Jammertest 2025
Test Catalogue

Jammertest Consortium

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Statens vegvesen
Norwegian Public Roads Administration

FFI Forsvarets forskningsinstitutt
Norwegian Defence Research Establishment

Norsk Romsenter
Norwegian Space Agency

NKOM Nasjonal kommunikasjons-myndighet

Kartverket

Justervesenet

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TESTNOR

Contents

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

Min: 0.01 W
Max: 0.0316 W

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

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

'S2.3'

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

Min: 0.0003 W
Max: 0.1 W

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 W
Max: 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

Min: 0.3981 W
Max: 1 W

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

Min: 0.3981 W
Max: 1 W

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

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'

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

'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

’F8.1’

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'

1.2.5 Jammer F8.1 "Porcus Major": 50 W CW: L1, G1, L2, L5, E6

Jammer F8.1 "Porcus Major": 50 W CW: L1, G1, L2, L5, E6

Power or power range

Min: 1 W
Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1', 'L2', 'L5', 'E5a', 'B2a', 'E6'

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

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50 W sweep: L1, sweep rate: 100 kHz

Power or power range

Min: 1 W
Max: 50 W

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

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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

'F8.1'

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’

1.3.9 Jammer F8.1 ”Porcus Major”: 50 W sweep: L1, G1, L2, L5, E6, 100 kHz

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Jammer F8.1 ”Porcus Major”: 50 W sweep: L1, G1, L2, L5, E6, 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’, ’E6’

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 chiprate used is described in each test. 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

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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

'F8.1'

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'

1.4.5 Jammer F8.1 ”Porcus Major”: 50 W PRN: L1, Chiprate: 1.023 MHz

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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’

1.4.6 Jammer F8.1 ”Porcus Major”: 50 W PRN: L1, G1, L2, L5, E6, Chiprate: 1.023 MHz

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Jammer F8.1 ”Porcus Major”: 50 W PRN: L1, G1, L2, L5, E6

Power or power range

Min: 1 W
Max: 50 W

Test bands/constellation

’L1’, ’E1’, ’B1C’, ’G1’, ’L2’, ’L5’, ’E5a’, ’B2a’, ’E6’

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)

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

Power or power range

Min: 1 W
Max: 50 W

Test bands/constellation

'L1'

Transmitter equipment

'F8.1'

1.5.2 50 W: G1, PRN (Mbaud of 10.23)

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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. The time between power level steps is specified for each test, 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 µW (-37dBm) to a maximum of 50 W (47dBm) with 2 dB increments, within the test band L1. Power level step time 10 seconds

Power or power range

Min: 2e-07 W
Max: 50 W

Test bands/constellation

’L1’, ’E1’, ’B1C’

Transmitter equipment

’F8.1’

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 level step time 10 seconds

Power or power range

Min: 2e-07 W
Max: 50 W

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 level step time 10 seconds

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 µW (-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 level step time 10 seconds

Power or power range

Min: 2e-07 W
Max: 50 W

Test bands/constellation

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

Transmitter equipment

’F8.1’

1.6.5 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 µW (-37dBm) to a maximum of 50 W (47dBm) with 2 dB increments, within the test band L1. Power level step time 20 seconds

Power or power range

Min: 2e-07 W
Max: 50 W

Test bands/constellation

’L1’, ’E1’, ’B1C’

Transmitter equipment

’F8.1’

1.6.6 Power ramping with Jammer F8.1 ”Porcus Major”: 0.2 µW (-37dBm) to 50 W (47dBm) with 2 dB increments PRN: L1, G1, L2, L5, E6

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, E6. Power level step time 20 seconds

Power or power range

Min: 2e-07 W
Max: 50 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1', 'L2', 'L5', 'E5a', 'B2a', 'E6'

Transmitter equipment

'F8.1'

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 µW (-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

’F8.1’

1.7.3 0.2 µW (-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

Min: 2e-07 W
Max: 50 W

Test bands/constellation

’L1’, ’E1’, ’B1C’, ’G1’, ’L2’

Transmitter equipment

’F8.1’

1.7.4 0.2 µW (-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

Min: 2e-07 W
Max: 50 W

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.

Tests within this test group

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

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'

1.9: 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.

Tests within this test group

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:
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
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

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).

Tests within this test group

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

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'

1.10.2 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 perfomred 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

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'

1.10.5 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

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', '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 dual- and 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 jammer-carrying 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

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'

1.11.4 (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

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'

1.11.5 (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'

Transmitter equipment

'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'

Transmitter equipment

'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

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'

1.12.3 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 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'

1.13: 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'

Transmitter equipment

'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

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'

1.13.8 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.

Power or power range

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 µW 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,

Power or power range

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.

Power or power range

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

'F8.1'

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

'F8.1'

1.16.5 High Power PRN jamming from multiple locations: L1, G1, L2, L5, E6

High Power PRN jamming from multiple locations: L1, G1, L2, L5, E6. One hour jamming from F8.1, then one hour jamming from both F8.1 and M1.1, then last hour jamming from M1.1 only

Power or power range

Min: 50 W
Max: 100 W

Test bands/constellation

'L1', 'E1', 'B1C', 'G1', 'L2', 'L5', 'E5a', 'B2a', 'E6'

Transmitter equipment

'F8.1', 'M1.1'

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

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10 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

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10 W PRN: L5

Power or power range

Min: 1 W
Max: 10 W

Test bands/constellation

'L5', 'E5a', 'B2a'

Transmitter equipment

'APJ'

1.17.3 10 W CW: L1, L5

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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

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10 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

'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

Power or power range

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 W 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.

Tests within this test group

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

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50 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

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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 W CW: L5

Power or power range

Min: 50 W
Max: 50 W

Test bands/constellation

’L5’, ’E5a’, ’B2a’

Transmitter equipment

’F8.1’

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 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

’F8.1’

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

Min: 50 W
Max: 50 W

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 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

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50 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

’F8.1’

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

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50 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

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50 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

’F8.1’

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

Min: 50 W
Max: 50 W

Test bands/constellation

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

Transmitter equipment

’F8.1’

1.18.16 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 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 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 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

’F8.1’

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 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

Min: 50 W
Max: 50 W

Test bands/constellation

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

Transmitter equipment

’F8.1’

1.19: 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 10 minutes) before being turned off. A break (of for example 6 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

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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’

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

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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

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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'

Transmitter equipment

'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

Min: 0.01 W
Max: 1.26 W

Test bands/constellation

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

Transmitter equipment

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

1.19.6 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).

Tests within this test group

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

Min: 0.1 W
Max: 0.116 W

Test bands/constellation

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

Transmitter equipment

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

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

HIGH PWR, L1 NB, L2 NB

Power or power range

Min: 0.1 W
Max: 0.116 W

Test bands/constellation

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

Transmitter equipment

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

1.20.4 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 W
Max: 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

Min: 200 W
Max: 200 W

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'

1.22: Circular testing with many handheld 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 many low-power handheld jammers for mulitple directions. Stress test for CRPA antennas

Test description

Circular testing with many handheld jammers

Tests within this test group

1.22.1 12 jammers at 50 meters from center

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12 jammers from A50, B50 and C50. USB, Cigarette jammers and handheld jammers at the same time to create a very strong field of jamming.

Power or power range

Min: 10 W
Max: 3 W

Test bands/constellation

'L1', 'L2', 'L5'

Transmitter equipment

'U1.1', 'U1.2', 'U1.3', 'S2.1', 'S2.2', 'S2.3', 'H1.1', 'H1.4', 'H1.5', 'H6.3', 'H6.4', 'H6.5'

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

'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

'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

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.
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'

2.1.8 Large position and time jump. GPS and Galileo , with initial and continuous jamming

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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

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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

'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

'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

Min: 3.16 W
Max: 3.16 W

Test bands/constellation

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

Transmitter equipment

'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

’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

’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

Min: 0.316 W
Max: 0.316 W

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

Min: 0.316 W
Max: 0.316 W

Test bands/constellation

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

Transmitter equipment

'S'

2.3.2 Small position jump with initial and continuous jamming

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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

'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

Min: 0.316 W
Max: 0.316 W

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

'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

'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

'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

'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 W
Max: 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

Min: 0.316 W
Max: 0.316 W

Test bands/constellation

'E1', 'E5a', 'E5b'

Transmitter equipment

'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

'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

Min: 0.316 W
Max: 0.316 W

Test bands/constellation

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

Transmitter equipment

'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

Min: 0.316 W
Max: 0.316 W

Test bands/constellation

’L1’, ’L2’, ’L5’, ’E1’, ’E5a’, ’E5b’

Transmitter equipment

’S’

2.3.14 Sailing (route 5) - ”ship scenario”

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

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 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'

2.3.16 Longer period with position and time spoofing

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

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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

'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.
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'

2.4.6 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'

2.4.7 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

Min: 0.001 W
Max: 0.001 W

Test bands/constellation

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

Transmitter equipment

'S'

2.4.8 Static + Frequency step, with initial and continous jamming

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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

'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

'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 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'

2.4.12 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

Min: 0.001 W
Max: 0.001 W

Test bands/constellation

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

Transmitter equipment

'S'

2.4.13 Static + Pseudorange error, with initial and continous jamming

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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

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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'

2.5.2 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

Min: 1e-05 W
Max: 0.0316 W

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

Min: 3.16e-07 W
Max: 0.0316 W

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

'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

'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'

Transmitter equipment

'S'

2.5.9 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

'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

'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

Min: 0.001 W
Max: 0.001 W

Test bands/constellation

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

Transmitter equipment

'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

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

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

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

'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

'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

'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

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

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

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 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'

2.5.21 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

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

Test bands/constellation

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

Transmitter equipment

'S'

2.5.22 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 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

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

Test bands/constellation

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

Transmitter equipment

'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

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

Test bands/constellation

'L1'

Transmitter equipment

'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

'S'

2.5.28 Static + UTC-parameter nav. data manipulation (removing 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 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

'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 W
Max: 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 thelatest 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

Min: 0.01 W
Max: 0.01 W

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 Static + Time manipulation (2 years backwards). GPS L1 and Galileo E1 only

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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

---

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 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'

2.7.6 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

'S'

2.7.7 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

'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

'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

'S'

2.7.11 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 Static + 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

Signals: EGNOS L1.
No jamming.
The transmission of false SBAS signals will start immediately upon test start.

Power or power range

Min: 1 W
Max: 1 W

Test bands/constellation

'L1'

Transmitter equipment

'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

Min: 0.1 W
Max: 0.1 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'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

Min: 0.1 W
Max: 0.1 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'S'

2.9.3 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 W
Max: 0.0316 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'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

'S'

2.9.5 Static + Nav. data manipulation (invalid ephemerids), with initial and continuous jamming

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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

---

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.
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

'S'

2.10: Stationary coherent spoofing with circle of jammers

Rationale

This testgroup is relevant for CRPA antenna testing and TDOA detection equipment, as well as drone testing. The main objective is saturate the CRPA nulling channels with jamming from many directions and then bring in a low powered coherent spoofer between the nulls that will get passed the CRPA electronics to the protected receivers. Three Novatel jammers of the same type are placed in a circle 120 degrees a part. Distance from center is 50 meters (A50, B50 and C50). A coherent spoofer is placed nearby, and will spoof you away from the center position (LOK2_ORIG) onto a given route. For the first test the spoofing signal will be shown. For the second test the cirle of jammers will start, and then the same spoofing route will come on air again. The testgroup will further expand with more jammers for each test, repeating the same spoofing route. You might want to set your protected receiver to use L1/E1 only for these tests.

Tests within this test group

2.10.1 Spoofing route GPS L1 and Galileo E1 only

Spoofing route that start at LOK2-ORIG, and goes out forming a spoofing cirle above position A150, B150 and C150. Spoofing signal will perfom power ramp from uW to mW during the first 30 minutes of the test. Signals: GPS L1 C/A. Galileo E1. No initial jamming. Spoofing route duration is 40 minutes.

Power or power range

Min: 0.0001 W
Max: 0.001 W

Test bands/constellation

'L1', 'E1'

Transmitter equipment

'Spoofer M1.1 Winnie-the-Spoof'

2.10.2 Circle of 3 stationary jammers, L1, L2 and spoofing route GPS L1 and Galileo E1 only

---

Jamming from A50, B50 and C50, with jammer H1.1, H1.4 and H1.5, L1, L2, CHIRP. HIGH PWR. The Jammers are connected to RHCP antennas to boost the power. 15 minutes of initial jamming first. Then spoofing starts. Spoofing route will start at LOK2-ORIG, and goes out forming a spoofing cirle above position A150, B150 and C150. Spoofing signal will perfom power ramp from uW to mW during the first 30 minutes of the test. Spoofing signals: GPS L1 C/A. Galileo E1. Spoofing route duration is 40 minutes.

Power or power range

Min: 1 W
Max: 3 W

Test bands/constellation

'JAM L1, L2', 'SPOOF L1 C/A, E1'

Transmitter equipment

'Jammer H1.1, H1.4, H1.5', 'Spoofer M1.1 Winnie-the-Spoof'

2.10.3 Circle of 3 stationary jammers, 2 moving jammers L1, L2 and spoofing route GPS L1 and Galileo E1 only

---

Jamming from A50, B50 and C50, with jammer H1.1, H1.4 and H1.5, L1, L2, CHIRP. HIGH PWR. The Jammers are connected to RHCP antennas to boost the power. Two additional mobile jammers will be added H1.6 and H1.7 with L1, L2 NB, HIGH PWR. 15 minutes of initial jamming first. Then spoofing starts. Spoofing route will start at LOK2-ORIG, and goes out forming a spoofing cirle above position A150, B150 and C150. Spoofing signal will perfom power ramp from uW to mW during the first 30 minutes of the test. Spoofing signals: GPS L1 C/A. Galileo E1. Spoofing route duration is 40 minutes.

Power or power range

Min: 1 W
Max: 4 W

Test bands/constellation

'JAM L1, L2', 'SPOOF L1 C/A, E1'

Transmitter equipment

'Jammer H1.1, H1.4, H1.5, H1.6, H1.7', 'Spoofer M1.1 Winnie-the-Spoof'

2.10.4 Circle of 3 stationary jammers, 5 moving jammers and spoofing route GPS L1 and Galileo E1 only

Jamming from A50, B50 and C50, with jammer H1.1, H1.4 and H1.5, L1, L2, CHIRP. HIGH PWR. The Jammers are connected to RHCP antennas to boost the power. Five additional mobile jammers will be added H1.6 and H1.7 with L1, L2 NB, HIGH PWR, and H6.3, H6.4 and H6.5, L1, L2. 15 minutes of initial jamming first. Then spoofing starts. Spoofing route will start at LOK2-ORIG, and goes out forming a spoofing cirle above position A150, B150 and C150. Spoofing signal will perfom power ramp from uW to mW during the first 30 minutes of the test. Spoofing signals: GPS L1 C/A. Galileo E1. Spoofing route duration is 40 minutes.

Power or power range

Min: 1 W
Max: 5 W

Test bands/constellation

'JAM L1, L2', 'SPOOF L1 C/A, E1'

Transmitter equipment

'Jammer H1.1, H1.4, H1.5, H1.6, H1.7, H6.3, H6.4, H6.5', 'Spoofer M1.1 Winnie-the-Spoof'

3 Meaconing

3.1: Stationary meaconing 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 initital 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 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 initital 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 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

Min: 10 W
Max: 10 W

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

Min: 10 W
Max: 10 W

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

Min: 10 W
Max: 10 W

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 meaconing 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 tranmission 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 – 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.

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

Min: 0.01 W
Max: 10 W

Test bands/constellation

’L1’, ’E1’, ’B1C’, ’L2’

Transmitter equipment

’F1.1’

3.4: Stationary meaconing from a single receiver in combination with other deceptive signals

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. In addition, multiple spoofing signals will be transmitted from different directions. The objective of these tests is to observe how equipment and systems behave under varying meaconing tranmission 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 antenna for the receiver 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.

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

3.4.1 Meacon F1.1 ”Porcellus”: RX1 and spoofing frm F?.? Winnie the Spoof

---

Meaconing from receiver RX1, combined with spoofing signal from location ???

Power or power range

Min: 10 W
Max: 10 W

Test bands/constellation

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

Transmitter equipment

'F1.1'

3.4.2 Meacon F1.1 "Porcellus": RX1 and spoofing from F?.? Winnie the Spoof

---

Meaconing from receiver RX1, combined with mobile spoofing signal

Power or power range

Min: 10 W
Max: 10 W

Test bands/constellation

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

Transmitter equipment

'F1.1'

3.4.3 Meacon F1.1 "Porcellus": RX1 and JV

Meaconing from receiver RX1 combined with meaconing from community house. RX1 power level is constant 10W, while the community house signal power level is ramped up

Power or power range

Min: 0.001 W
Max: 10 W

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=0.64m

$E\ WGS84\ epoch2024.7$ = $EEUREF89UTM33epoch1989.0$ + ΔE where ΔE = 0.46m

$\varphi\ WGS84\ epoch2024.7$ = $\varphi EUREF89UTM33epoch1989.0$ + ΔLat where ΔLat =0.0000056°

λ $WGS84\ epoch2024.7$ = λ$EUREF89UTM33epoch1989.0$ + $\Delta Long$ where $\Delta Long$= 0.0000119

Seven significant decimal digits for latitude and longitude will ensure cm-precision.

Point ID	Latitude	Longitude	Ellipsoidal height	Physical height	Northing UTM33	Easting UTM33	Mark
SAMF	69.27560042	15.96812897	42.73	6.88	7685395.45	538232.98	Foot antenna at roof
MECONING	69.28000843	16.00593213	370.23	334.44	7685910.97	539717.71	rig
RX_1	69.28031078	16.01065010	352.50	316.72	7685947.75	539903.42	Green antenna
RX_2	69.27876623	16.01691109	358.16	322.39	7685779.63	540153.46	White antenna
SENDER	69.28007238	16.00643461	381.98	346.19	7685918.43	539737.43	rig
REFANTENNA	69.27538406	15.96826115	41.01	5.16	7685371.41	538238.59	Grey ant. yellow tripod
E-BLEIK-RF	69.27560844	15.96881180	42.64	6.79	7685396.77	538259.93	Ericsson Right Front
E-BLEIK-LF	69.27560014	15.96882632	42.60	6.75	7685395.85	538260.52	Ericsson Left Front
E-BLEIK-LB	69.27560509	15.96884918	42.60	6.75	7685396.42	538261.42	Ericsson Left Back
E-BLEIK-RB	69.27561842	15.96885426	42.65	6.80	7685397.91	538261.59	Ericsson Right Back
11	69.27548568	15.96814545	40.85	5.00	7685382.66	538233.84	Antenna rig

12	69.27549051	15.96816671	40.84	4.99	7685383.22	538234.67	Antenna rig
13	69.27549534	15.96818795	40.85	5.00	7685383.77	538235.50	Antenna rig
14	69.27550022	15.96820929	40.86	5.01	7685384.32	538236.33	Antenna rig
21	69.27549321	15.96813174	40.86	5.01	7685383.49	538233.28	Antenna rig
22	69.27549803	15.96815312	40.87	5.02	7685384.05	538234.12	Antenna rig
23	69.27550290	15.96817433	40.88	5.03	7685384.60	538234.95	Antenna rig
24	69.27550779	15.96819577	40.89	5.04	7685385.16	538235.79	Antenna rig
31	69.27550083	15.96811797	40.89	5.04	7685384.34	538232.73	Antenna rig
32	69.27550562	15.96813928	40.89	5.04	7685384.88	538233.56	Antenna rig
33	69.27551050	15.96816054	40.91	5.06	7685385.44	538234.39	Antenna rig
34	69.27551533	15.96818190	40.92	5.07	7685385.99	538235.22	Antenna rig
41	69.27550813	15.96810477	40.92	5.07	7685385.14	538232.19	Antenna rig
42	69.27551297	15.96812596	40.93	5.08	7685385.69	538233.02	Antenna rig
43	69.27551782	15.96814729	40.94	5.09	7685386.25	538233.85	Antenna rig
44	69.27552264	15.96816853	40.96	5.11	7685386.80	538234.68	Antenna rig
1	69.27553403	15.96883049	39.86	4.01	7685388.48	538260.80	Asphalt nail
2	69.27523091	15.96674688	40.48	4.63	7685353.39	538179.06	Asphalt nail
LOK2-ORIG	69.22249871	15.93303984	66.92	31.04	7679453.28	536937.52	Tree stick, Height ref: terrain
A50	69.22293289	15.93335322	65.69	29.80	7679501.88	536949.19	Tree stick,

							Height ref: top
A100	69.22336709	15.93366659	65.76	29.87	7679550.48	536960.86	Tree stick, Height ref: top
A150	69.22380127	15.93398000	65.64	29.75	7679599.08	536972.52	Tree stick, Height ref: top
B50	69.22218526	15.93394222	65.80	29.91	7679418.87	536973.77	Tree stick, Height ref: top
B100	69.22187181	15.93484460	66.76	30.88	7679384.47	537010.03	Tree stick, Height ref: top
B150	69.22155835	15.93574693	67.95	32.07	7679350.07	537046.28	Tree stick, Height ref: top
C50	69.22237796	15.93182408	64.44	28.55	7679439.08	536889.60	Tree stick, Height ref: top
C100	69.22225721	15.93060834	63.97	28.08	7679424.89	536841.68	Tree stick, Height ref: top
C150	69.22213644	15.92939261	63.64	27.75	7679410.69	536793.75	Tree stick, Height ref: top

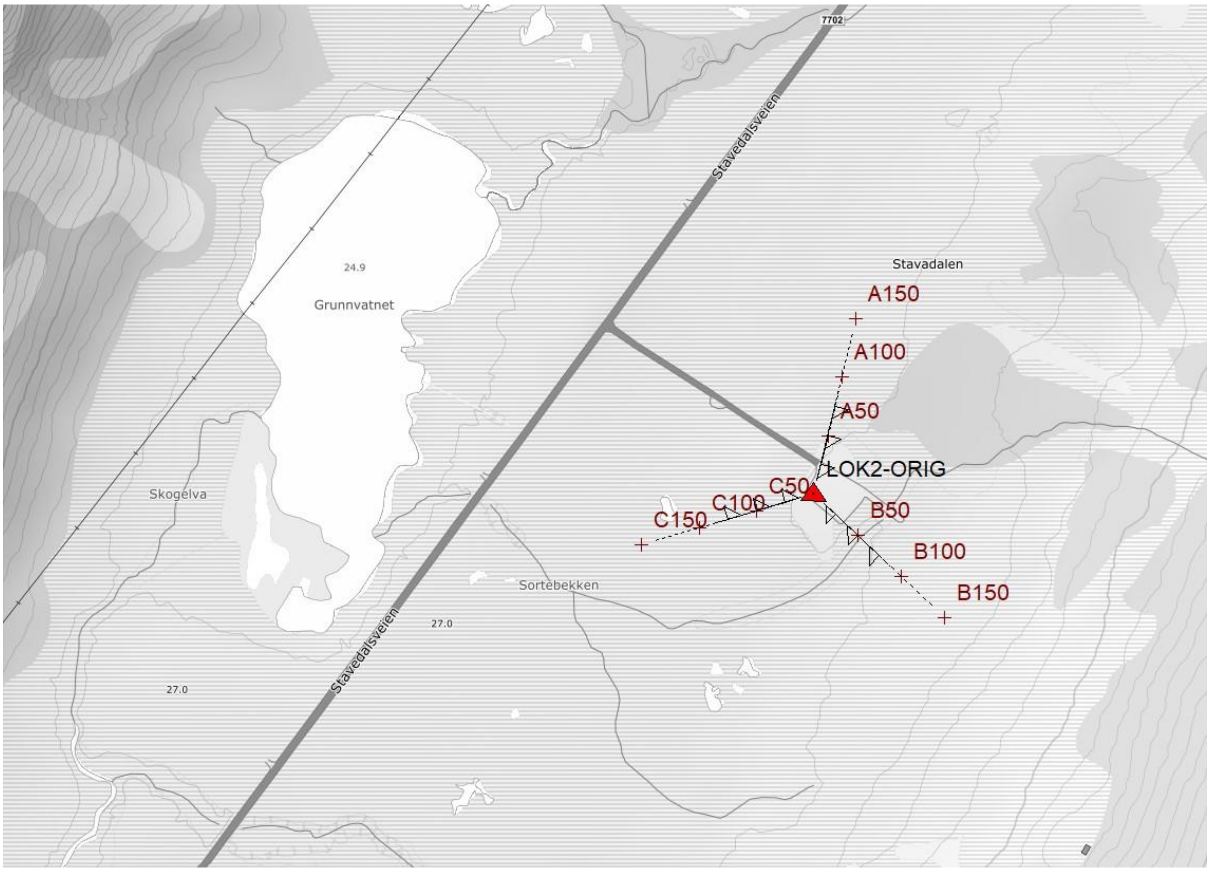
Description of site 1

Overview of survey points

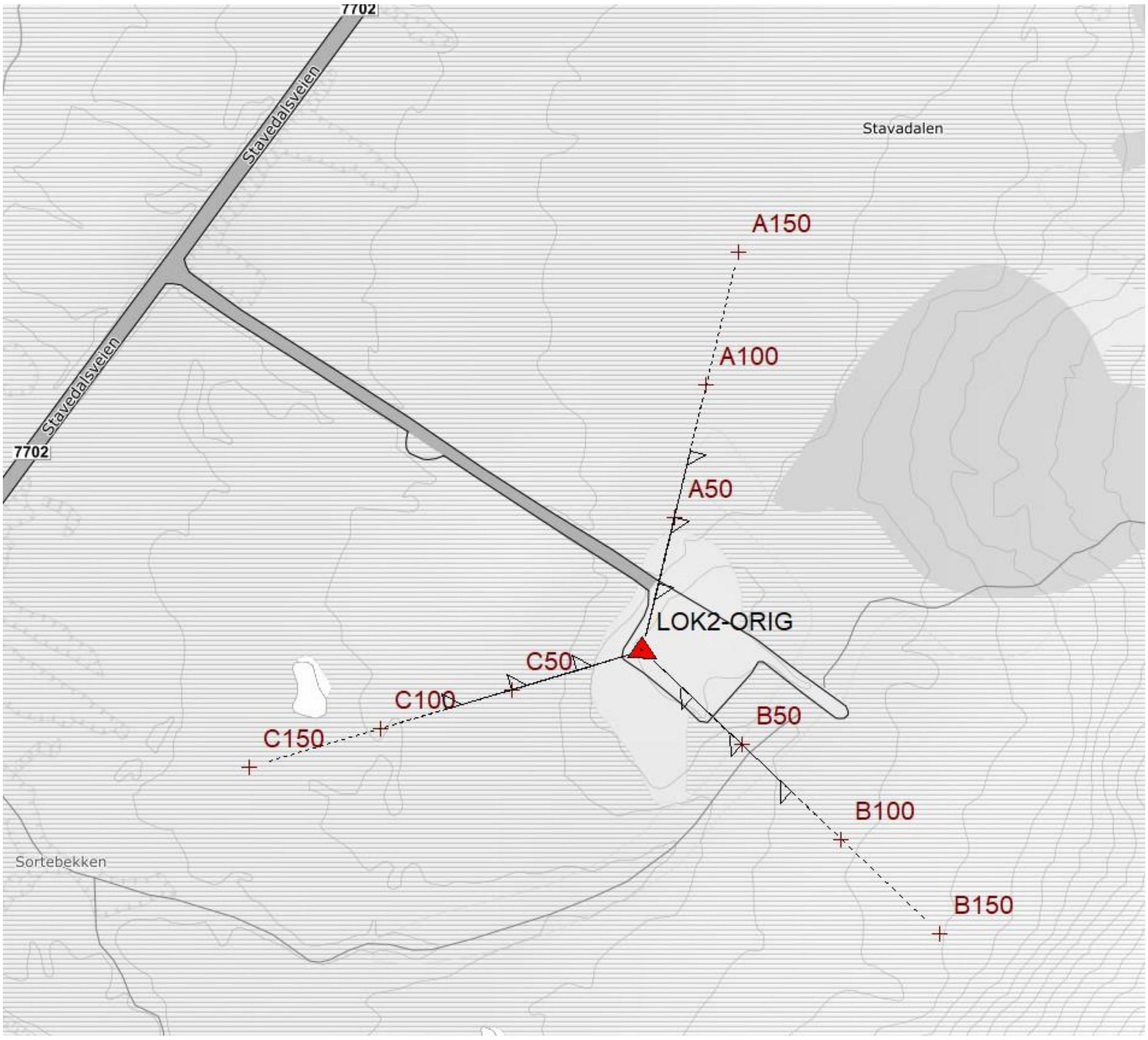
More detailed view of surveyed points.

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

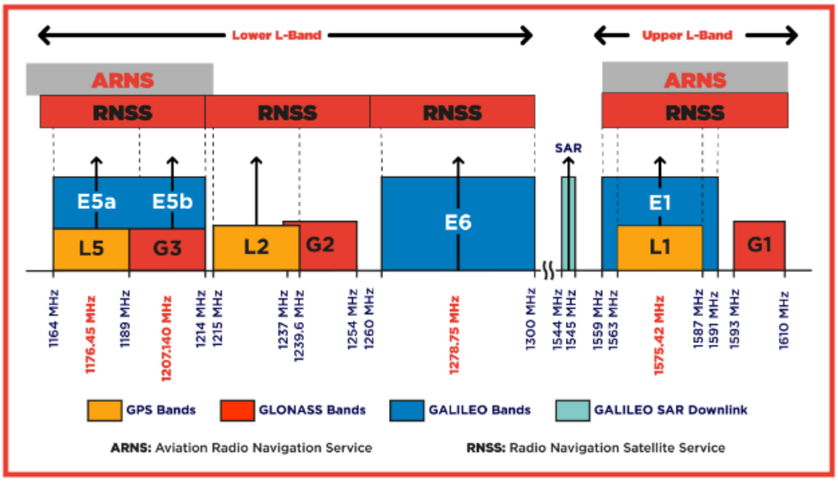
GNSS band acronym	Frequency band
L1 = GPS band L1,	1563 – 1587 MHz
L2 = GPS band L2,	1215 – 1240 MHz
L5 = GPS band L5,	1164 – 1189 MHz
G1 = GLONASS band G1	1593 – 1610 MHz
G2 = GLONASS band G2	1237 – 1254 MHz
G3 = GLONASS band G3	1189 – 1214 MHz
B1I = BeiDou legacy band B1I	1559 – 1563 MHz
B1C = BeiDou 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

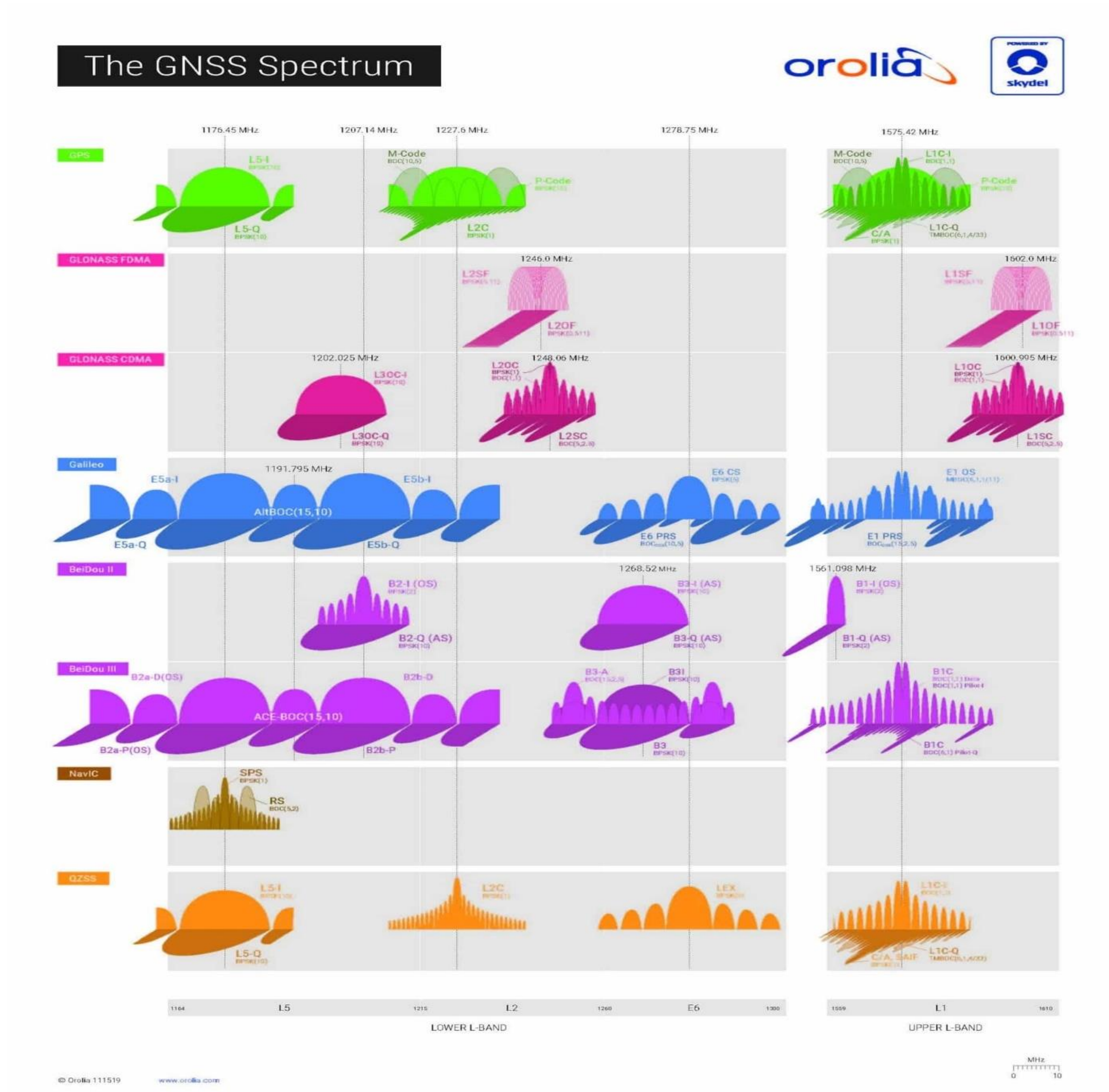
Disclaimers:

When GNSS bands are proclaimed in a given test, the transmissions will be somewhere in the above-mentioned 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)
GPS	L1 C/A	1575.42
	L1C	1575.42
	L2 C	1227.6
	L2 P	1227.6
	L5	1176.45
GLONASS	L1 C/A	1598.0625-1609.3125
	L2 C	1242.9375-1251.6875
	L2 P	1242.9375-1251.6875
	L3 OC	1202.025
Galileo	E1	1575.42
	E5a	1176.45
	E5b	1207.14
	E5 AltBOC	1191.795
	E6	1278.75
BeiDou	B1I	1561.098
	B2I	1207.14
	B3I	1268.52
	B1C	1575.42
	B2a	1176.45
	B2b	1207.14
NAVIC	L5	1176.45
SBAS	L1	1575.42
	L5	1176.45
QZSS	L1 C/A	1575.42
	L1 C	1575.42
	L1S	1575.42
	L2C	1227.6
	L5	1176.45
	L6	1278.75





The GNSS Spectrum
orolia
skydel
1176.45 MHz
1207.14 MHz
1227.6 MHz
1278.75 MHz
1575.42 MHz
GPS
L5-I
L5-Q
M-Code
P-Code
L2C
L1C-I
C/A
L1C-Q
GLONASS FDMA
1246.0 MHz
L2SF
L2OF
1602.0 MHz
L1SF
L1OF
GLONASS CDMA
1202.025 MHz
L3OC-I
L3OC-Q
1248.06 MHz
L2OC
L2SC
1600.995 MHz
L1OC
L1SC
Galileo
1191.795 MHz
E5a-I
E5b-I
AltBOC(15,10)
E5a-Q
E5b-Q
E6 CS
E6 PRS
E1 OS
E1 PRS
BeiDou II
1268.52 MHz
1561.098 MHz
B2-I (OS)
B2-Q (AS)
B3-I (AS)
B3-Q (AS)
B1-I (OS)
B1-Q (AS)
BeiDou III
B2a-D(OS)
B2b-D
ACE-BOC(15,10)
B2a-P(OS)
B2b-P
B3-A
B3I
B3
B1C
NavIC
SPS
RS
QZSS
L5-I
L5-Q
L2C
LEX
L1C-I
C/A, SAIF
L1C-Q
L5
L2
E6
L1
LOWER L-BAND
UPPER L-BAND
MHz
0
10
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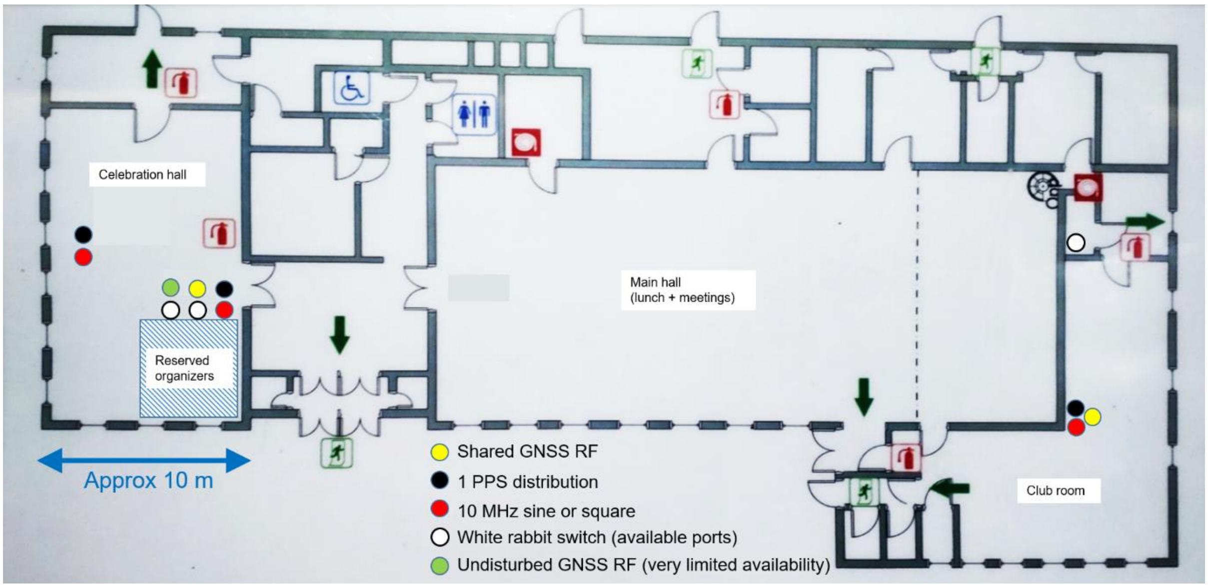
Appendix C - Timing and RF signal distribution at Bleik community house

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

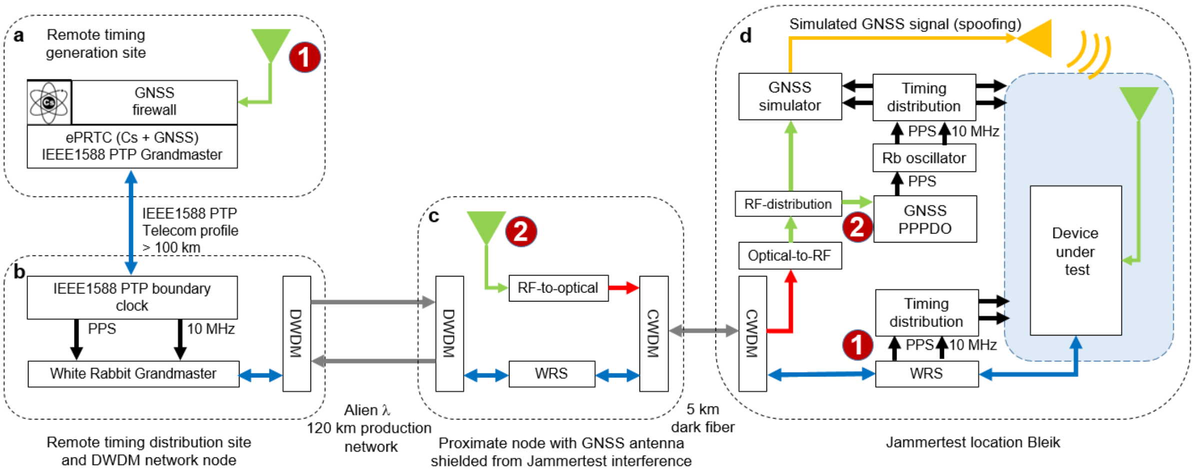
GNSS RF distribution

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)

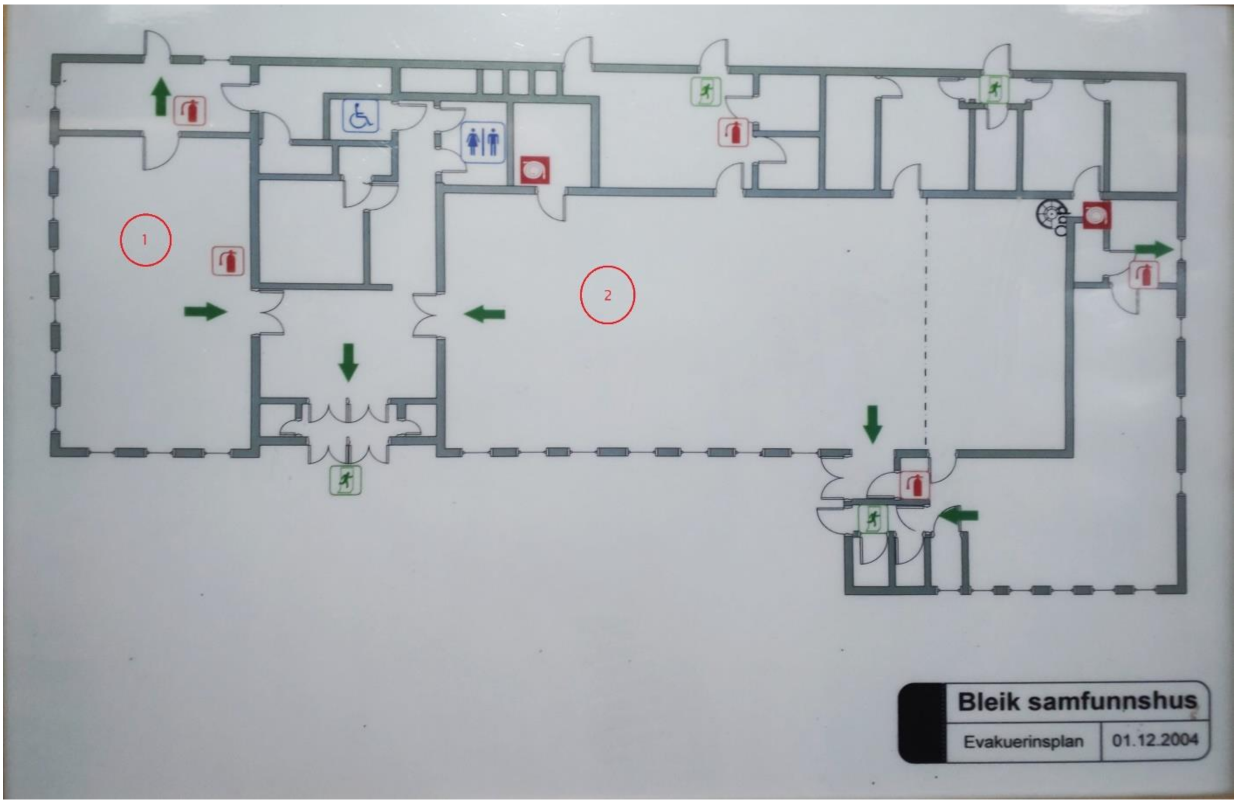
'Club room' - timing signal availability

- 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.

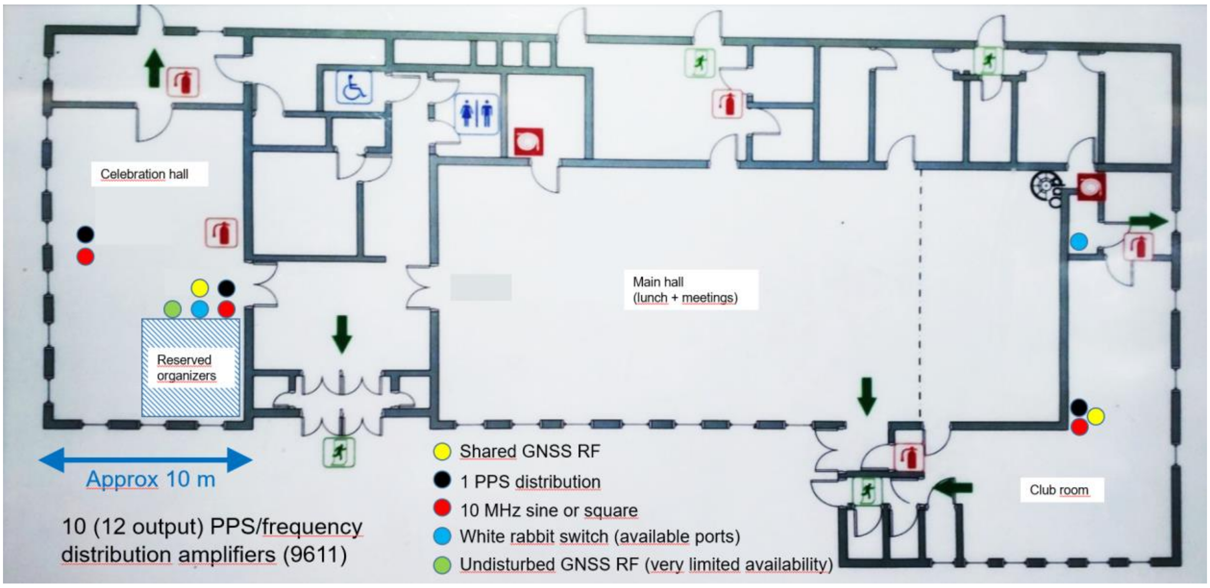


D 1: Floor plan of Bleik samfunnshus ('Bleik community house').

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.

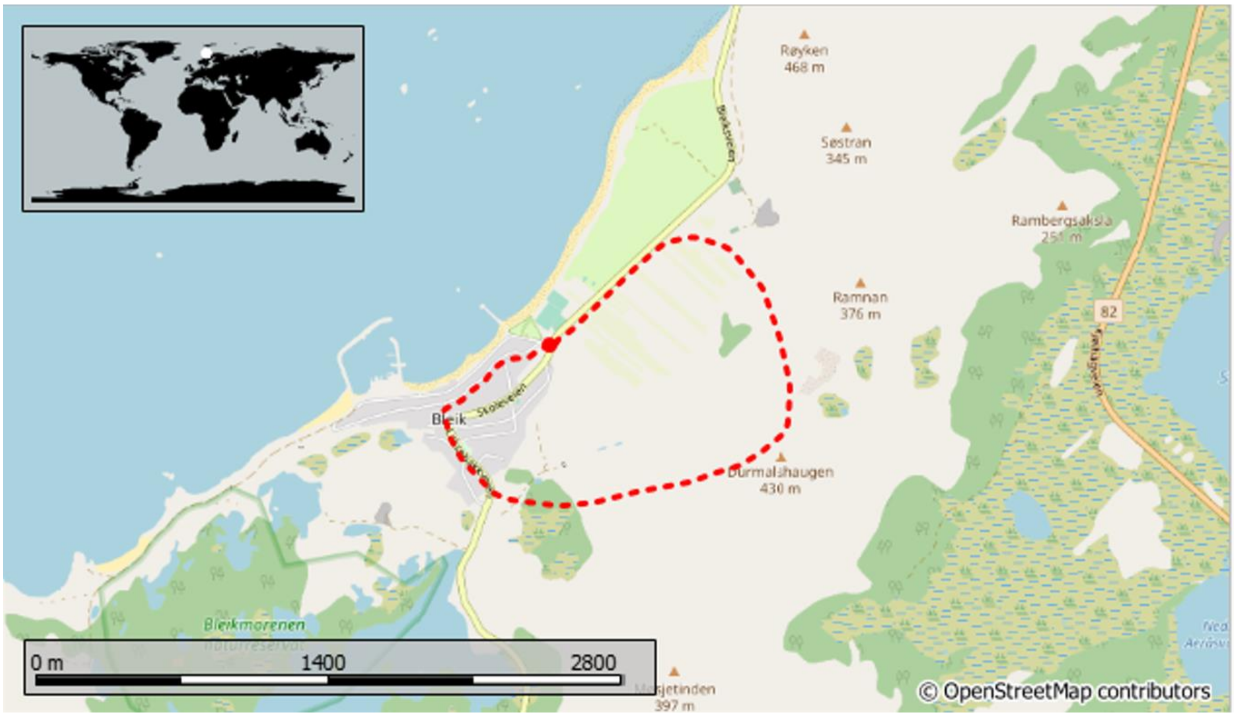
E 3: Overview of Bleik HQ and close surrounding areas. Aerial photo from norgeskart.no

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

Introduction

The following section provides technical details on the jammer equipment used in the experiments. The jammers are categorized according to the following scheme:

1st Letter (Norwegian / English)	1St digit	2nd digit
S = Sigarett / Cigarette	Number of antennas	# jammer within same category
H = Håndholdt / Handheld		
U = USB / USB stick		
F = Fastmontert / Permanently installed (Fixed)		
M = Mobil / Mobile (Car mounted)		

Exempli gratia: S1.2, is a cigarette type jammer, that has 1 antenna, and is unit nr.2 in this category.

Additional information:

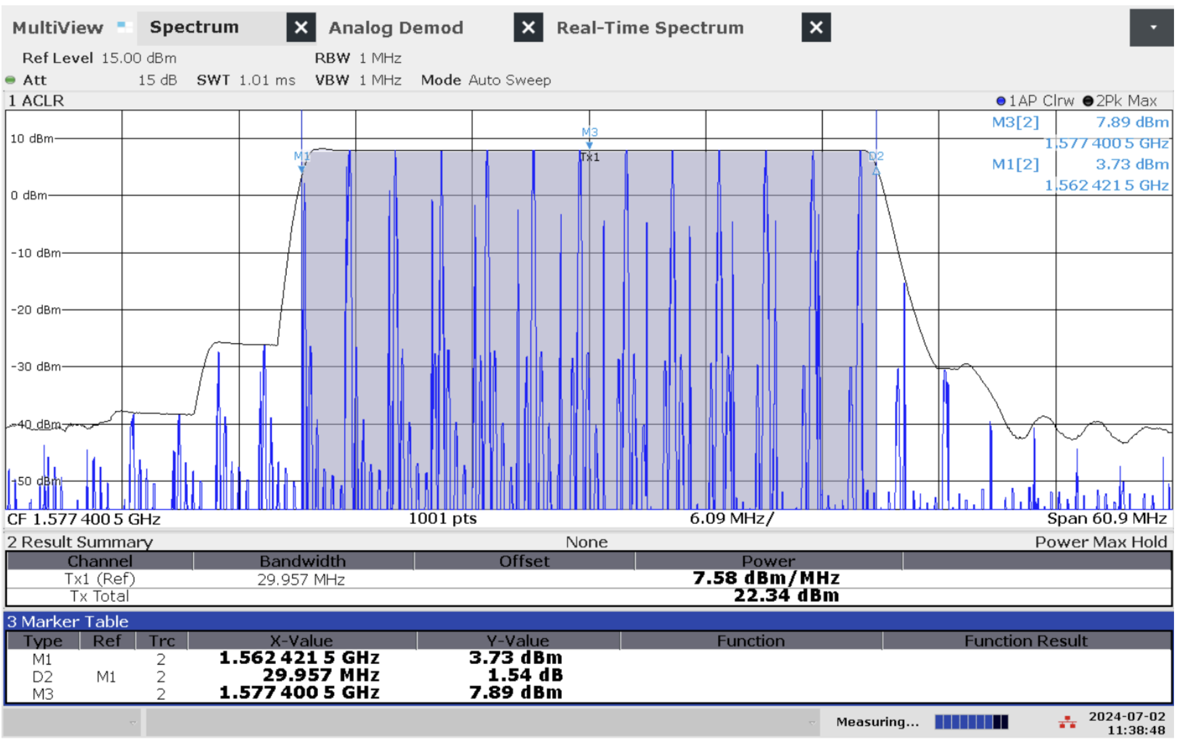
- Each chapter gives an overview of each jammer brought to Jammertest. As far as possible, it gives information on
  - Centre frequency [MHz]
  - Bandwidth [MHz]
  - Power Spectral Density (PSD) [dBm/MHz] for the entire bandwidth
  - Total output power (TX total) [dBm] for the entire bandwidth
  - CF max [dBm] (maxhold power at the centre frequency)
  - Sweep rate [μs] (if applicable)
  - 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.

Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
1577.40	29.96	7.58	22.34	7.89	37.1	Sawtooth

Table 5.1: Technical characteristics of S1.1 jammer



11:38:48 AM 07/02/2024

Figure 5.1: Frequency and power measurement of jammer S1.1

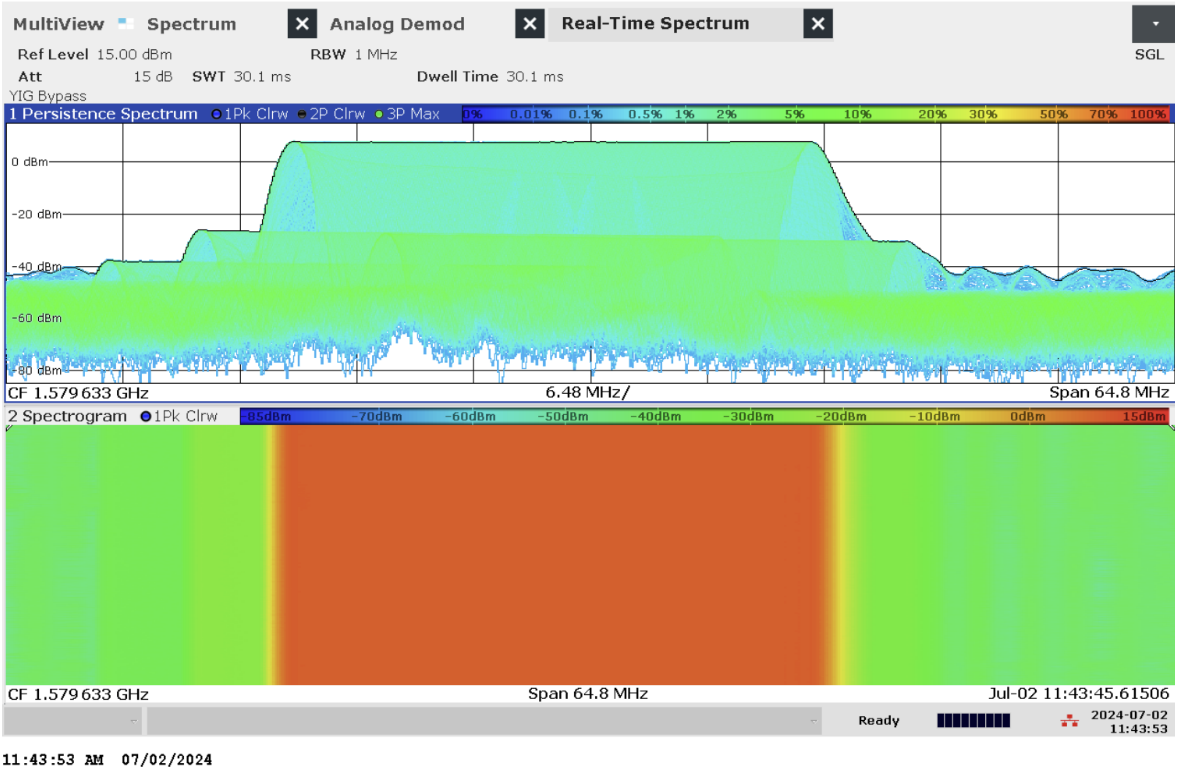


Figure 5.2: Real-time persistence and spectrogram measurement of jammer S1.1

Figure 5.3: 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.

Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
1582.56	40.03	12.38	29.01	12.61	21.56	Sawtooth

Table 5.2: Technical characteristics of S1.2 jammer

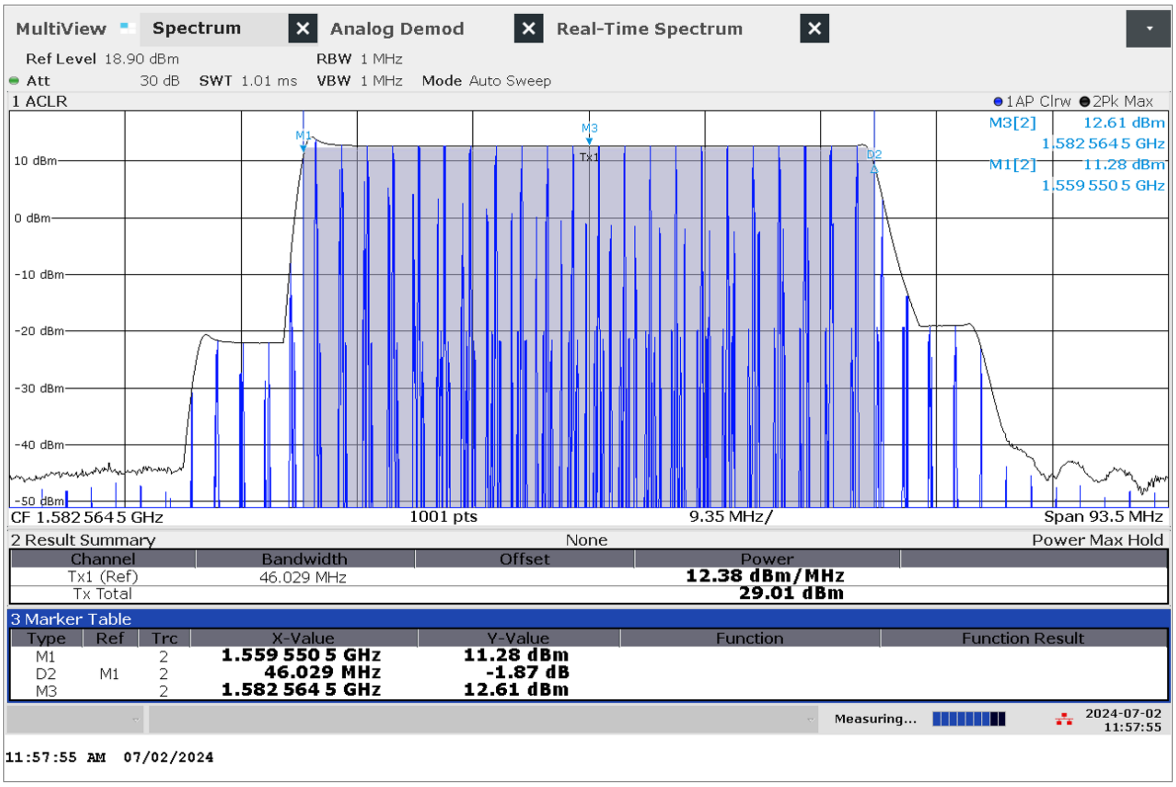


Figure 5.4: Frequency and power measurement of jammer S1.2

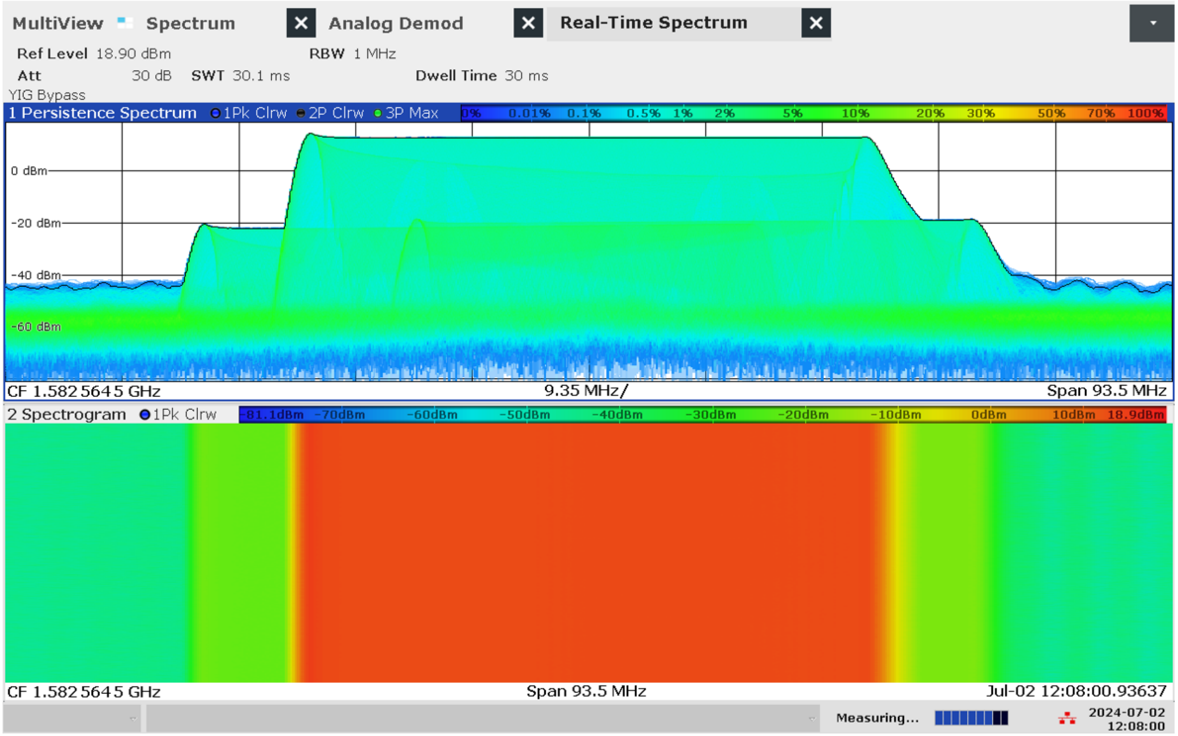


Figure 5.5: Real-time persistence and spectrogram measurement of jammer S1.2

Figure 5.6: 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.

Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
1579.63	31.88	7.56	22.60	7.93	37.5	Sawtooth

Table 5.3: Technical characteristics of S1.3 jammer

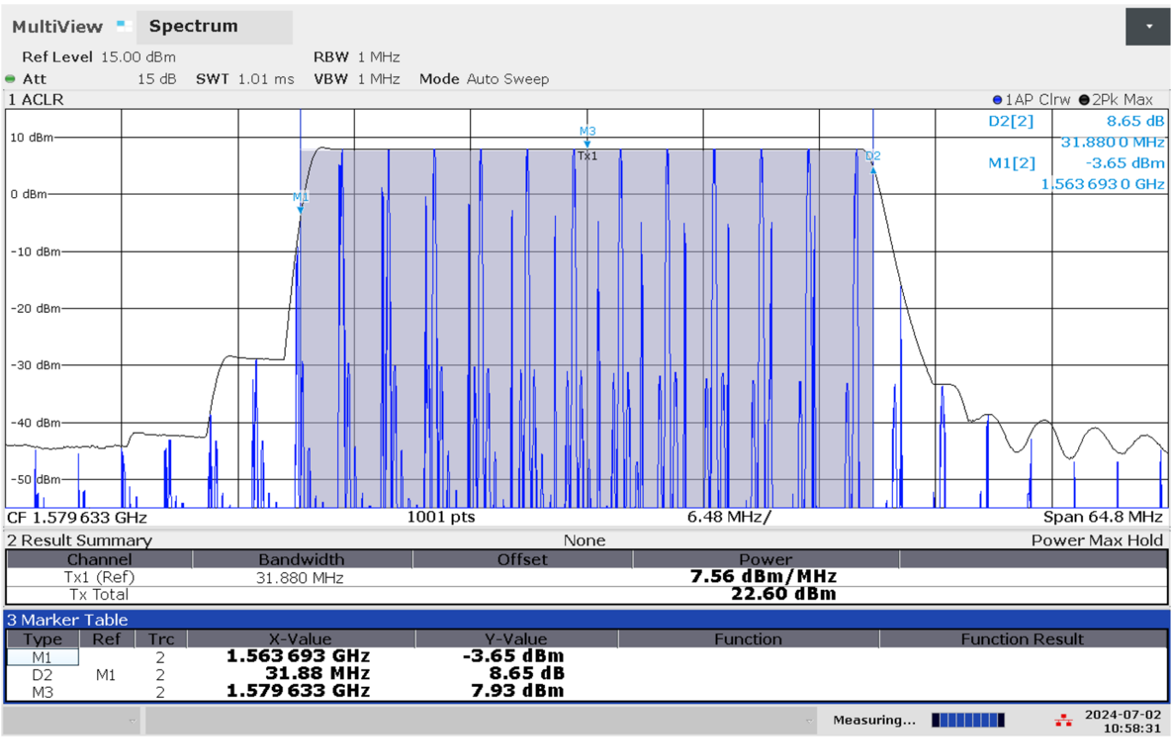


Figure 5.7: Frequency and power measurement of jammer S1.3

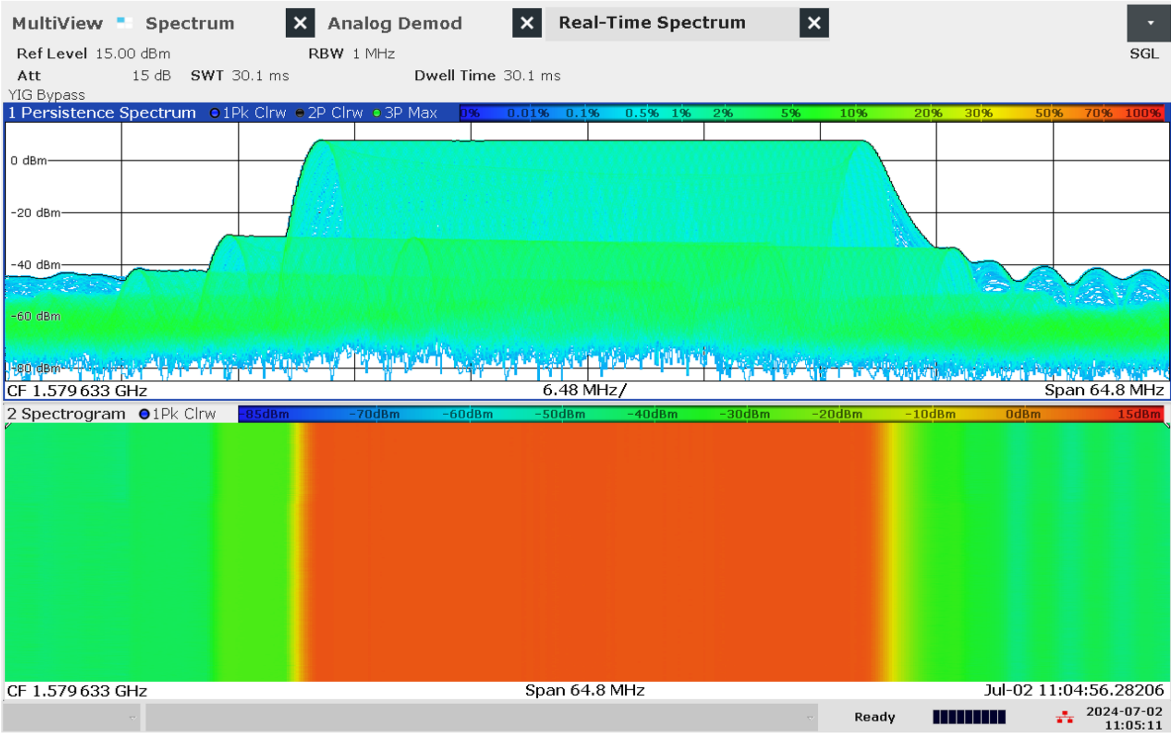


Figure 5.8: Real-time persistence and spectrogram measurement of jammer S1.3

Figure 5.9: 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.

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

Table 5.4: Technical characteristics of S2.1 jammer

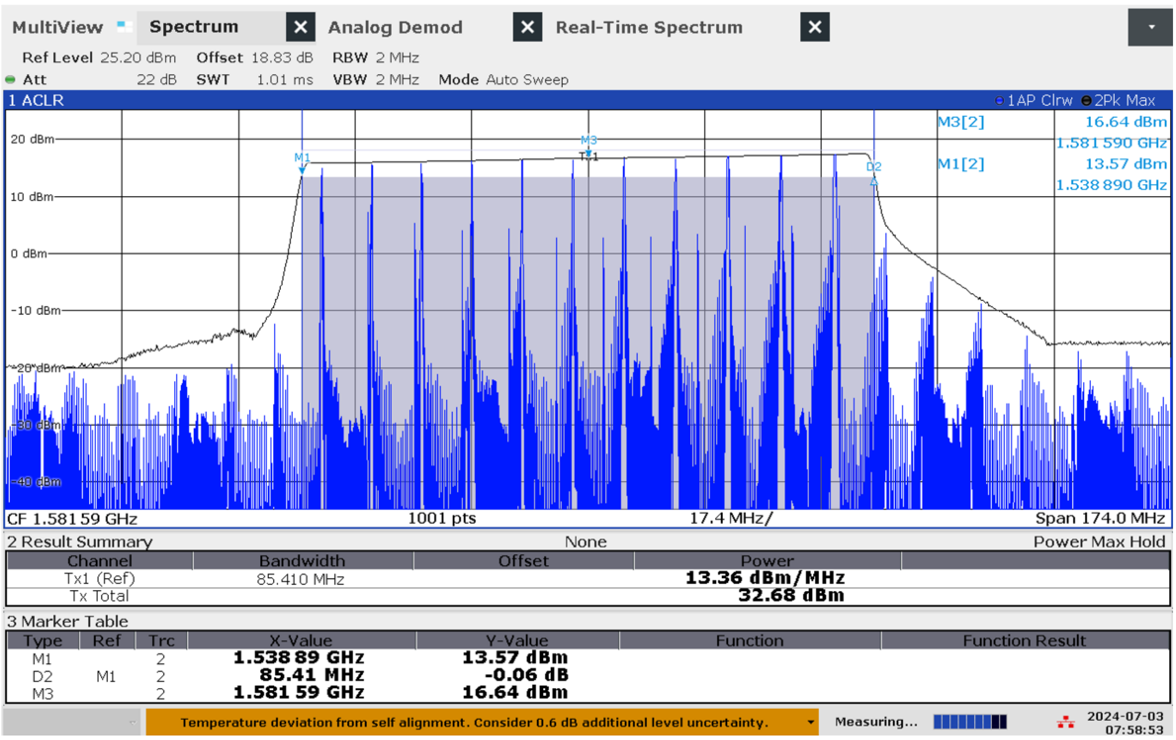


Figure 5.10: Frequency and power measurement of jammer S2.1 on antenna ’L1’

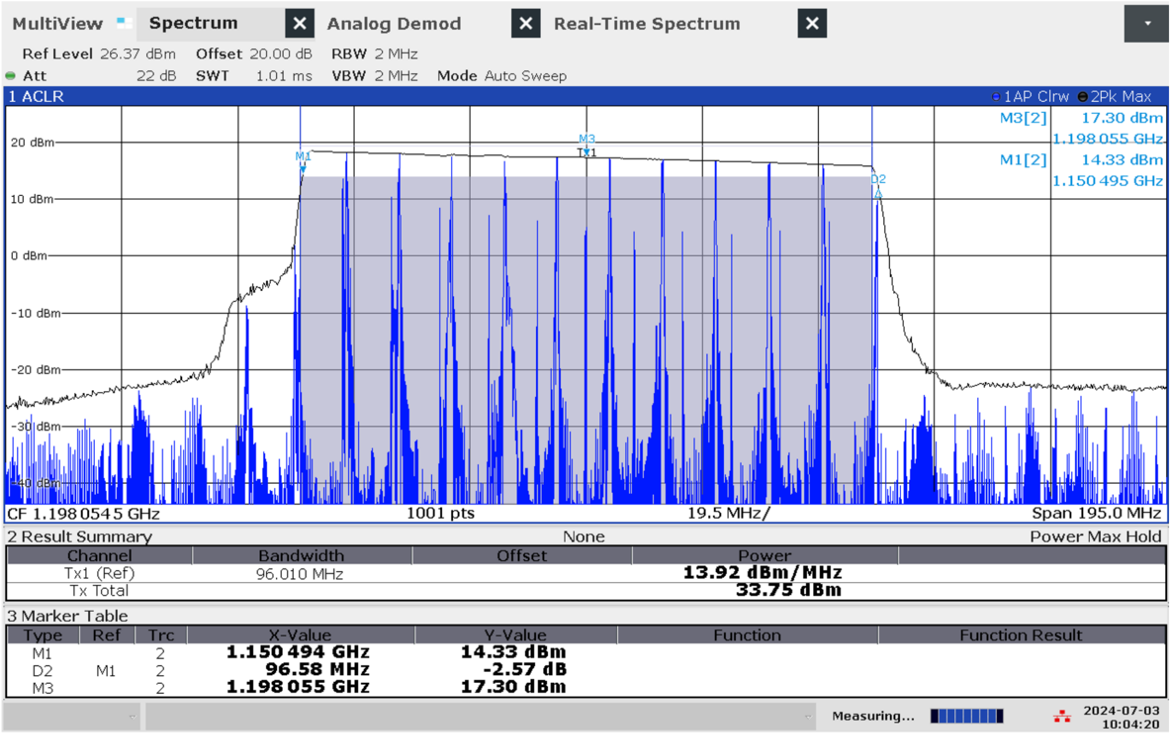


Figure 5.11: Frequency and power measurement of jammer S2.1 on antenna 'L2'

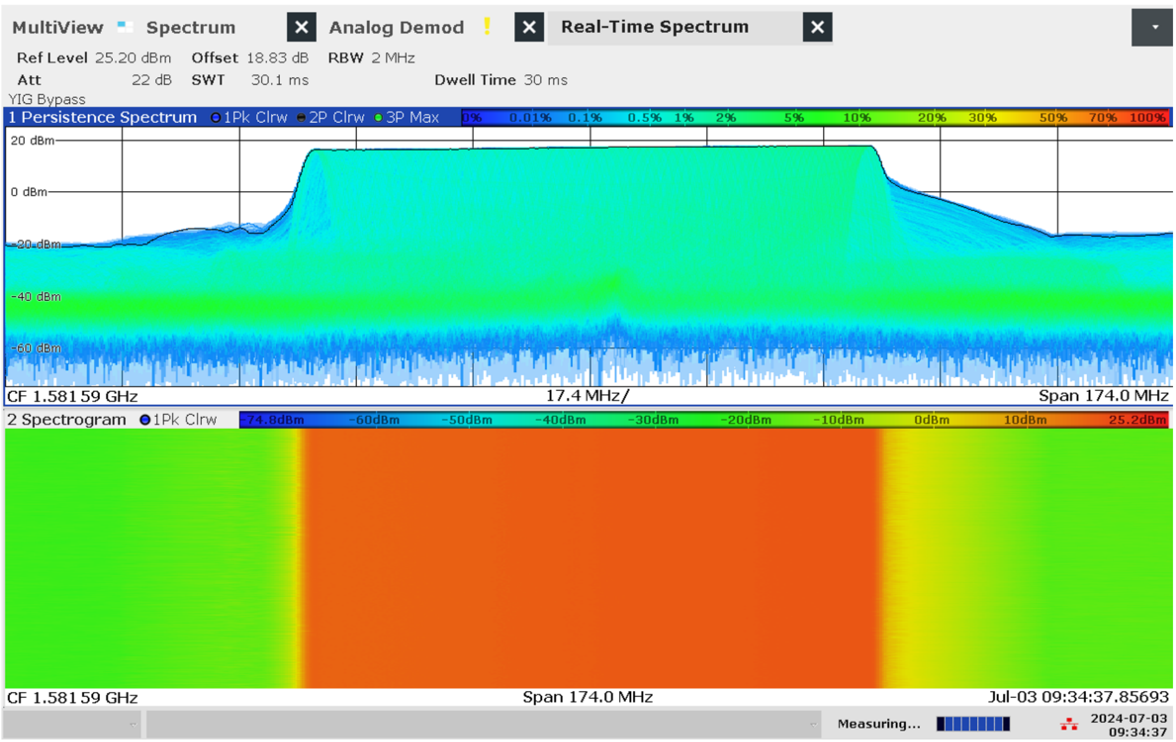


Figure 5.12: Real-time persistence and spectrogram measurement of jammer S2.1 on antenna 'L1'

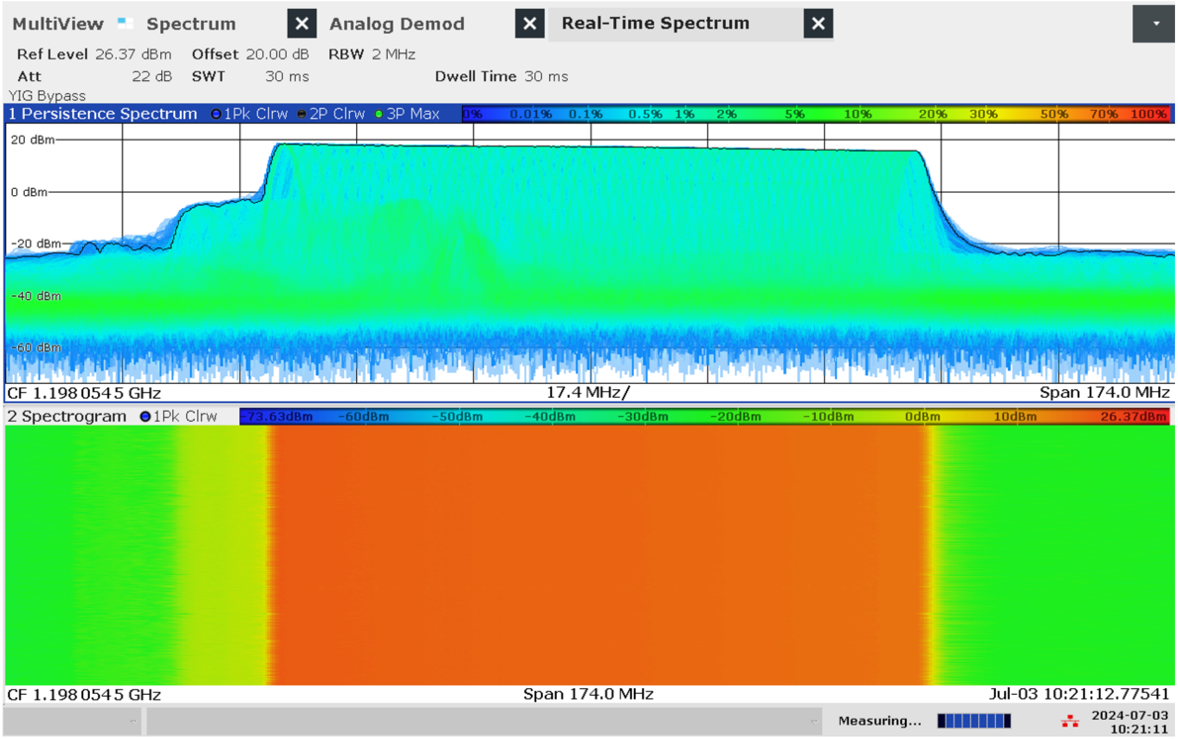
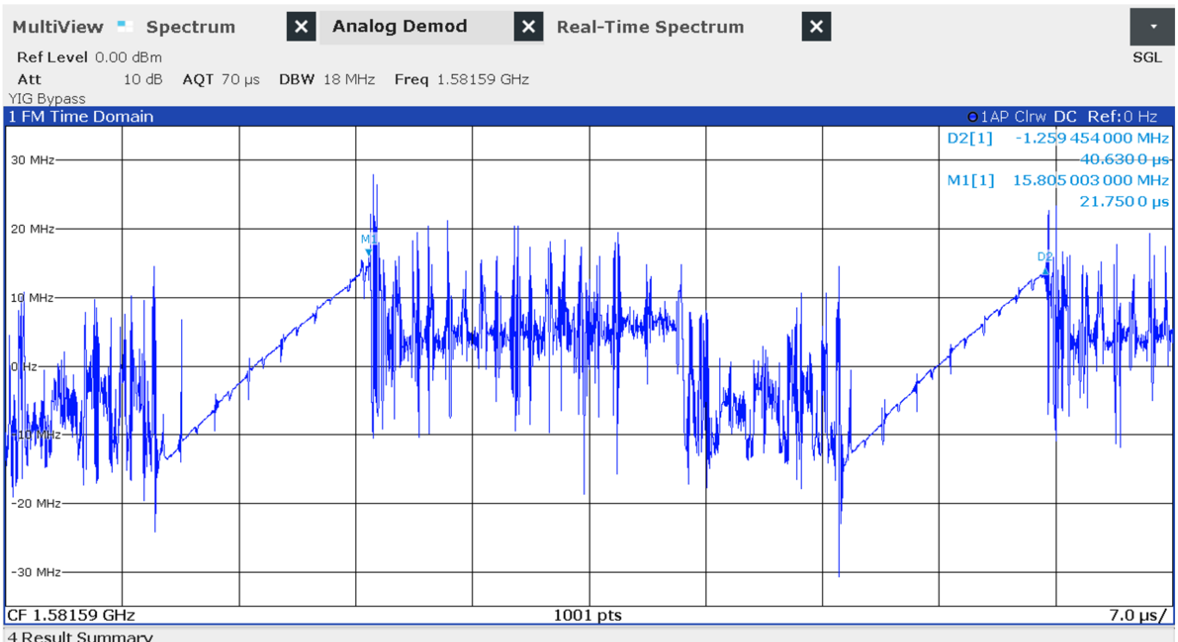


Figure 5.13: Real-time persistence and spectrogram measurement of jammer S2.1 on antenna ’L2’



	+Peak	-Peak	±Peak/2	RMS	Mod. Freq.	SINAD	DISTORT	THD
FM	27.941 MHz	-30.658 MHz	29.299 MHz	8.2188 MHz	---	---	---	---

Figure 5.14: Time domain (analog demod) measurement of jammer S2.1 on antenna ’L1’

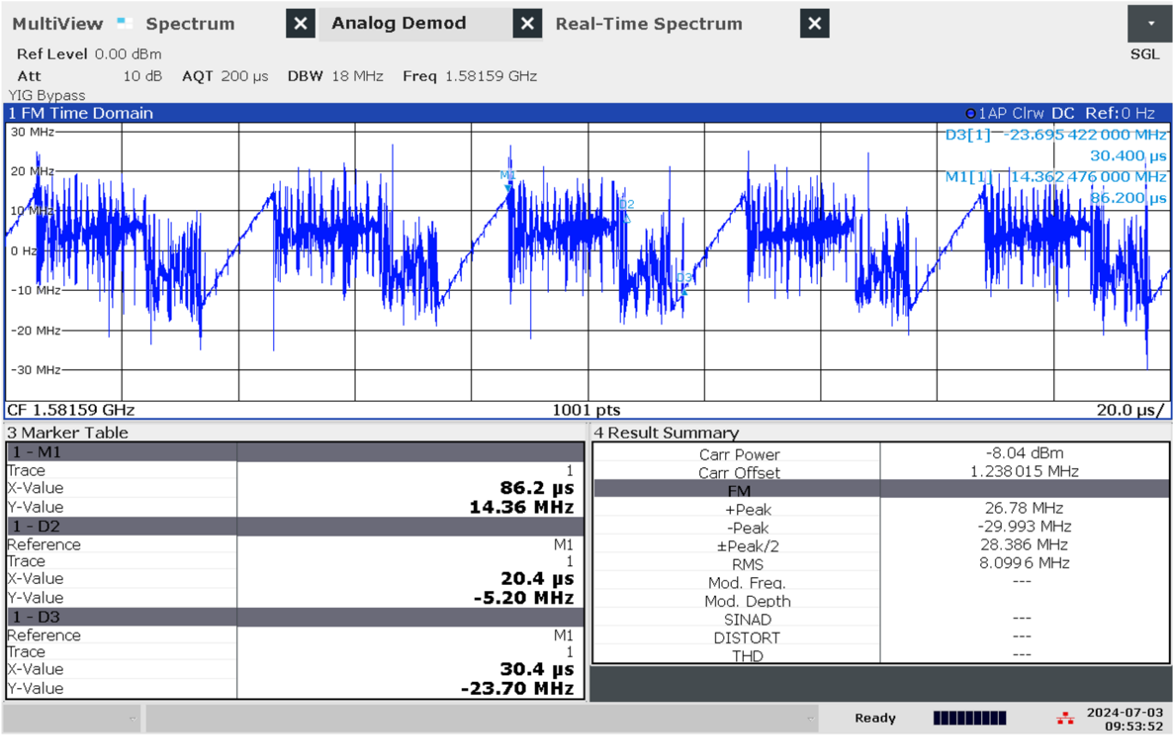


Figure 5.15: Time domain (analog demod) measurement with wider span of jammer S2.1 on antenna 'L1'

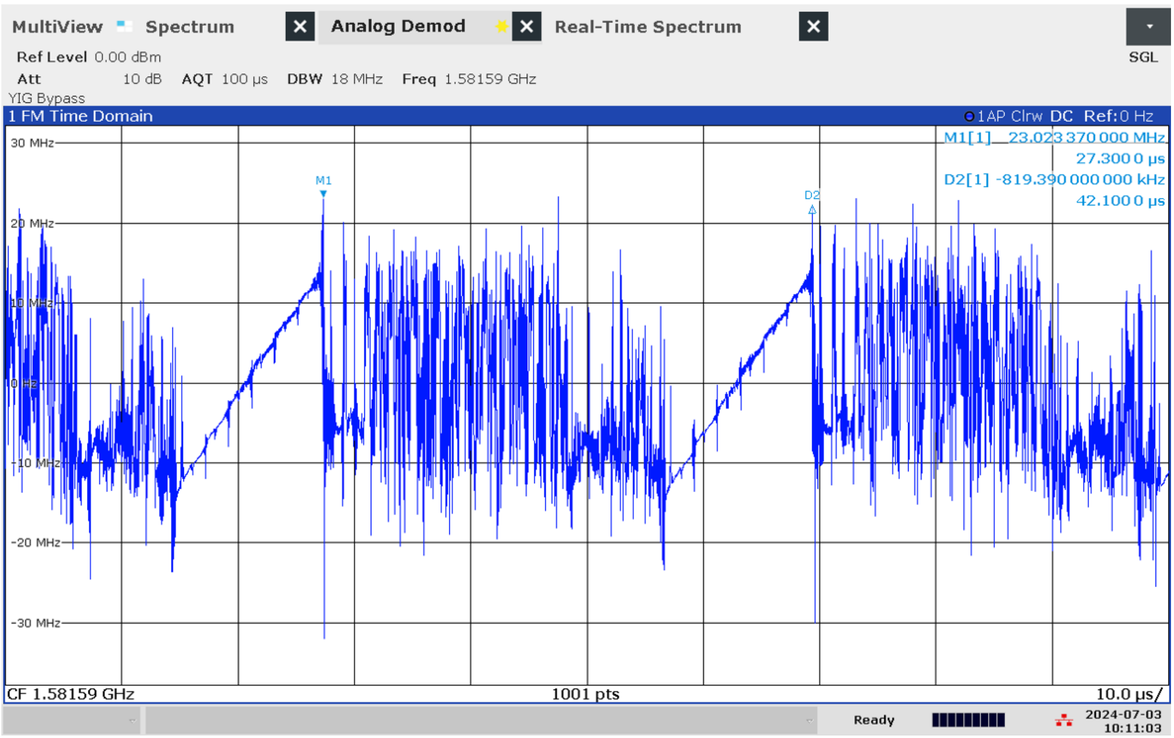


Figure 5.16: Time domain (analog demod) measurement of jammer S2.1 on antenna 'L2'

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.

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

Table 5.5: Technical characteristics of S2.2 jammer

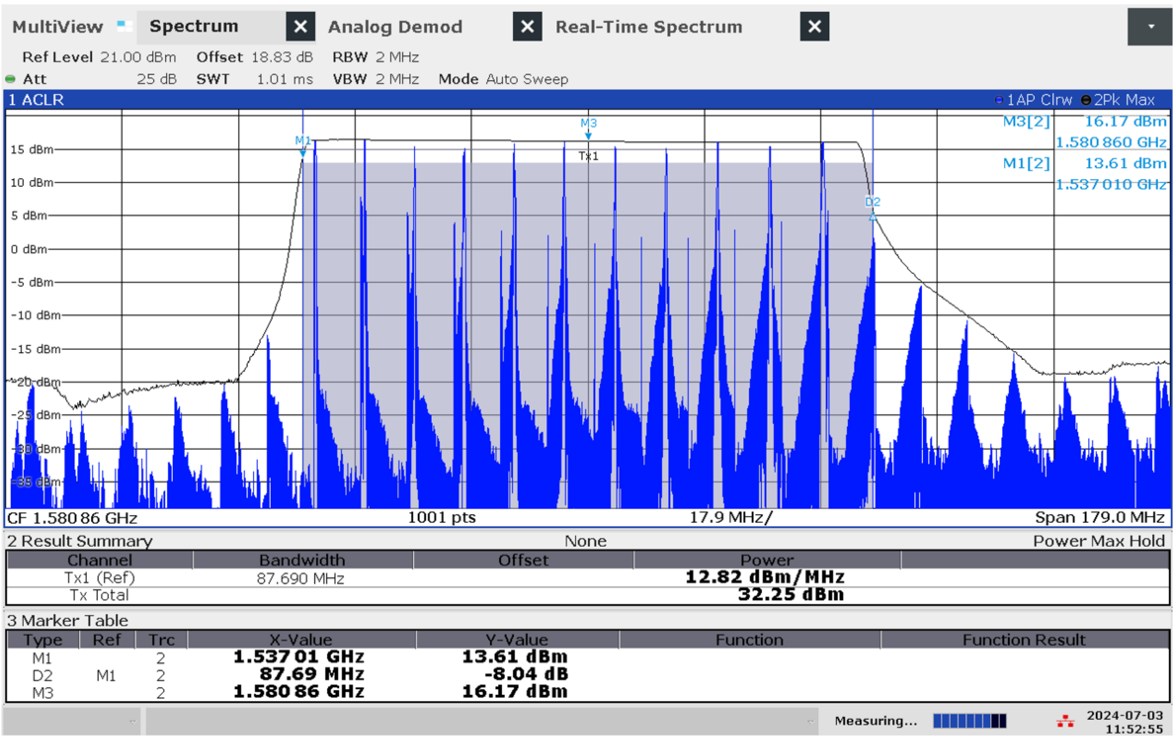


Figure 5.17: Frequency and power measurement of jammer S2.2 on antenna 'L1'

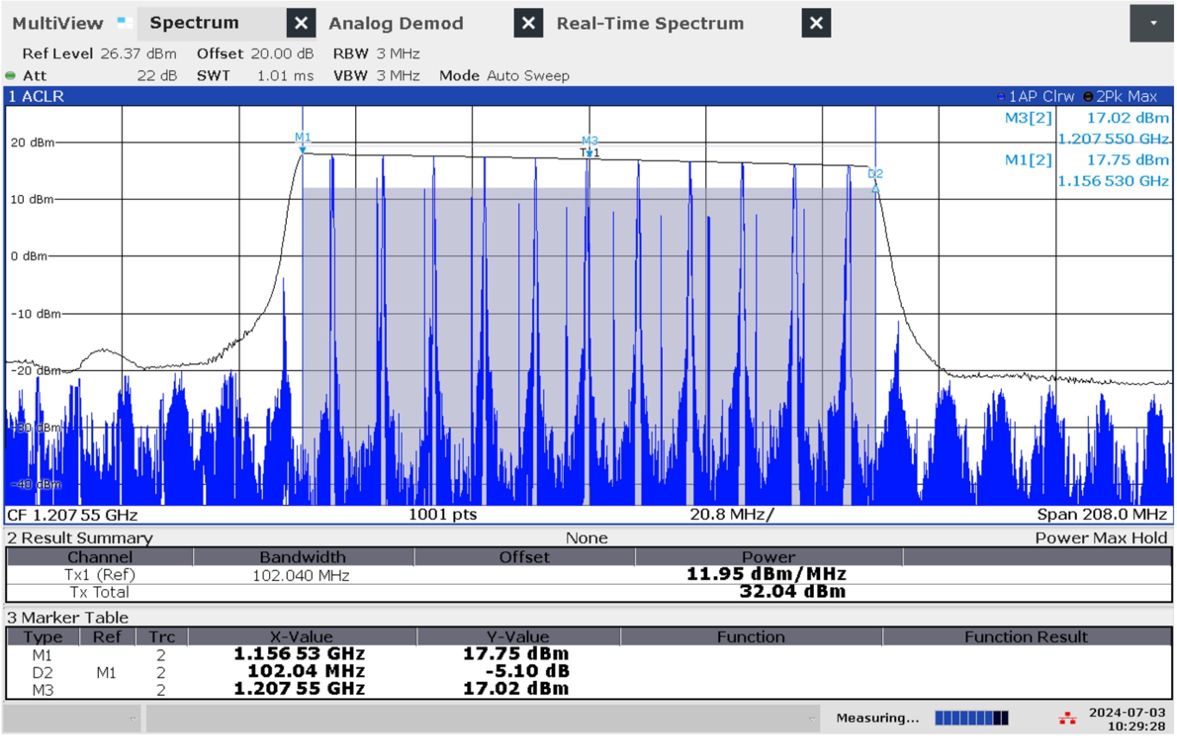


Figure 5.18: Frequency and power measurement of jammer S2.2 on antenna 'L2'

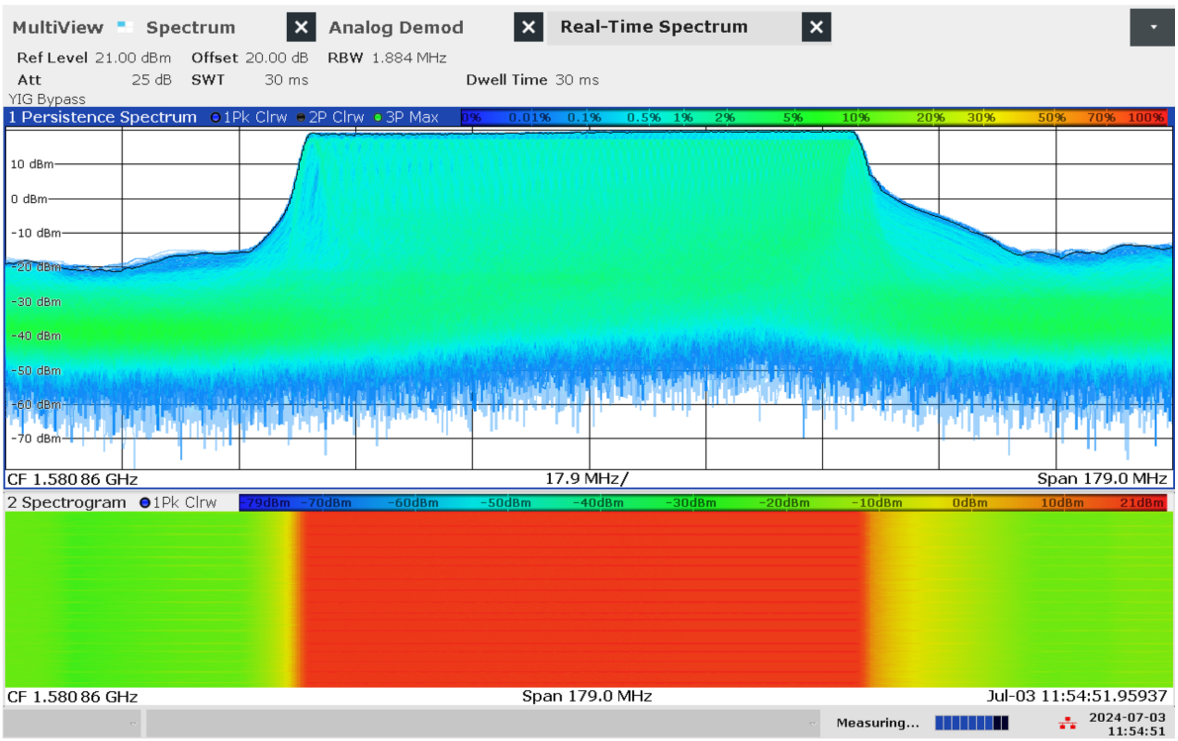


Figure 5.19: Real-time persistence and spectrogram measurement of jammer S2.2 on antenna 'L1'

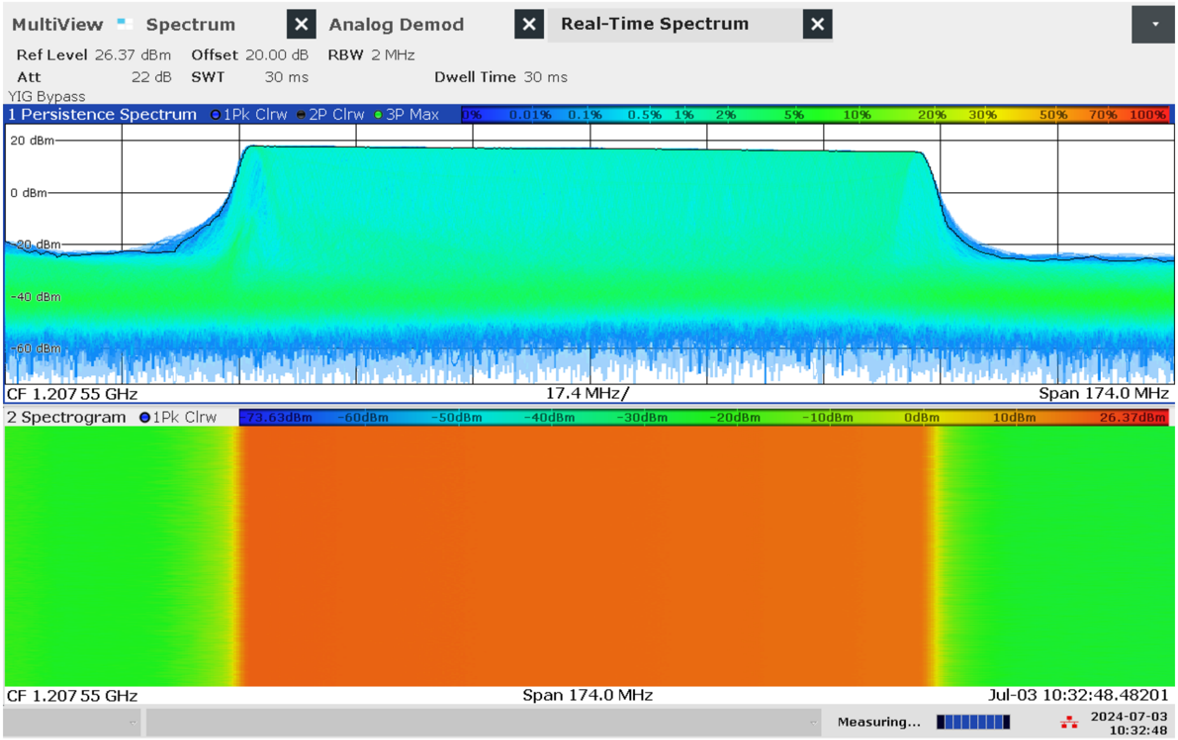


Figure 5.20: Real-time persistence and spectrogram measurement of jammer S2.2 on antenna 'L2'

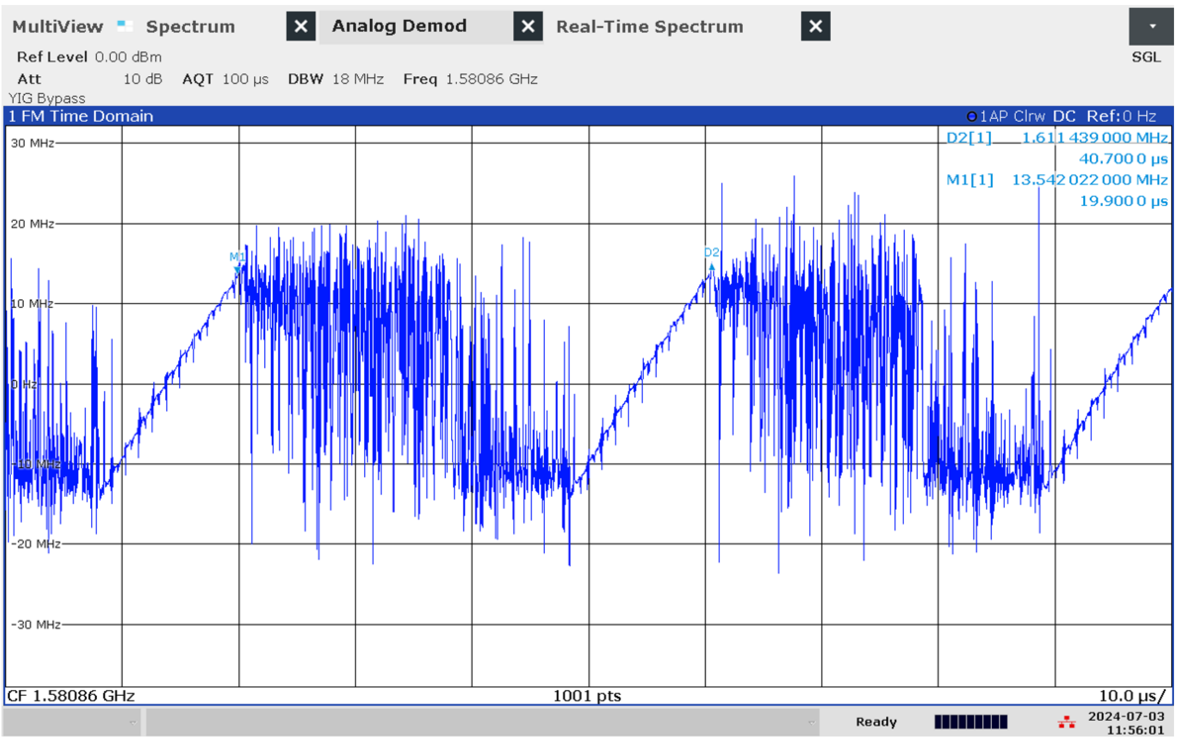


Figure 5.21: Time domain (analog demod) measurement of jammer S2.2 on antenna 'L1'

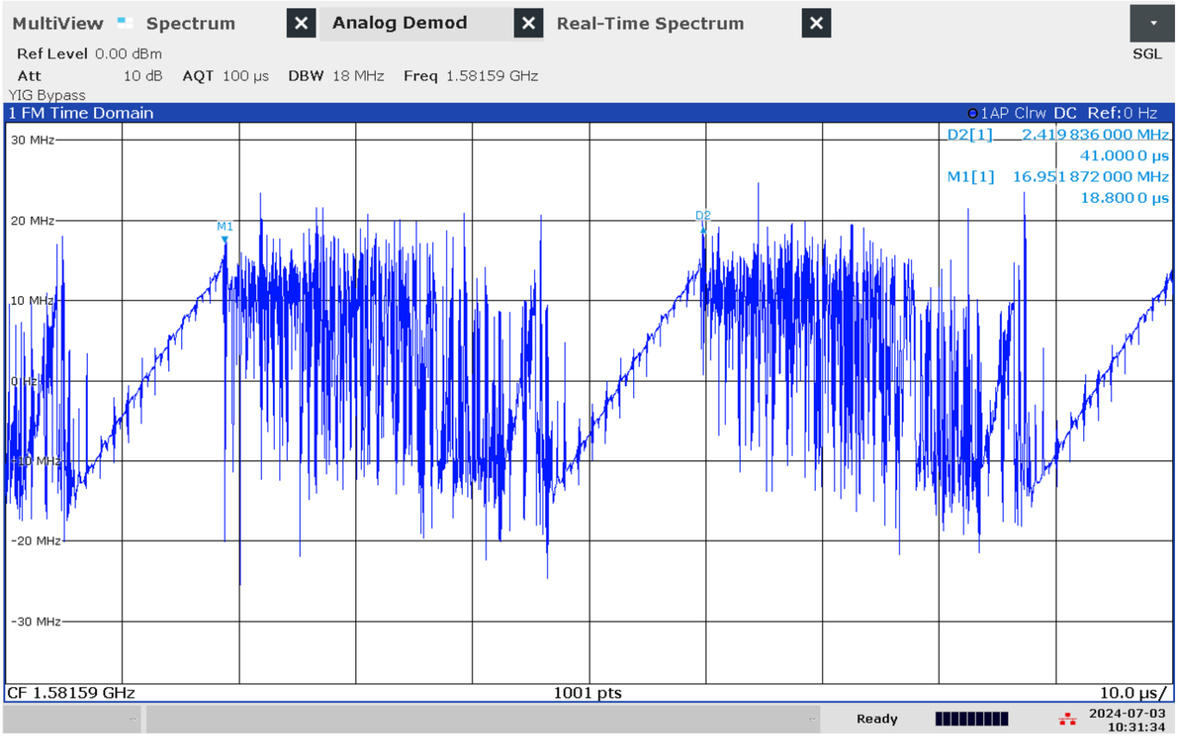


Figure 5.22: Time domain (analog demod) measurement of jammer S2.2 on antenna 'L2'

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.

