), a geoid model must be applied. Geoid models originate from gravimetric measurements. If high accuracy of the physical heights is required, height reference models (which are geoid models adjusted by a combination of GNSS measurements and levelling) must be used. Many GNSS receivers have built-in geoid models or height reference models.

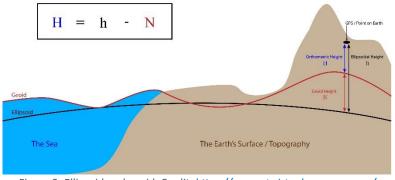


Figure 3: Ellipsoid and geoid. Credit: <u>https://support.virtual-surveyor.com/</u>

The differences [ellipsoidal heights minus physical heights] (N in Figure 3) in the Jammertest areas vary from about +35.6 meters at Andenes to about +36.2 meters at Nordmela just south of test area 3.

8. References

- [1] GNSS Global Navigation Satellite Systems, Hofmann-Wellenhof, Lichtenegger and Wasle ISBN 978-3-211-73012-6 SpringerWienNewYork 2008
- [2] <u>Geodetisk grunnlag [Geodetic datum] (in Norwegian language only)</u>
- [3] <u>Referanserammer og transformasjoner</u> [Reference frames and transformations](in Norwegian language only) NMA report: 19-04811-18, ISBN: 978-82-7945-476-2



Statens vegvesen

Norwegian Public Roads Administration