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

Table 5.6: Technical characteristics of S2.3 jammer

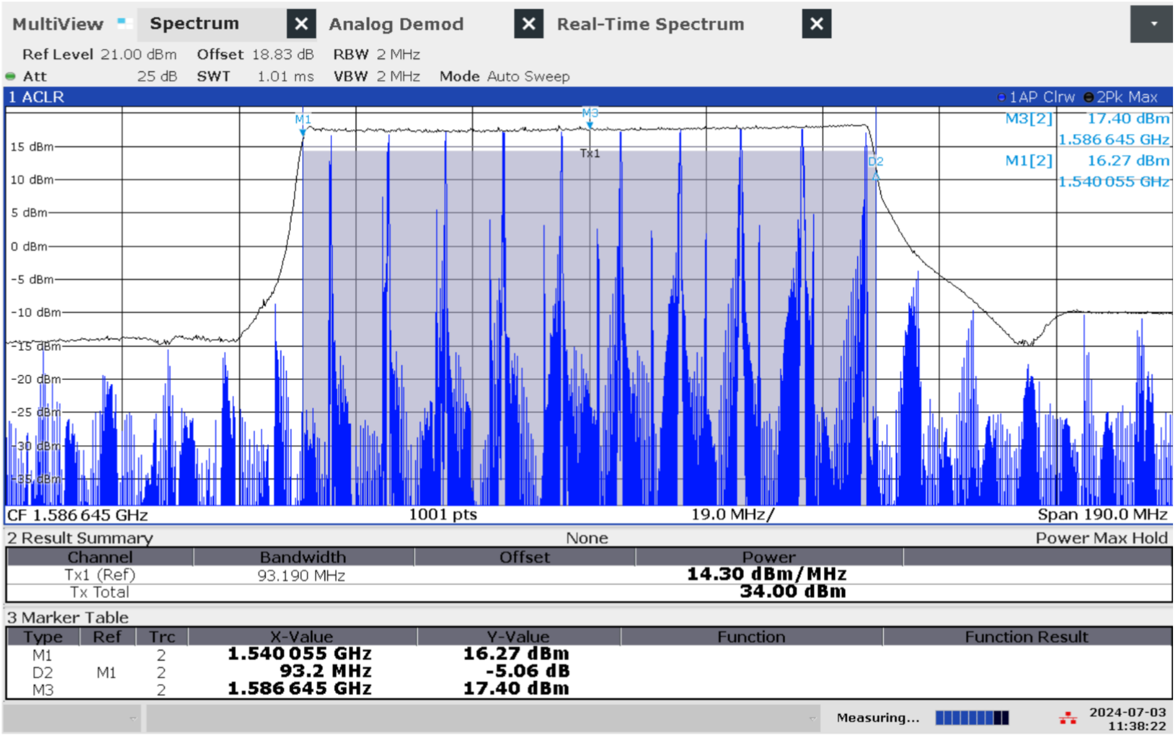


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Figure 5.23: Frequency and power measurement of jammer S2.3 on antenna 'L1'

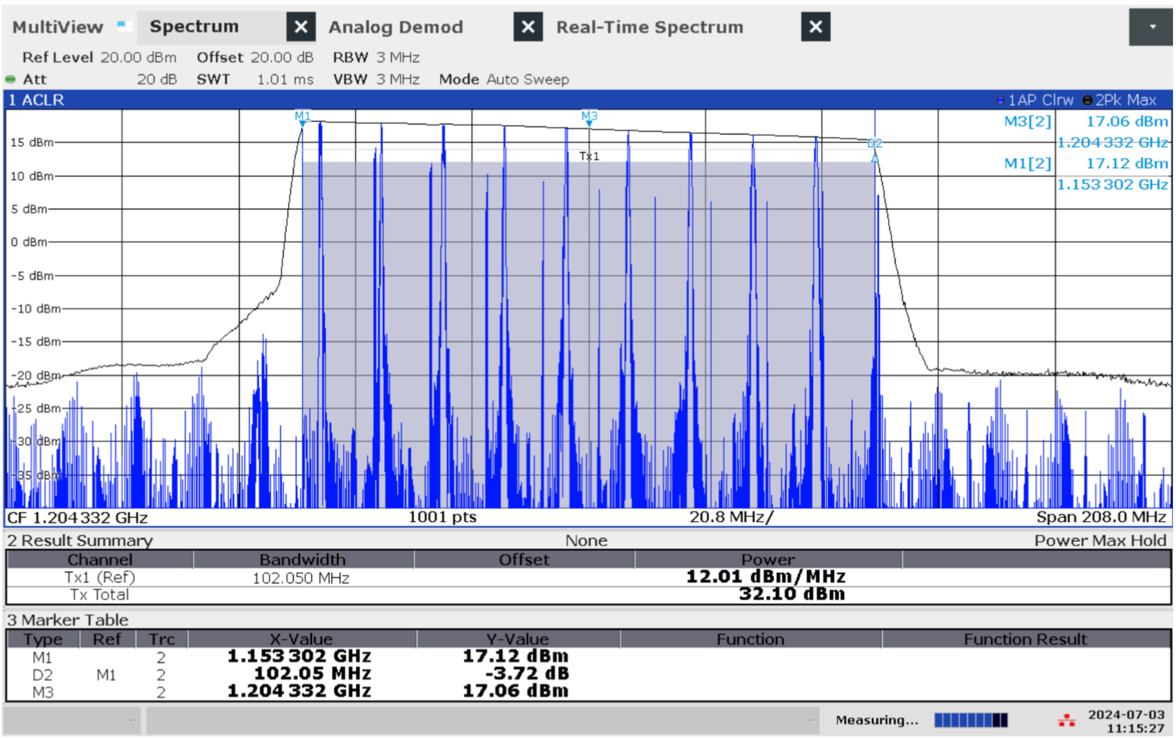

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Figure 5.24: Frequency and power measurement of jammer S2.3 on antenna 'L2'

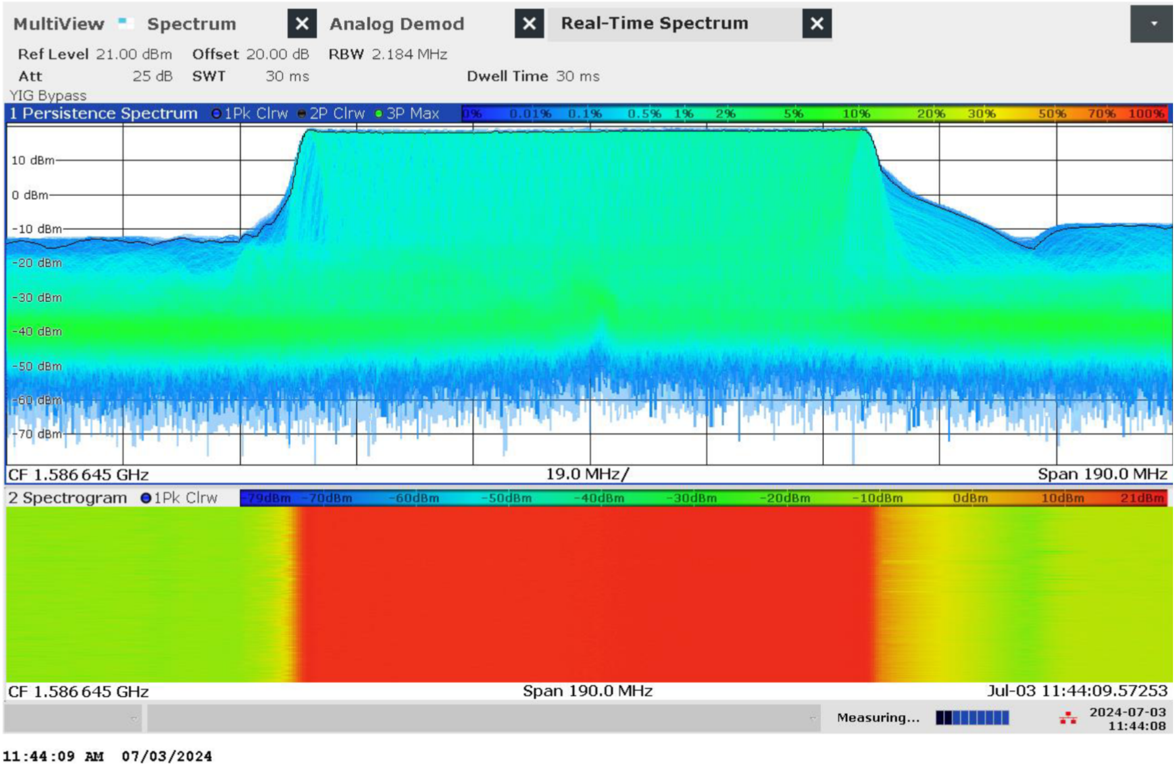

Figure 5.25: Real-time persistence and spectrogram measurement of jammer S2.3 on antenna 'L1'

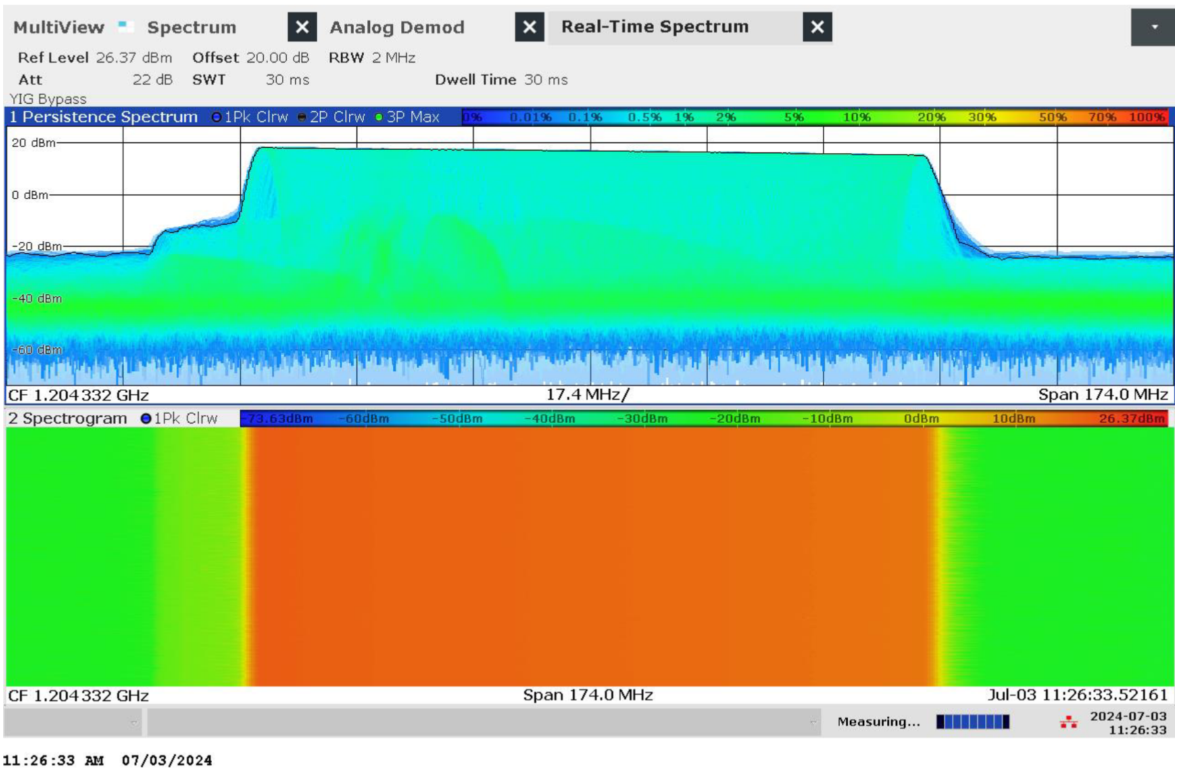

Figure 5.26: Real-time persistence and spectrogram measurement of jammer S2.3 on antenna 'L2'

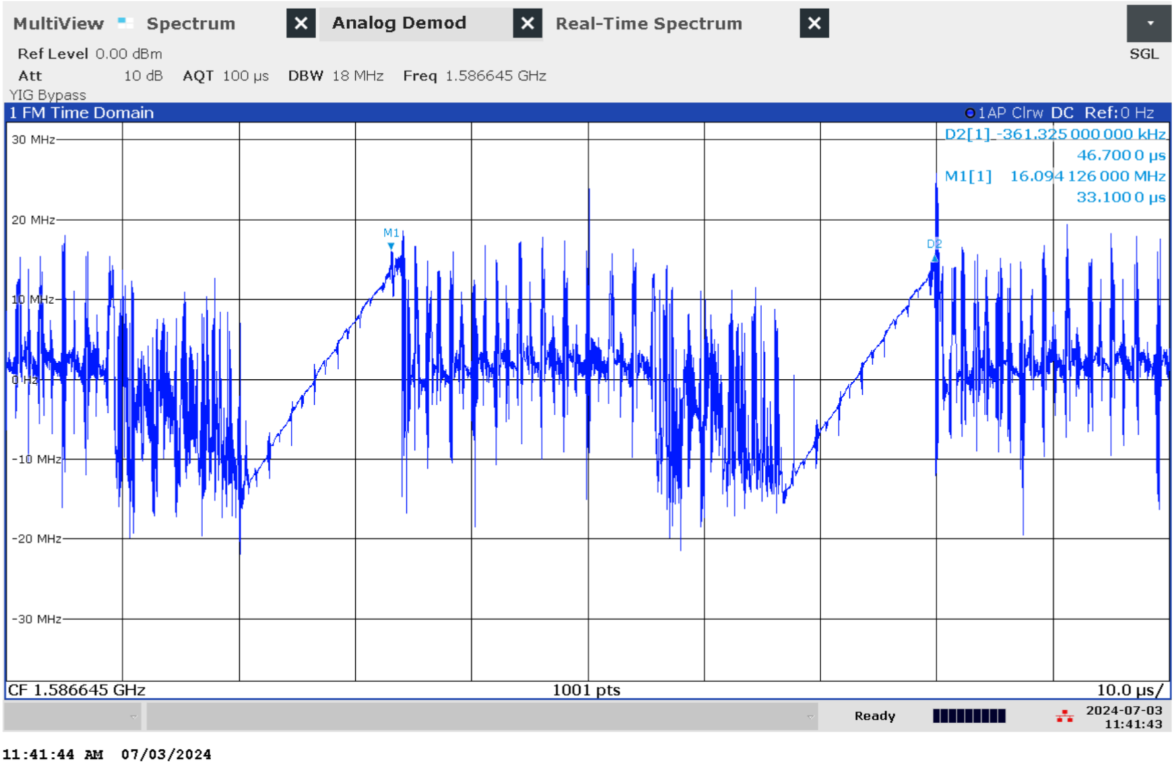

Figure 5.27: Time domain (analog demod) measurement of jammer S2.3 on antenna 'L1'

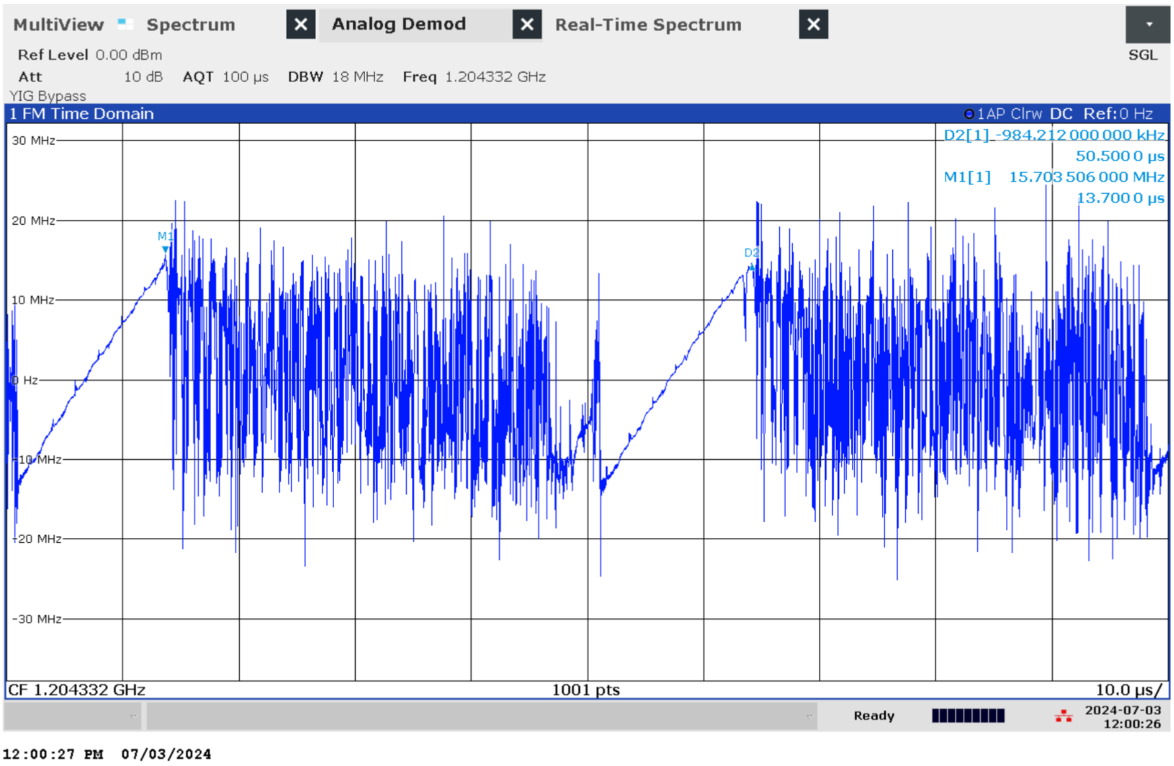

Figure 5.28: Time domain (analog demod) measurement of jammer S2.3 on antenna 'L2'

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.

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

Table 5.7: Technical characteristics of S2.4 jammer

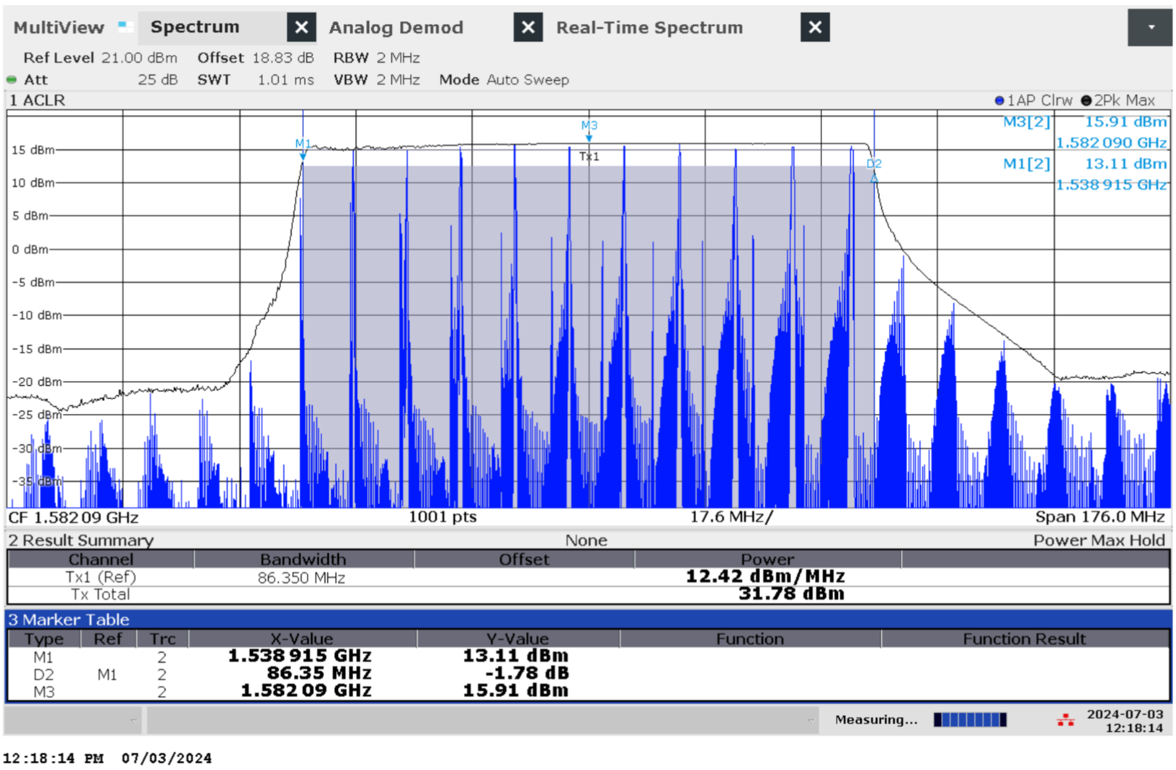

Figure 5.29: Frequency and power measurement of jammer S2.4 on antenna ’L1’

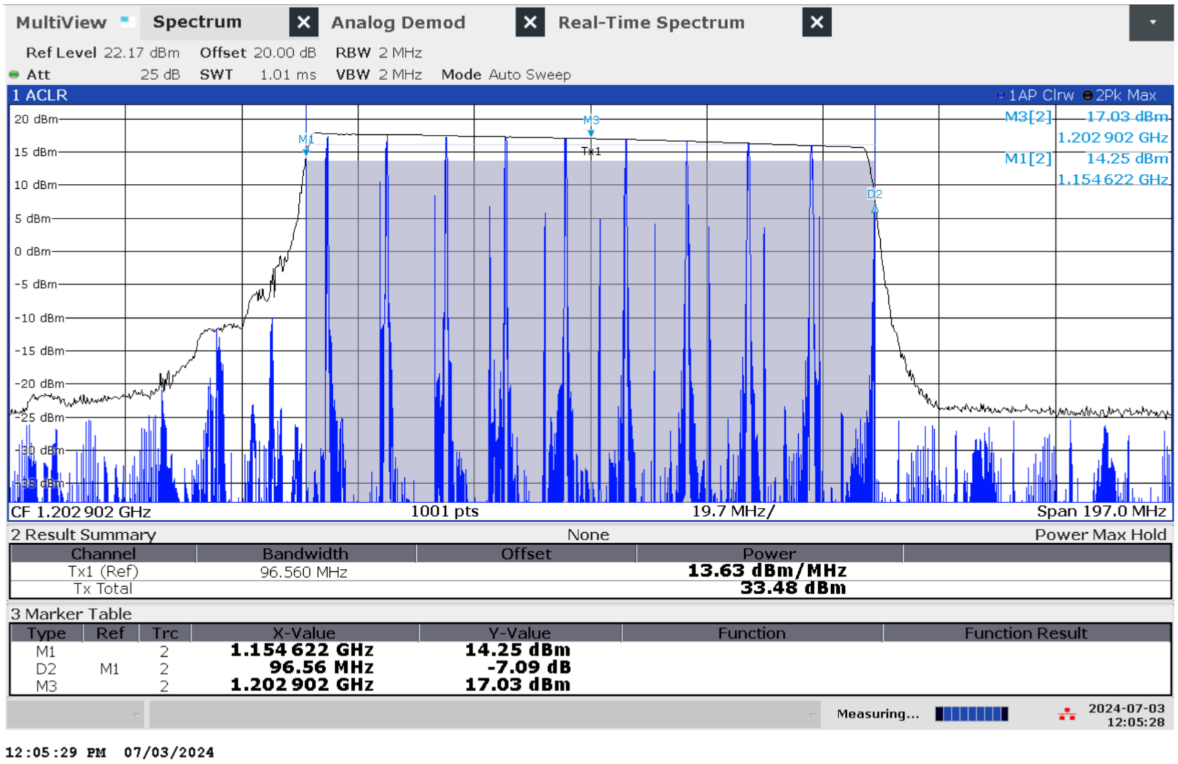

Figure 5.30: Frequency and power measurement of jammer S2.4 on antenna 'L2'

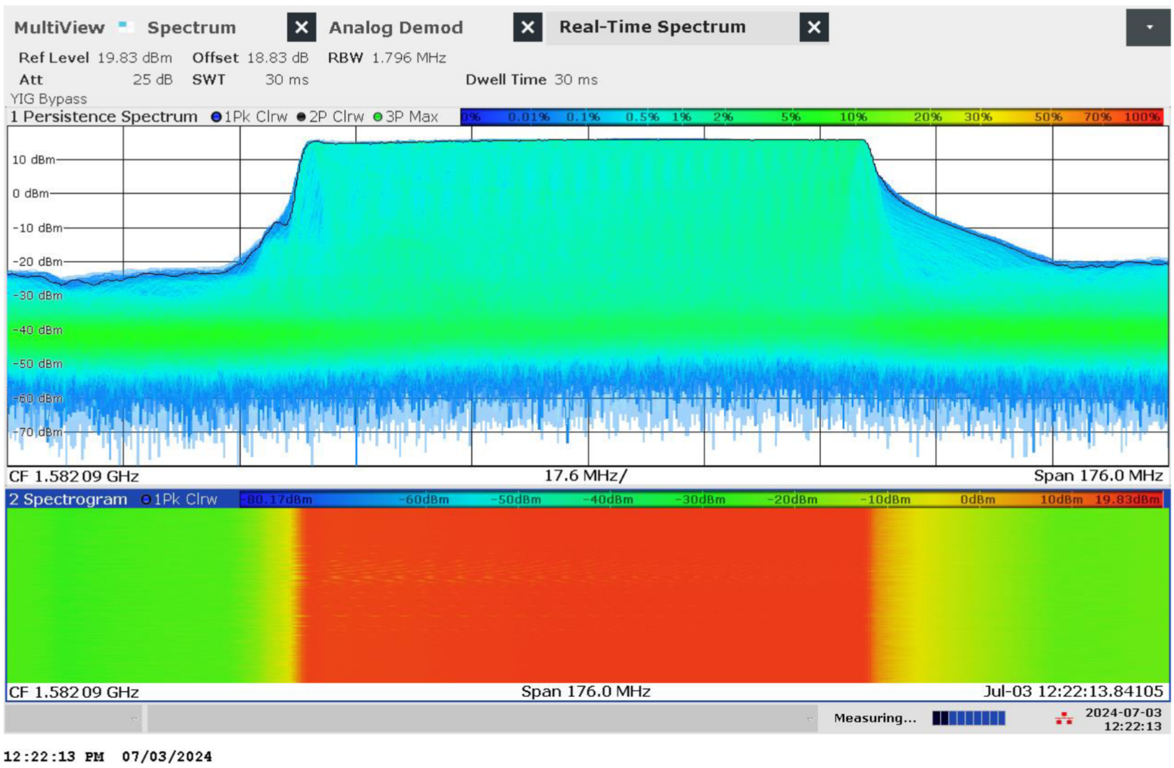

Figure 5.31: Real-time persistence and spectrogram measurement of jammer S2.4 on antenna 'L1'

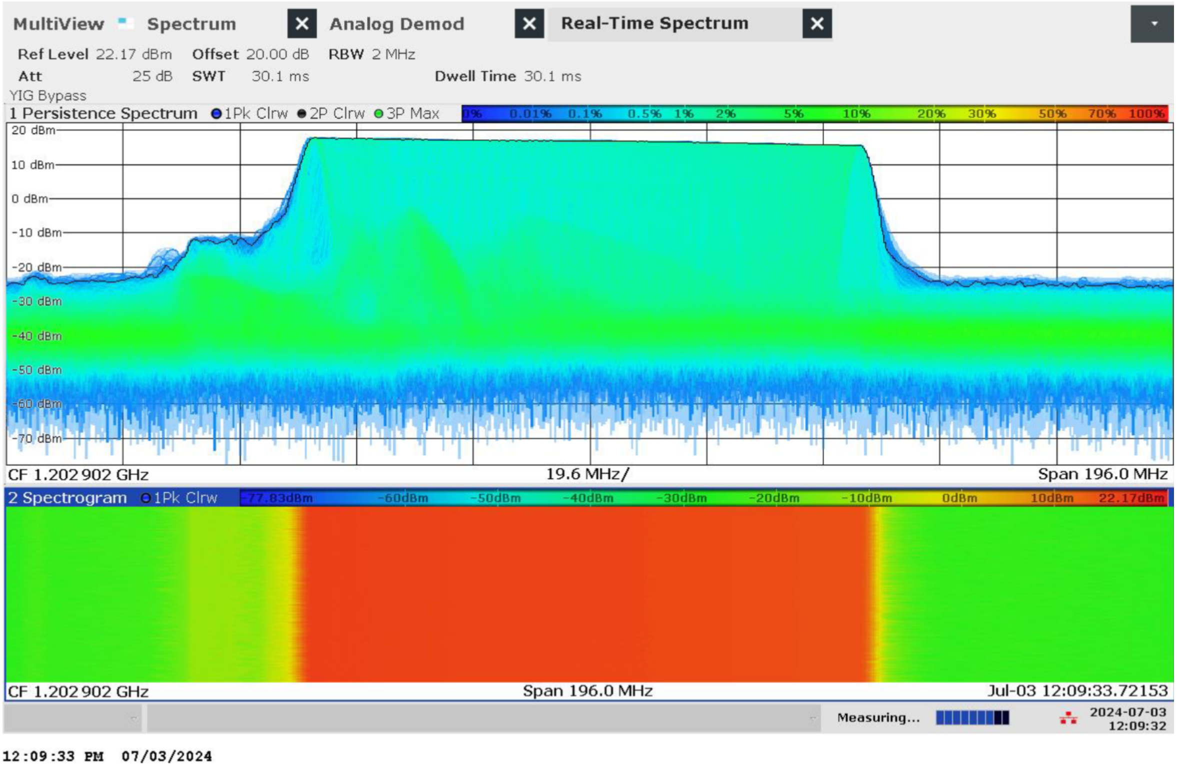

Figure 5.32: Real-time persistence and spectrogram measurement of jammer S2.4 on antenna 'L2'

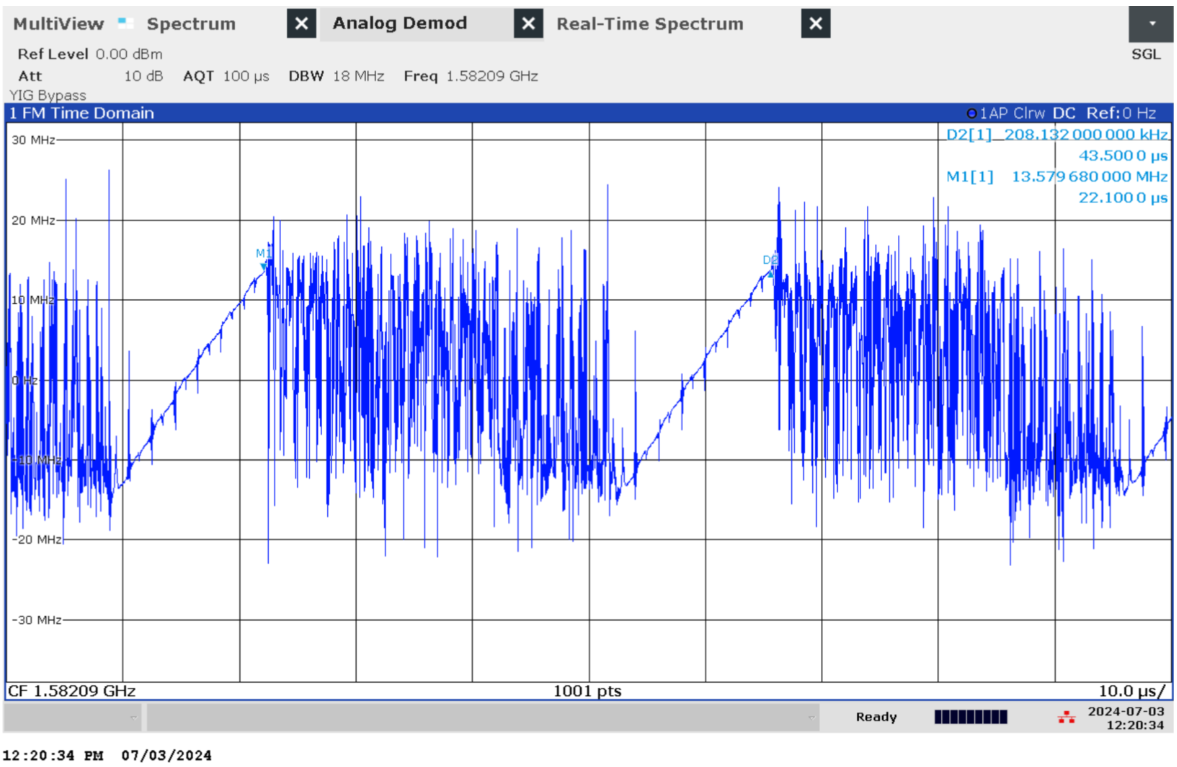

Figure 5.33: Time domain (analog demod) measurement of jammer S2.4 on antenna 'L1'

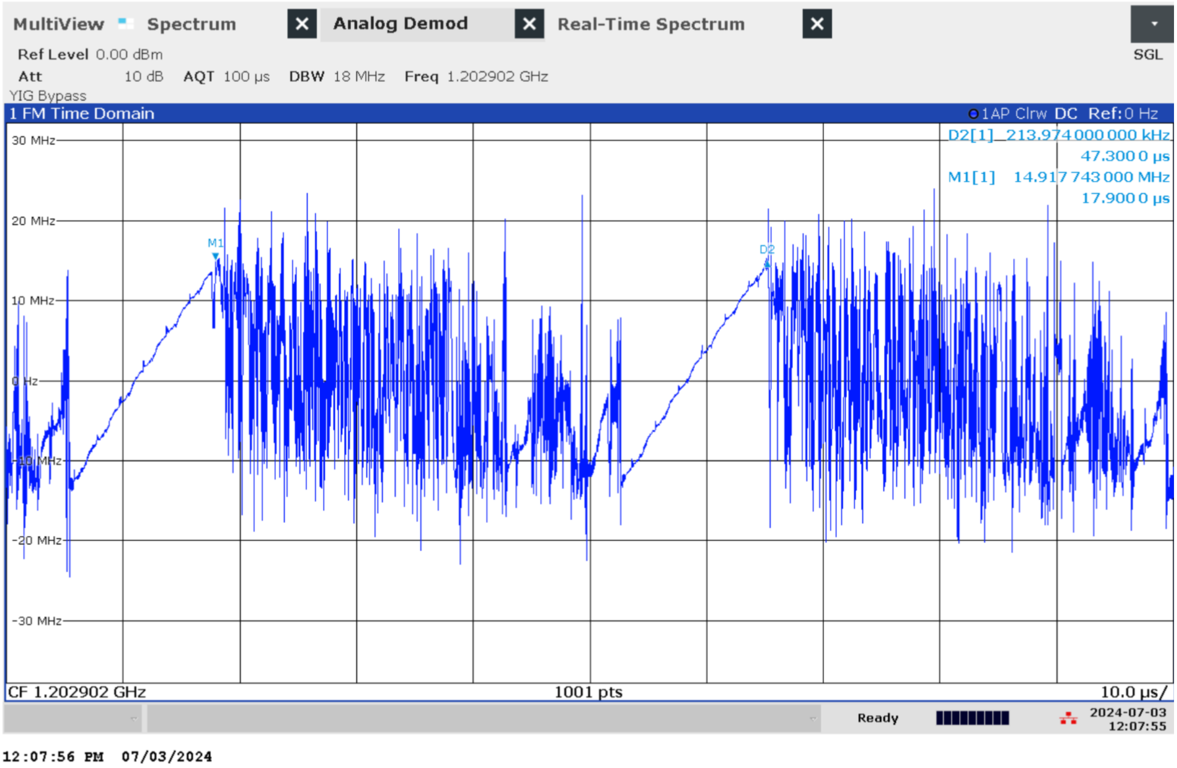

Figure 5.34: Time domain (analog demod) measurement of jammer S2.4 on antenna 'L2'

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

Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
1590-1600	70-80	N/A	N/A	N/A	5-8	Sawtooth

Table 5.8: Technical characteristics of U1.1-U1.4 jammer

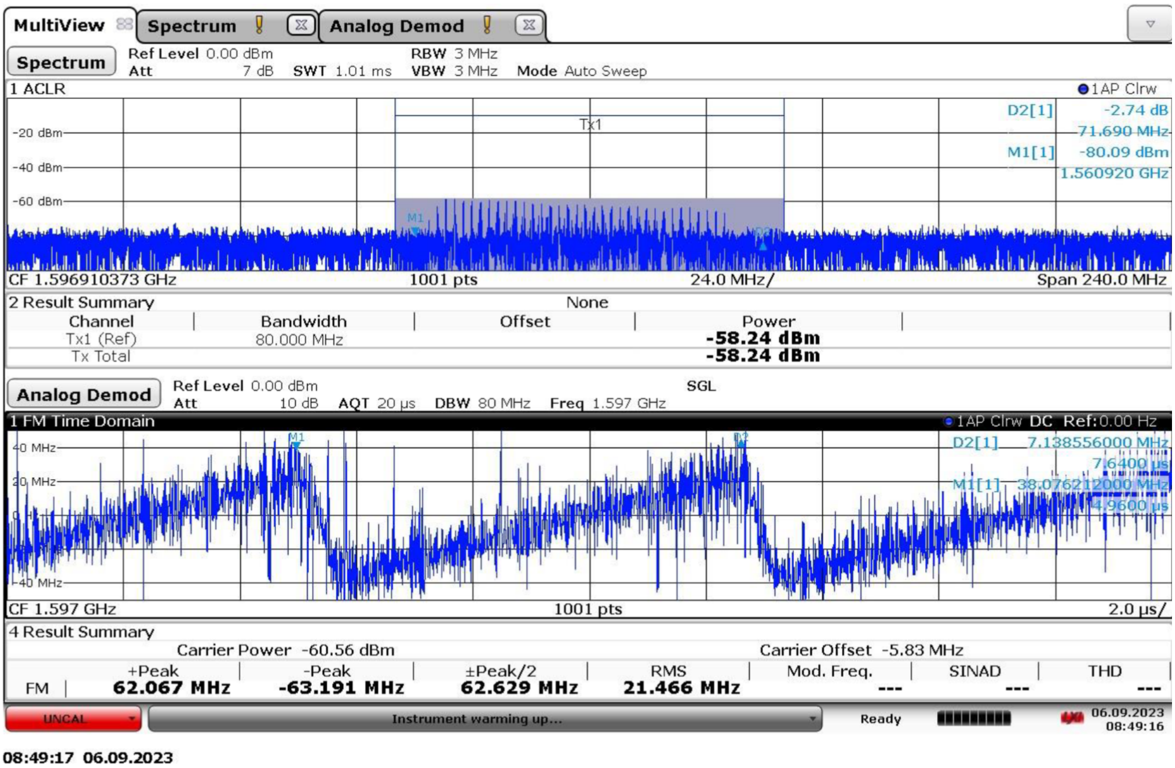

Figure 5.35: Example measurement of a U1.1 - U1.4 jammer

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 a one-antenna, yet multi-frequency, jammer, therefore a so-called 'L1+L2', disrupting parts of both the upper and lower L-band. Jammer (H1.4, H1.5, H1.6 and H1.7) are the same type as H1.1, but the measuremensts are all done on H1.1.

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

Antenna configuration	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	
L1. NB. HIGH PWR	1575.42	2.05	17.52	20.63	11.07	N/A	(sprea
L1. WB. HIGH PWR	1575.40	20.03	8.20	21.25	11.43	N/A	(sprea
L1. CW. HIGH PWR	1575.42	0.103	22.50	12.62	13.67	N/A	
L1. CHIRP. HIGH PWR	1575.60	18.75	3.10	15.83	-5.73	10.42	
L1. NB. LOW PWR	1575.42	2.05	-12.84	-9.73	-19.35	N/A	(sprea
L1. WB. LOW PWR	1575.40	19.93	-21.66	-8.66	-17.91	N/A	(sprea
L1. CW. LOW PWR	1575.42	0.10	-7.55	-17.46	-16.37	N/A	
L1. CHIRP. LOW PWR	1575.60	18.75	-27.03	-14.31	-35.65	10.46	
L2. NB. HIGH PWR	1227.42	2.049	18.73	21.84	12.17	N/A	(sprea
L2. WB. HIGH PWR	1227.36	20.30	9.27	22.34	12.09	N/A	(sprea
L2. CW. HIGH PWR	1227.42	0.10	23.96	14.13	15.17	N/A	
L2. CHIRP. HIGH PWR	1227.22	18.79	4.98	17.72	-4.11	10.4	
L2. NB. LOW PWR	1227.42	2.05	-11.20	-8.09	-17.79	N/A	(sprea
L2. WB. LOW PWR	1227.36	20.30	-20.39	-7.32	-17.41	N/A	(sprea
L2. CW. LOW PWR	1227.42	0.10	-5.98	-15.81	-14.77	N/A	
L2. CHIRP. LOW PWR	1227.22	18.76	-24.97	-12.23	-33.98	10.4	

Table 5.9: Technical characteristics of H1.1 jammer

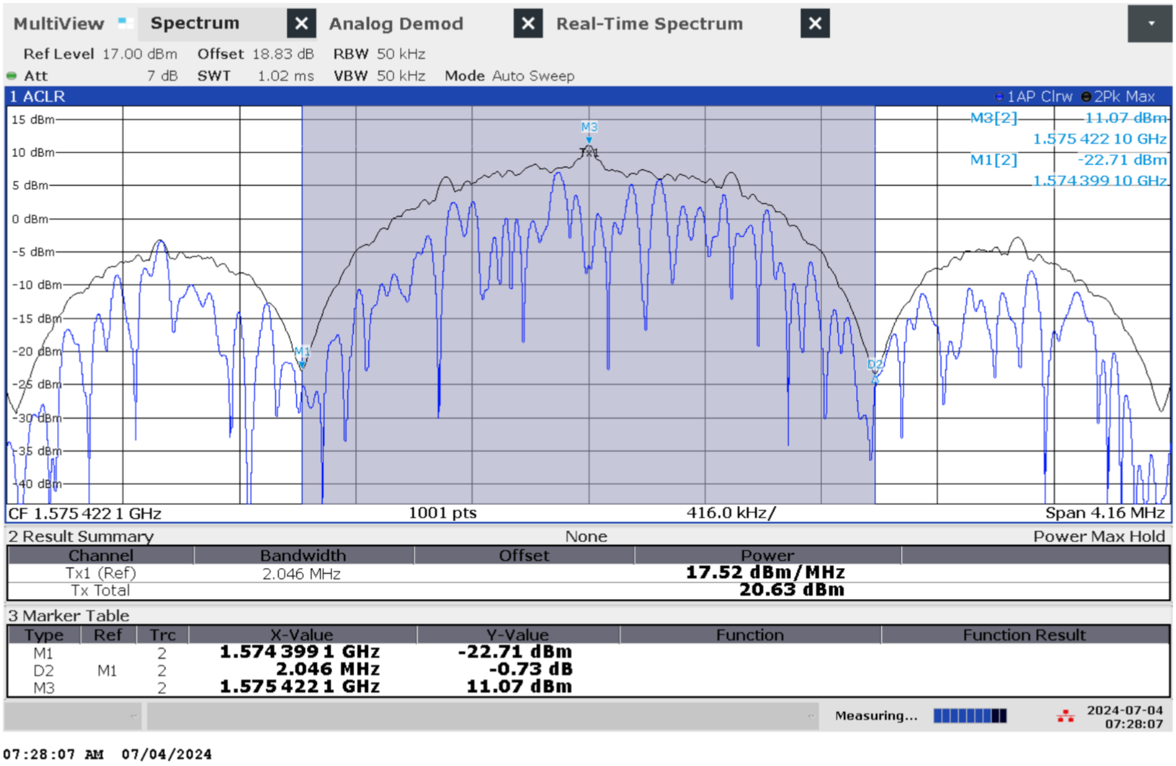

Figure 5.36: Frequency and power measurement of jammer H1.1 with antenna configuration L1 Narrow band High Power (NB HIGH PWR)

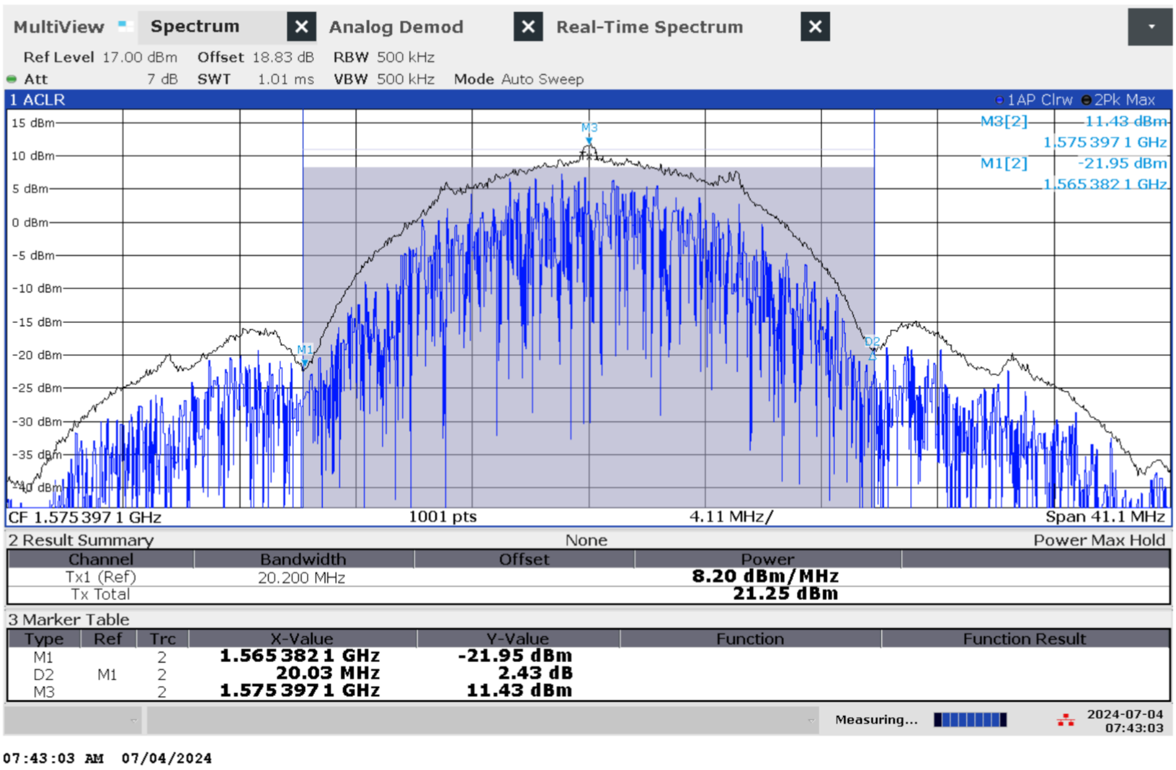

Figure 5.37: Frequency and power measurement of jammer H1.1 with antenna configuration L1 Wide band High Power (WB HIGH PWR)

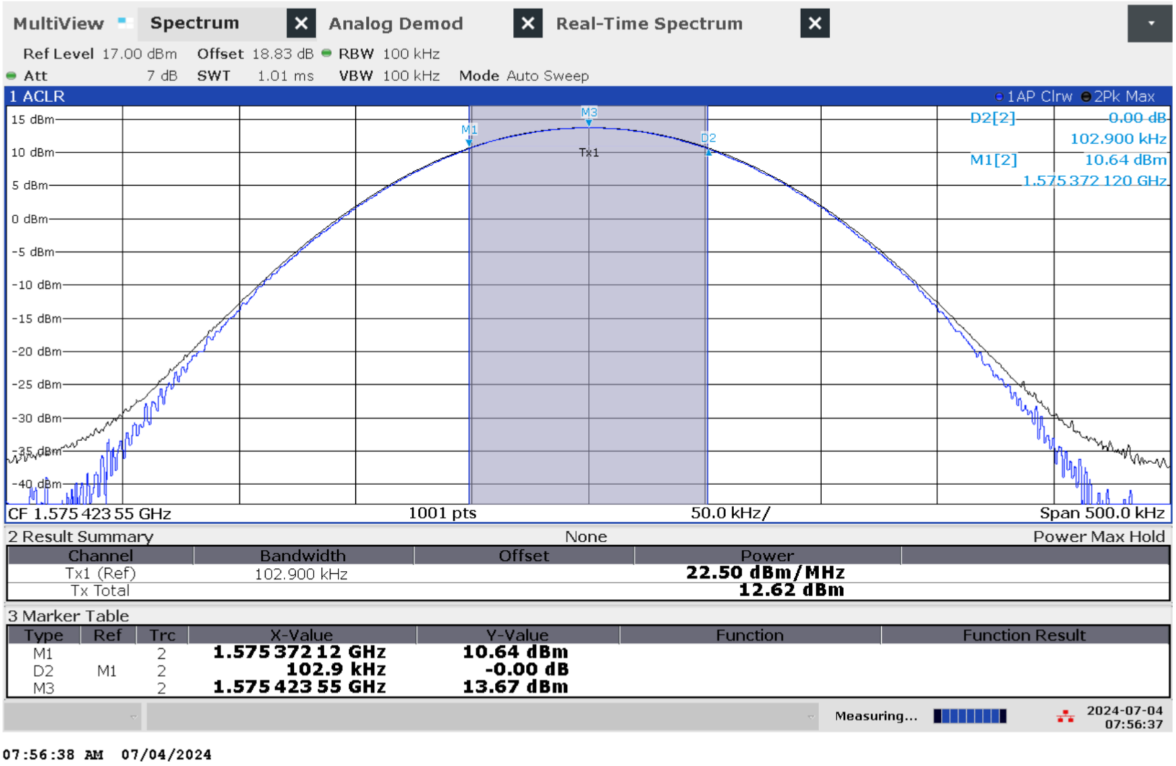

Figure 5.38: Frequency and power measurement of jammer H1.1 with antenna configuration L1 Continuous Wave band High Power (CW HIGH PWR)

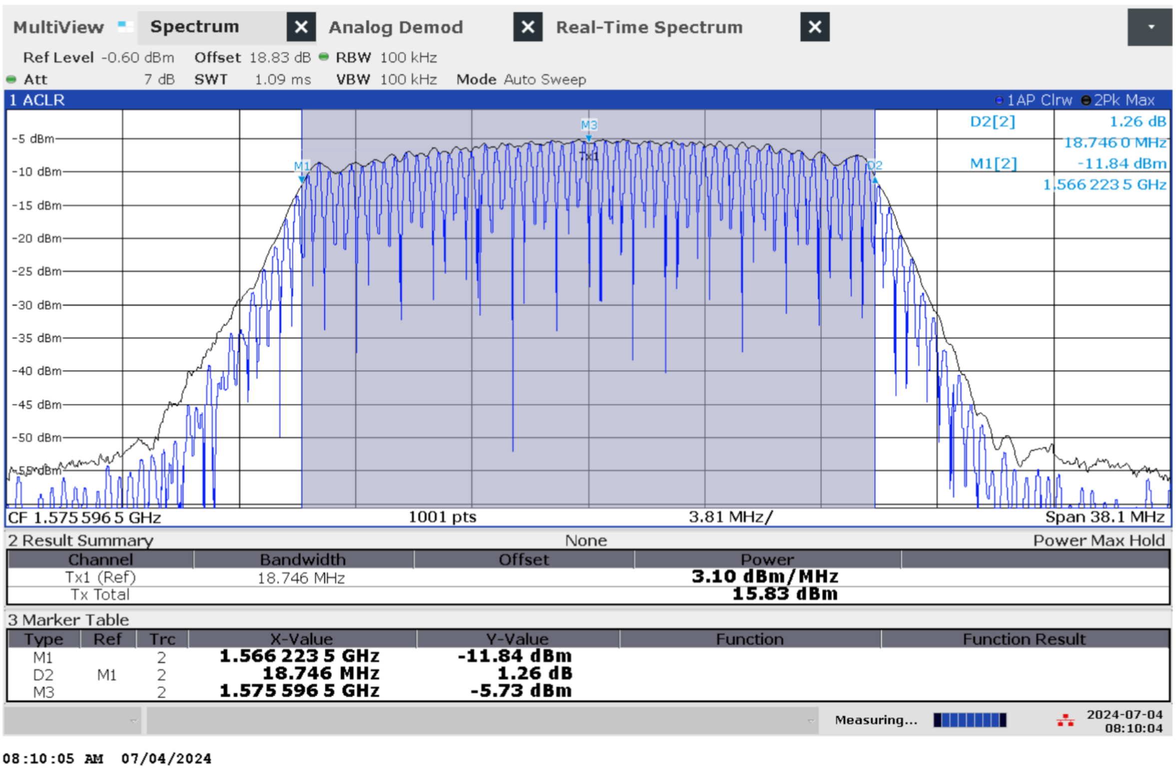

Figure 5.39: Frequency and power measurement of jammer H1.1 with antenna configuration L1 Chirp High Power (CHIRP HIGH PWR)

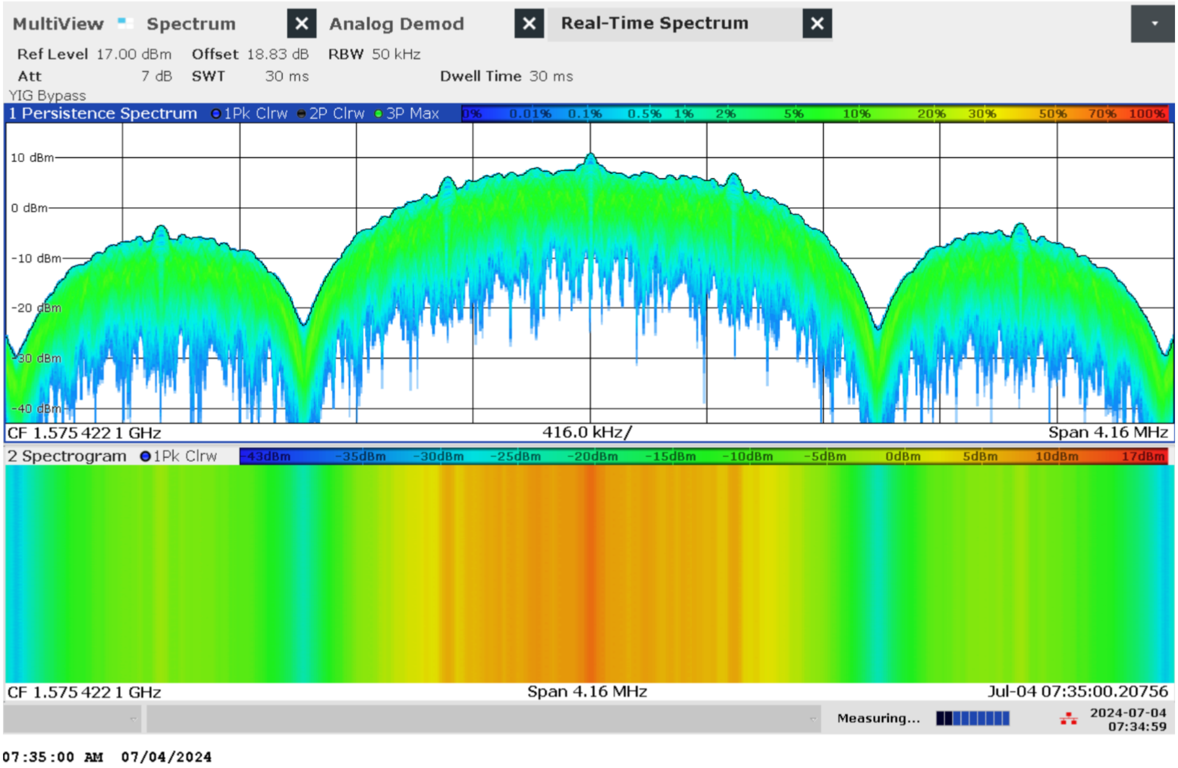

Figure 5.40: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L1 Narrow band High Power (NB HIGH PWR)

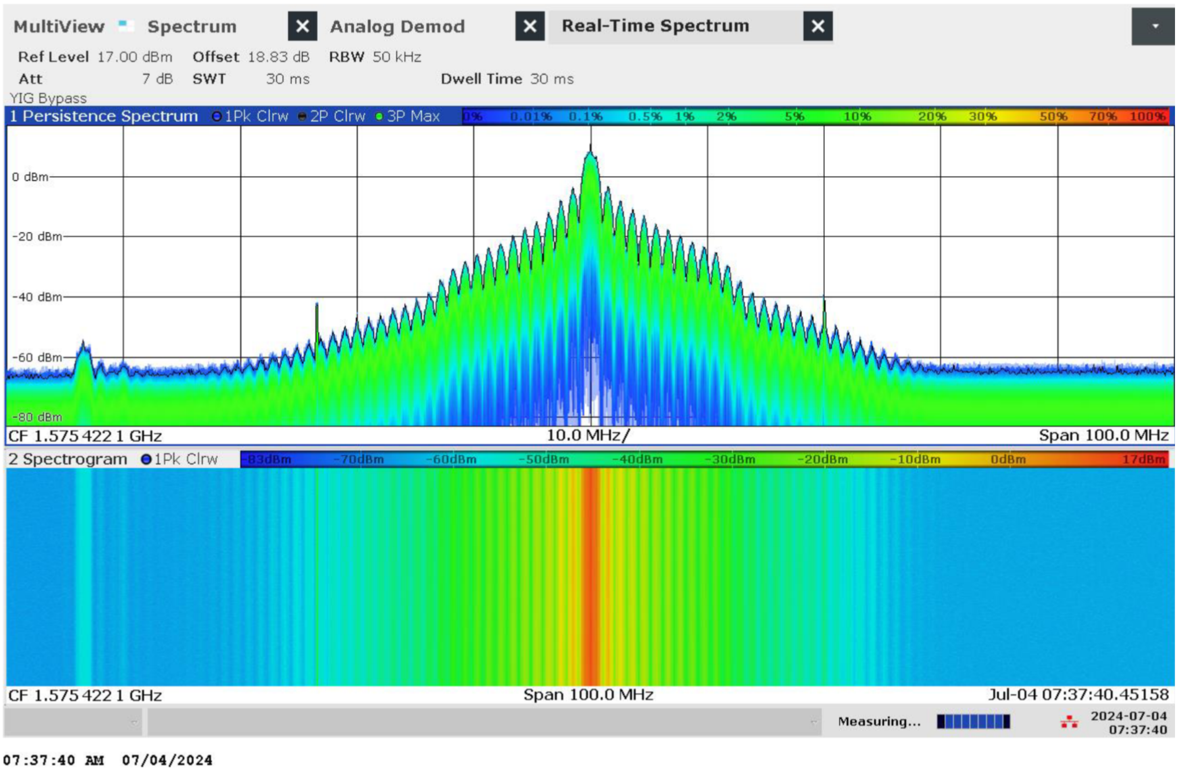

Figure 5.41: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L1 Narrow band High Power (NB HIGH PWR)

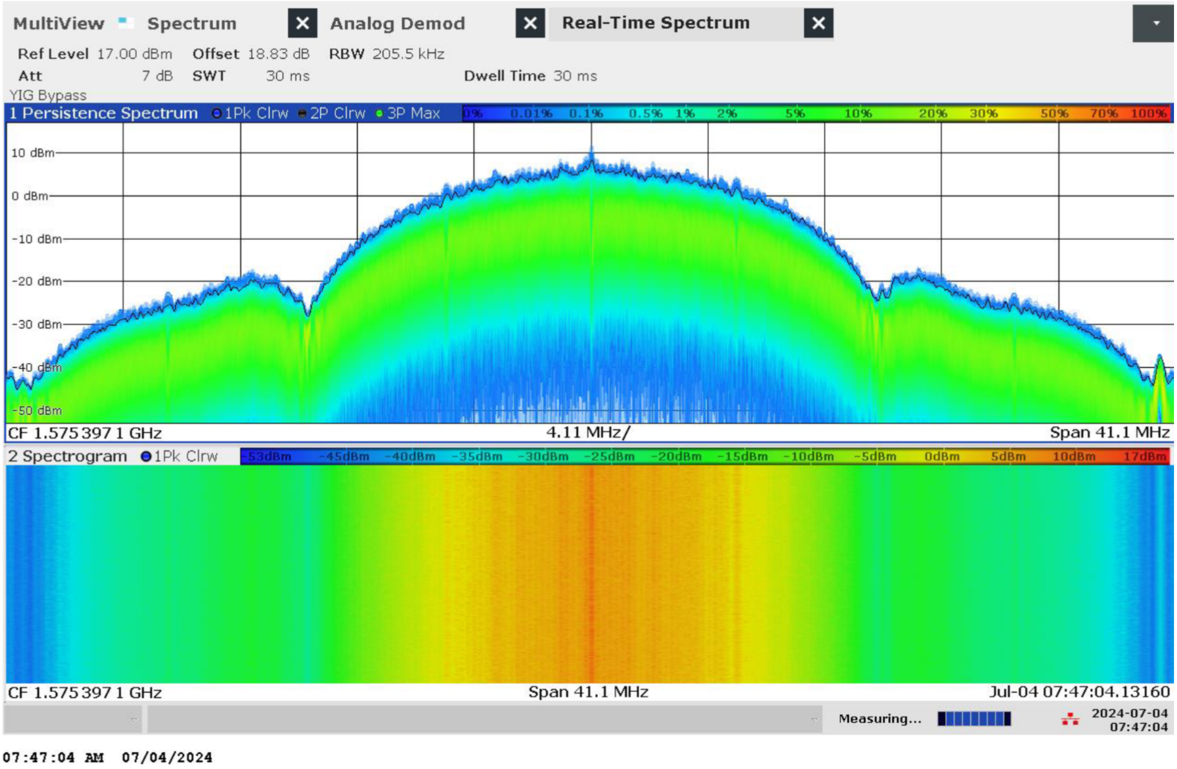

Figure 5.42: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L1 Wide band High Power (WB HIGH PWR)

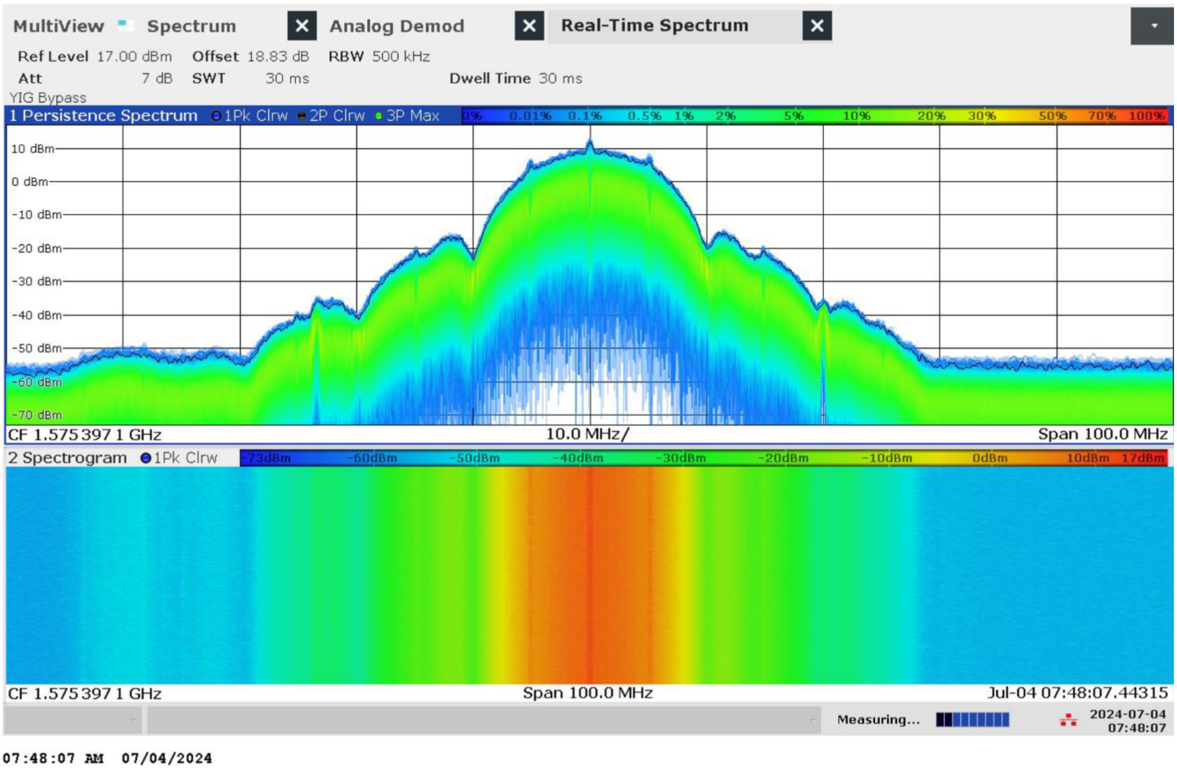

Figure 5.43: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L1 Wide band High Power (WB HIGH PWR)

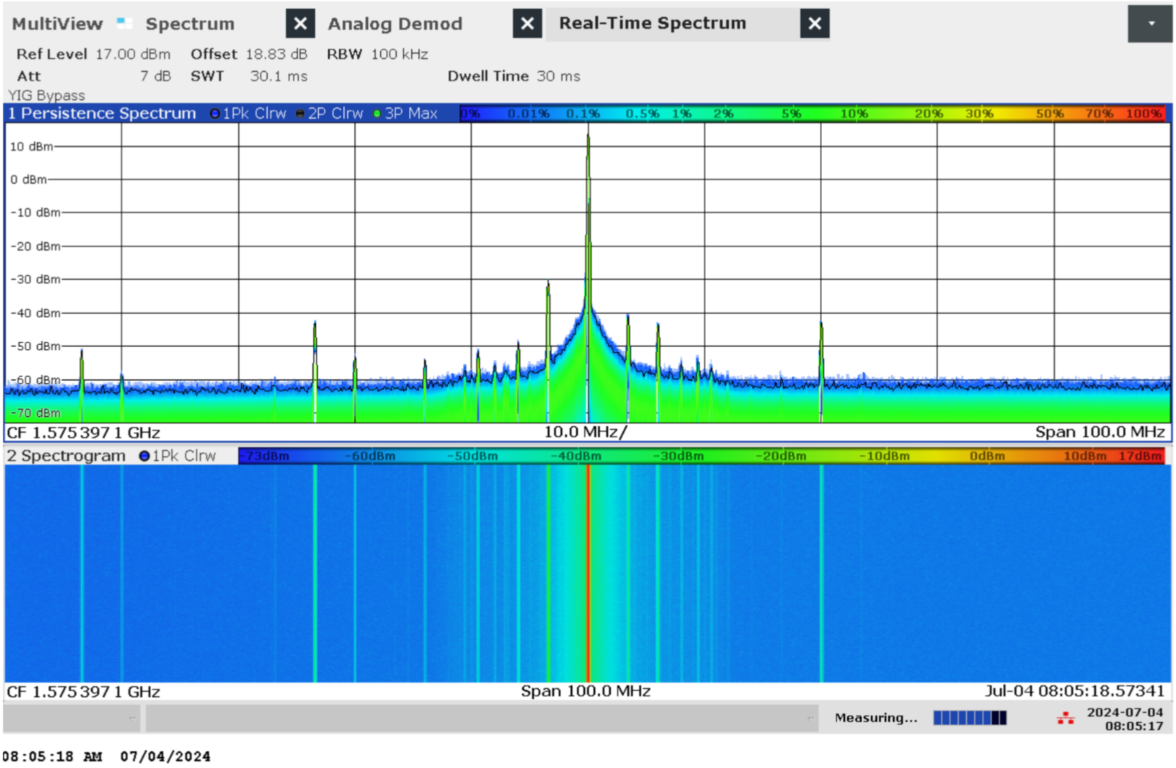

Figure 5.44: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L1 Continuous Wave band High Power (CW HIGH PWR)

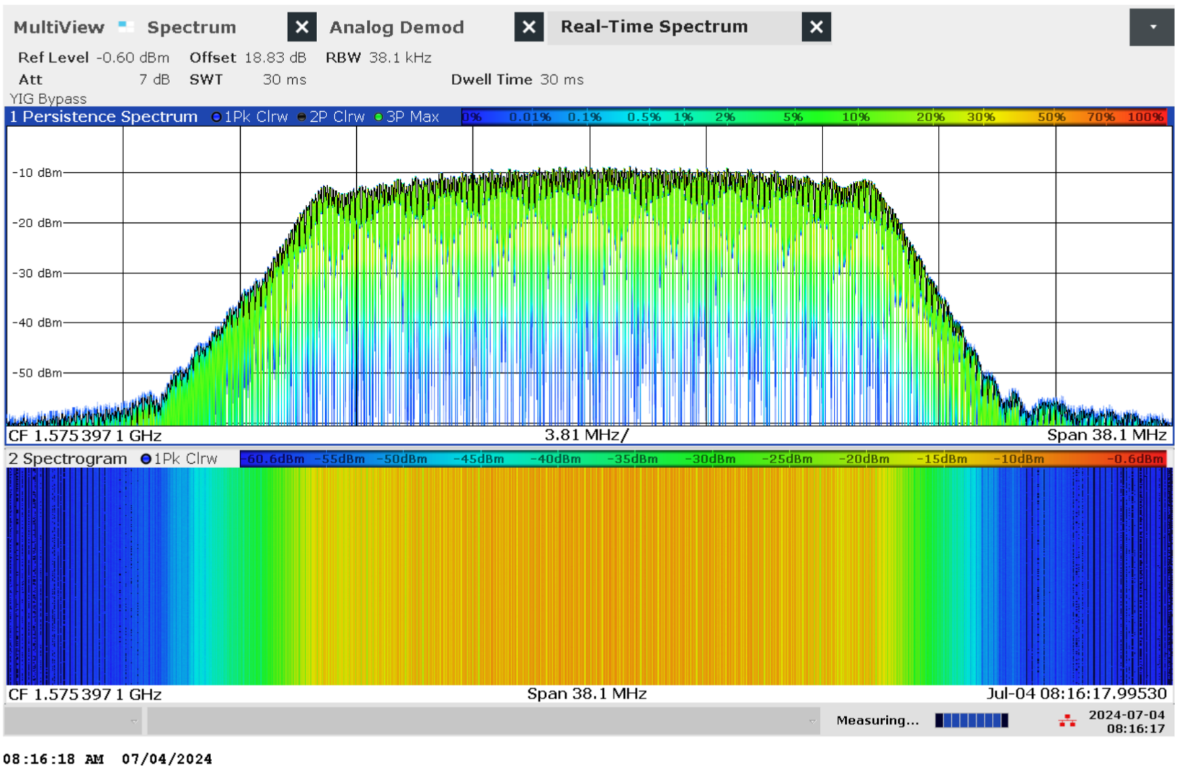

Figure 5.45: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L1 Chirp High Power (CHIRP HIGH PWR)

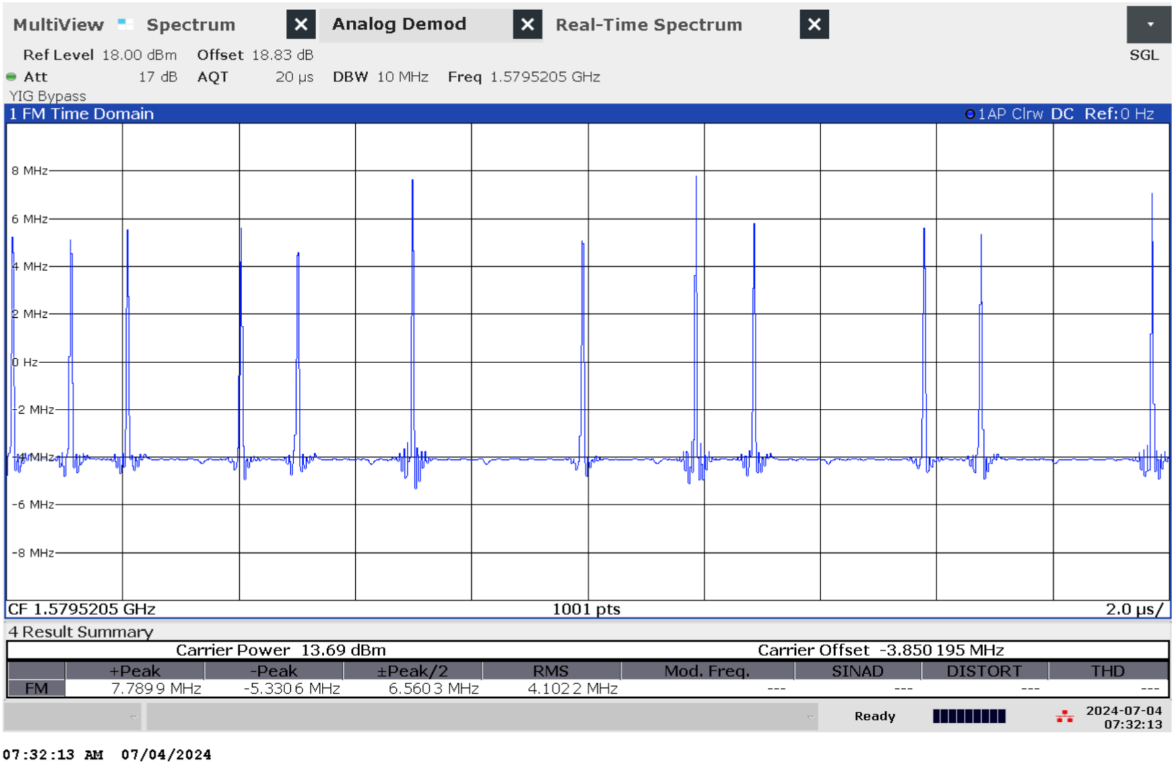

Figure 5.46: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L1 Narrow band High Power (NB HIGH PWR)

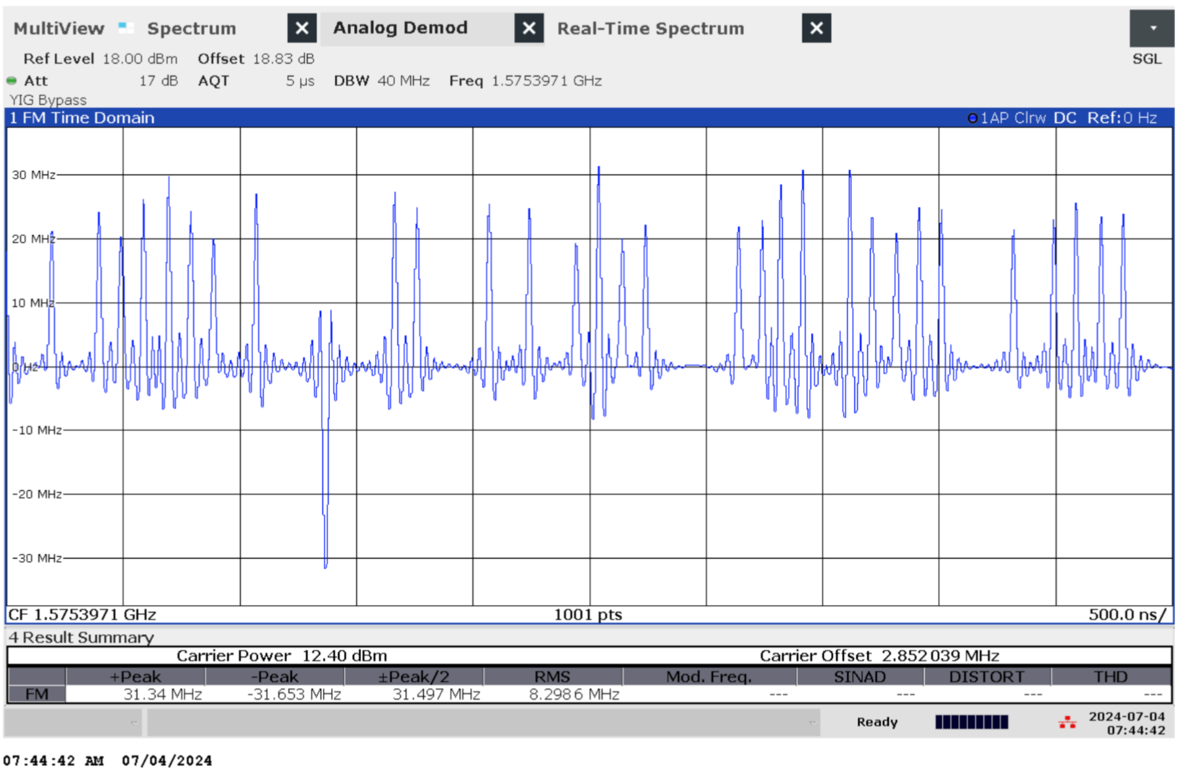

Figure 5.47: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L1 Wide band High Power (WB HIGH PWR)

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Figure 5.48: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L1 Continuous Wave band High Power (CW HIGH PWR)

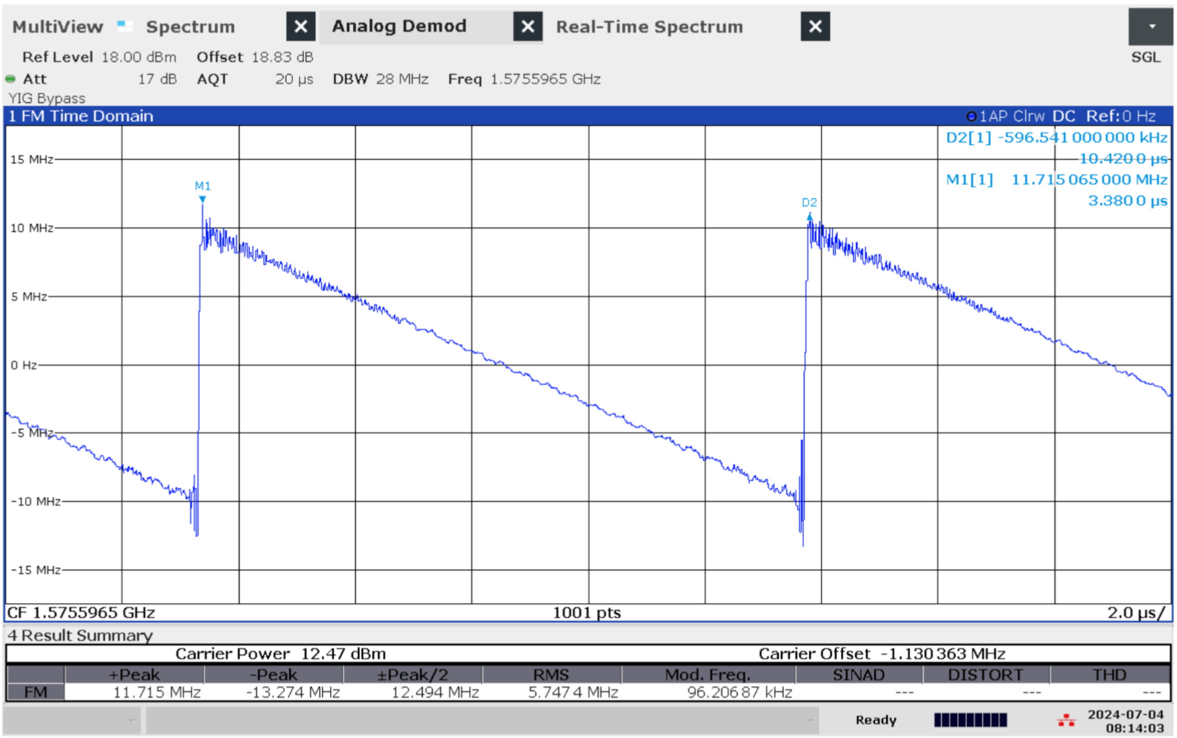

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Figure 5.49: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L1 Chirp High Power (CHIRP HIGH PWR)

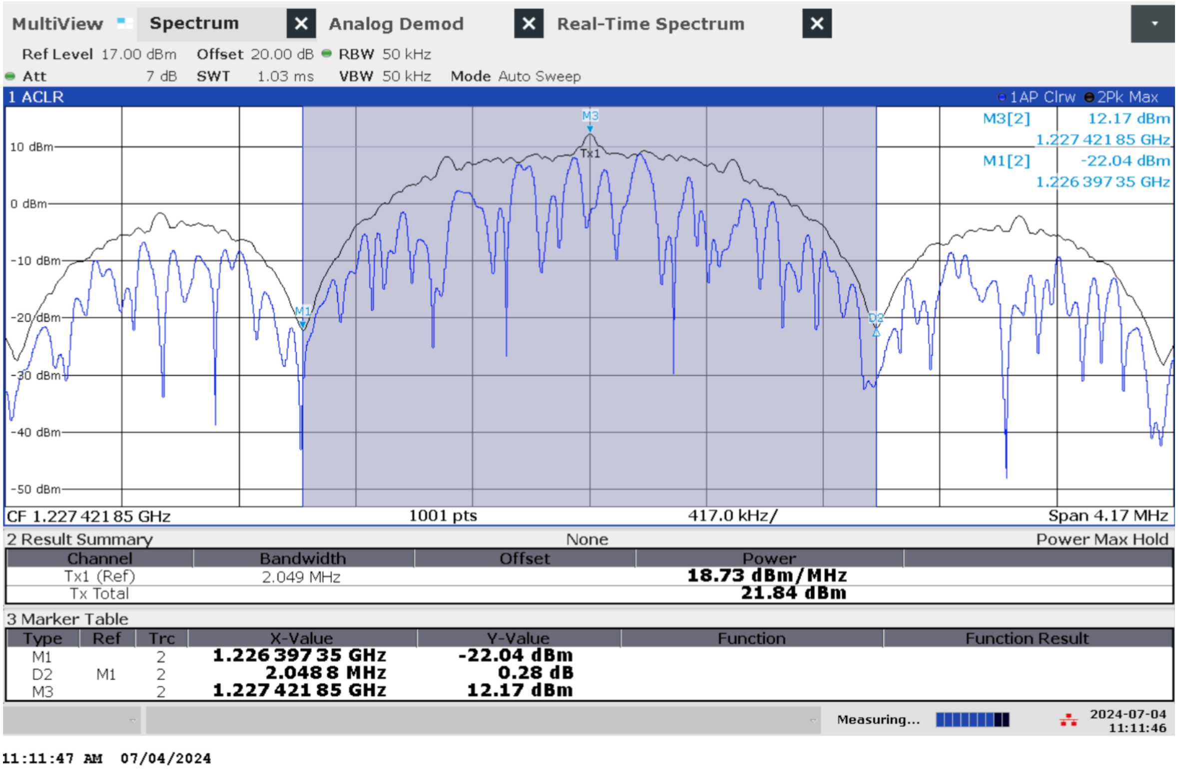

Figure 5.50: Frequency and power measurement of jammer H1.1 with antenna configuration L2 Narrow band High Power (NB HIGH PWR)

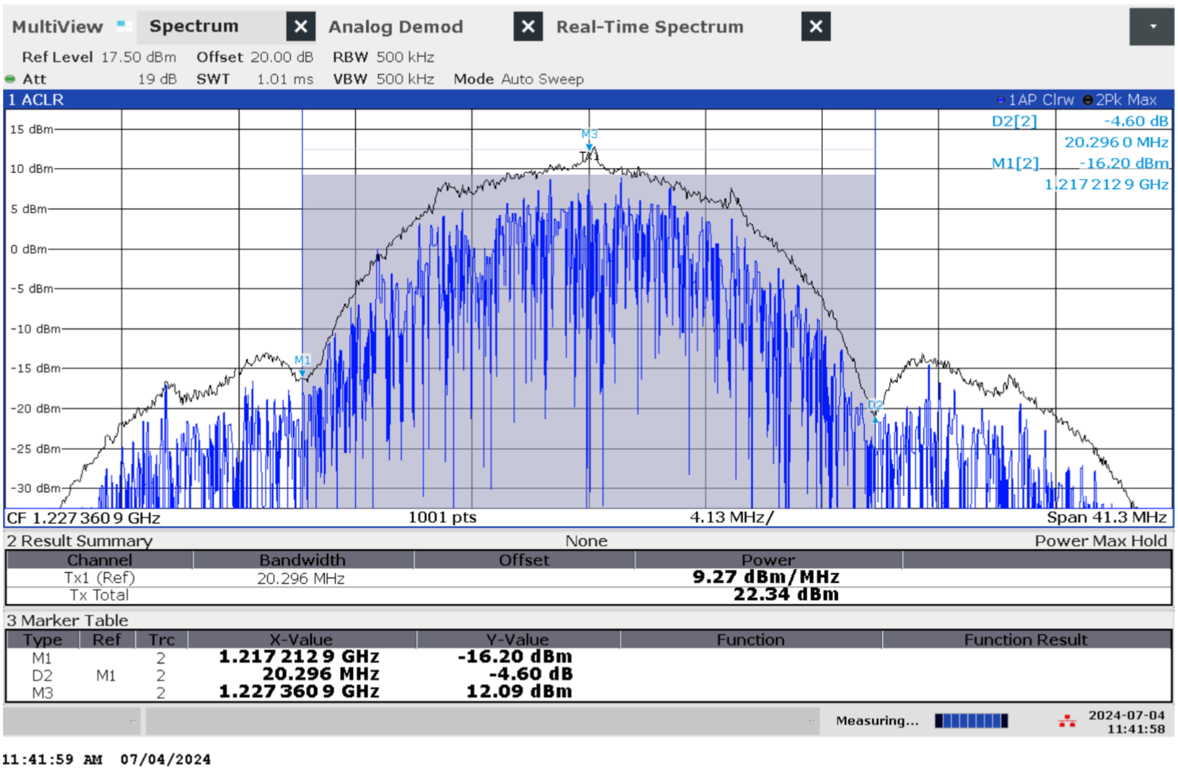

Figure 5.51: Frequency and power measurement of jammer H1.1 with antenna configuration L2 Wide band High Power (WB HIGH PWR)

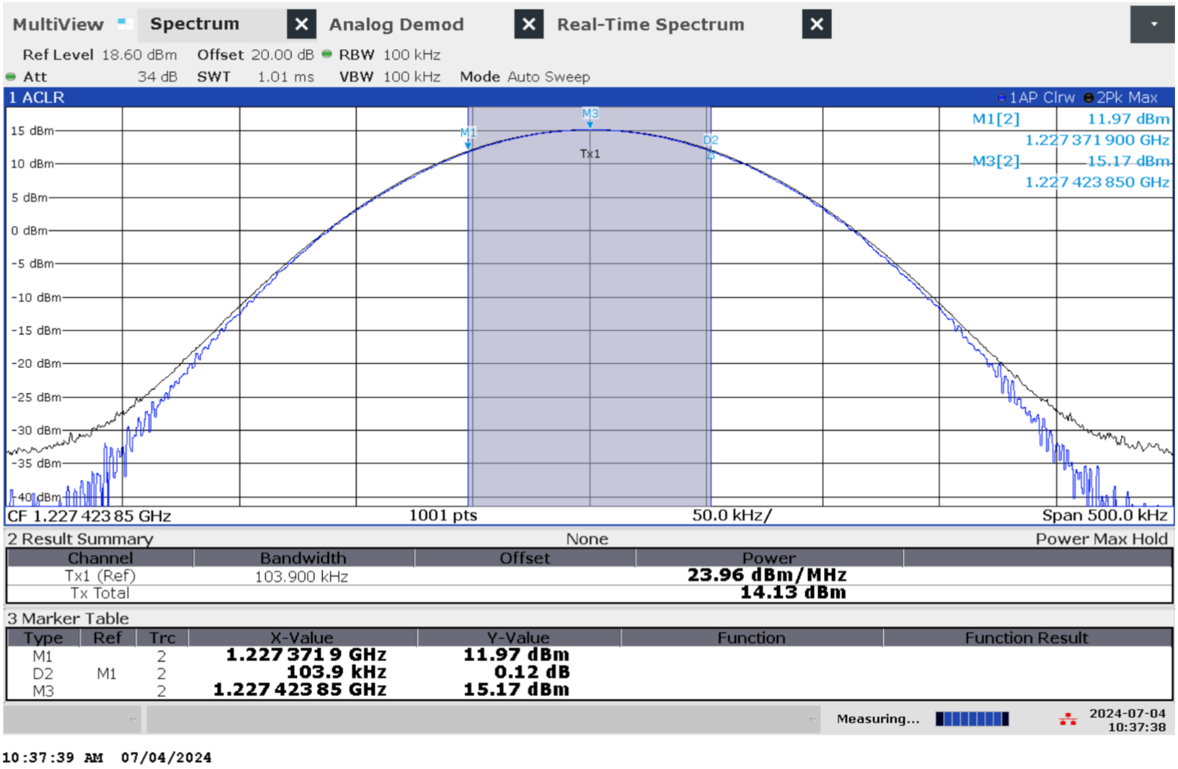

Figure 5.52: Frequency and power measurement of jammer H1.1 with antenna configuration L2 Continuous Wave band High Power (CW HIGH PWR)

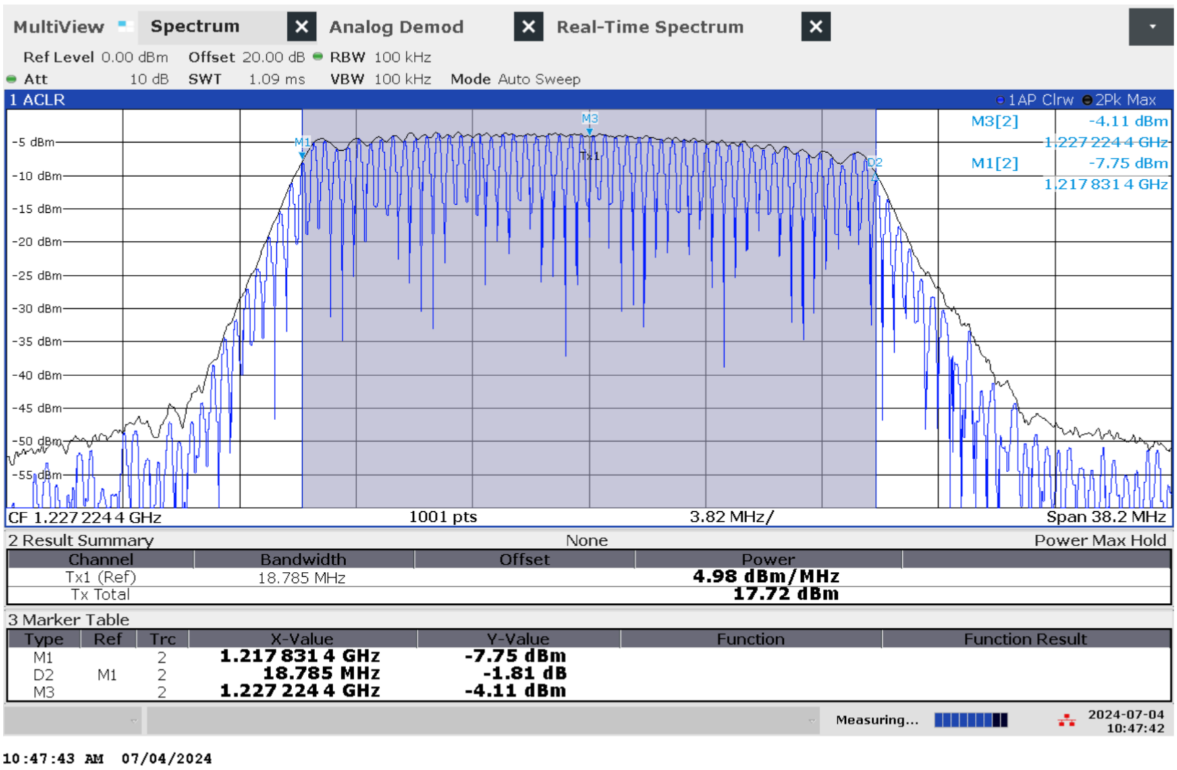

Figure 5.53: Frequency and power measurement of jammer H1.1 with antenna configuration L2 Chirp High Power (CHIRP HIGH PWR)

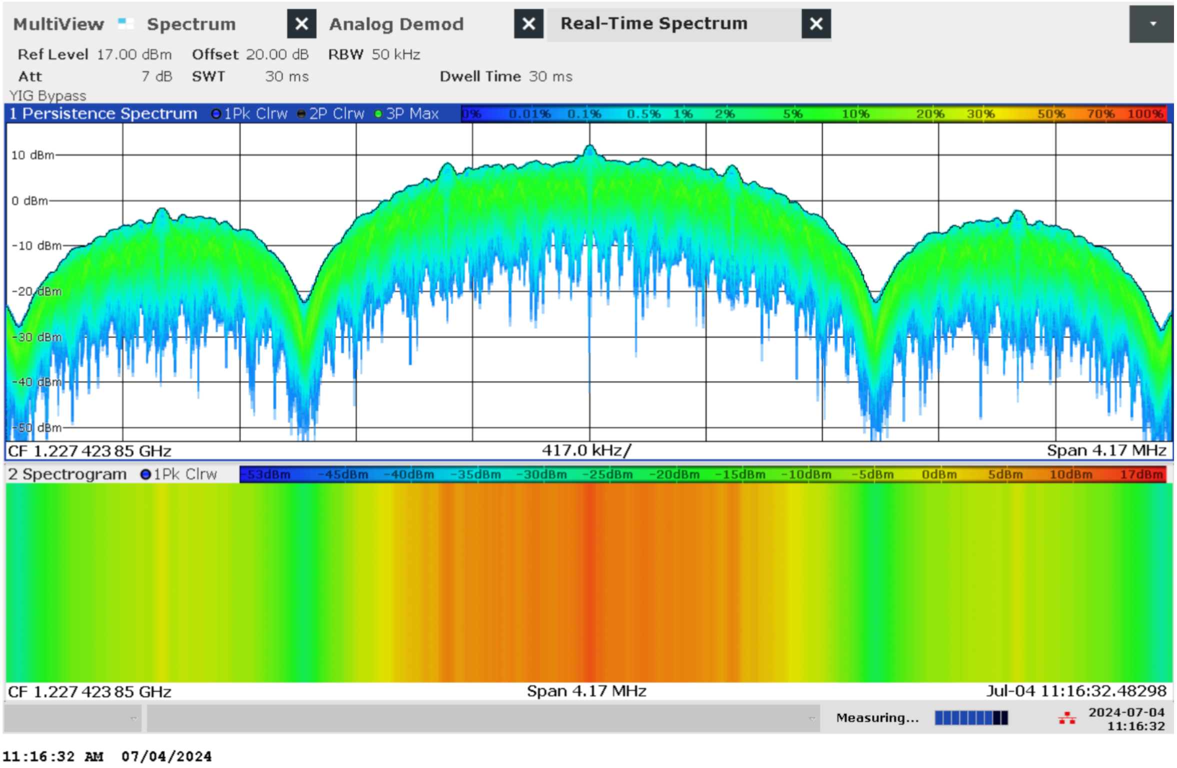

Figure 5.54: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L2 Narrow band High Power (NB HIGH PWR)

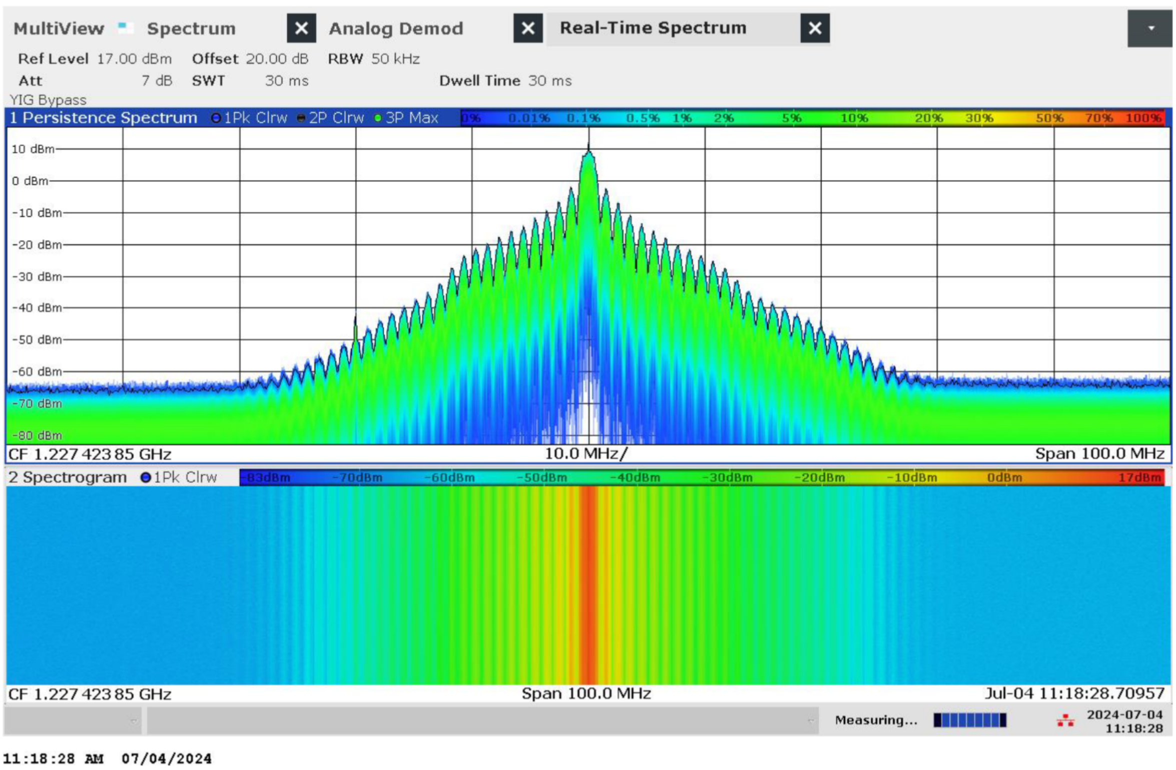

Figure 5.55: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L2 Narrow band High Power (NB HIGH PWR)

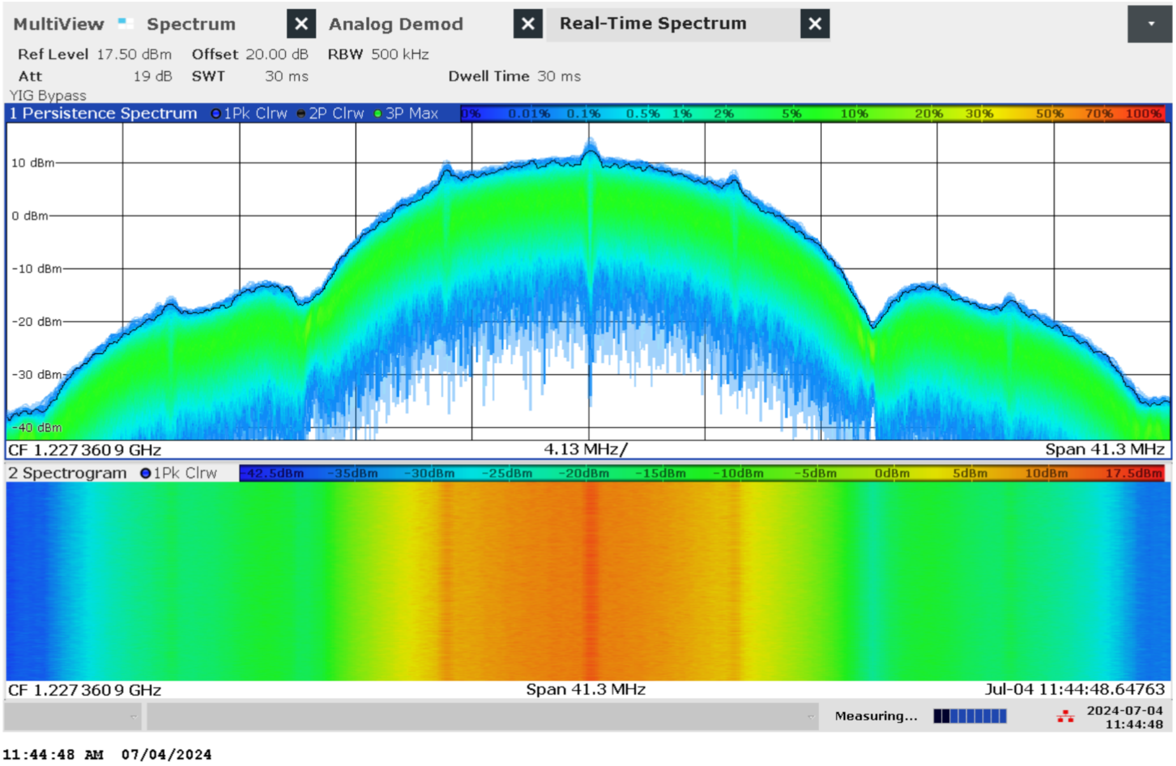

Figure 5.56: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L2 Wide band High Power (WB HIGH PWR)

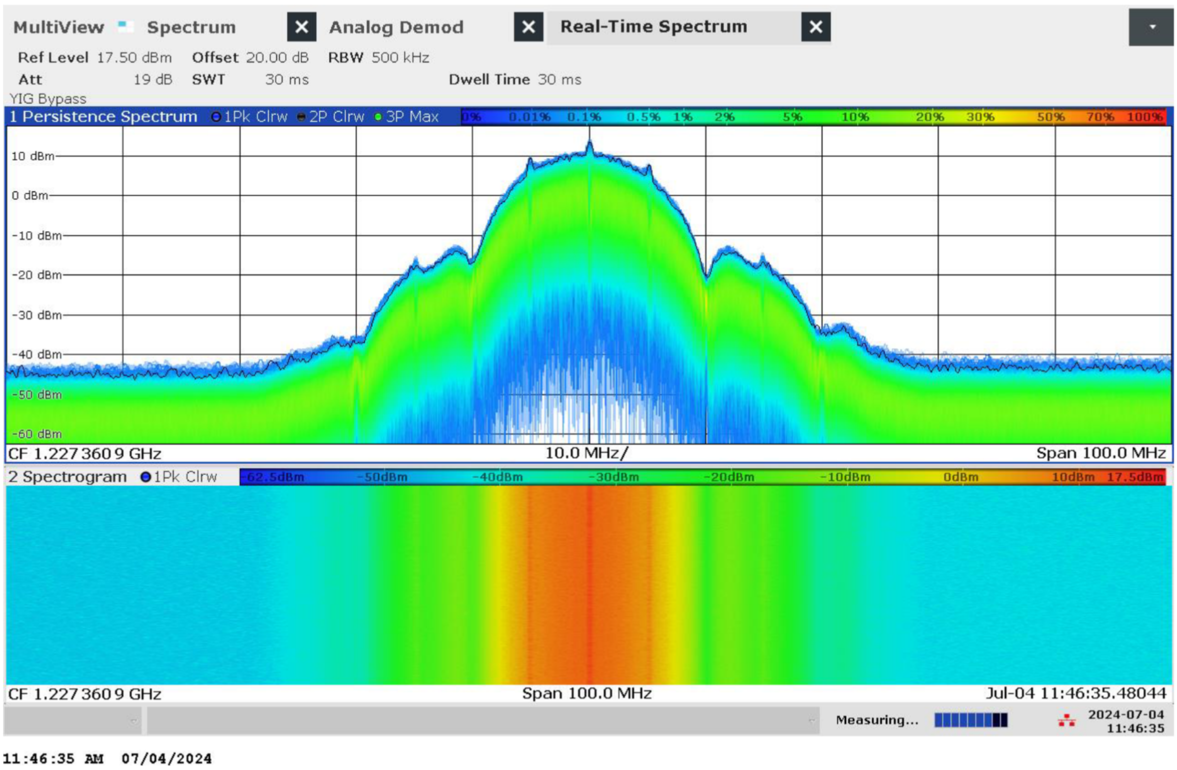

Figure 5.57: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L2 Wide band High Power (WB HIGH PWR)

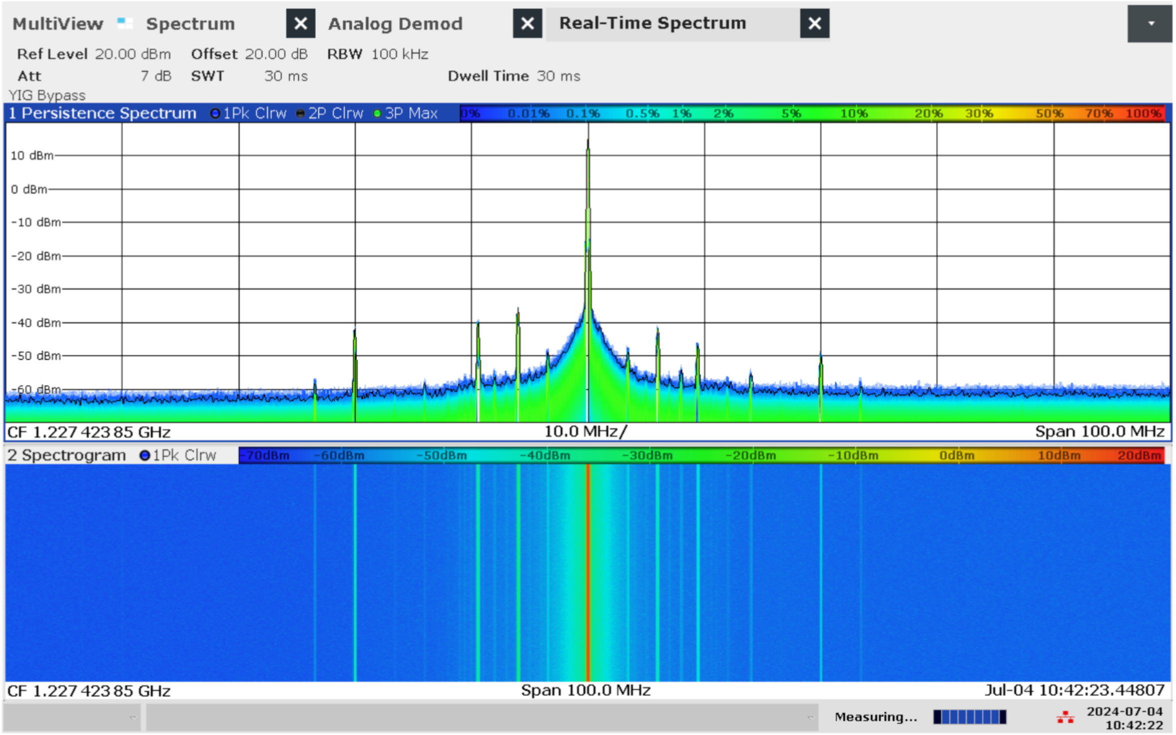

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Figure 5.58: Real-time persistence and spectrogram measurement with wider span of jammer H1.1 with antenna configuration L2 Continuous Wave band High Power (CW HIGH PWR)

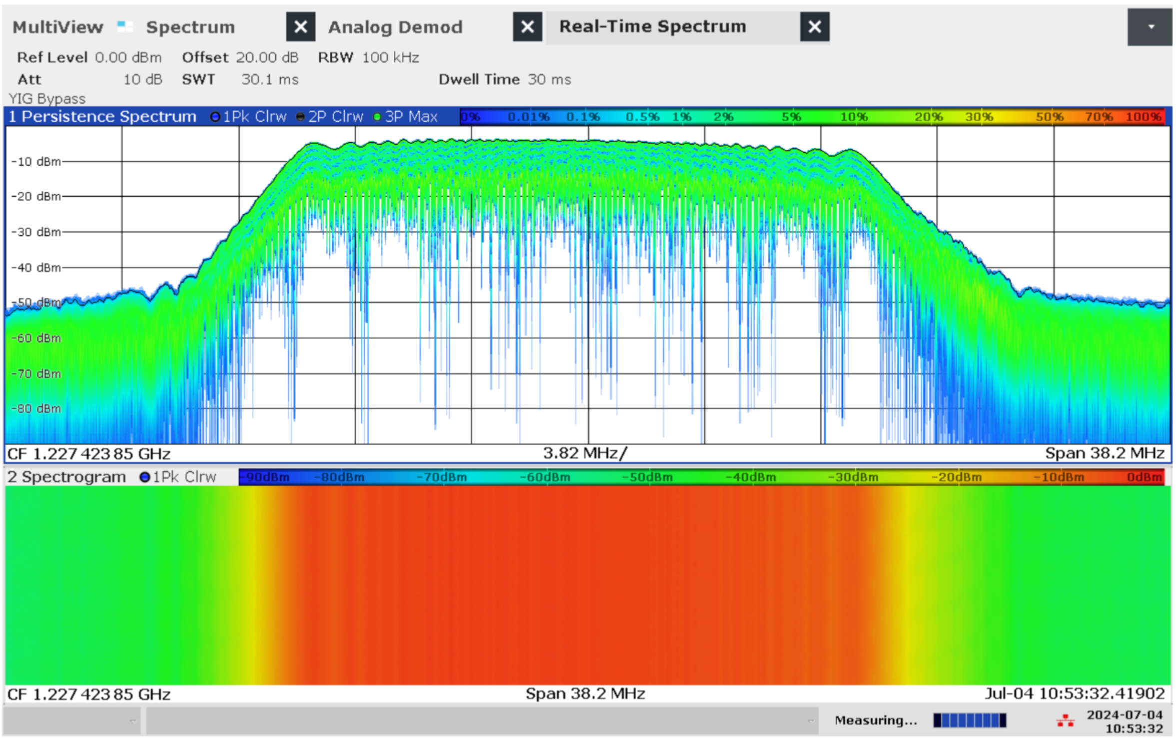

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Figure 5.59: Real-time persistence and spectrogram measurement of jammer H1.1 with antenna configuration L2 Chirp High Power (CHIRP HIGH PWR)

Figure 5.60: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L2 Narrow band High Power (NB HIGH PWR)

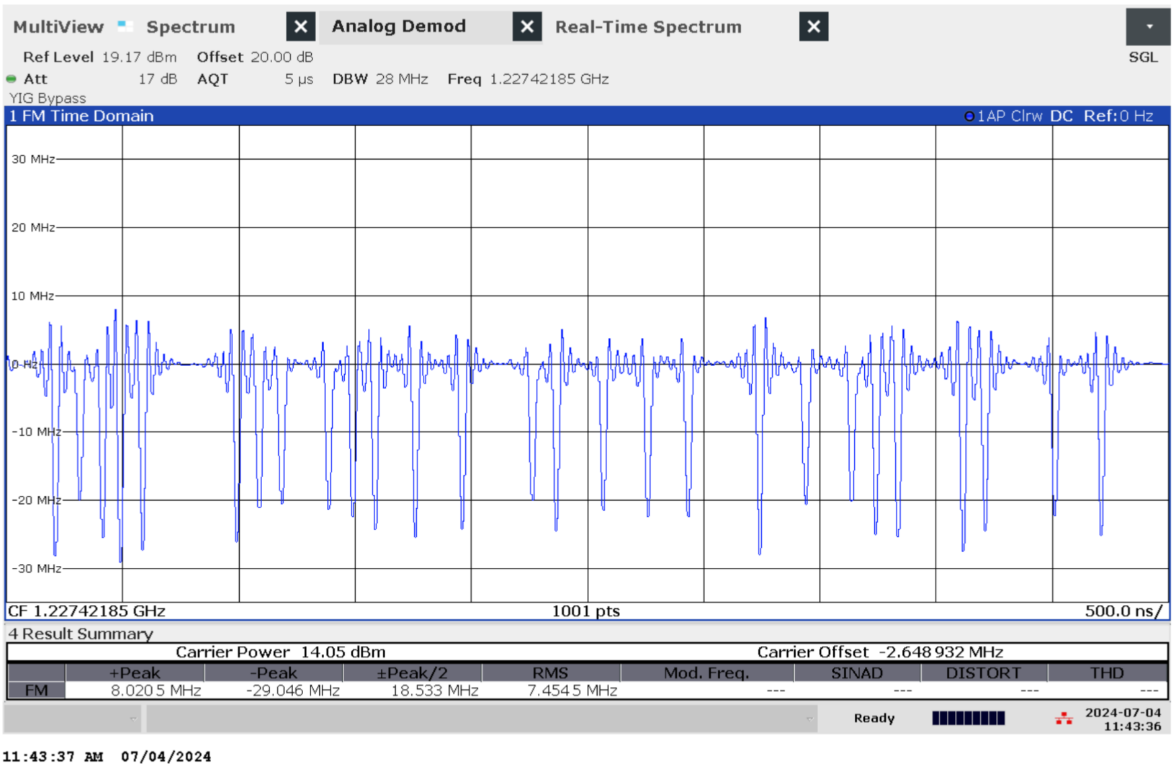

Figure 5.61: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L2 Wide band High Power (WB HIGH PWR)

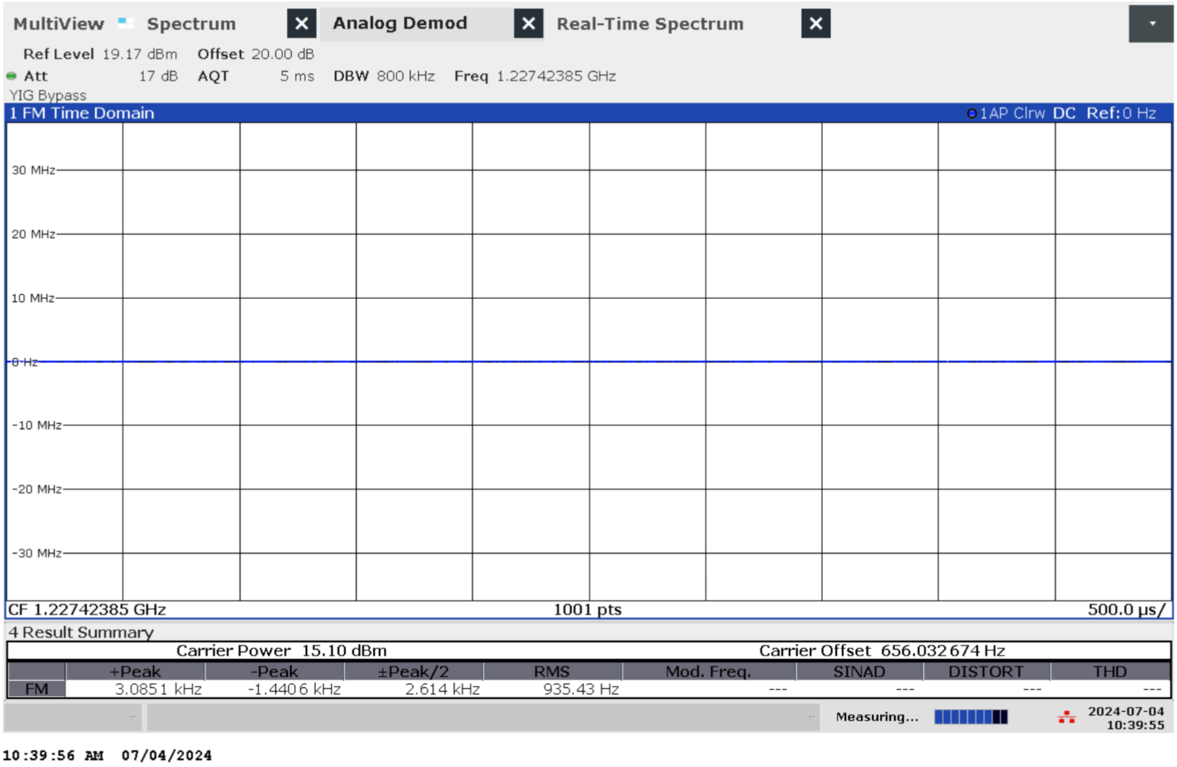

Figure 5.62: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L2 Continuous Wave band High Power (CW HIGH PWR)

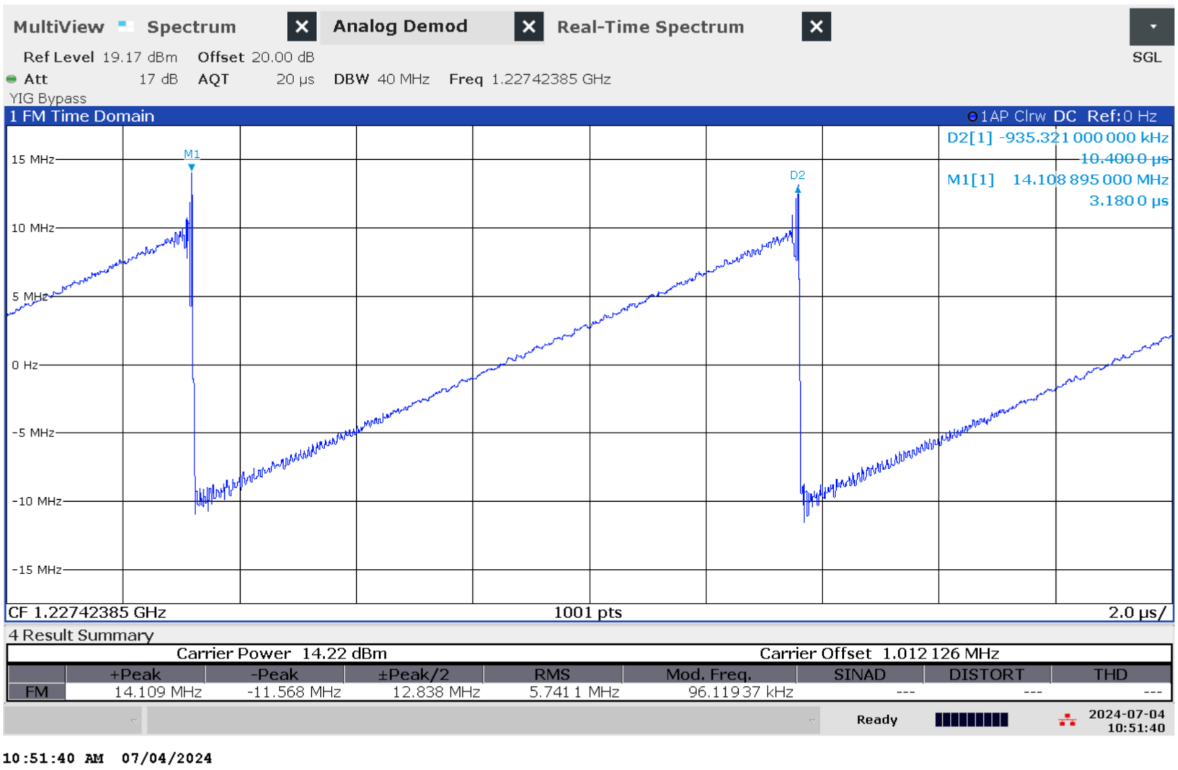

Figure 5.63: Time domain (analog demod) measurement of jammer H1.1 with antenna configuration L2 Chirp High Power (CHIRP HIGH PWR)

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.

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulation
L1	1575.22	21.99	14.35	27.78	9.36	6.08	Sawtooth

Table 5.10: Technical characteristics of H1.2 jammer

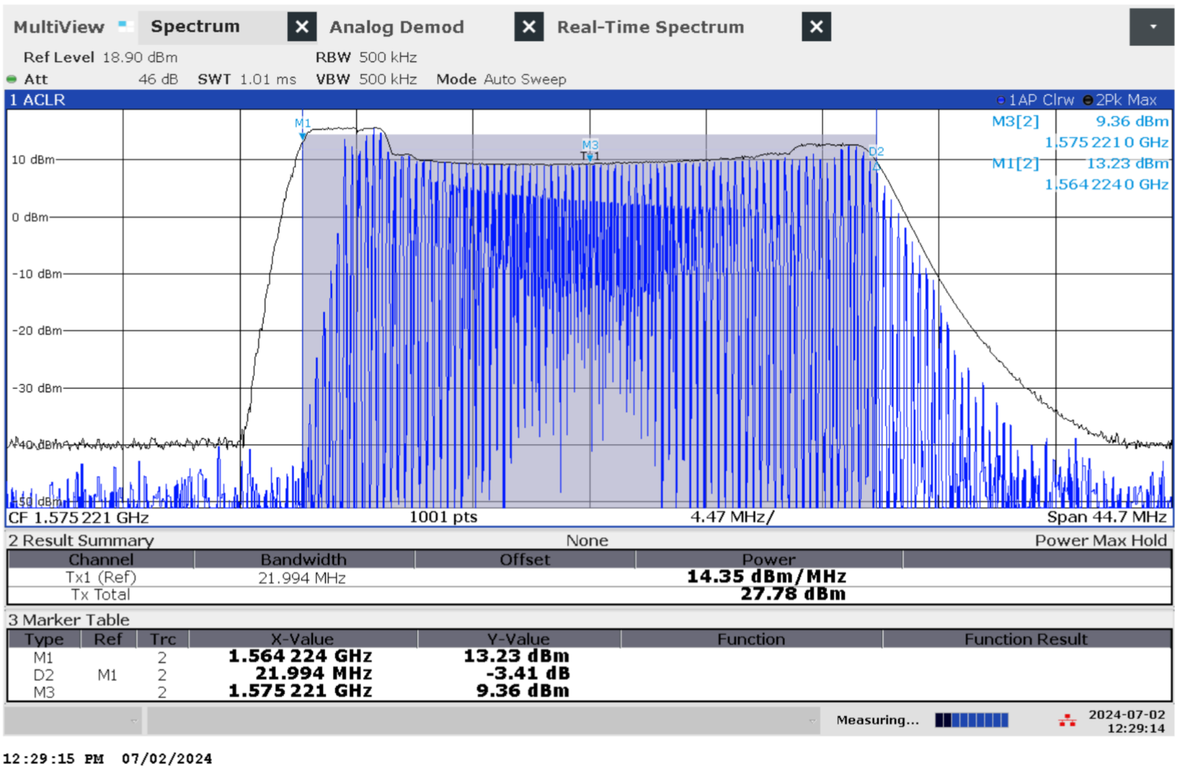

Figure 5.64: Frequency and power measurement of jammer H1.2

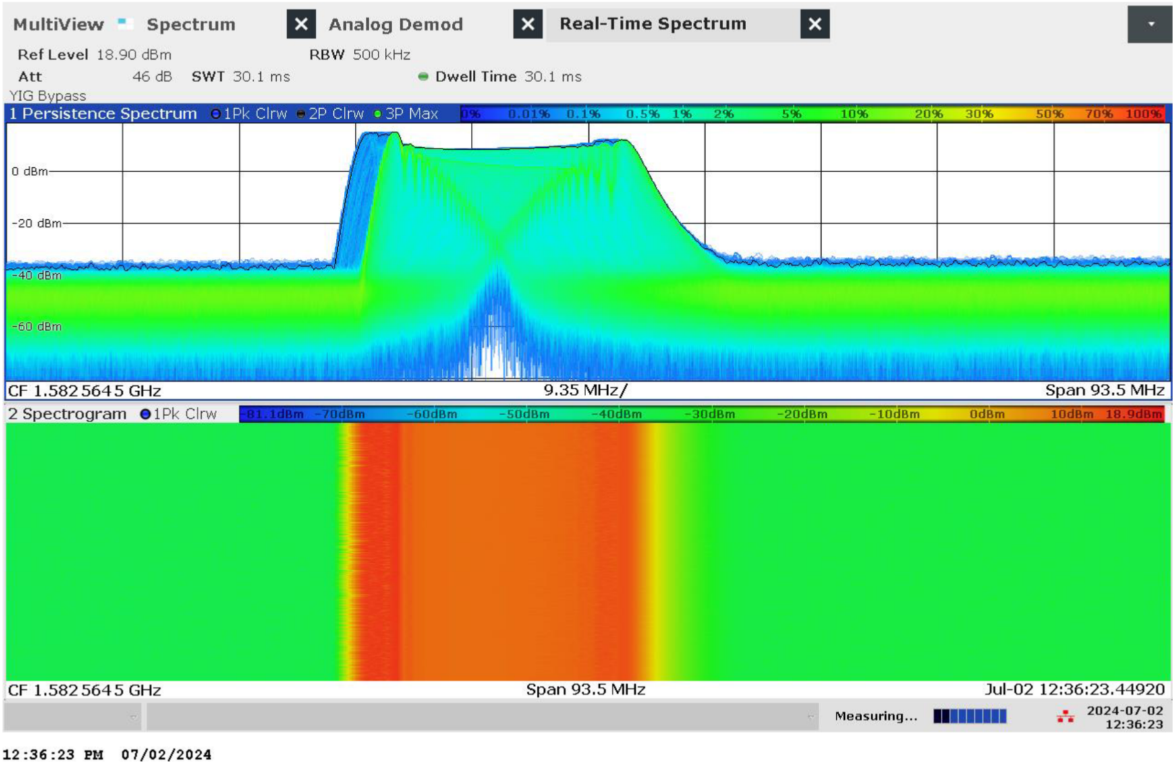

Figure 5.65: Real-time persistence and spectrogram measurement of jammer H1.2

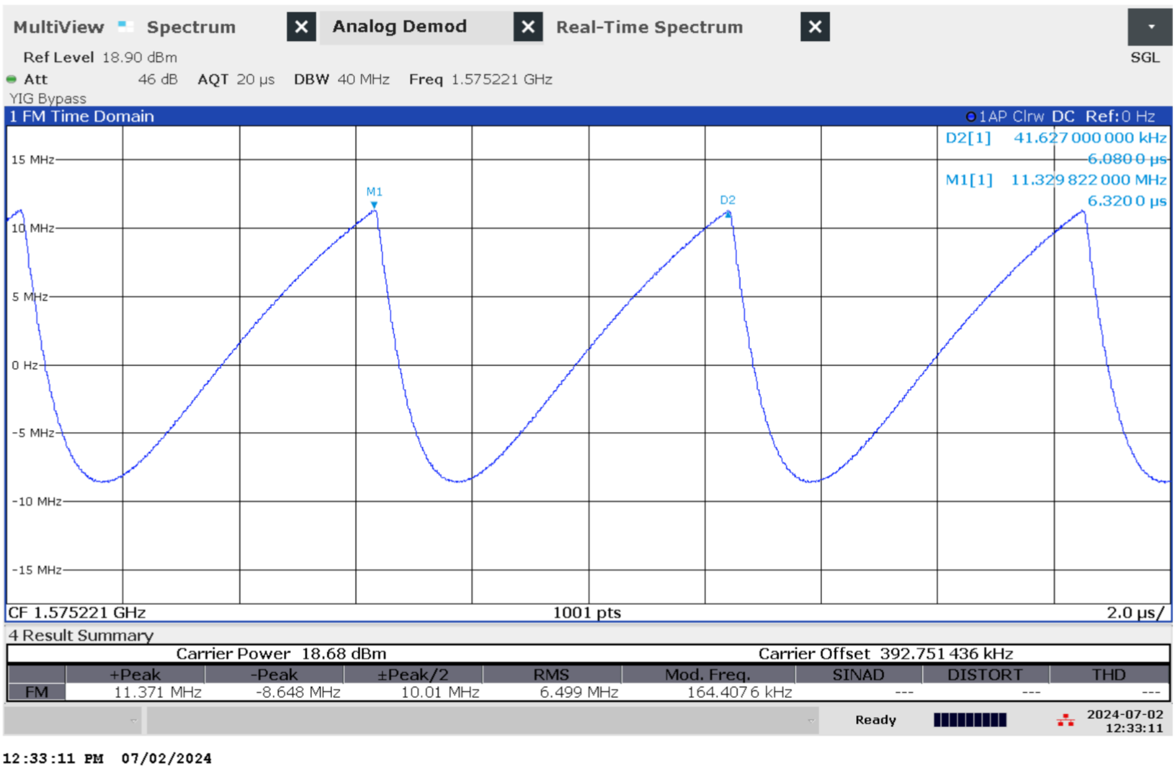

Figure 5.66: Time domain (analog demod) measurement of jammer H1.2

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.

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.

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

Table 5.11: Technical characteristics of H1.3 jammer

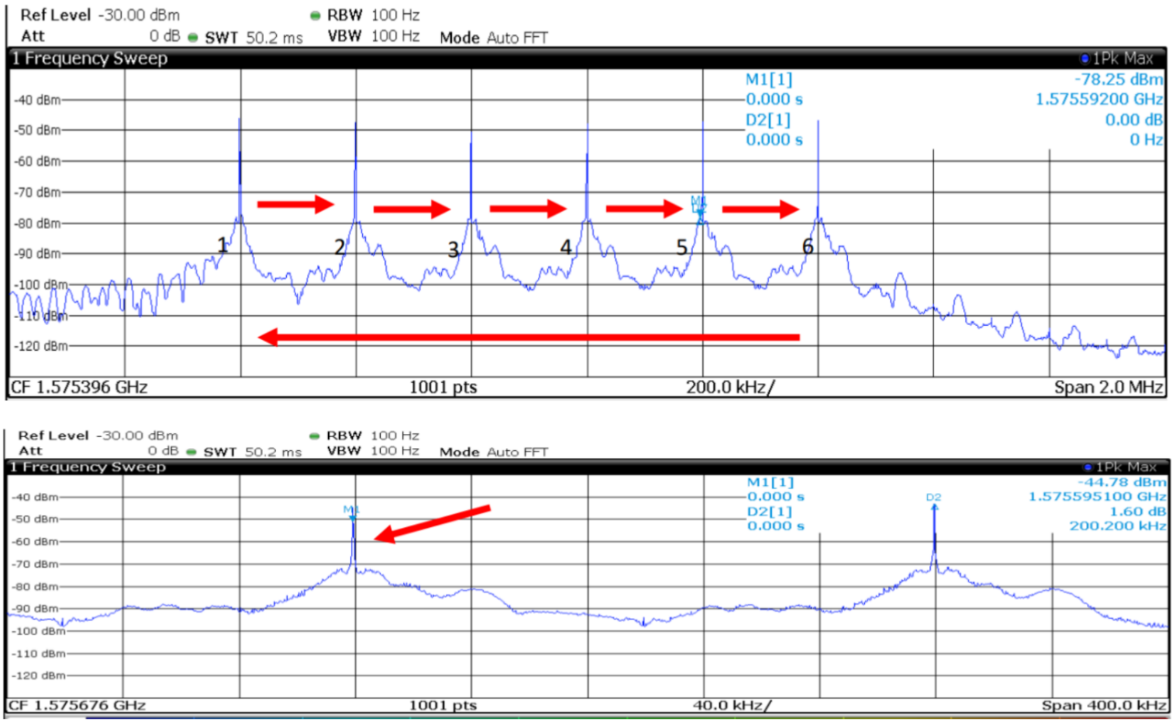

Figure 5.67: Example measurement of H1.3 jammer

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.

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

Table 5.12: Technical characteristics of H2.1-H2.2 jammer

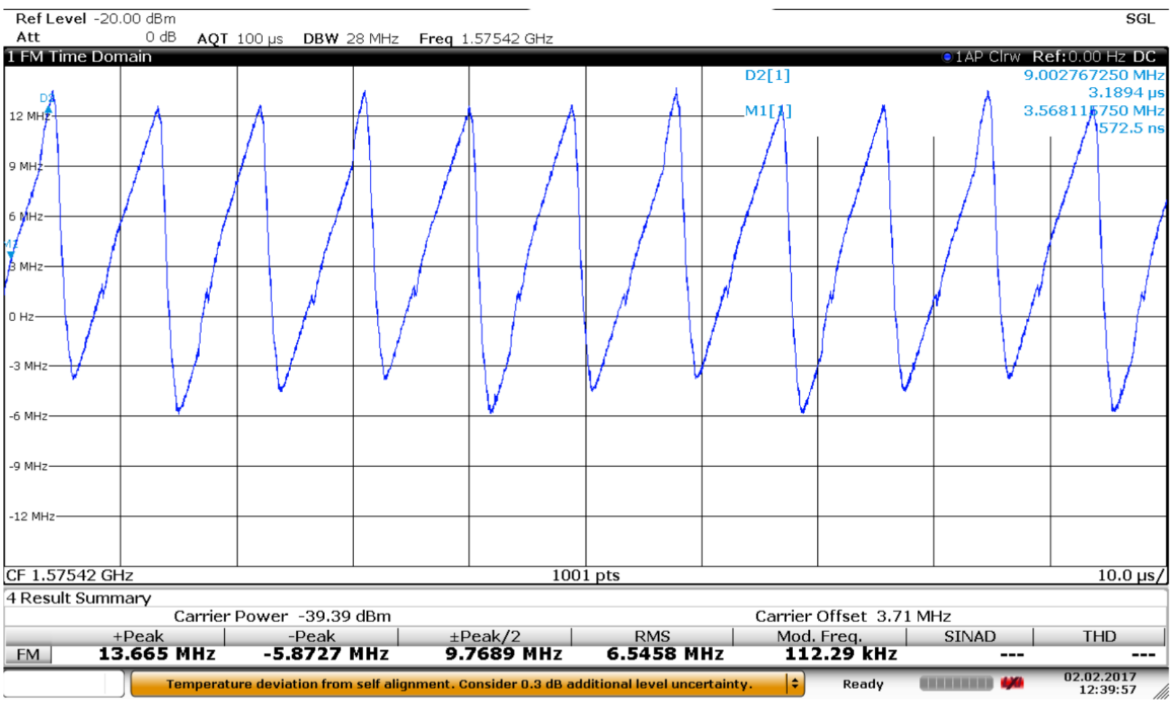

Figure 5.68: Example measurement of H2.1 and H2.2 jammer

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'

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

Table 5.13: Technical characteristics of H3.1 jammer

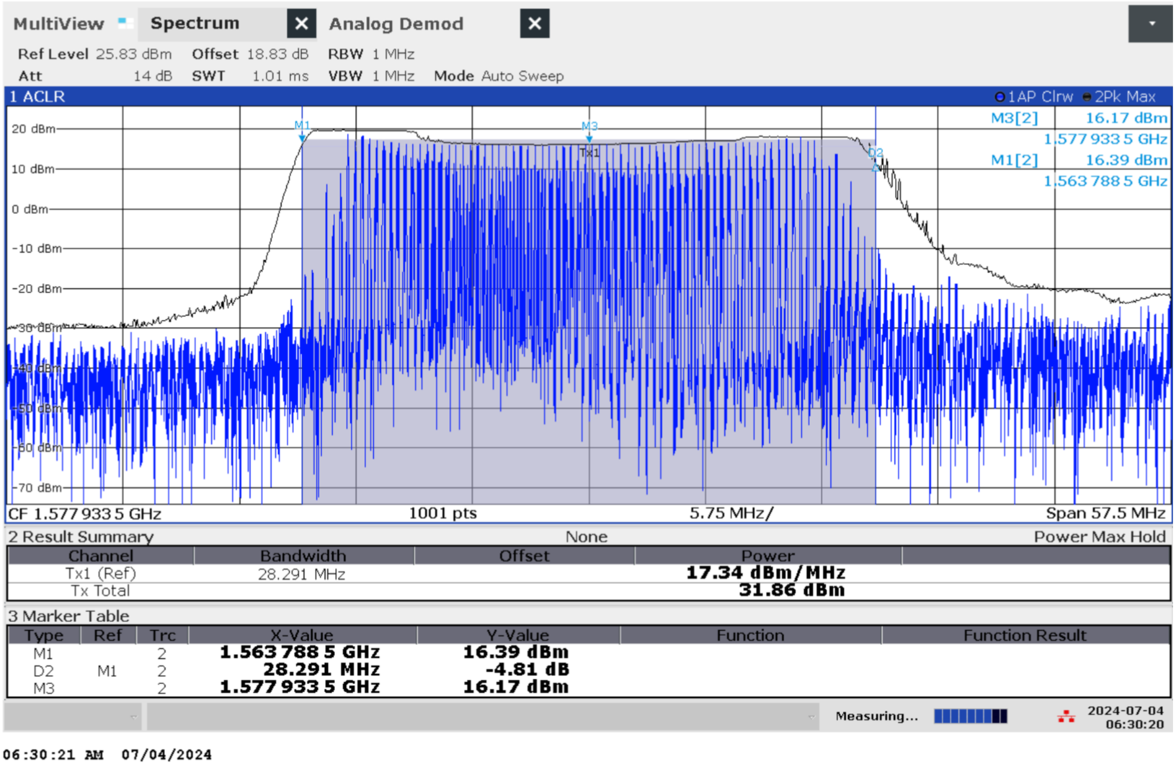

Figure 5.69: Frequency and power measurement of jammer H3.1 on antenna 'GPS'

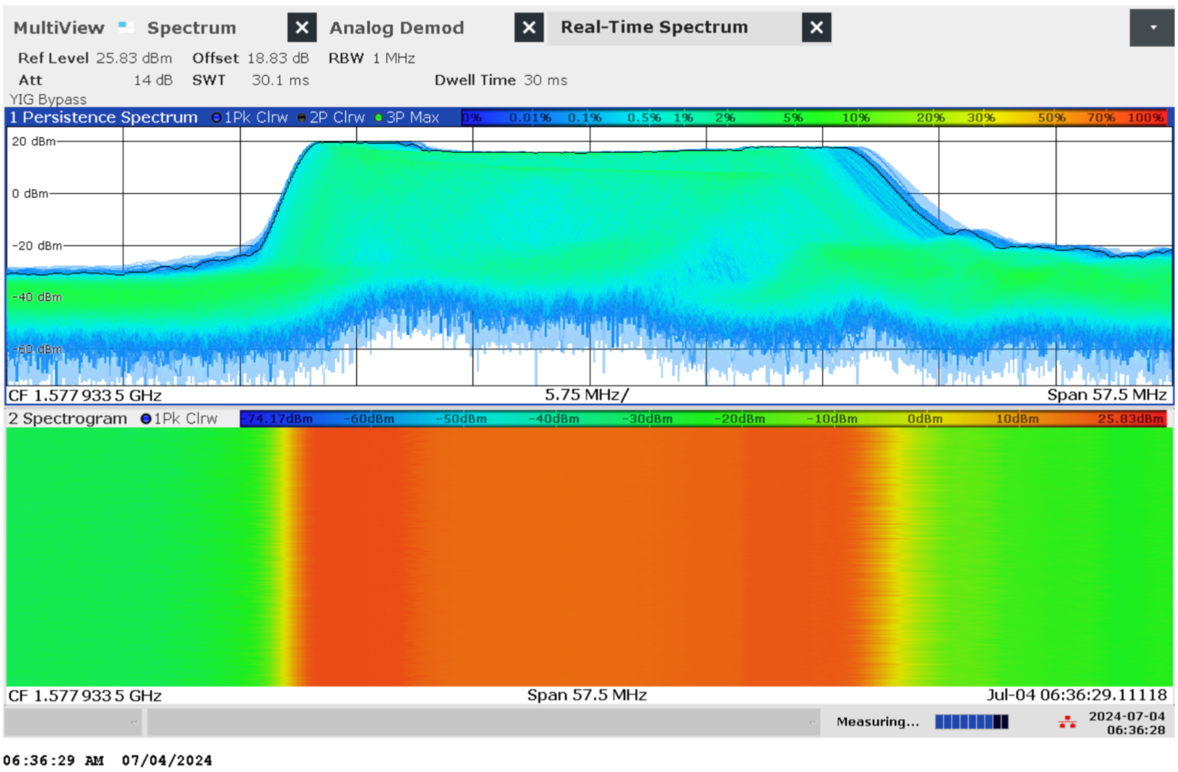

Figure 5.70: Real-time persistence and spectrogram measurement of jammer H3.1 on antenna 'GPS'

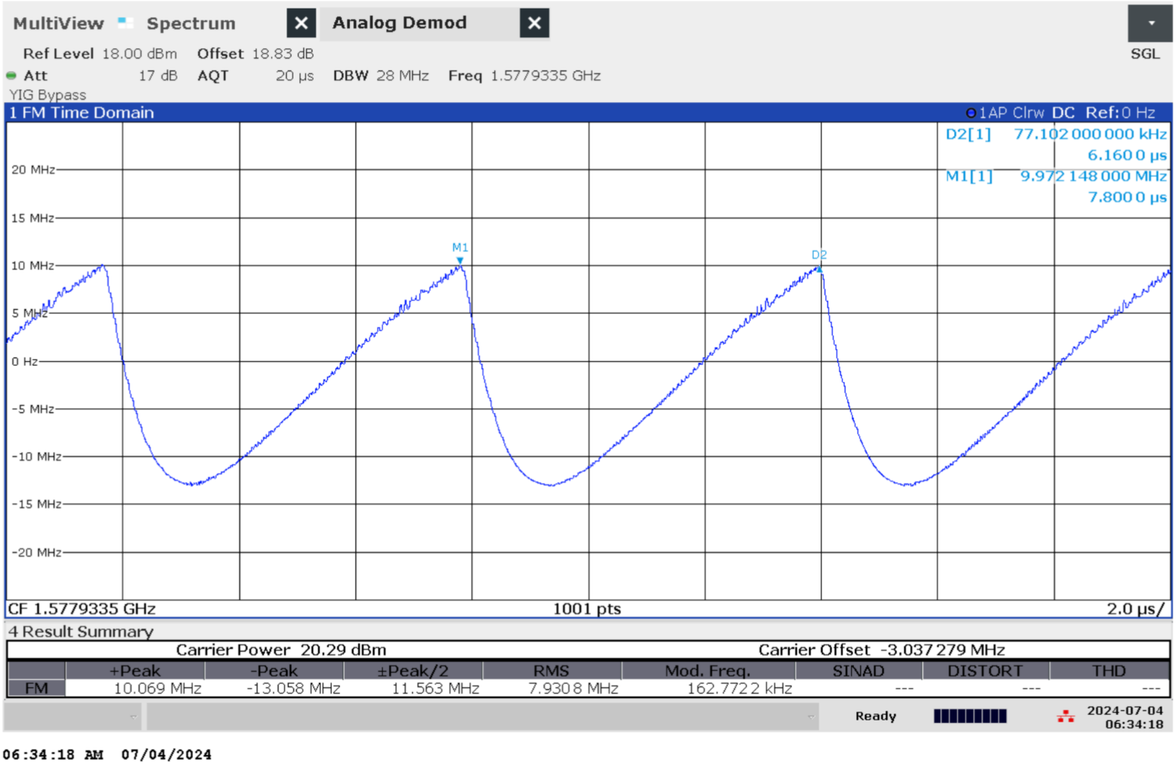

Figure 5.71: Time domain (analog demod) measurement of jammer H3.1 on antenna 'GPS'

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'

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

Table 5.14: Technical characteristics of H3.2 jammer

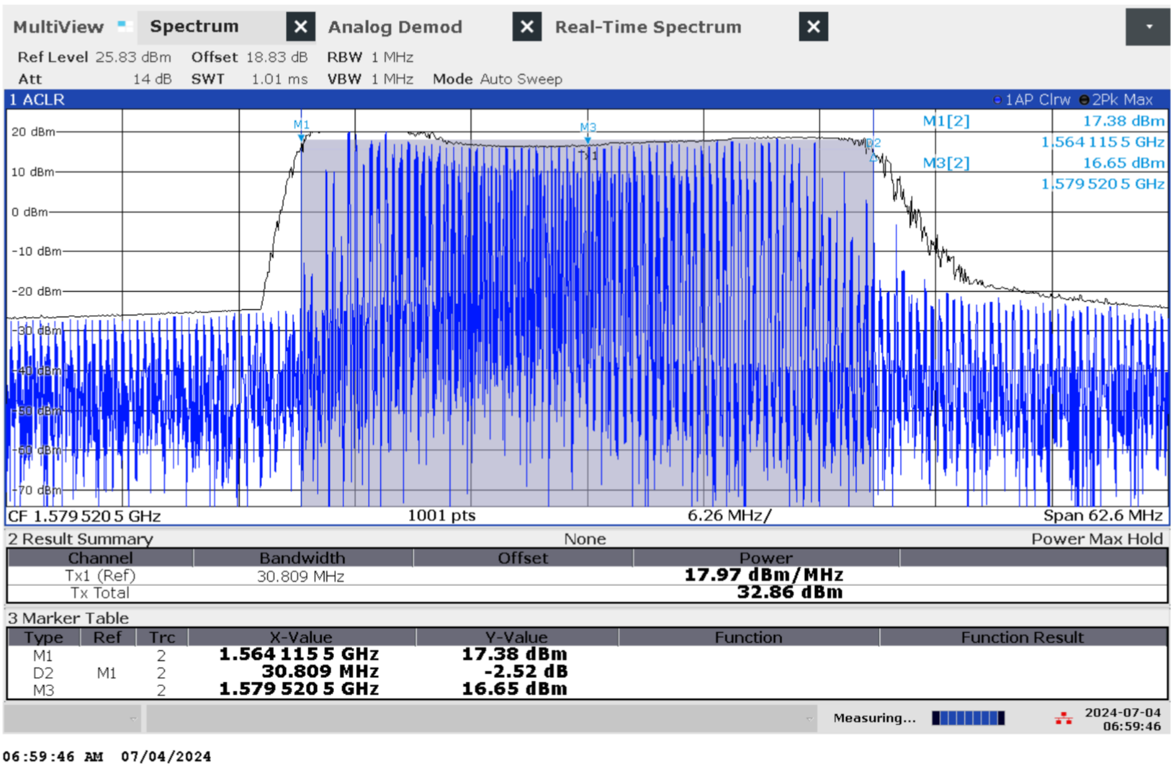

Figure 5.72: Frequency and power measurement of jammer H3.2 on antenna 'GPS'

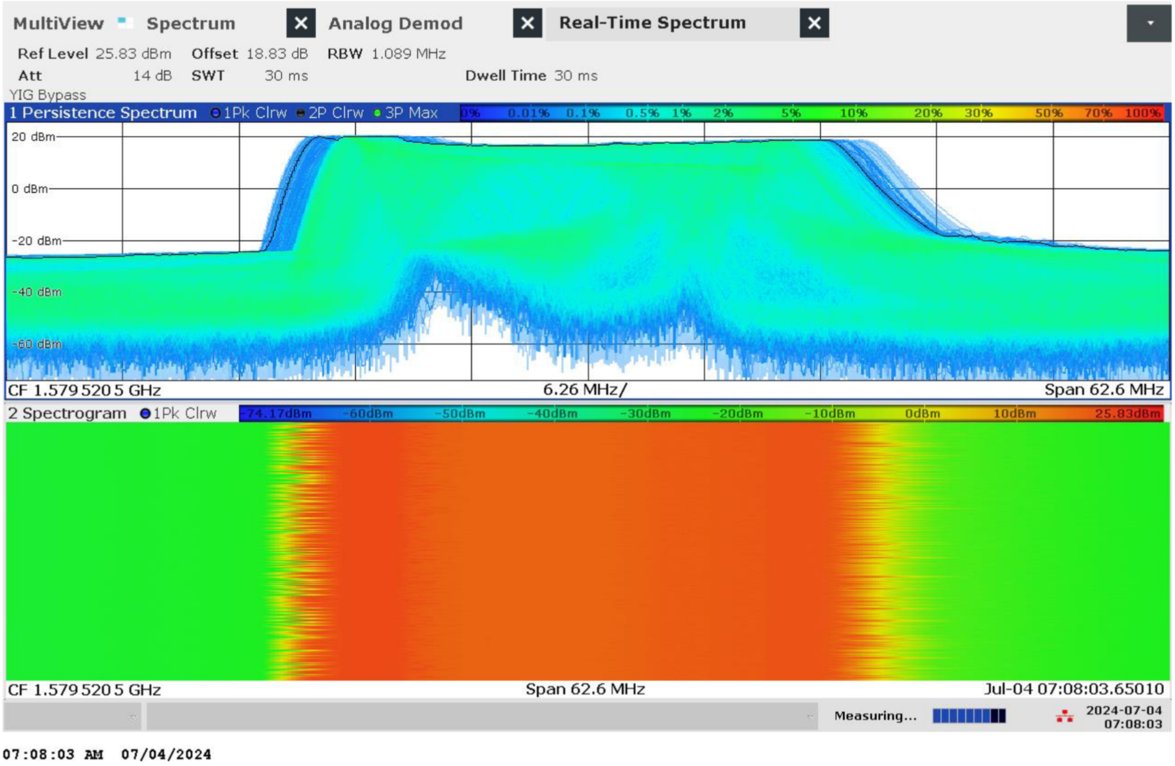

Figure 5.73: Real-time persistence and spectrogram measurement of jammer H3.2 on antenna 'GPS'

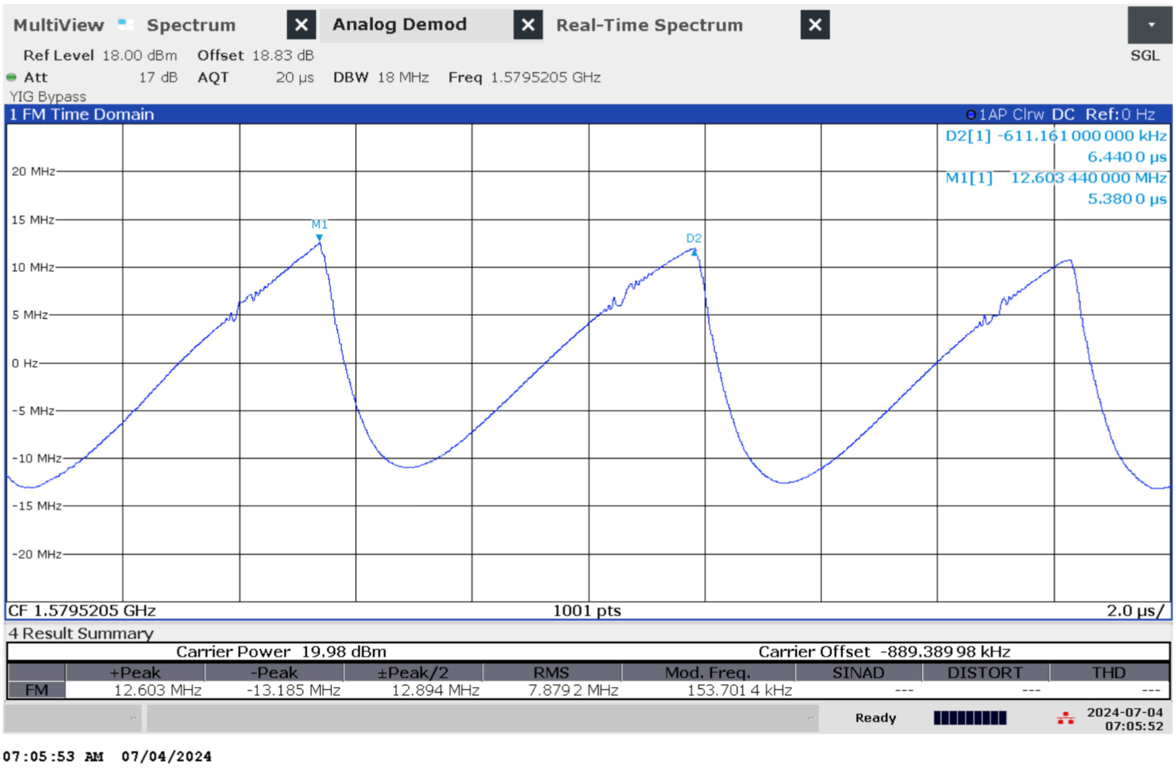

Figure 5.74: Time domain (analog demod) measurement of jammer H3.2 on antenna 'GPS'

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.

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

Table 5.15: Technical characteristics of H3.3 jammer

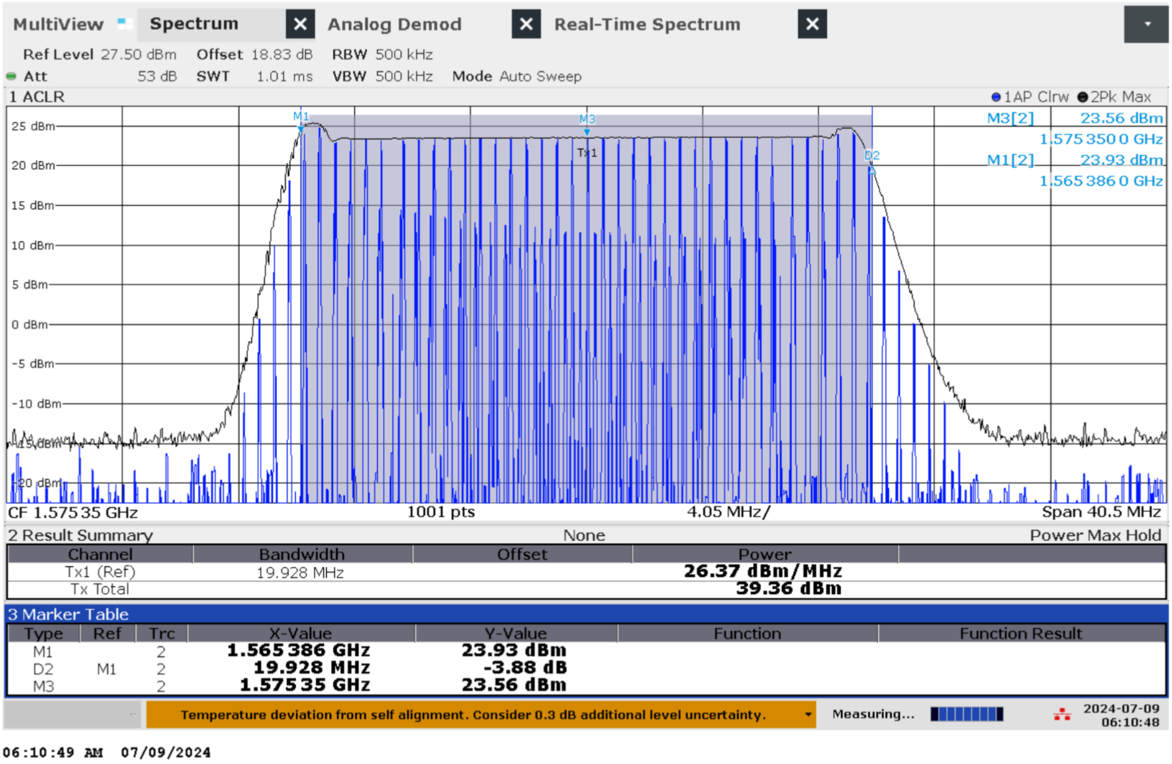

Figure 5.75: Frequency and power measurement of jammer H3.3 on antenna 'short' (L1)

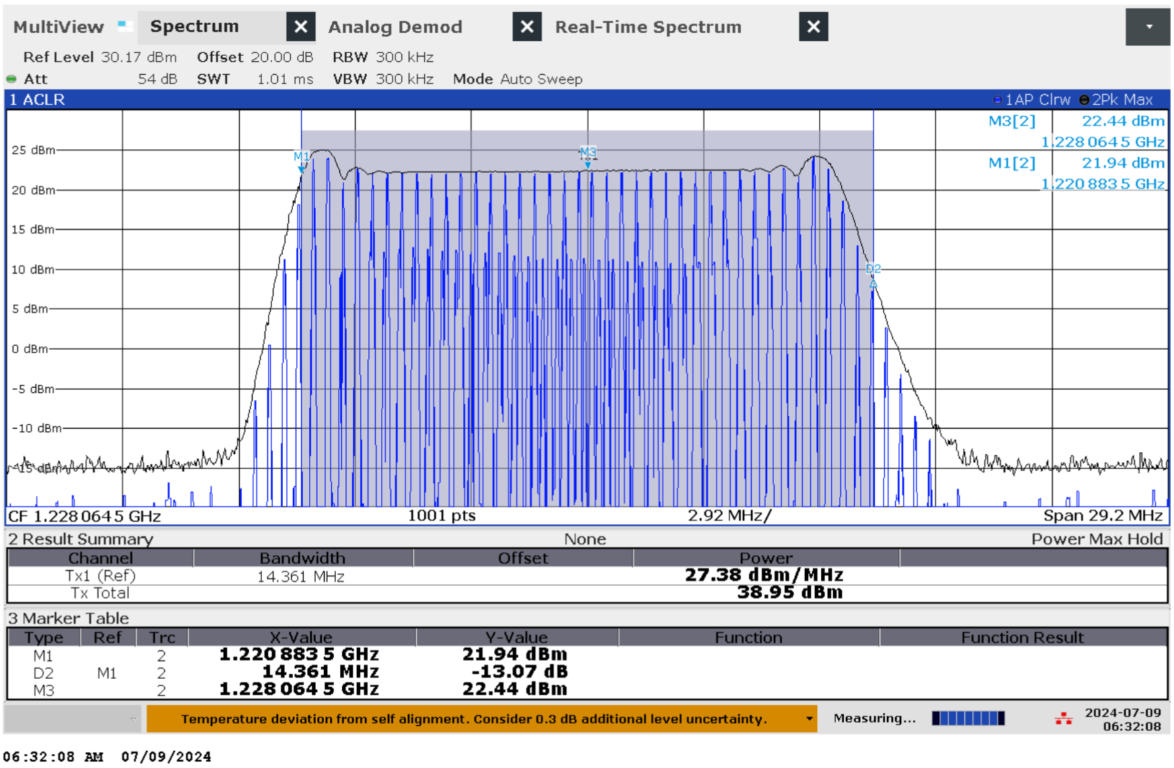

Figure 5.76: Frequency and power measurement of jammer H3.3 on antenna 'medium' (L2)

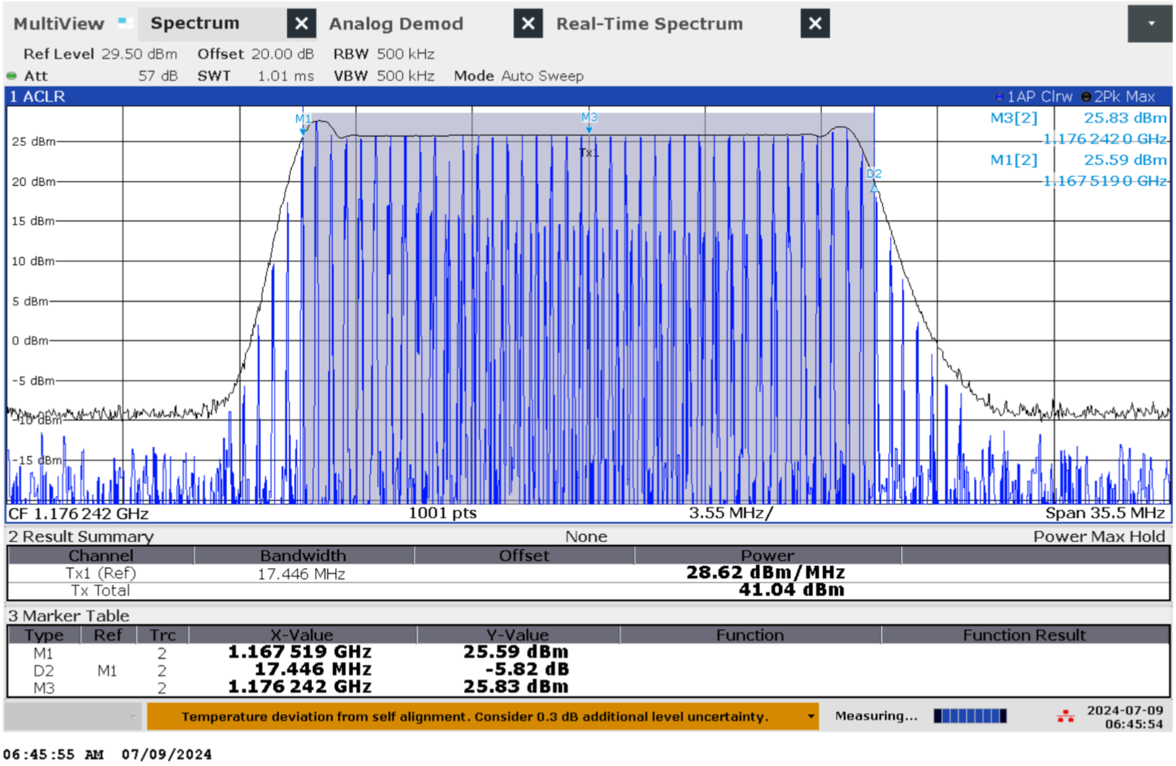

Figure 5.77: Frequency and power measurement of jammer H3.3 on antenna ’long’ (L5)

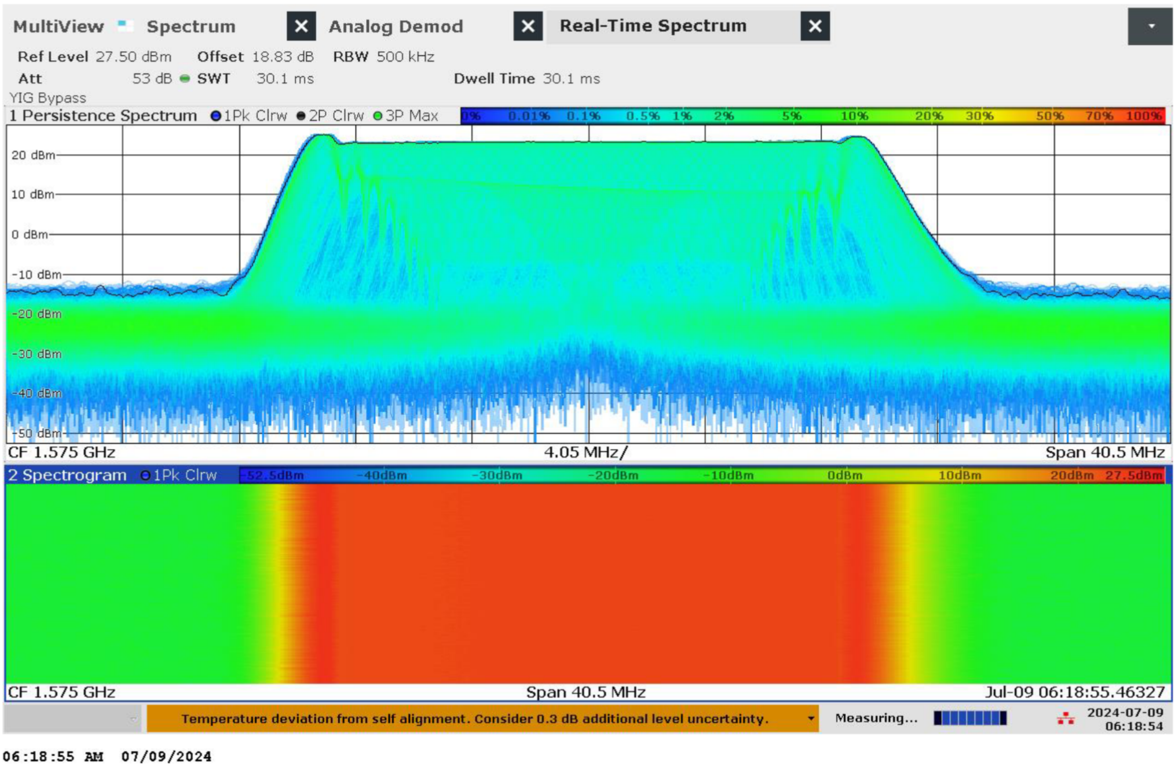

Figure 5.78: Real-time persistence and spectrogram measurement of jammer H3.3 on antenna ’short’ (L1)

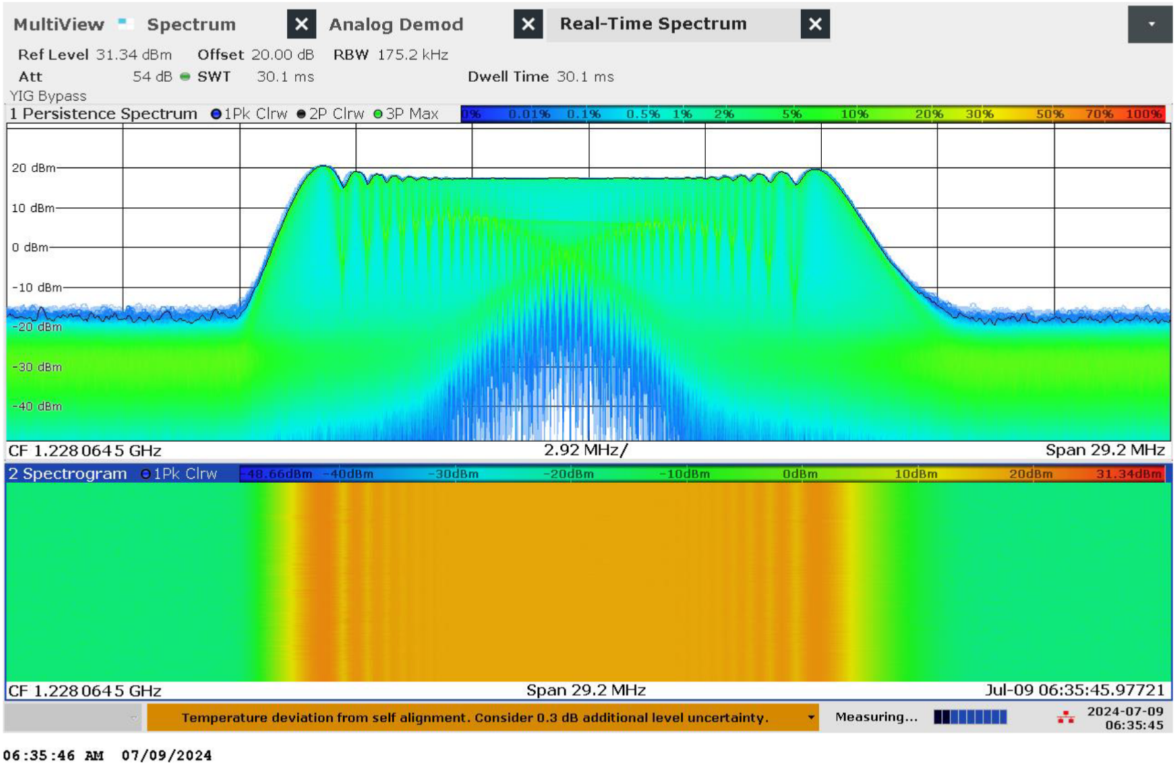

Figure 5.79: Real-time persistence and spectrogram measurement of jammer H3.3 on antenna 'medium' (L2)

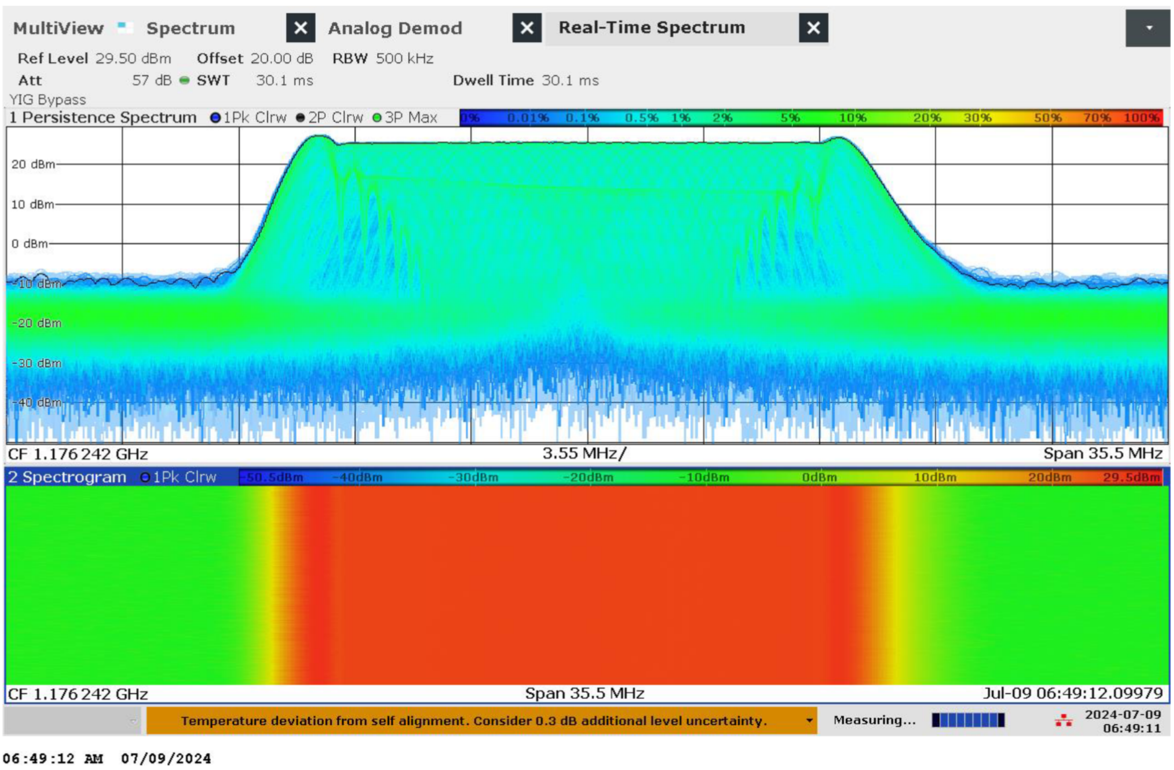

Figure 5.80: Real-time persistence and spectrogram measurement of jammer H3.3 on antenna 'long' (L5)

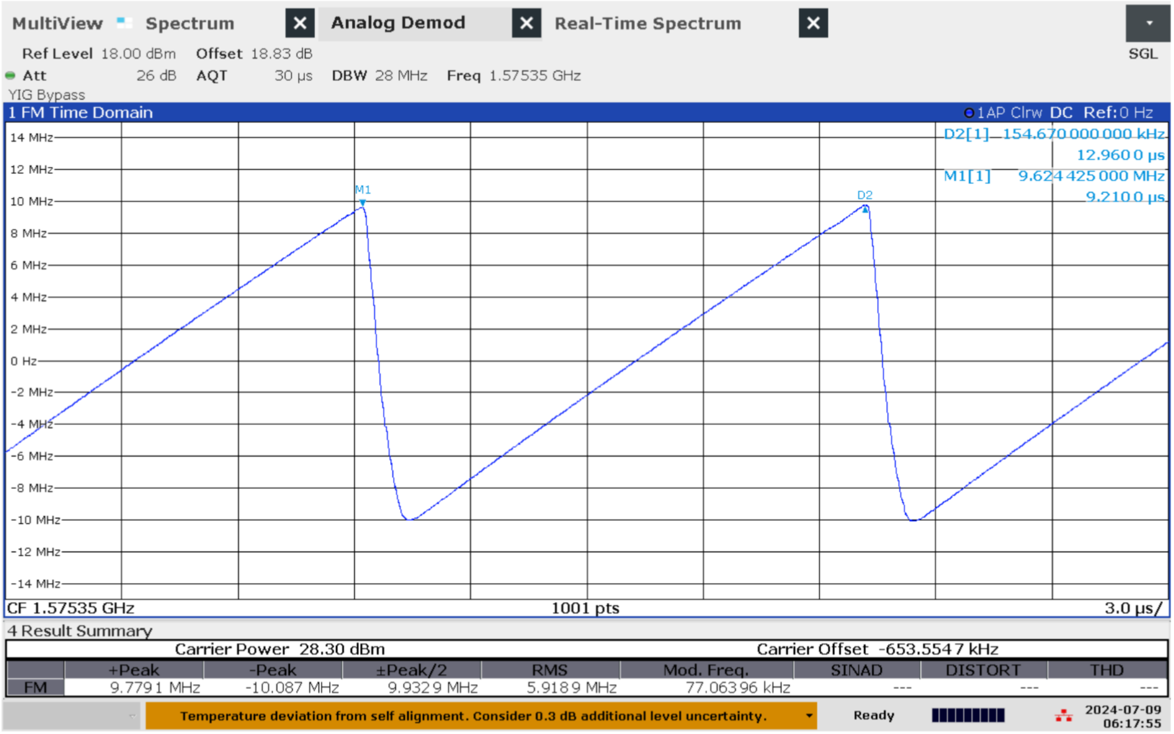

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Figure 5.81: Time domain (analog demod) measurement of jammer H3.3 on antenna 'short' (L1)

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Figure 5.82: Time domain (analog demod) measurement of jammer H3.3 on antenna 'medium' (L2)

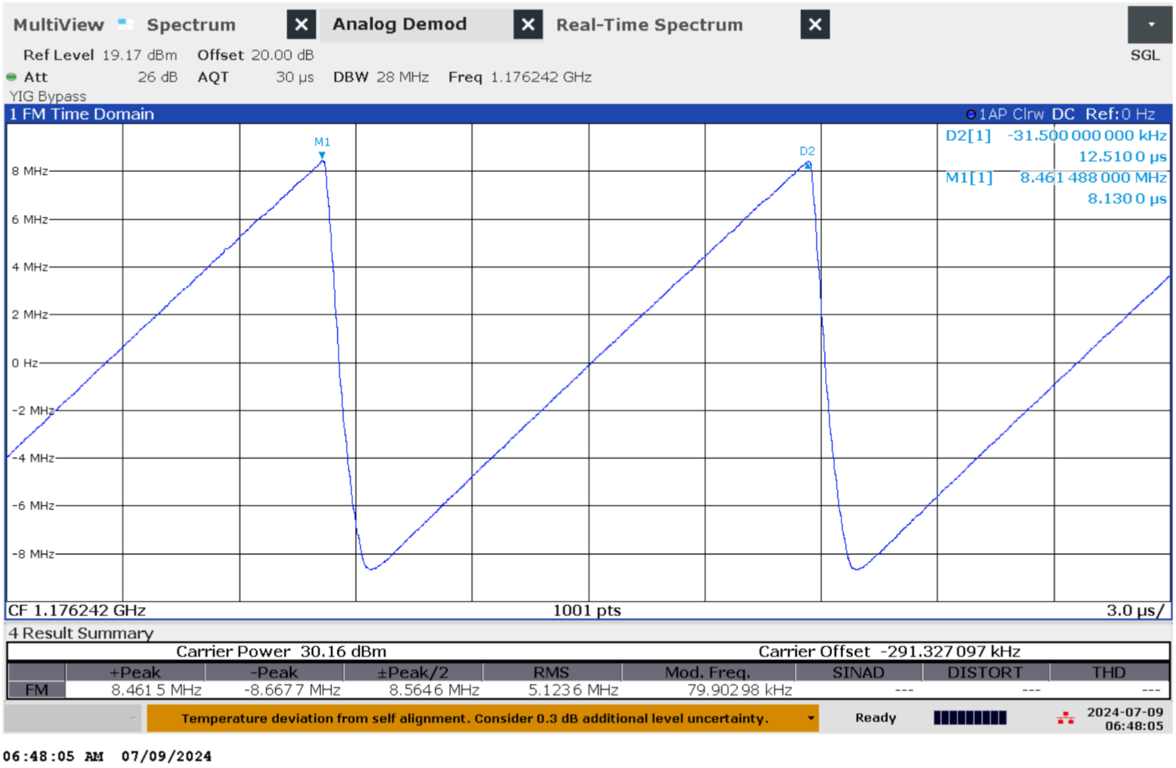

Figure 5.83: Time domain (analog demod) measurement of jammer H3.3 on antenna 'long' (L5)

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.

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
'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

Table 5.16: Technical characteristics of H4.1 jammer

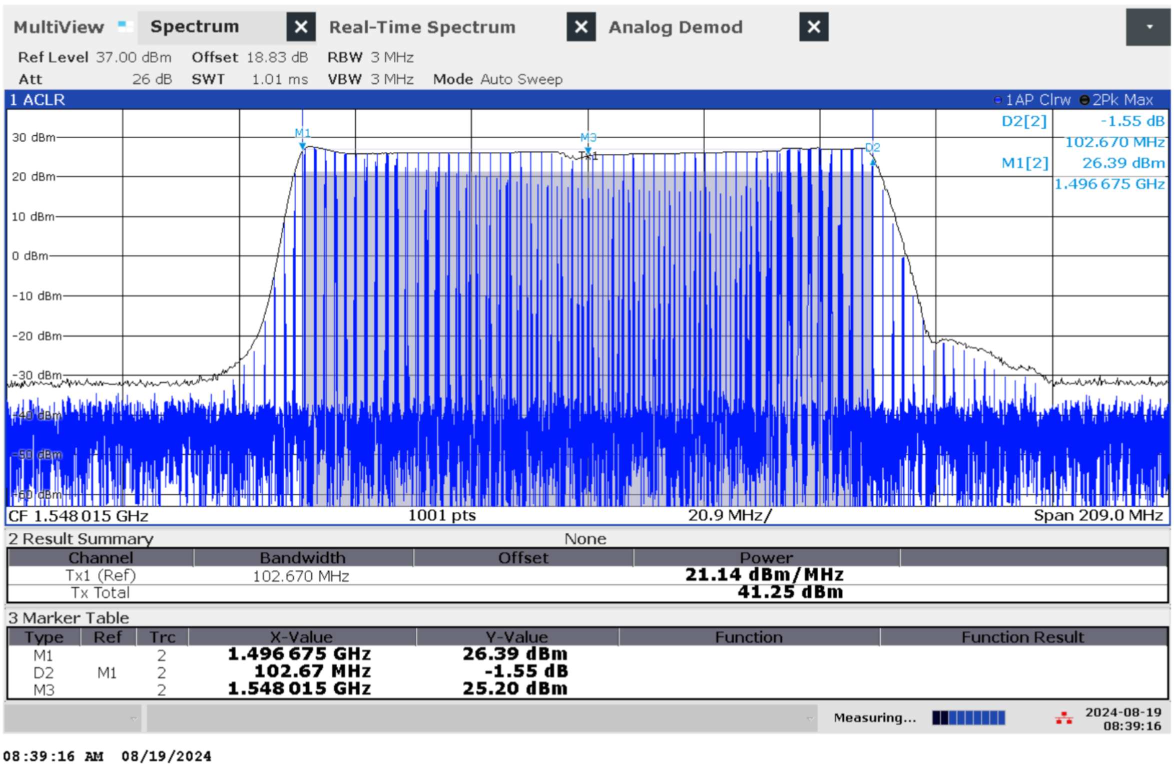

Figure 5.84: Frequency and power measurement of jammer H4.1 on antenna '1' (L1)

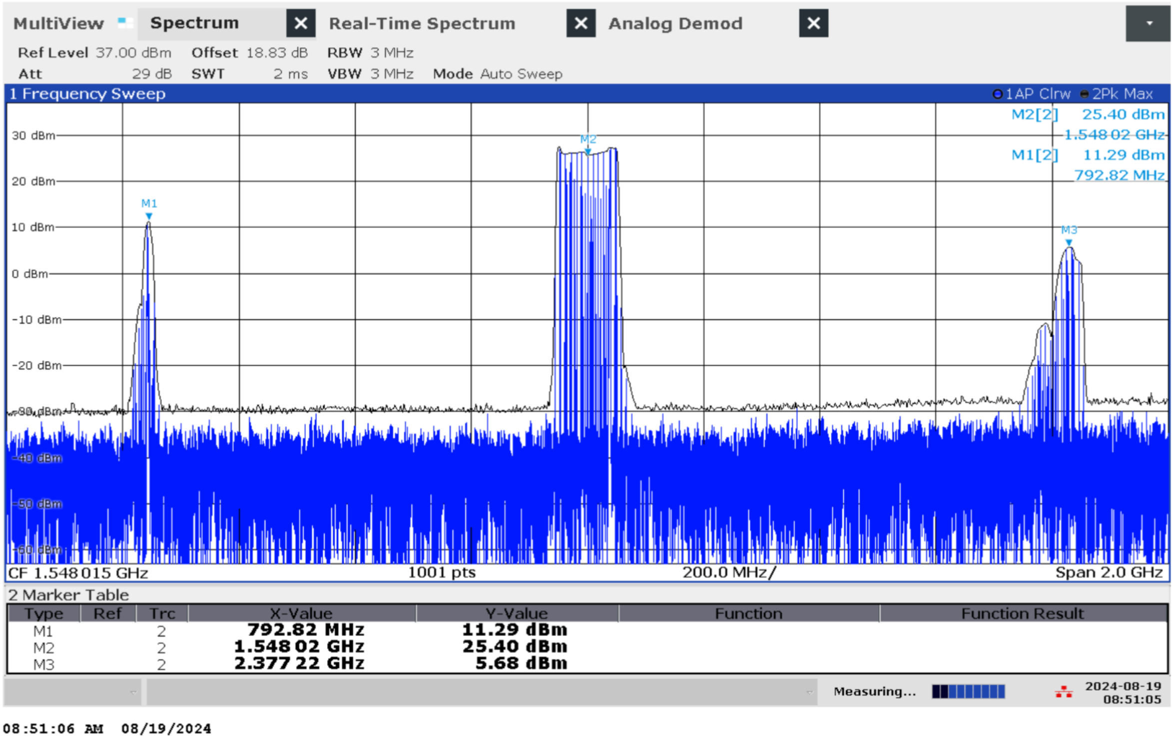

Figure 5.85: Frequency and power measurement with wider span of jammer H4.1 on antenna '1' (L1)

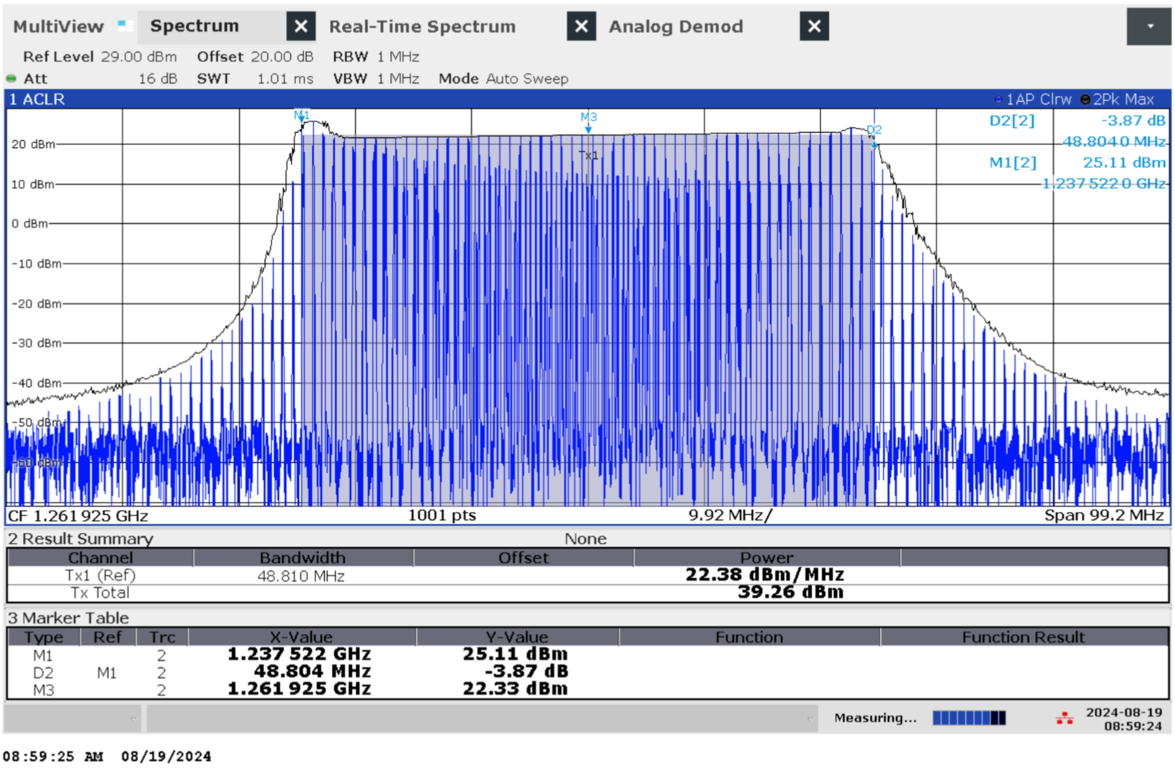

Figure 5.86: Frequency and power measurement of jammer H4.1 on antenna '2' (E6)

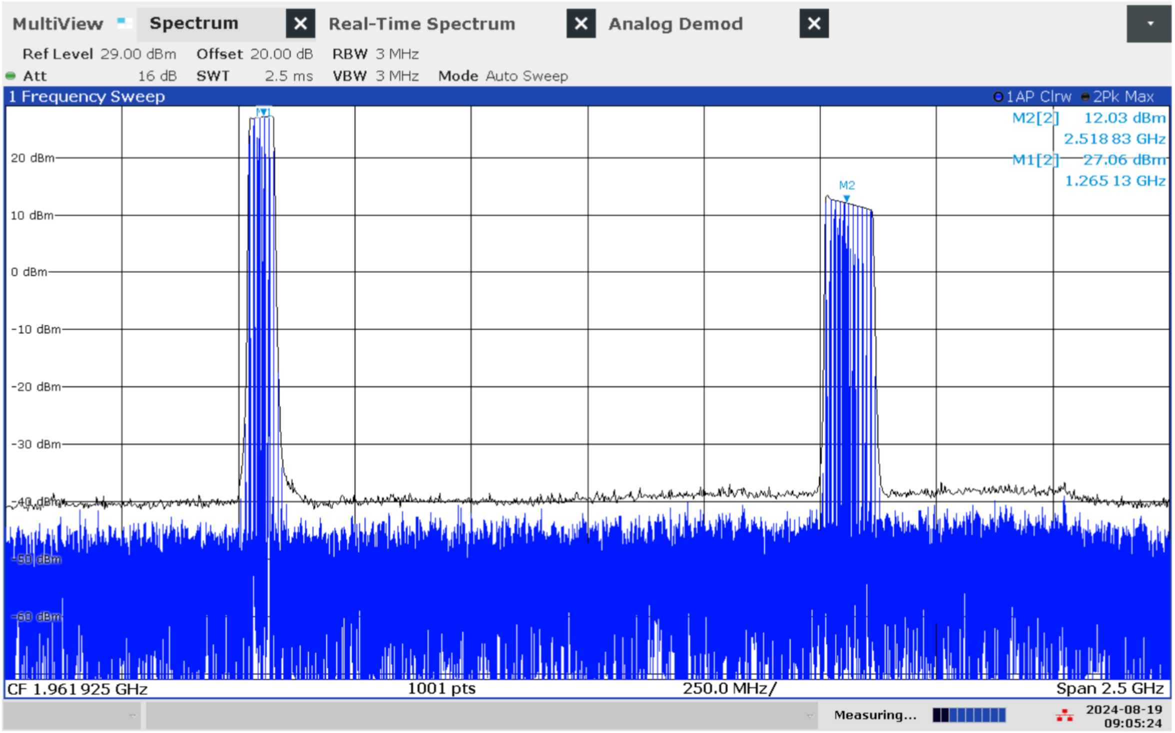

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Figure 5.87: Frequency and power measurement with wider span of jammer H4.1 on antenna '2' (E6)

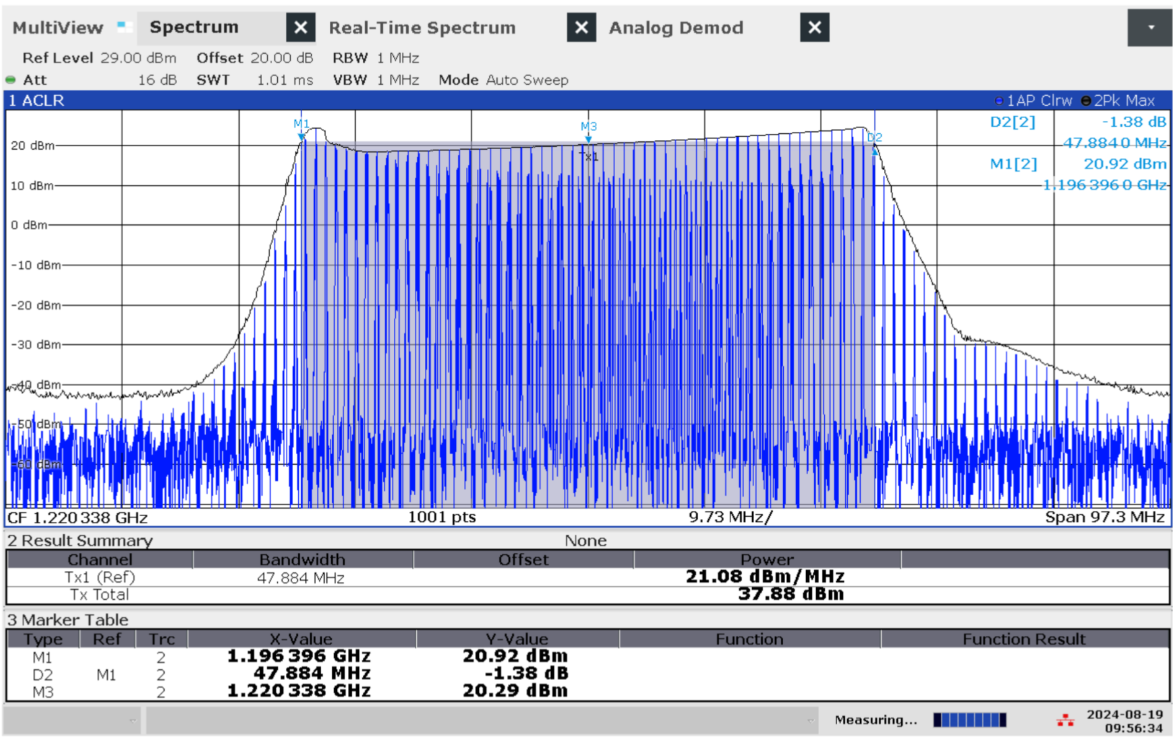

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Figure 5.88: Frequency and power measurement of jammer H4.1 on antenna '3' (L2)

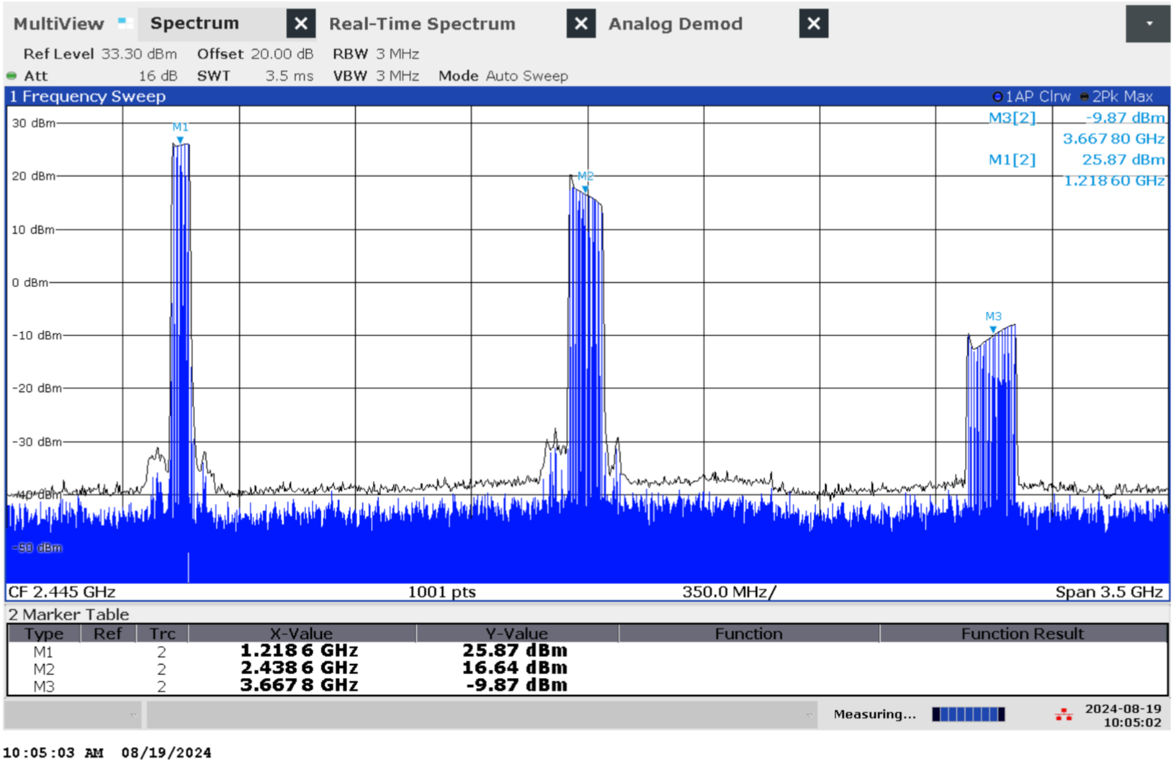

Figure 5.89: Frequency and power measurement with wider span of jammer H4.1 on antenna ’3’ (L2)

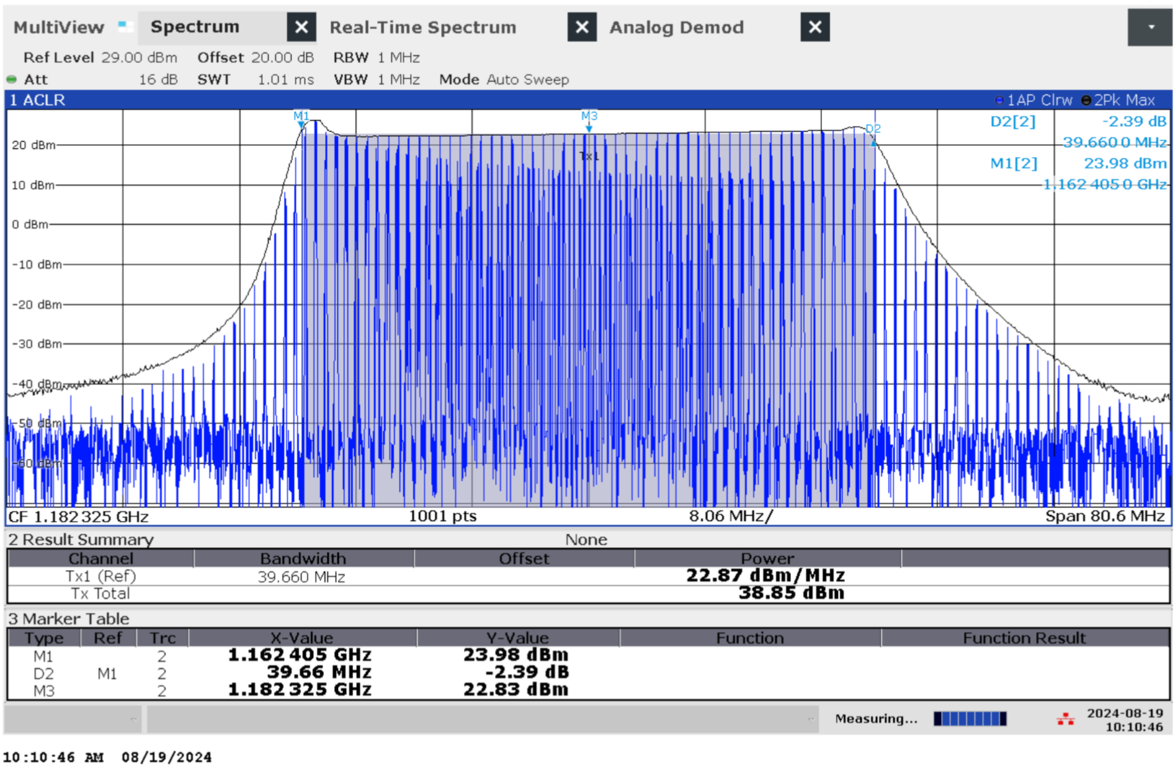

Figure 5.90: Frequency and power measurement of jammer H4.1 on antenna ’4’ (L5)

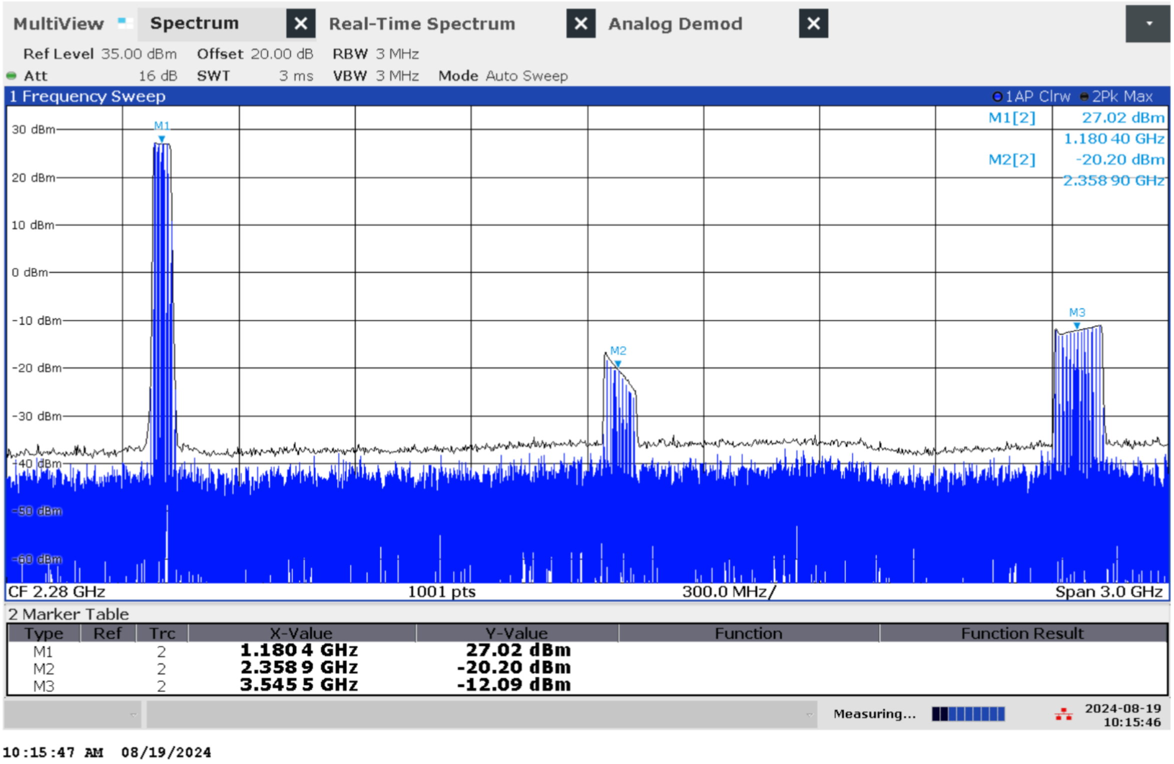

Figure 5.91: Frequency and power measurement with wider span of jammer H4.1 on antenna '4' (L5)

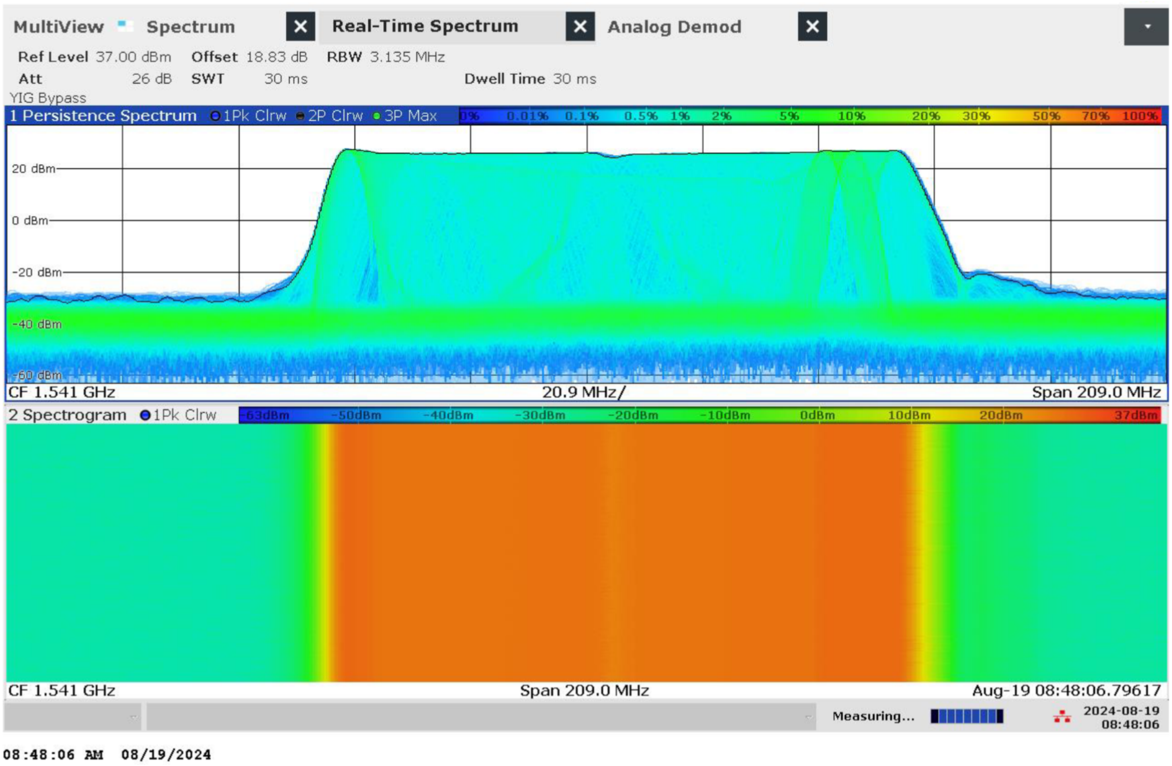

Figure 5.92: Real-time persistence and spectrogram measurement of jammer H4.1 on antenna '1' (L1)

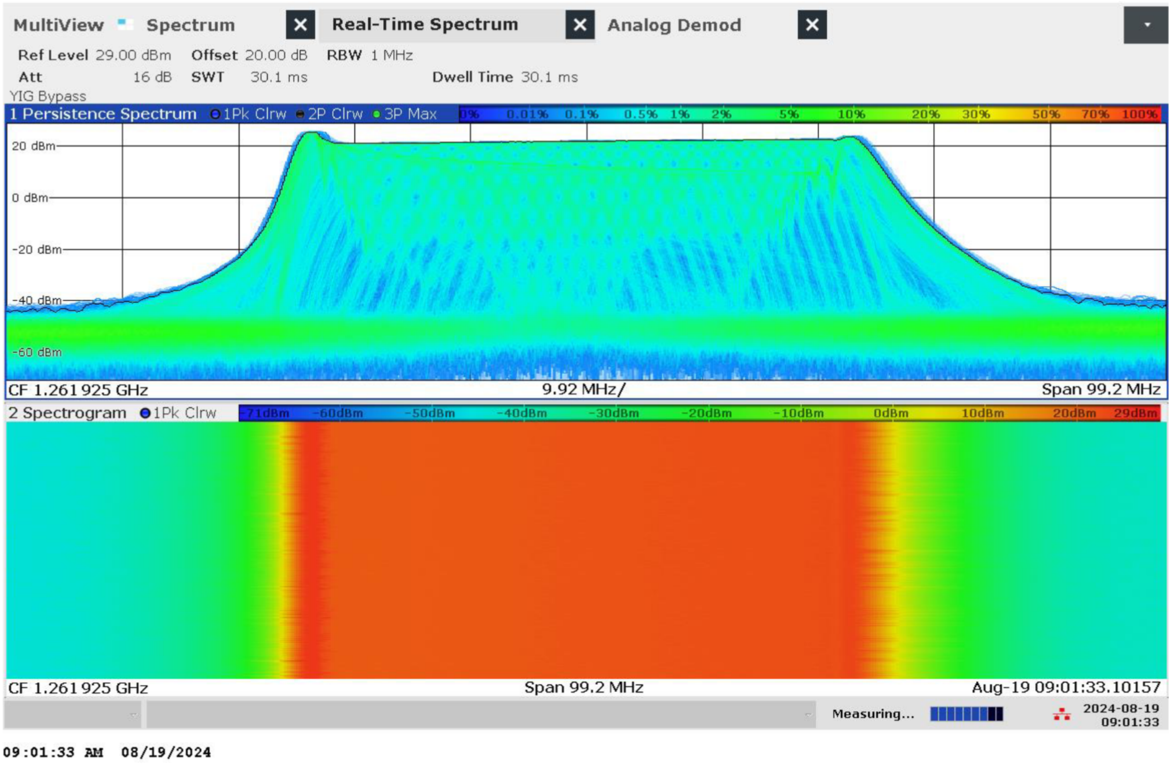

Figure 5.93: Real-time persistence and spectrogram measurement of jammer H4.1 on antenna '2' (E6)

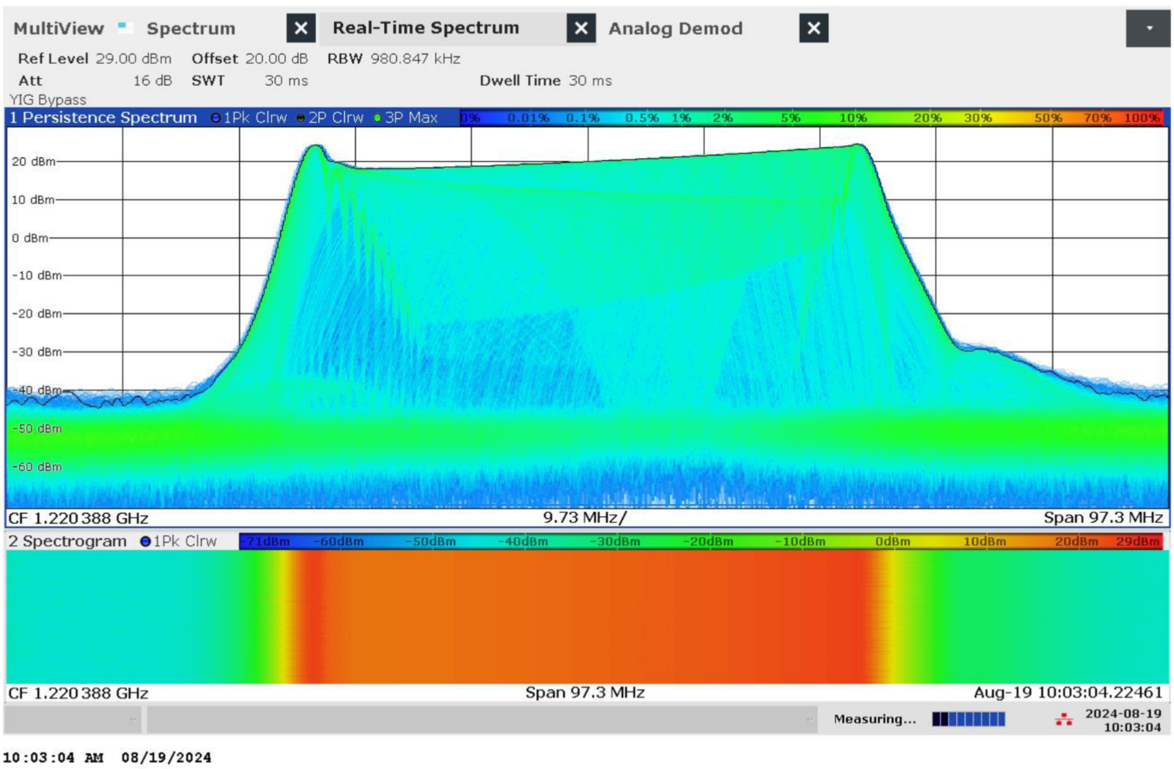

Figure 5.94: Real-time persistence and spectrogram measurement of jammer H4.1 on antenna '3' (L2)

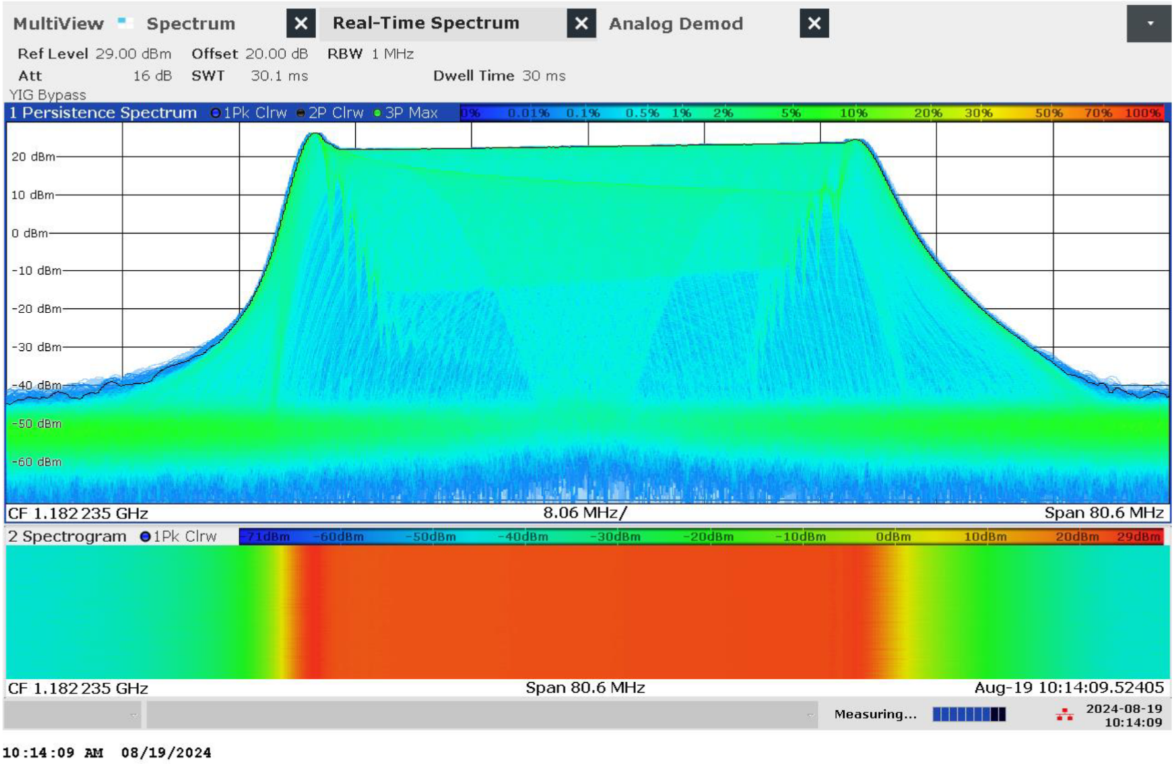

Figure 5.95: Real-time persistence and spectrogram measurement of jammer H4.1 on antenna '4' (L5)

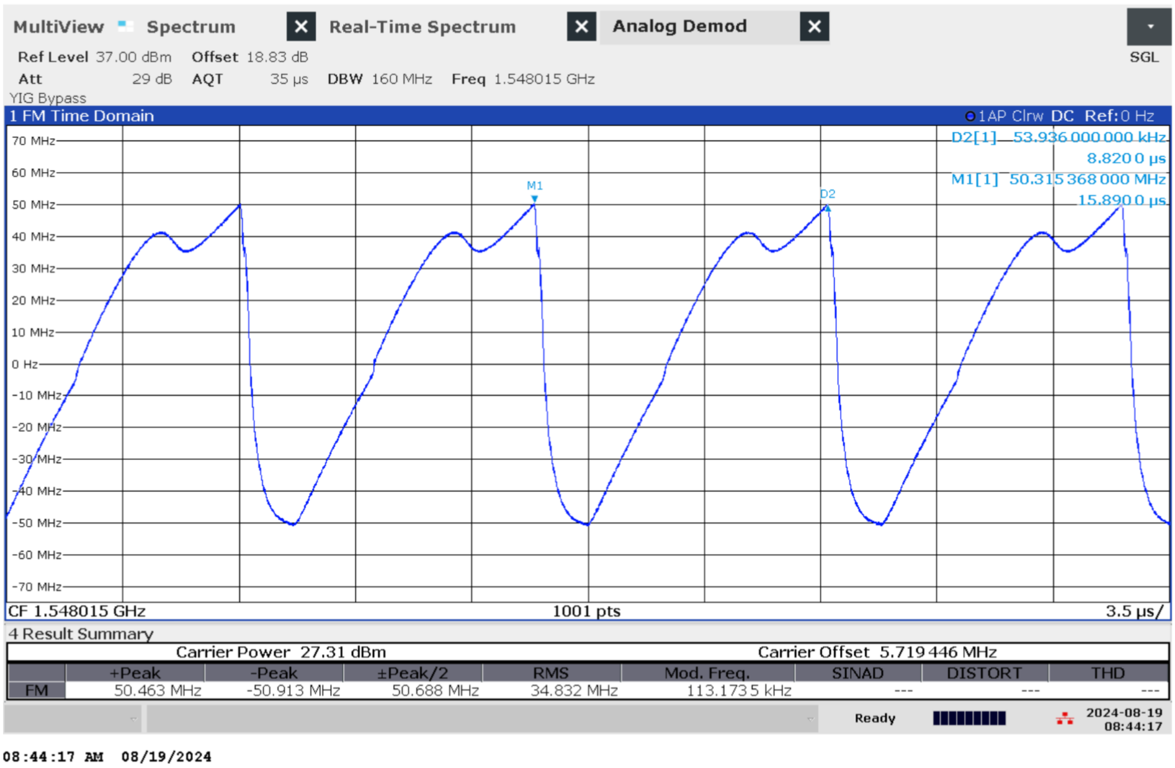

Figure 5.96: Time domain (analog demod) measurement of jammer H4.1 on antenna '1' (L1)

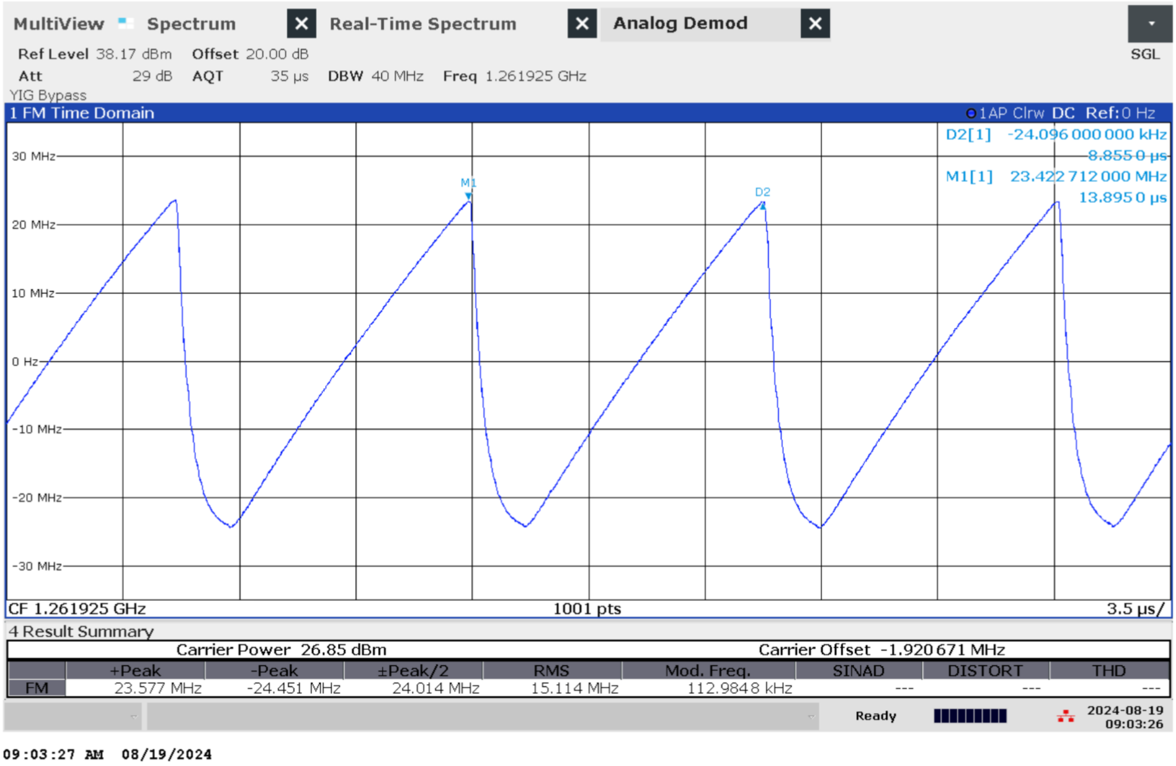

Figure 5.97: Time domain (analog demod) measurement of jammer H4.1 on antenna '2' (E6)

Figure 5.98: Time domain (analog demod) measurement of jammer H4.1 on antenna '3' (L2)

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Figure 5.99: 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’.

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

Table 5.17: Technical characteristics of H6.1 jammer

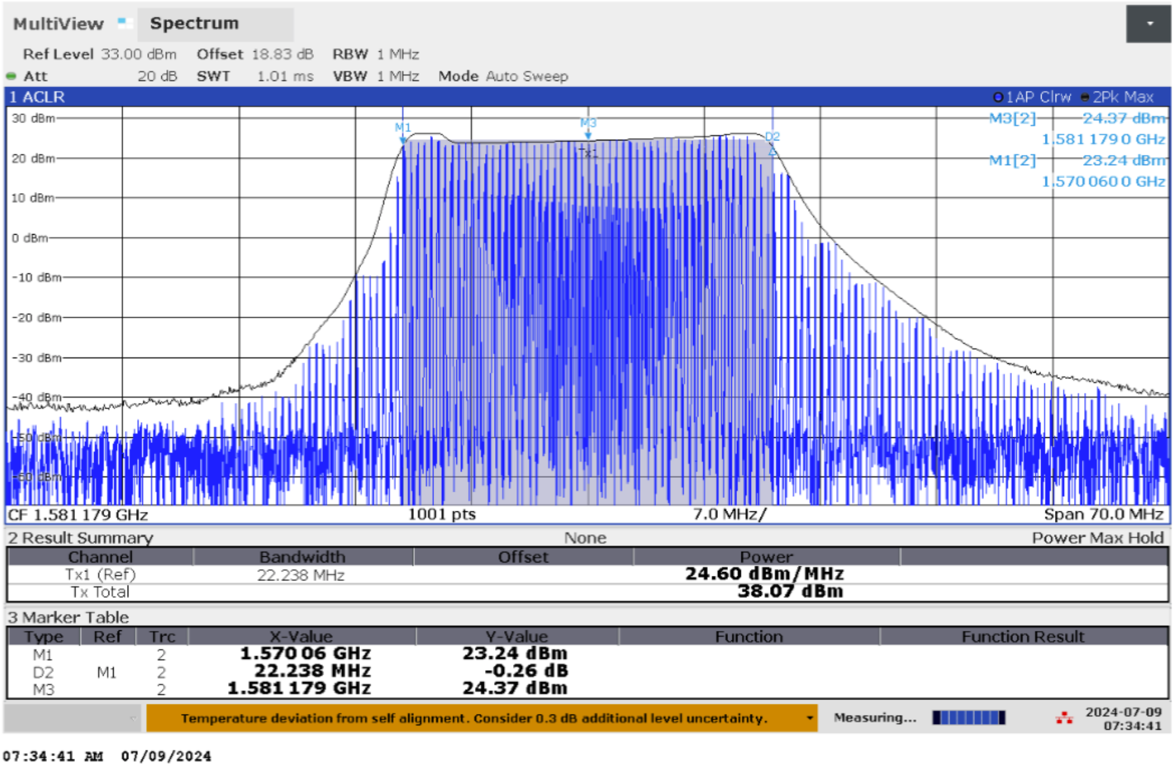

Figure 5.100: Frequency and power measurement of jammer H6.1 on antenna '6' (L1)

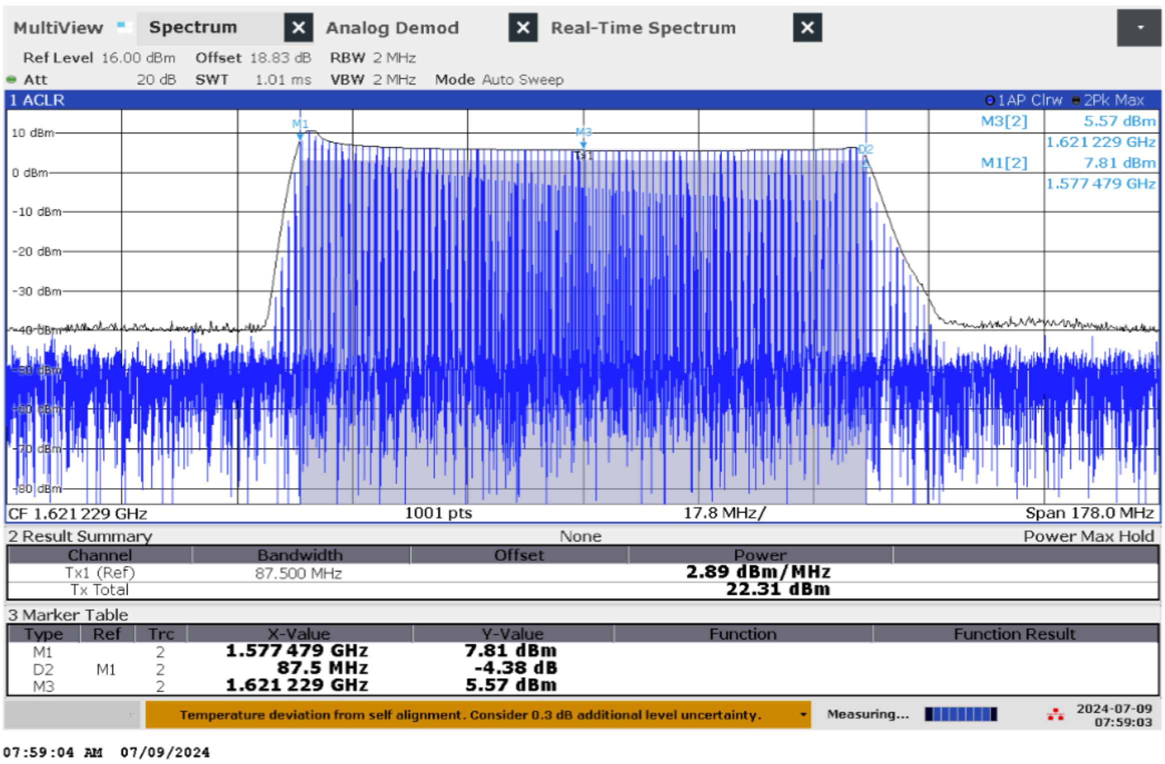

Figure 5.101: Frequency and power measurement of jammer H6.1 on antenna '4'

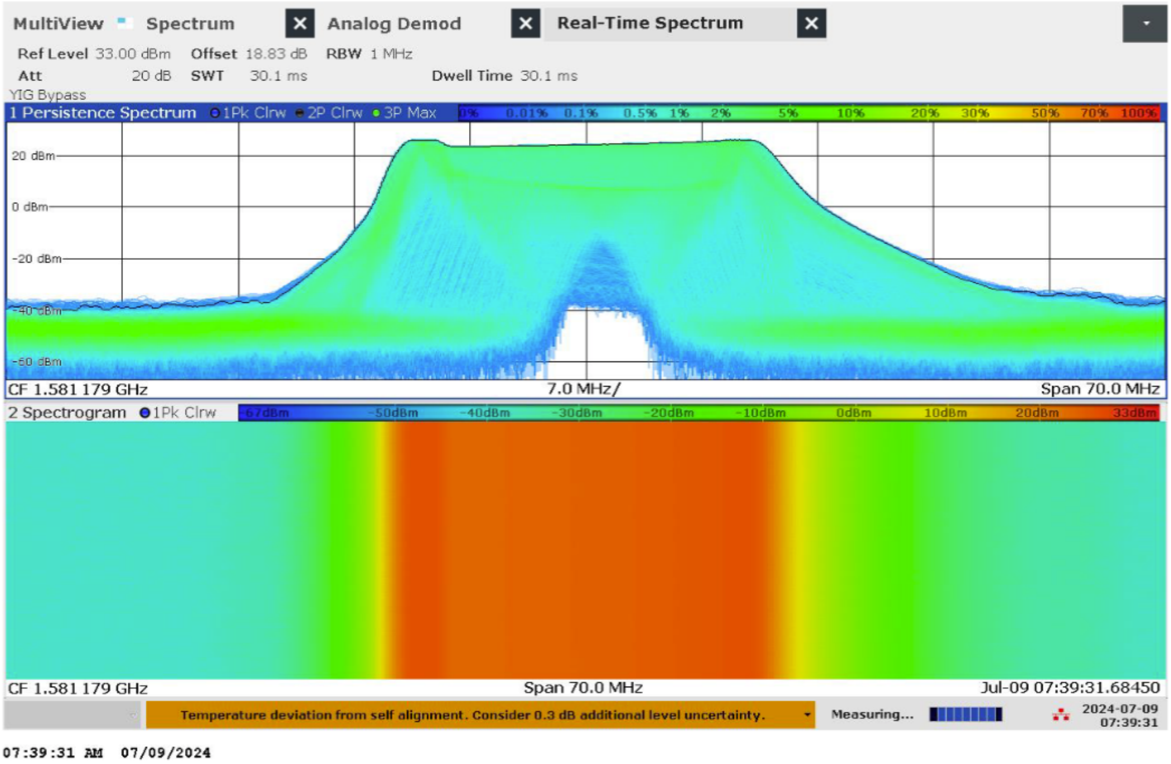

Figure 5.102: Real-time persistence and spectrogram measurement of jammer H6.1 on antenna '6' (L1)

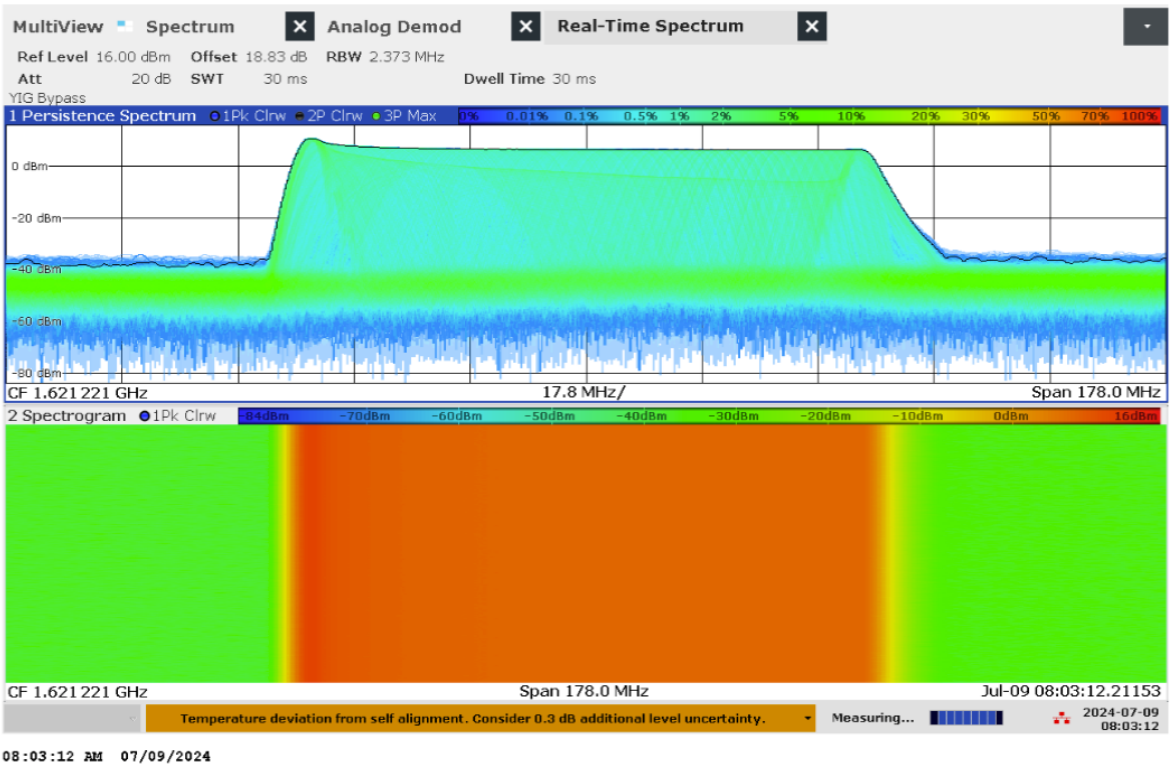

Figure 5.103: Real-time persistence and spectrogram measurement of jammer H6.1 on antenna '4'

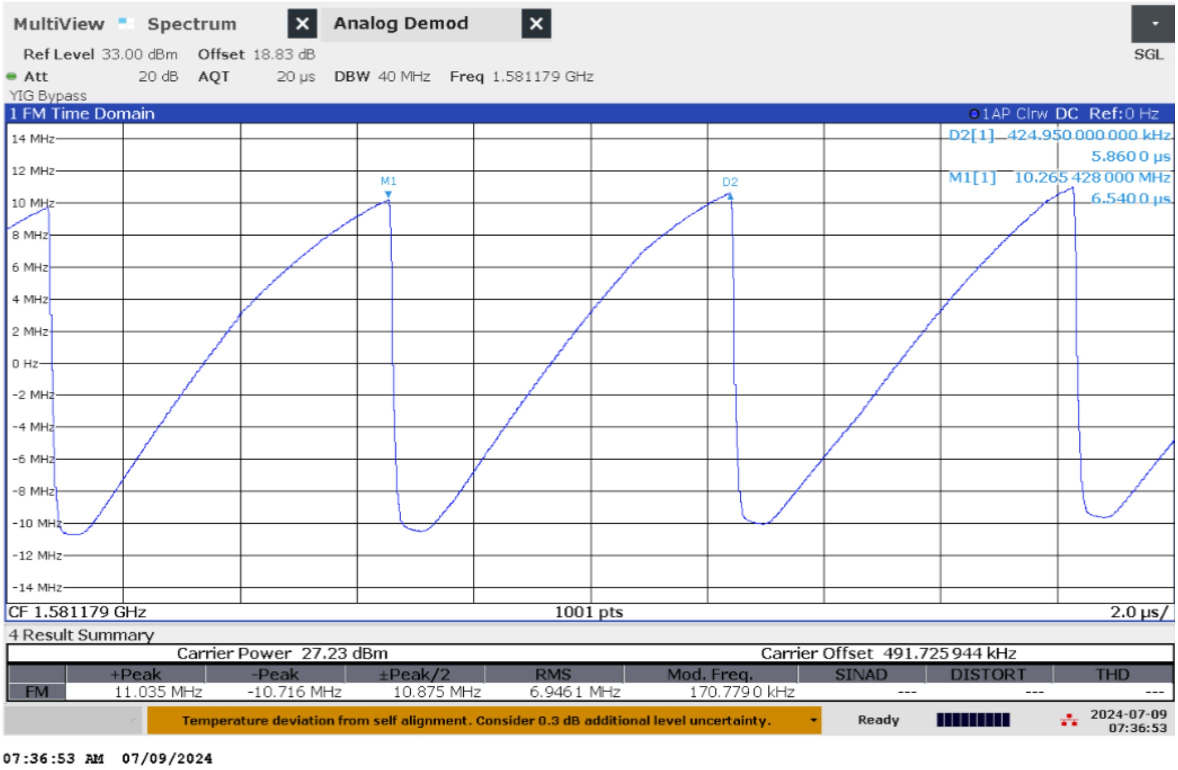

Figure 5.104: Time domain (analog demod) measurement of jammer H6.1 on antenna '6' (L1)

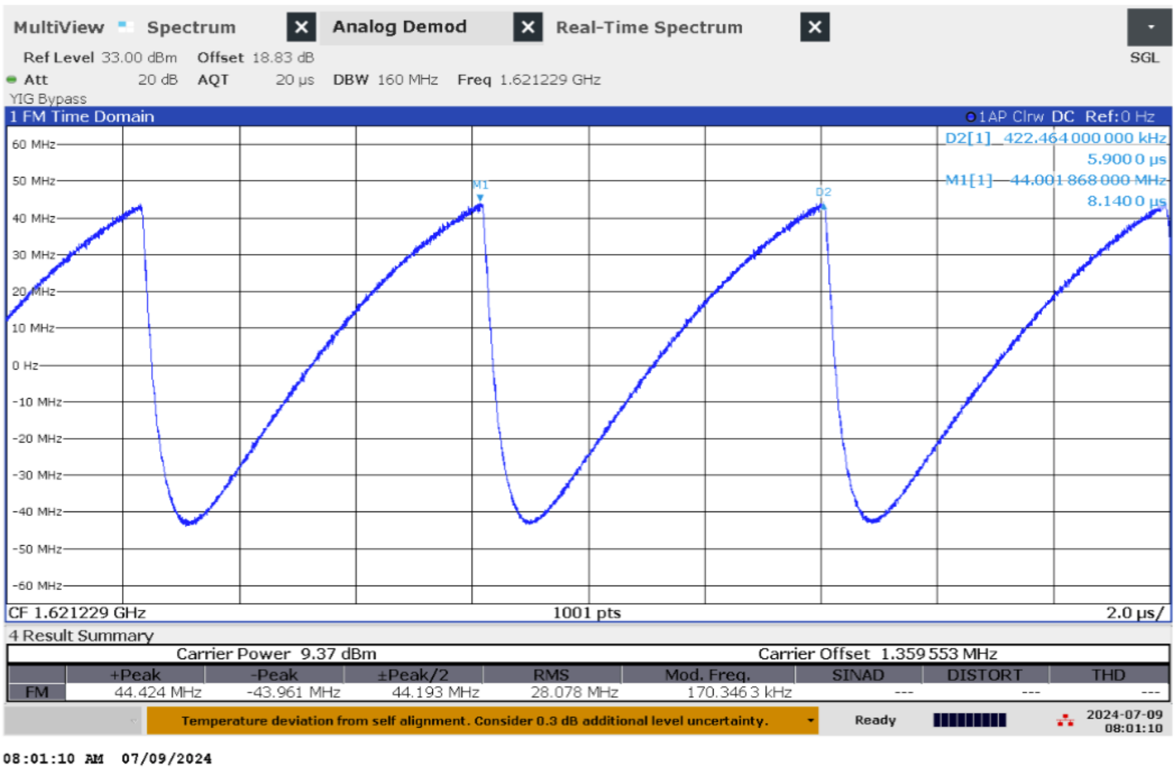

Figure 5.105: Time domain (analog demod) measurement of jammer H6.1 on antenna '4'

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 peration, 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.

Antenna	Centre frequency [MHz]	Bandwidth [MHz]	PSD [dBm/MHz]	TX total [dBm]	CF max [dBm]	Sweep rate [µs]	Modulati
'4' (L1)	1581.51	30.00	26.50	41.27	25.99	7.0/28.2	Sawtooth modulate
'5' (L5)	1154.62	110.77	19.98	40.42	24.57	7.14	Sawtoot
'6' (L2)	1247.94	113.14	21.85	42.39	26.78	7.1	Sawtoot

Table 5.18: Technical characteristics of H6.2 jammer

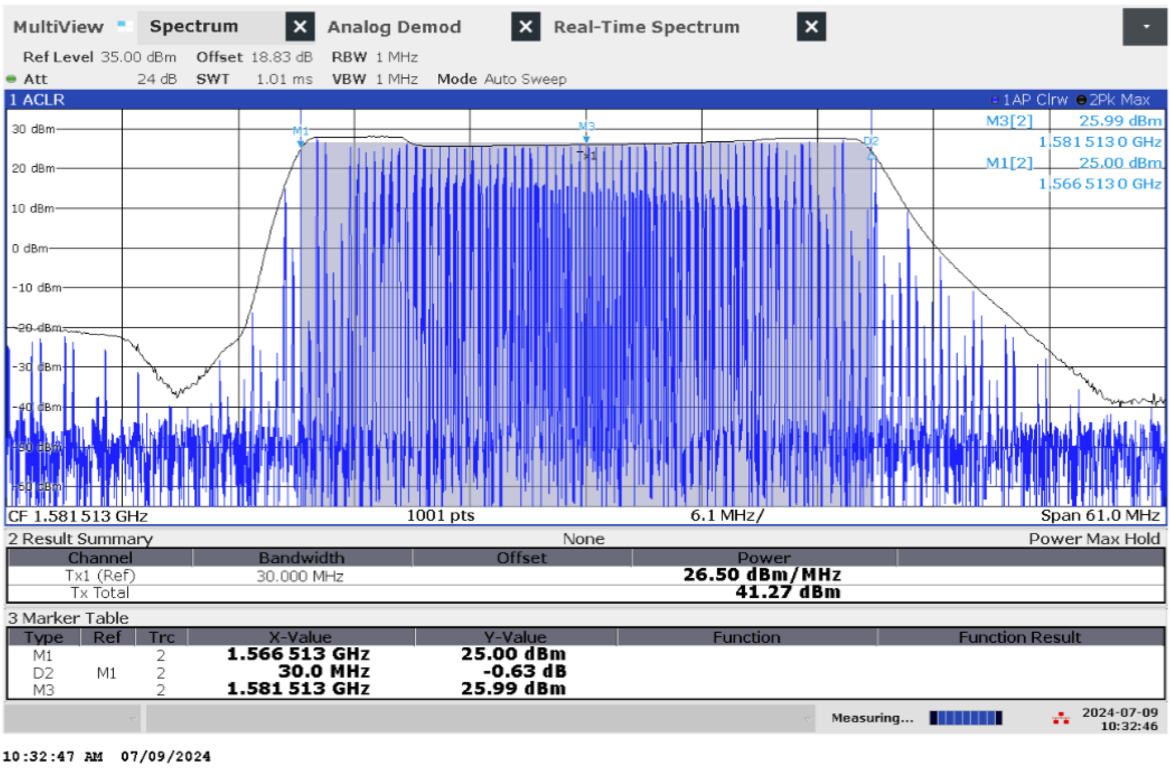

Figure 5.106: Frequency and power measurement of jammer H6.2 on antenna '4' (L1)

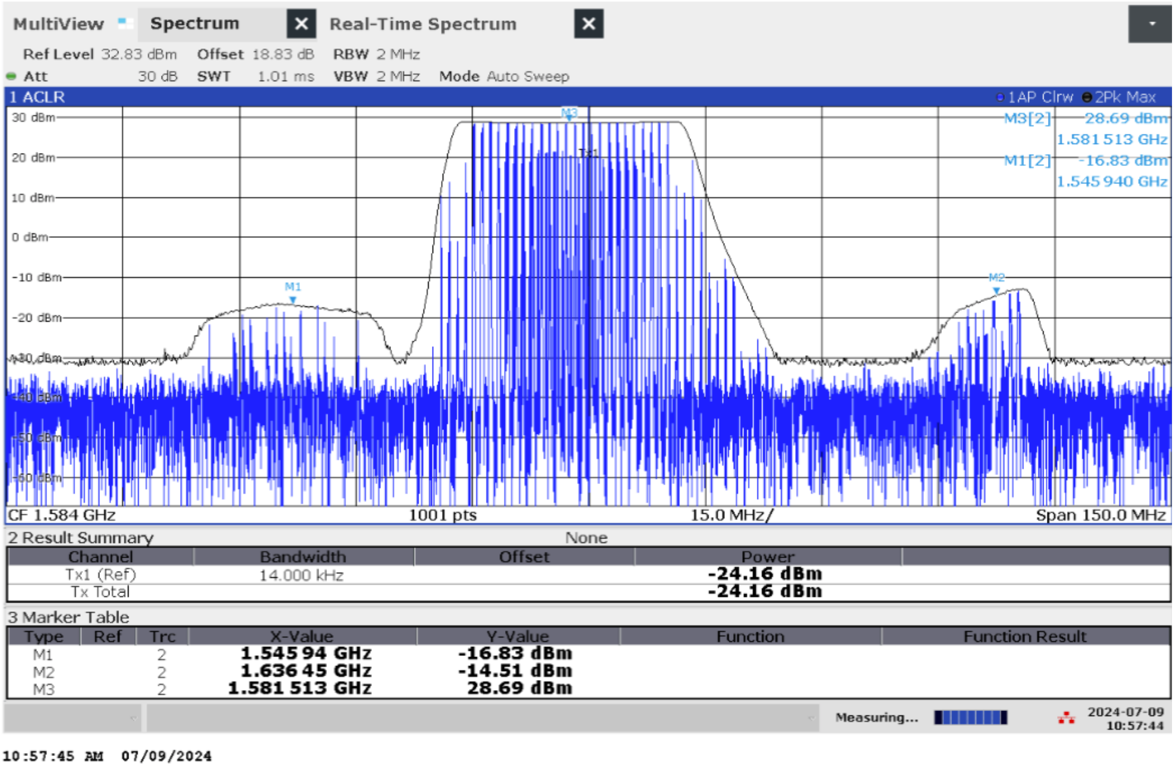

Figure 5.107: Frequency and power measurement with wider band of jammer H6.2 on antenna '4' (L1)

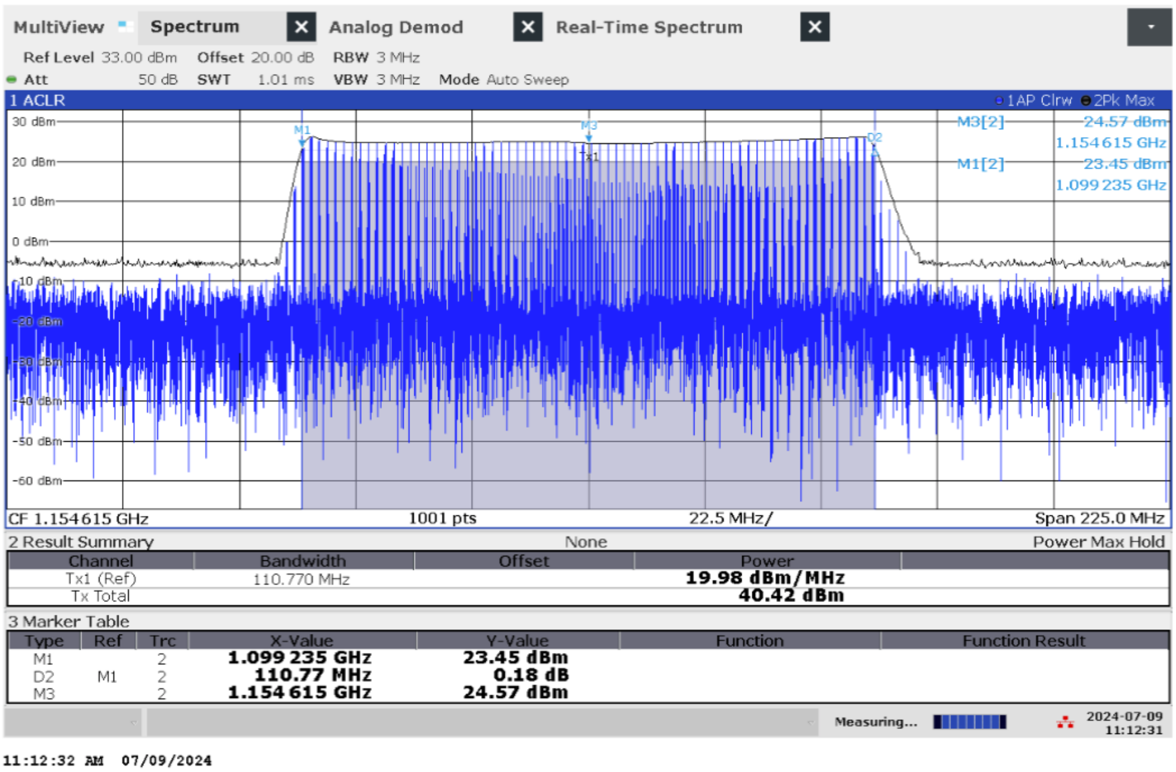

Figure 5.108: Frequency and power measurement of jammer H6.2 on antenna '5' (L5)

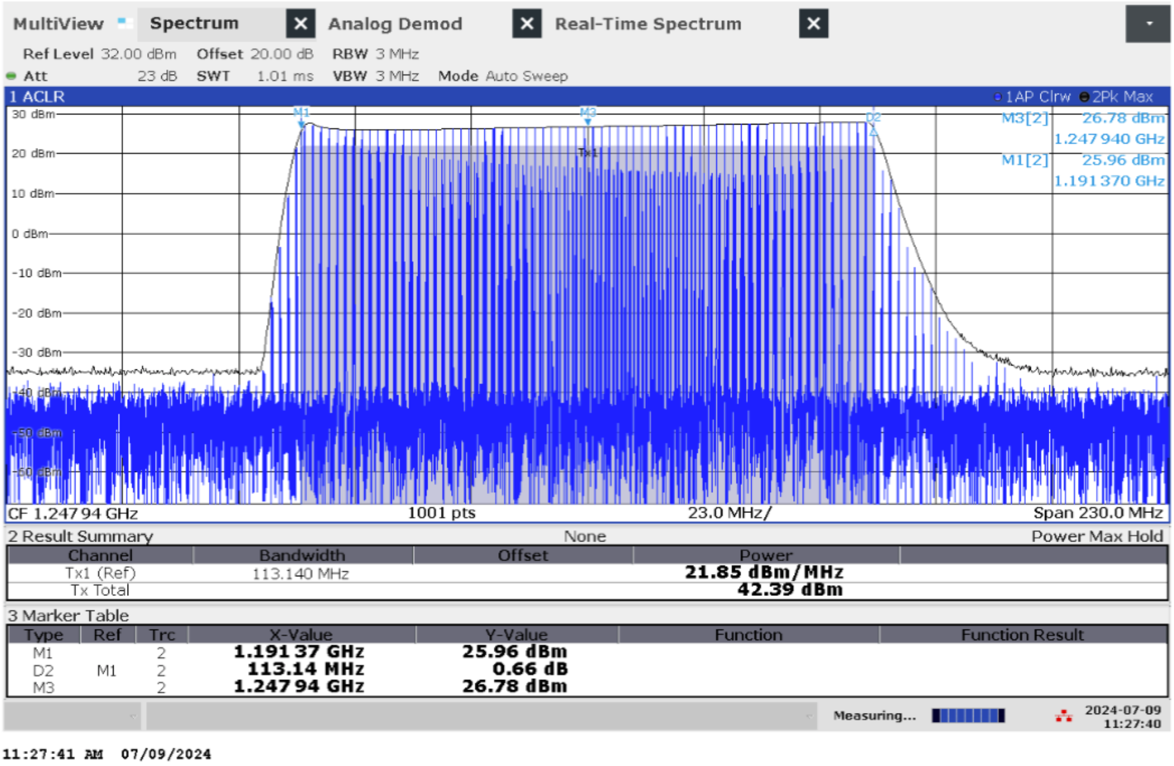

Figure 5.109: Frequency and power measurement of jammer H6.2 on antenna '6' (L2)

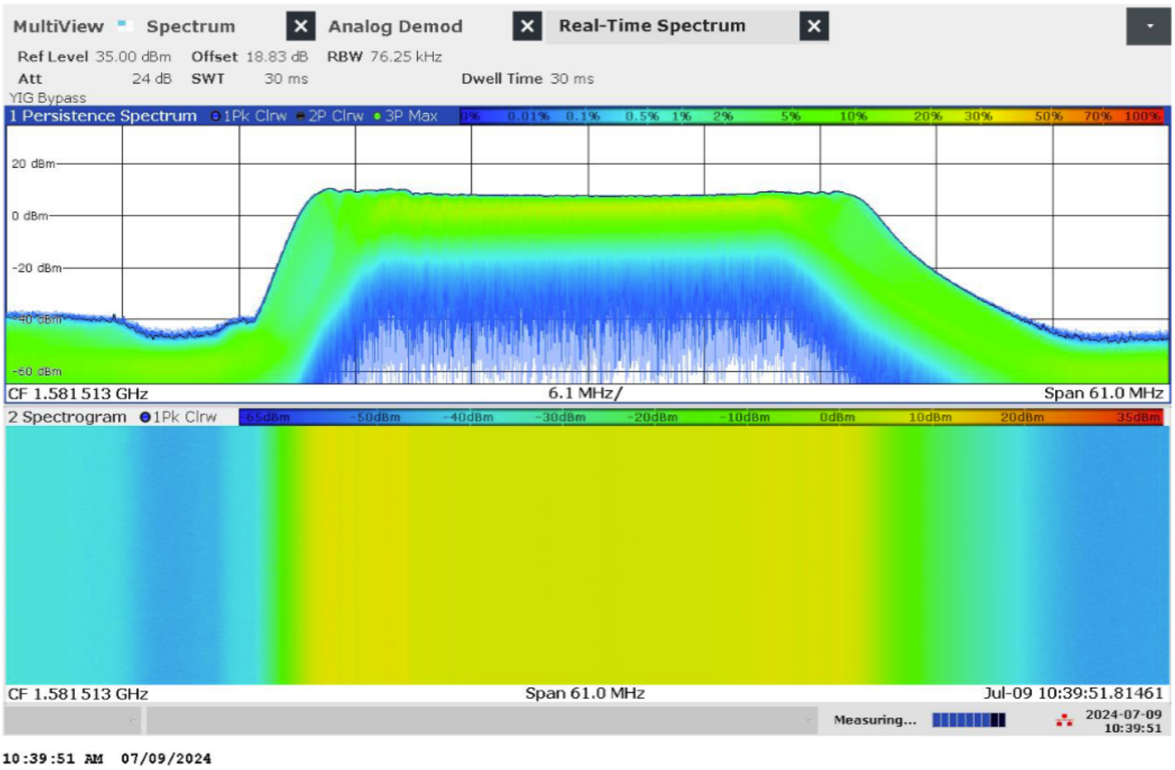

Figure 5.110: Real-time persistence and spectrogram measurement of jammer H6.2 on antenna '4' (L1)

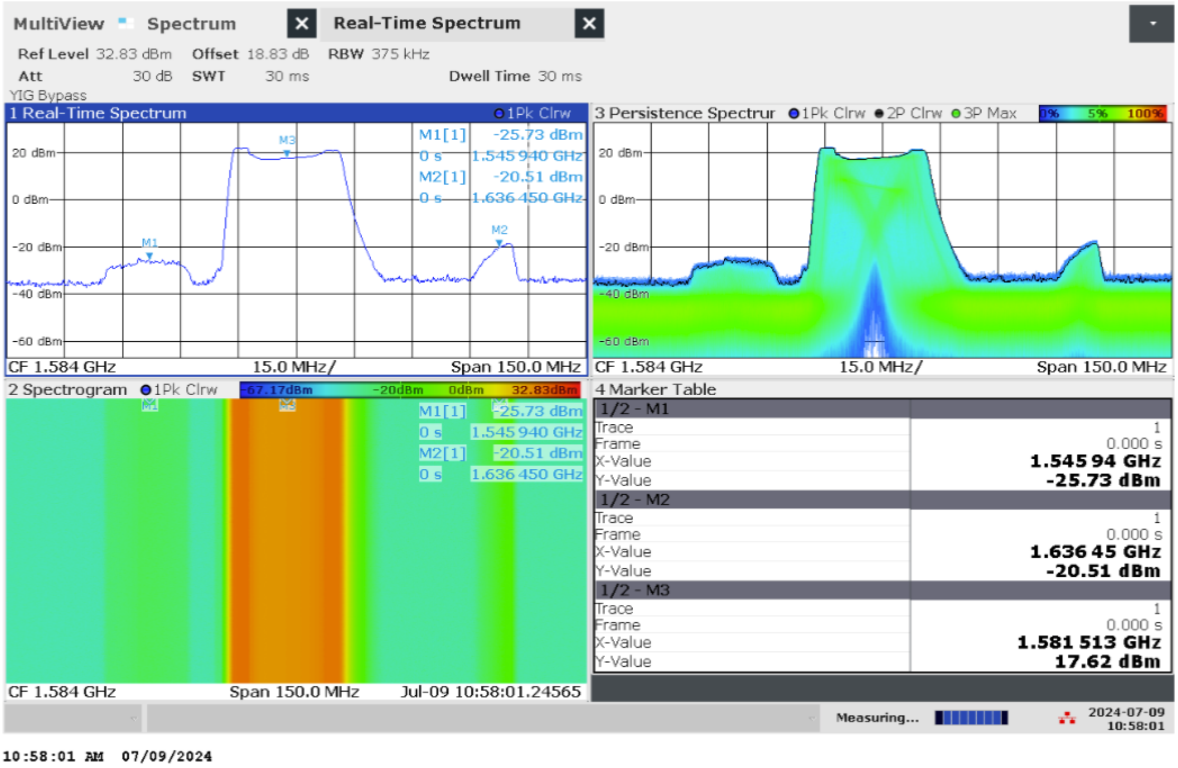

Figure 5.111: Real-time persistence and spectrogram measurement with wider span of jammer H6.2 on antenna '4' (L1)

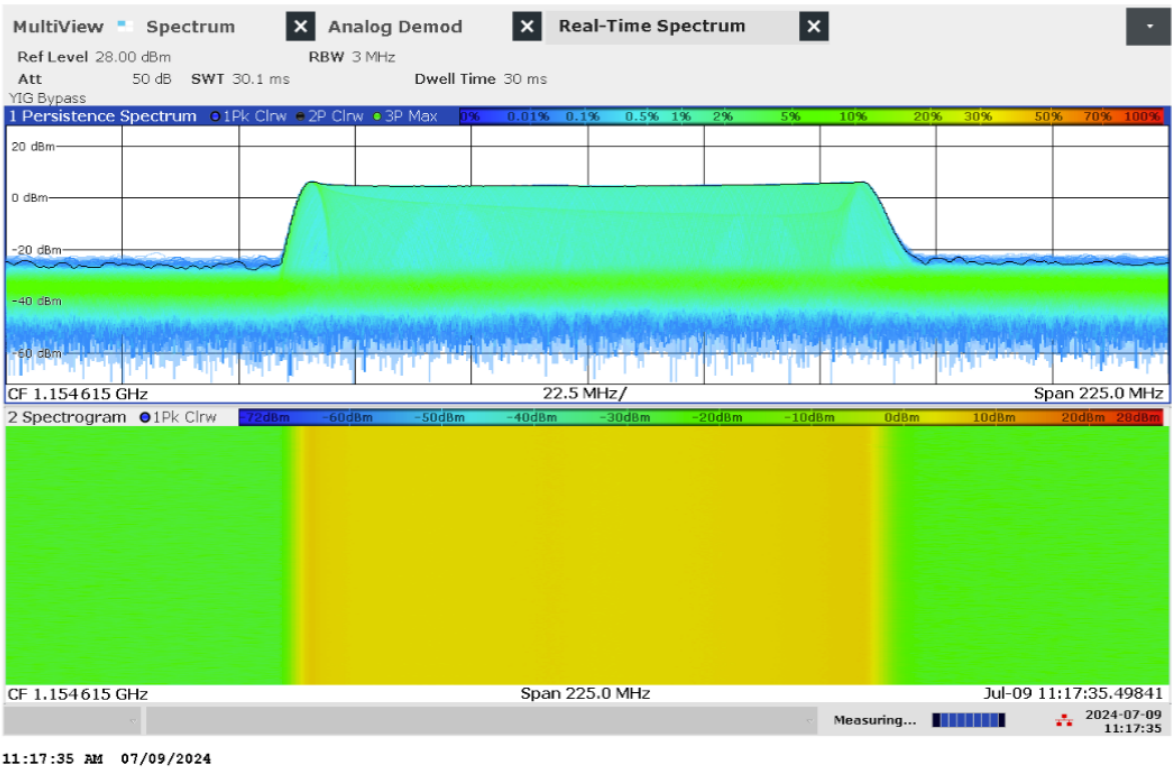

Figure 5.112: Real-time persistence and spectrogram measurement of jammer H6.2 on antenna '5' (L5)

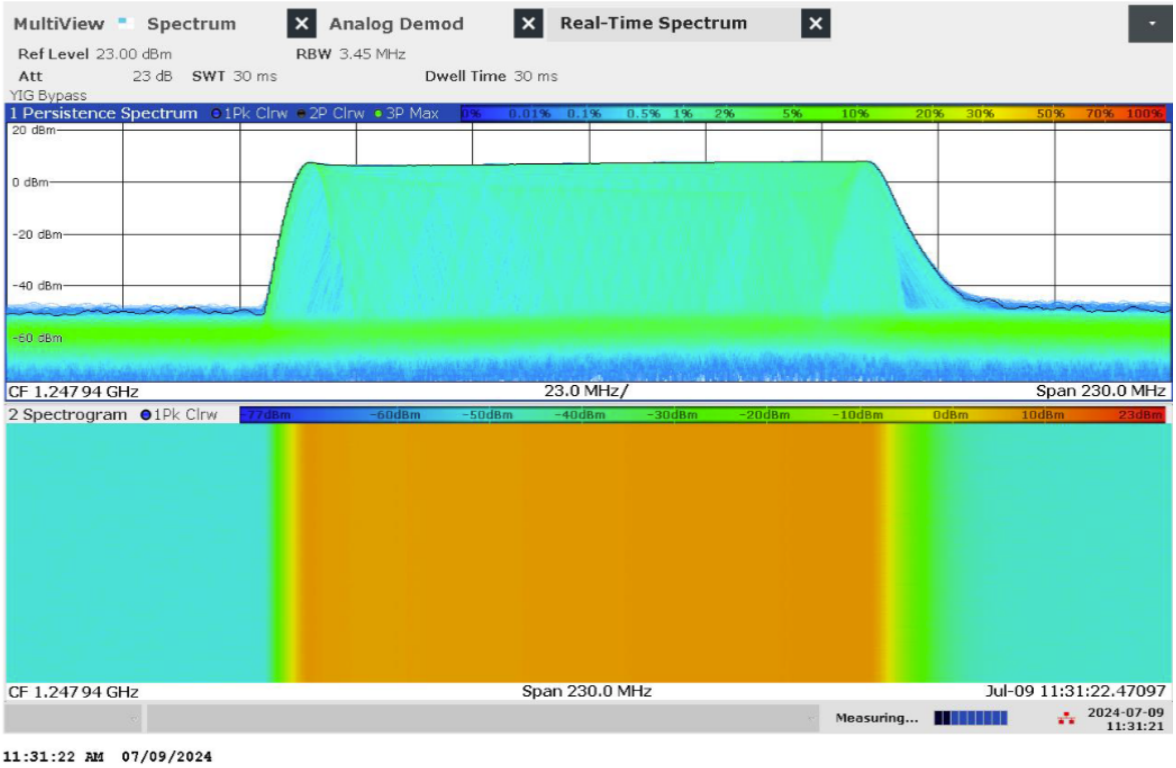

Figure 5.113: Real-time persistence and spectrogram measurement of jammer H6.2 on antenna ’6’ (L2)

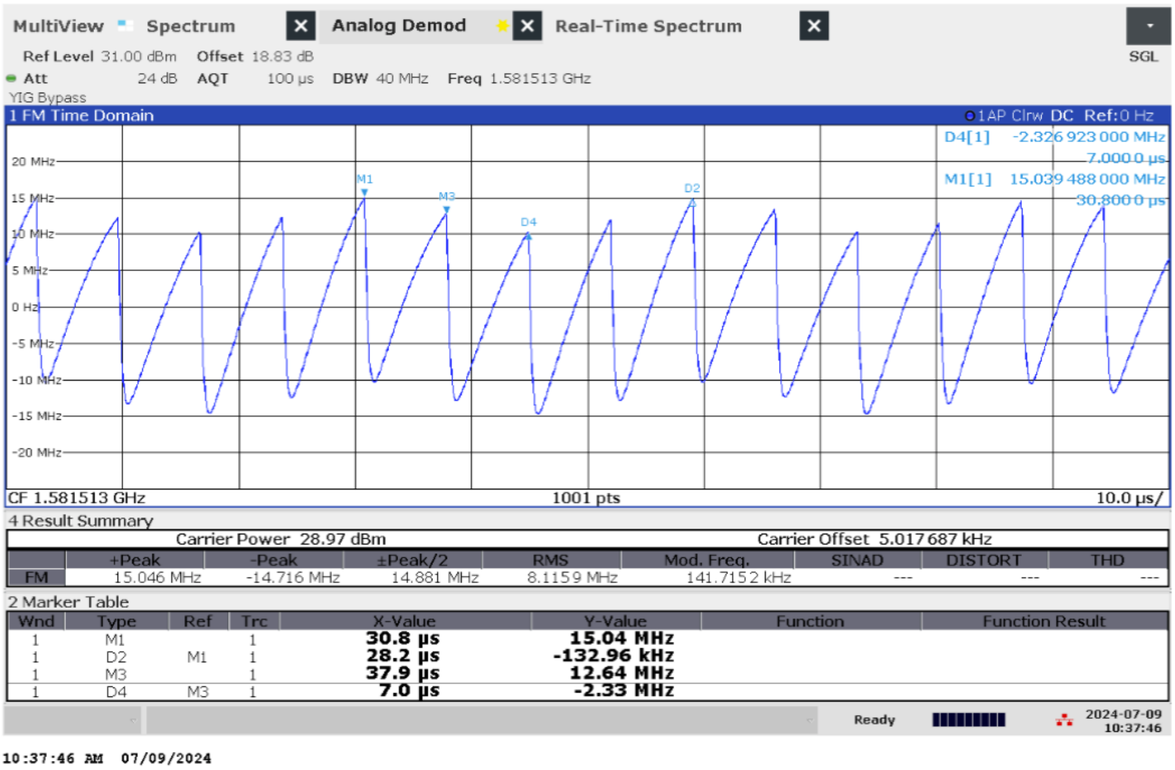

Figure 5.114: Time domain (analog demod) measurement with wider sweep of jammer H6.2 on antenna ’4’ (L1)

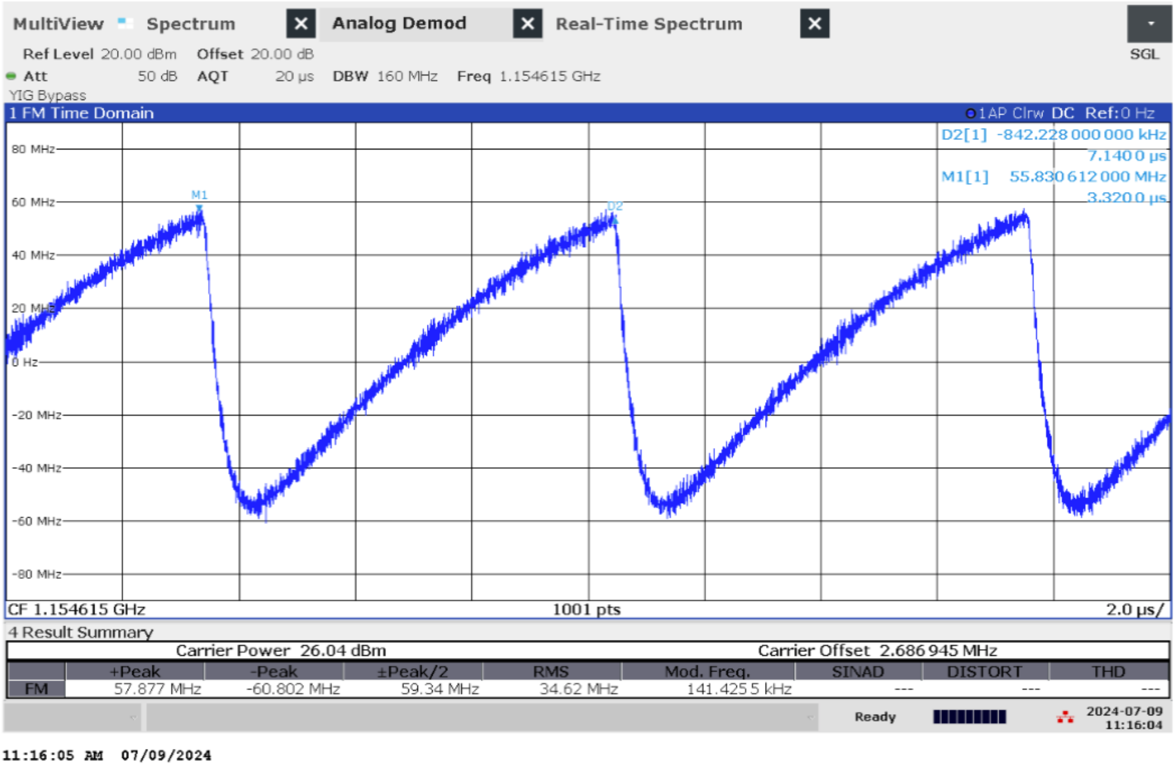

Figure 5.115: Time domain (analog demod) measurement of jammer H6.2 on antenna '5' (L5)

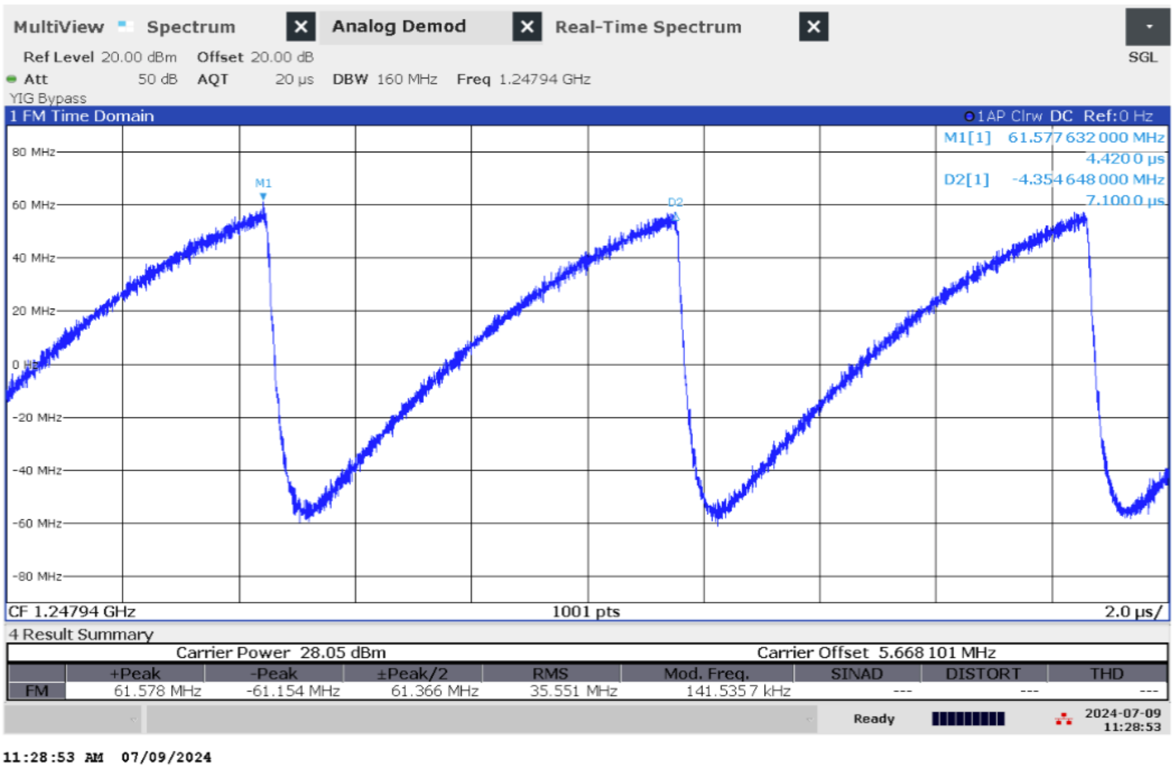

Figure 5.116: Time domain (analog demod) measurement of jammer H6.2 on antenna '6' (L2)

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 peration, 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).

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

Table 5.19: Technical characteristics of H6.3 jammer

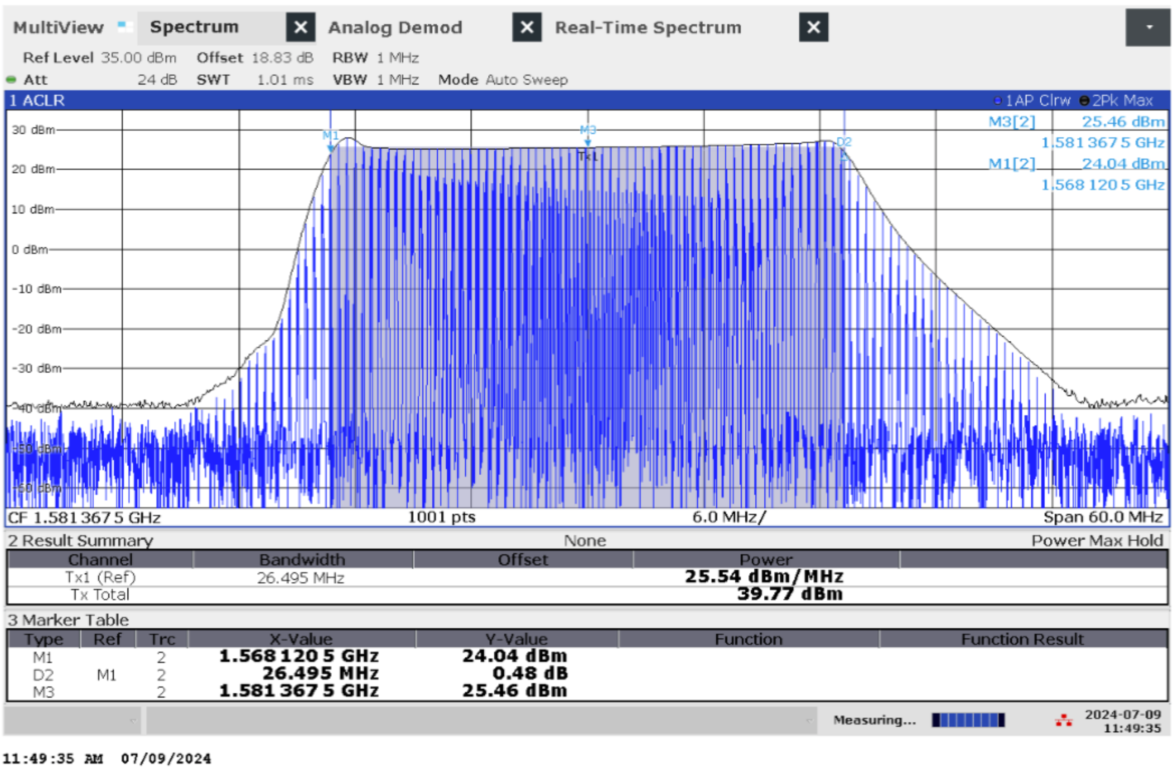

Figure 5.117: Frequency and power measurement of jammer H6.3 on antenna '4' (L1)

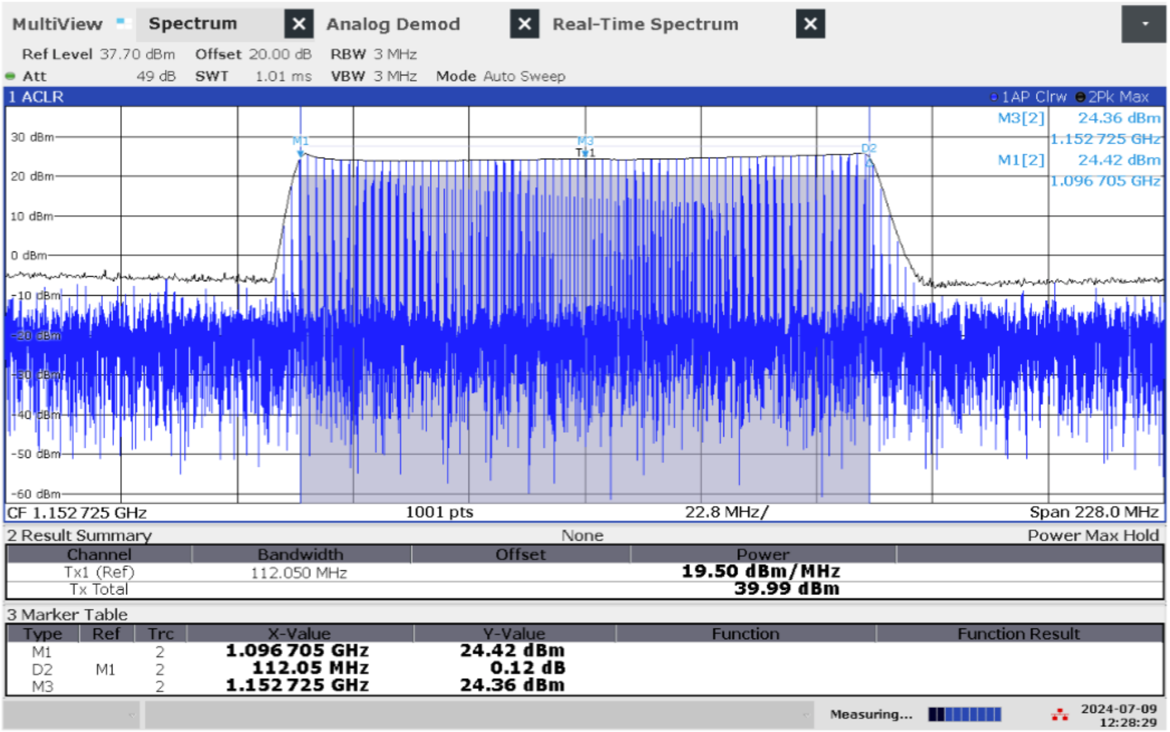

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Figure 5.118: Frequency and power measurement of jammer H6.3 on antenna '5' (L5)

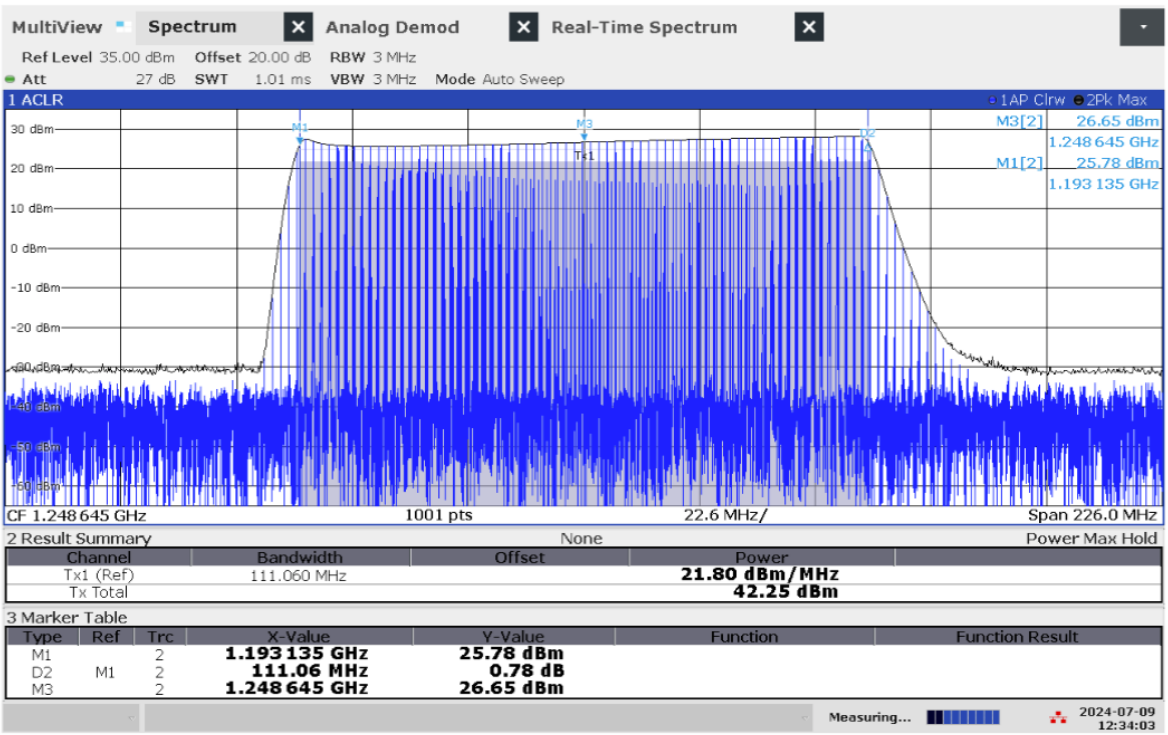

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Figure 5.119: Frequency and power measurement of jammer H6.3 on antenna '6' (L2)

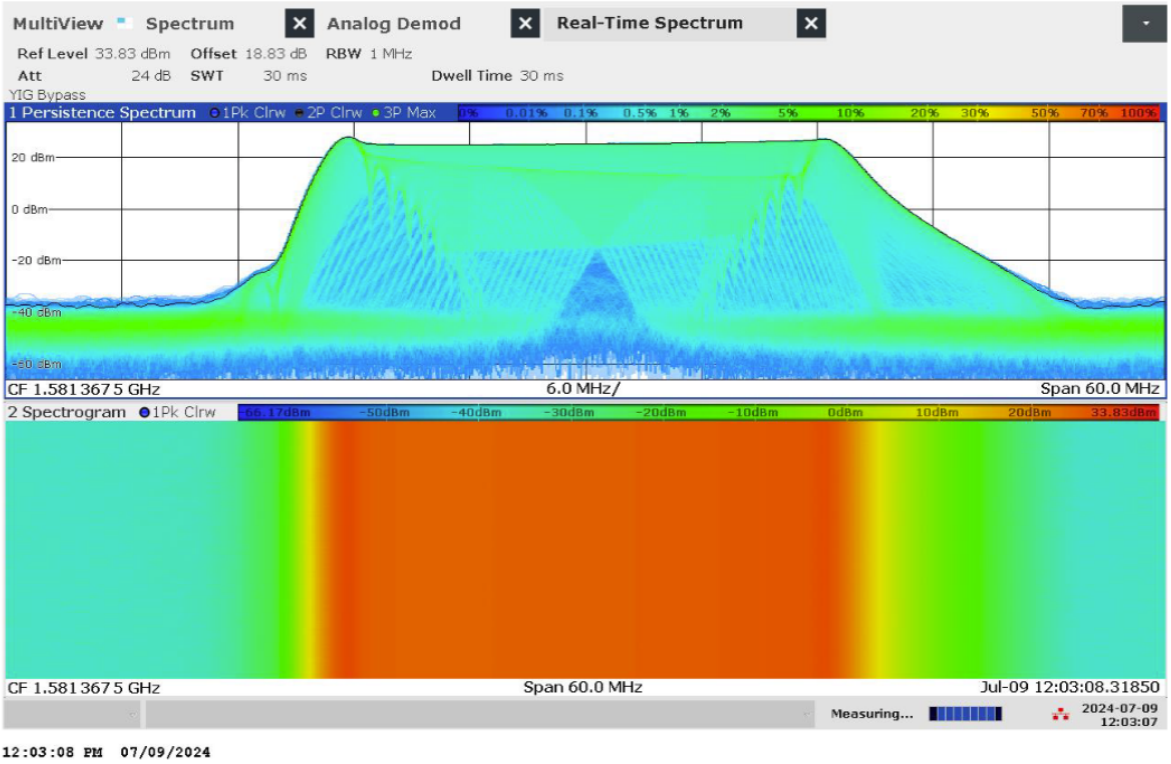

Figure 5.120: Real-time persistence and spectrogram measurement of jammer H6.3 on antenna '4' (L1)

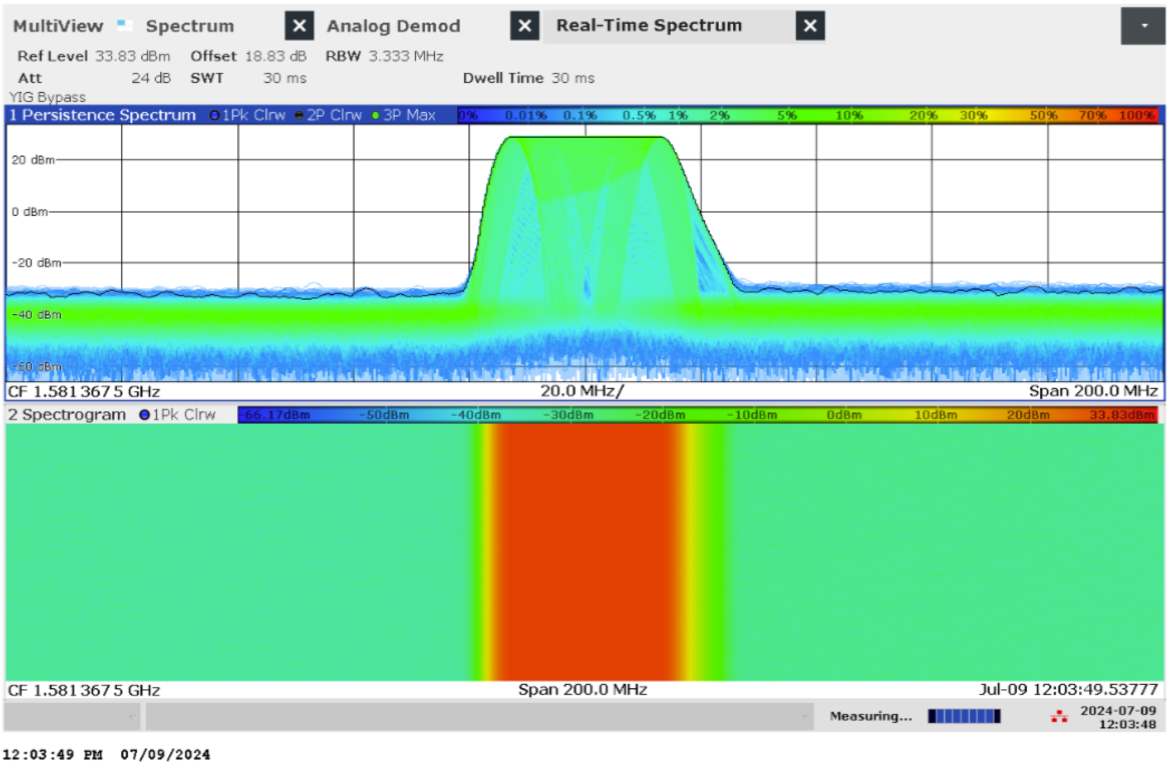

Figure 5.121: Real-time persistence and spectrogram measurement with wider span of jammer H6.3 on antenna '4' (L1)

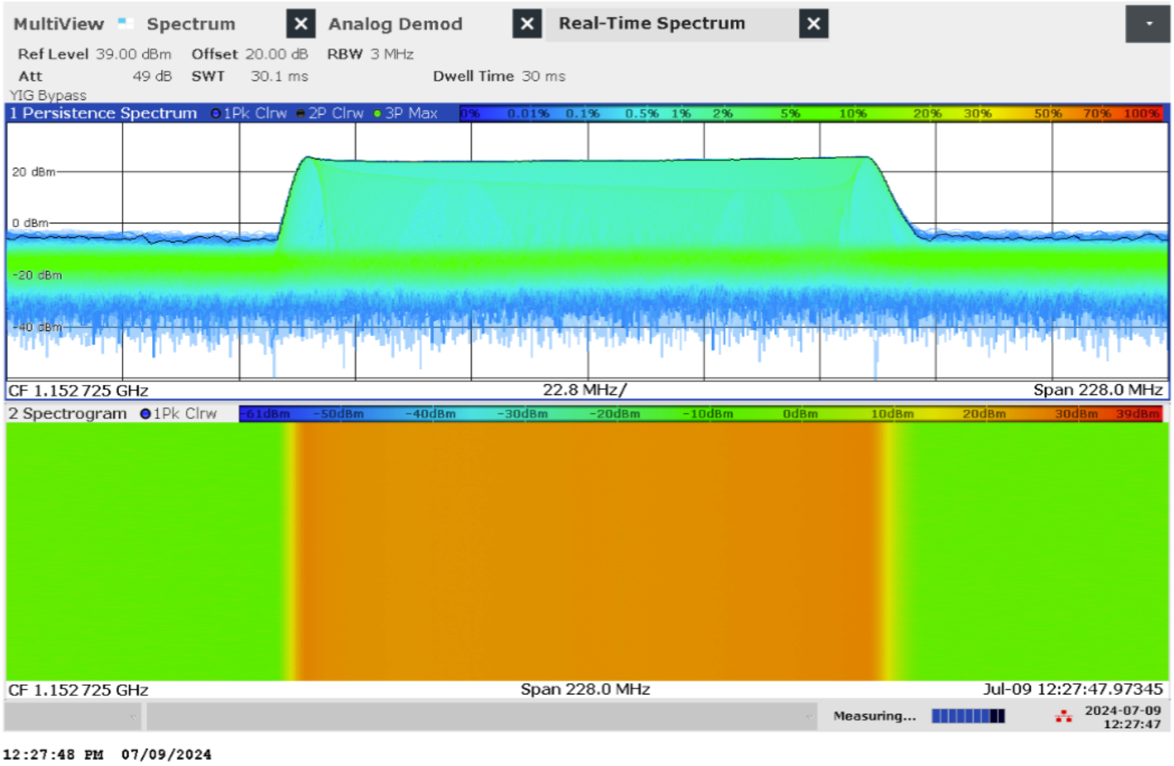

Figure 5.122: Real-time persistence and spectrogram measurement of jammer H6.3 on antenna '5' (L5)

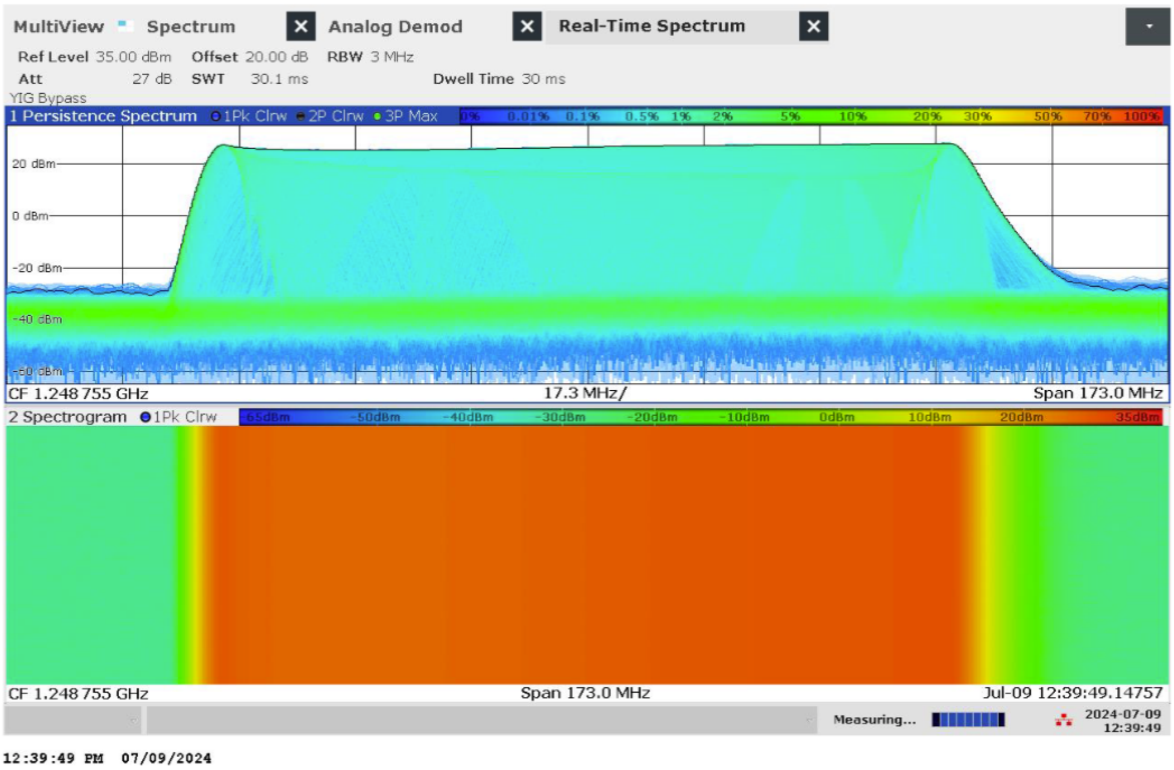

Figure 5.123: Real-time persistence and spectrogram measurement of jammer H6.3 on antenna '6' (L2)

Figure 5.124: Time domain (analog demod) measurement of jammer H6.3 on antenna '4' (L1)

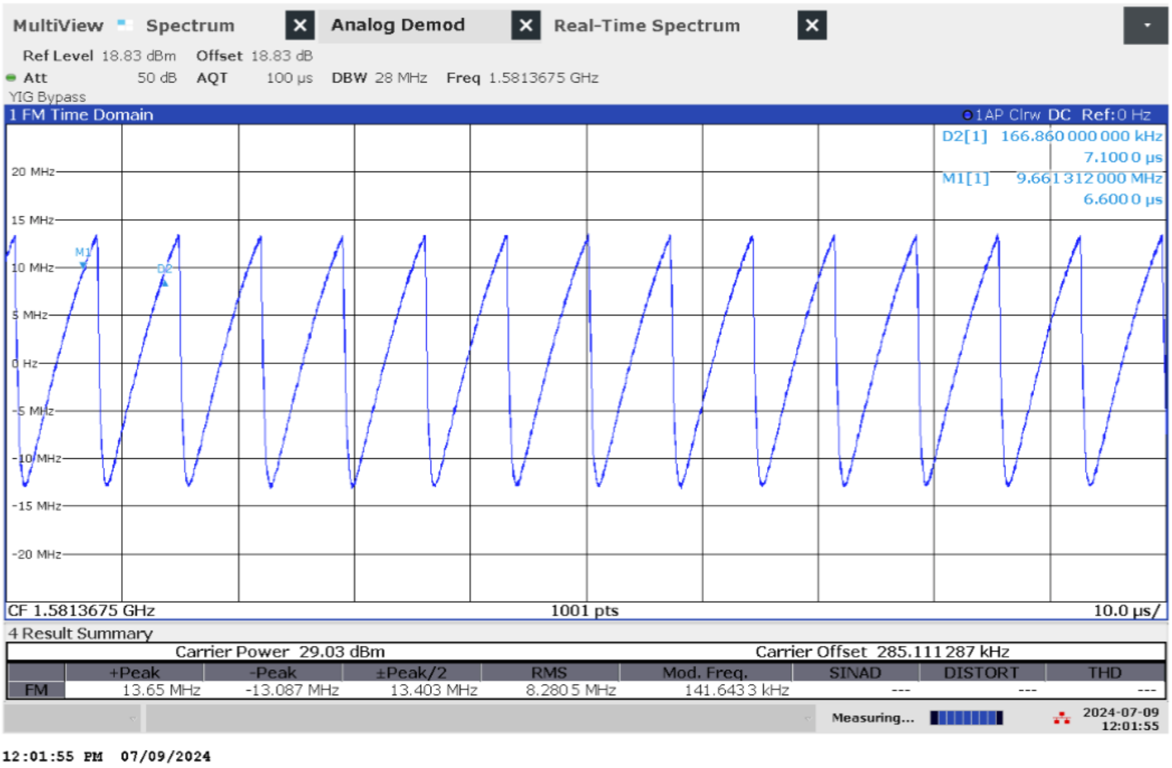

Figure 5.125: Time domain (analog demod) measurement with wider sweep of jammer H6.3 on antenna '4' (L1)

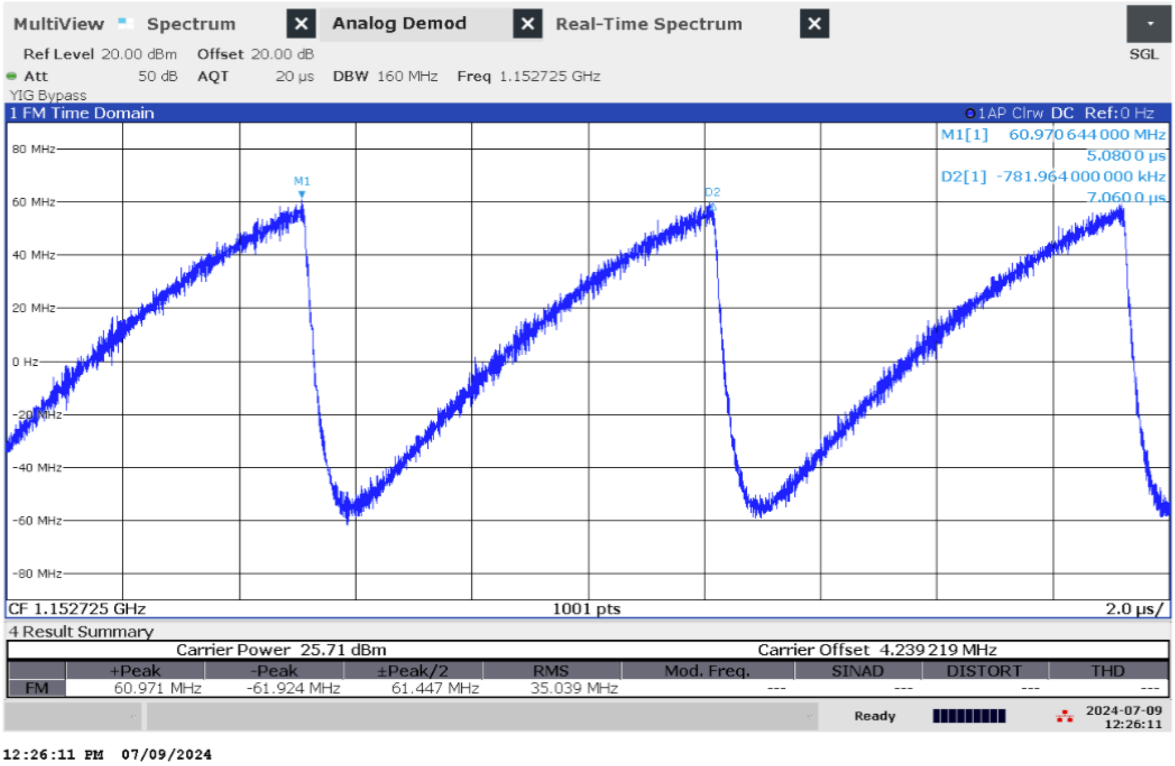

Figure 5.126: Time domain (analog demod) measurement of jammer H6.3 on antenna ’5’ (L5)

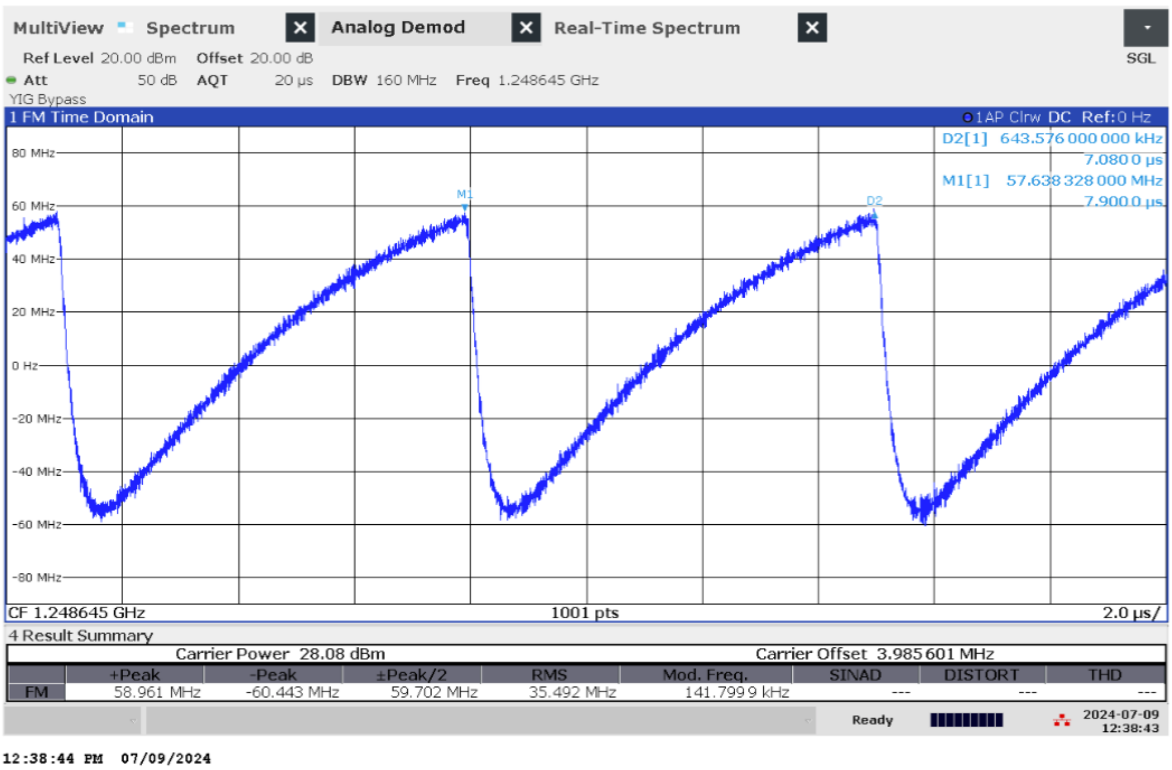

Figure 5.127: Time domain (analog demod) measurement of jammer H6.3 on antenna ’6’ (L2)

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 peration, 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).

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

Table 5.20: Technical characteristics of H6.4 jammer

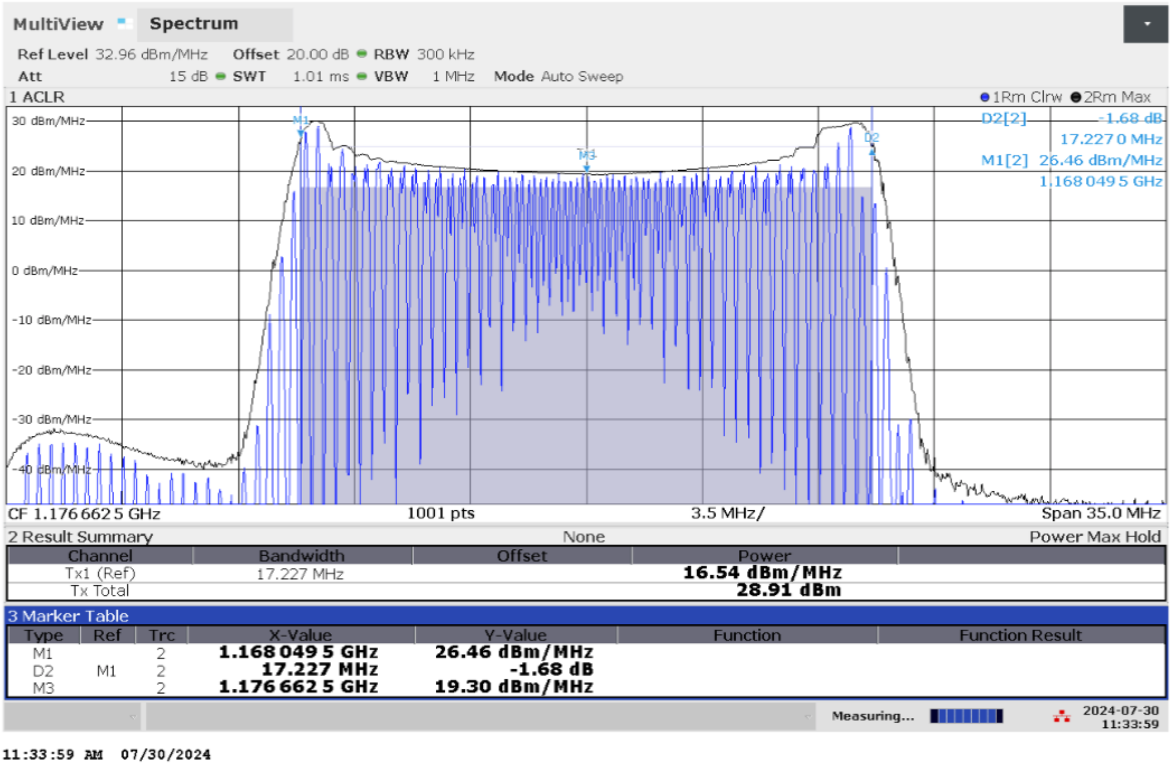

Figure 5.128: Frequency and power measurement of jammer H6.4 on antenna '1' (L5)

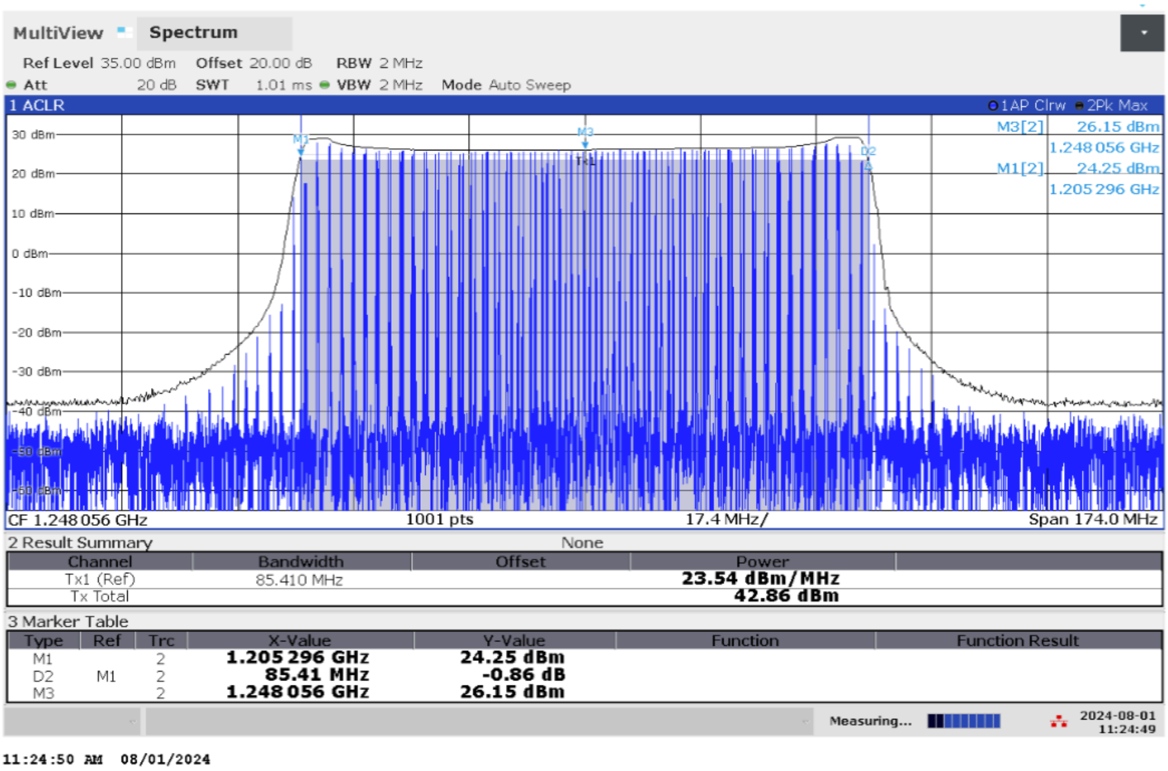

Figure 5.129: Frequency and power measurement of jammer H6.4 on antenna '3' (L2)

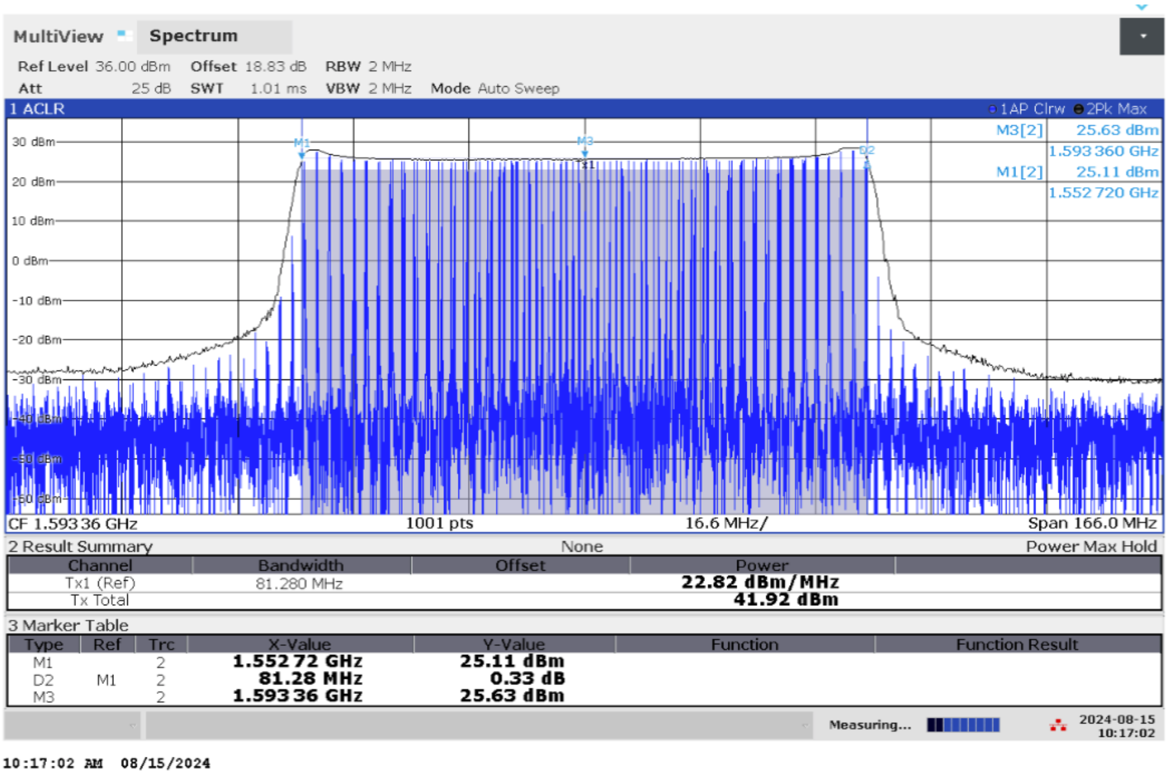

Figure 5.130: Frequency and power measurement of jammer H6.4 on antenna '5' (L1)

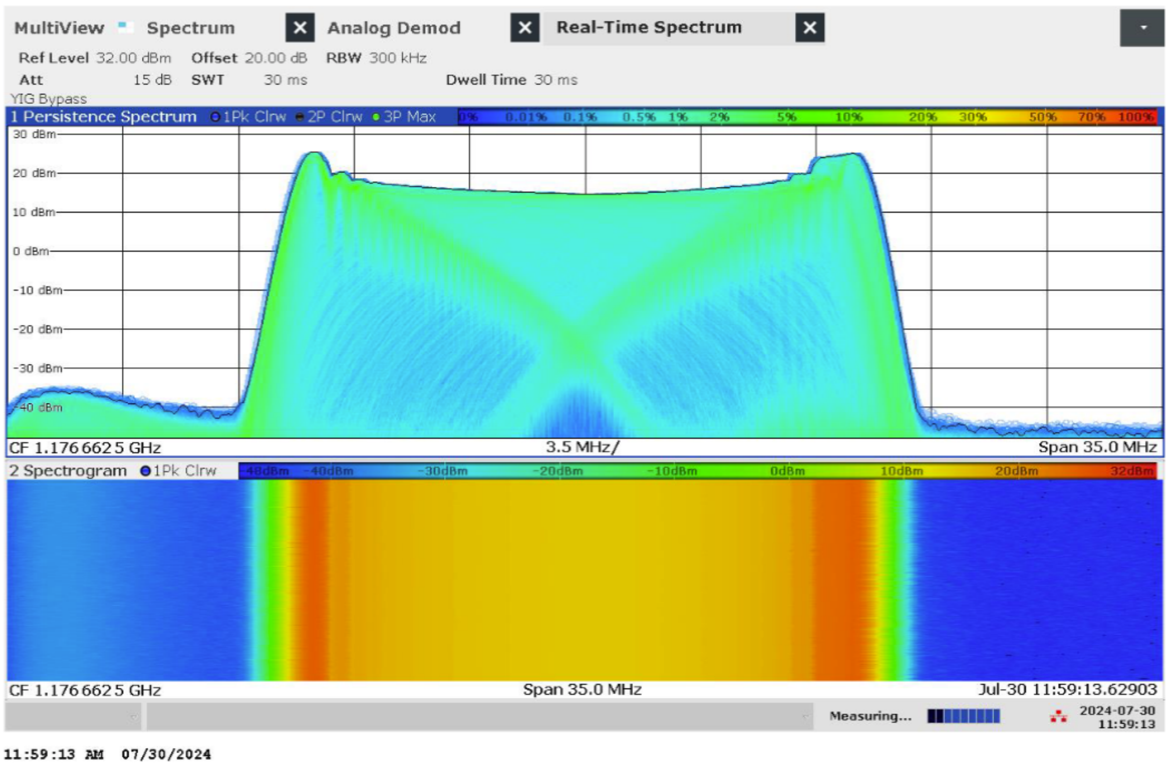

Figure 5.131: Real-time persistence and spectrogram measurement of jammer H6.4 on antenna '1' (L5)

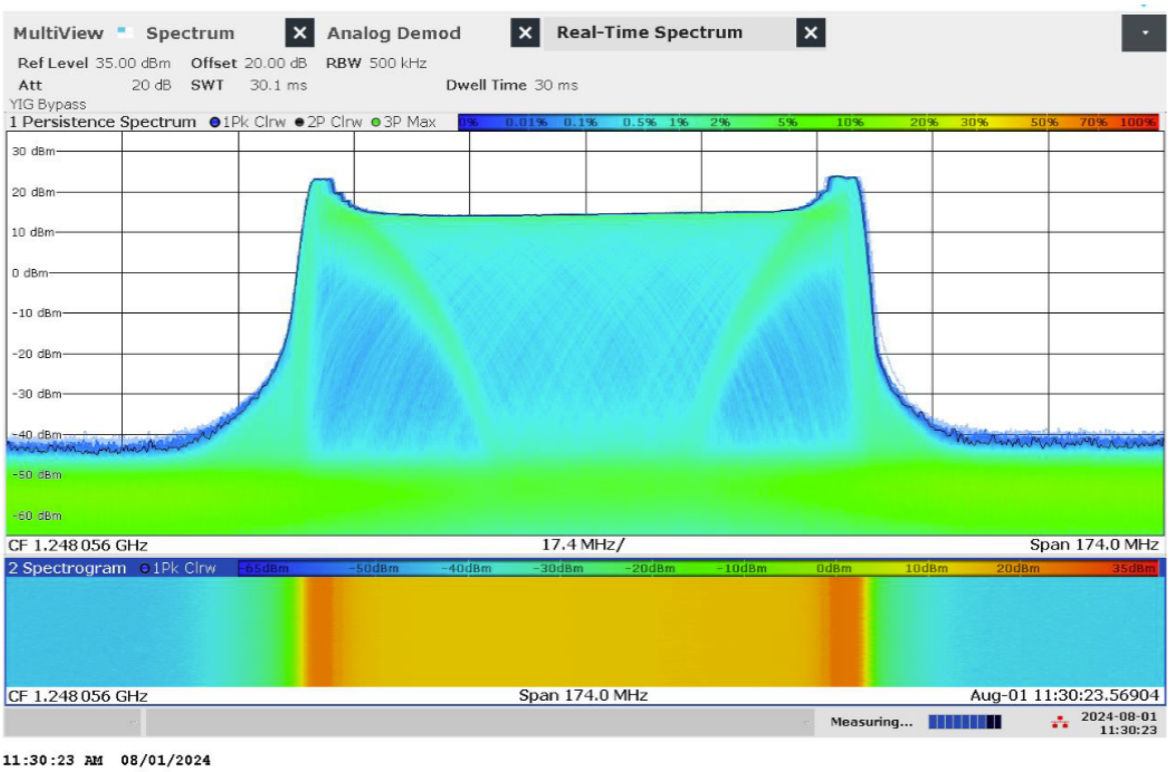

Figure 5.132: Real-time persistence and spectrogram measurement of jammer H6.4 on antenna '3' (L2)

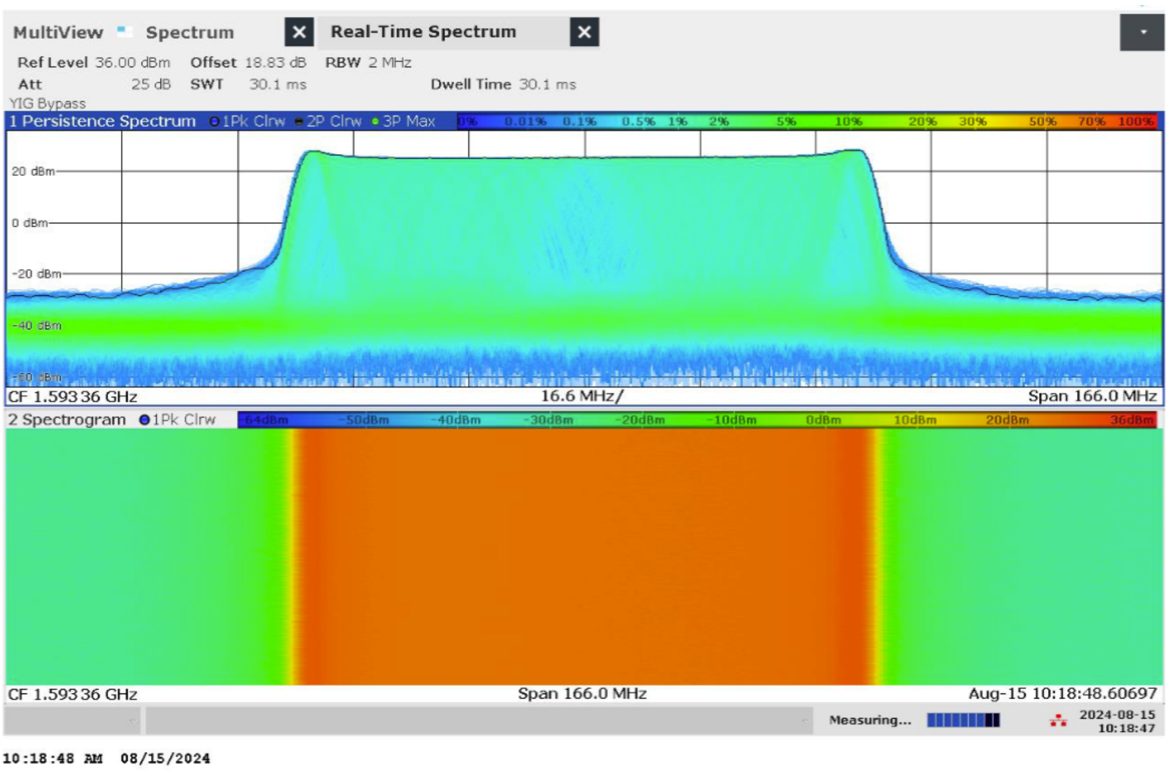

Figure 5.133: Real-time persistence and spectrogram measurement of jammer H6.4 on antenna '5' (L1)

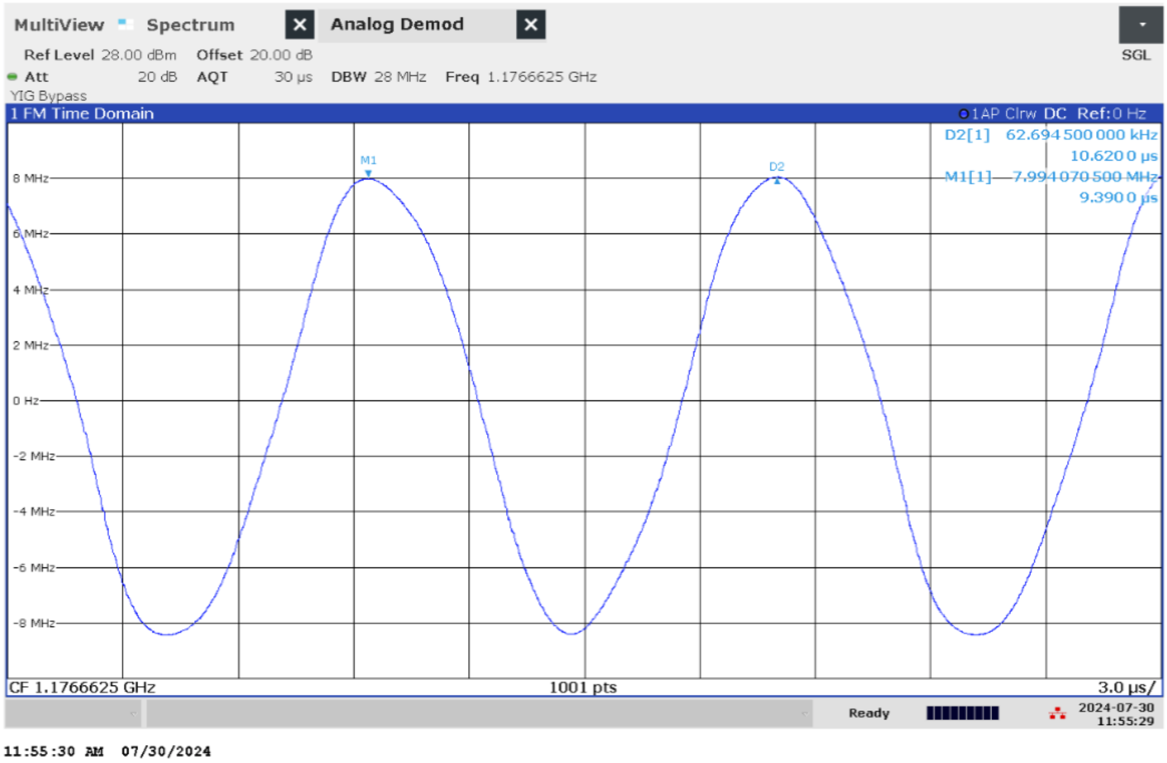

Figure 5.134: Time domain (analog demod) measurement of jammer H6.4 on antenna ’1’ (L5)

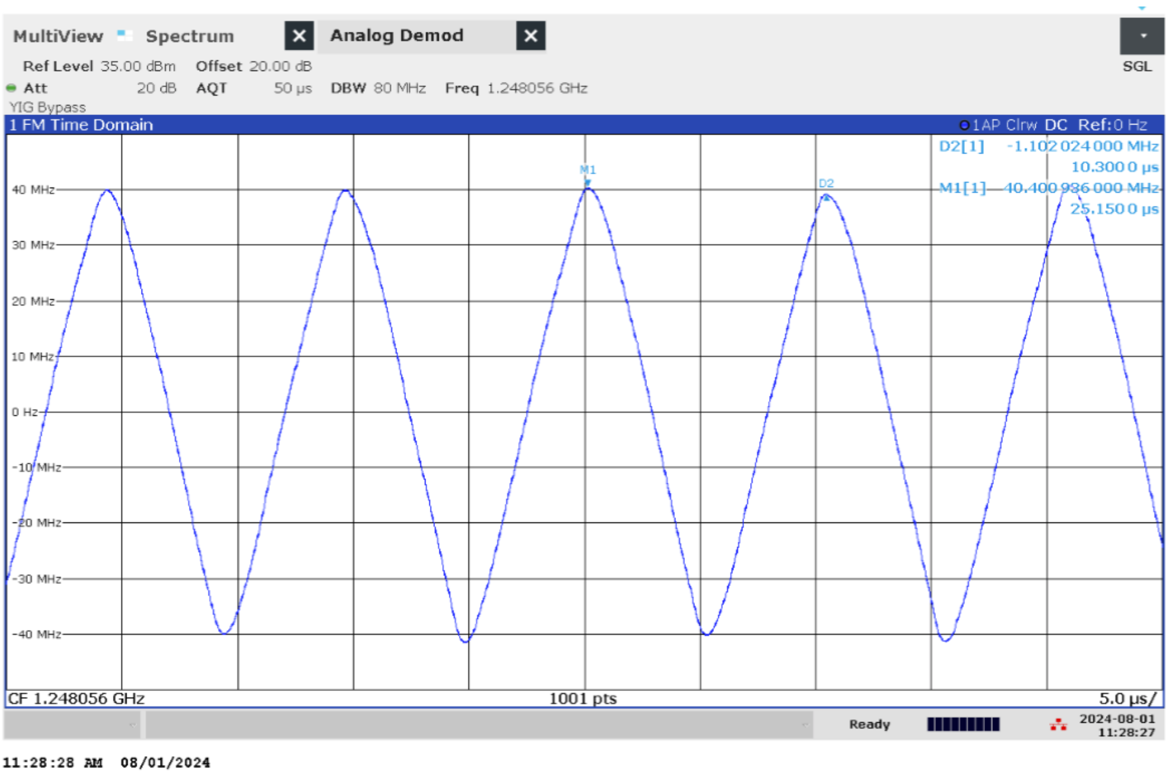

Figure 5.135: Time domain (analog demod) measurement of jammer H6.4 on antenna ’3’ (L2)

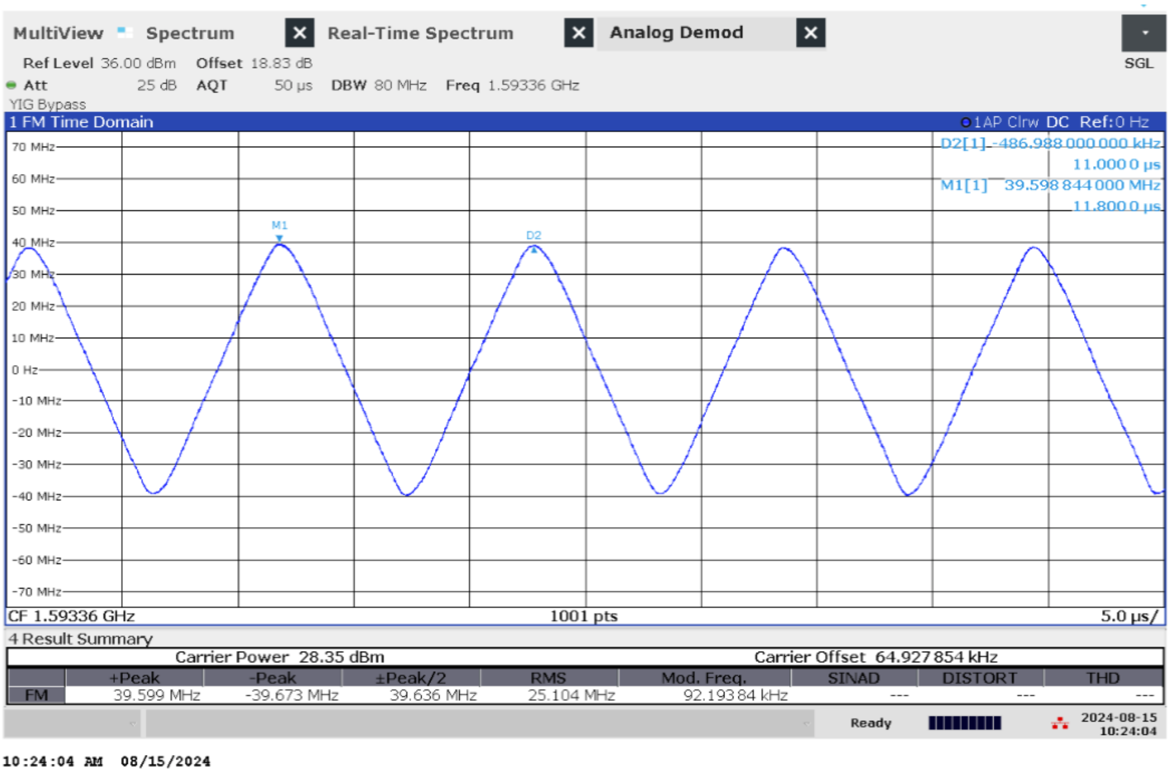

Figure 5.136: Time domain (analog demod) measurement of jammer H6.4 on antenna '5' (L1)

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 peration, 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).

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)	1595.60	80.12	22.62	41.65	25.41	10.30	Triangle

Table 5.21: Technical characteristics of H6.5 jammer

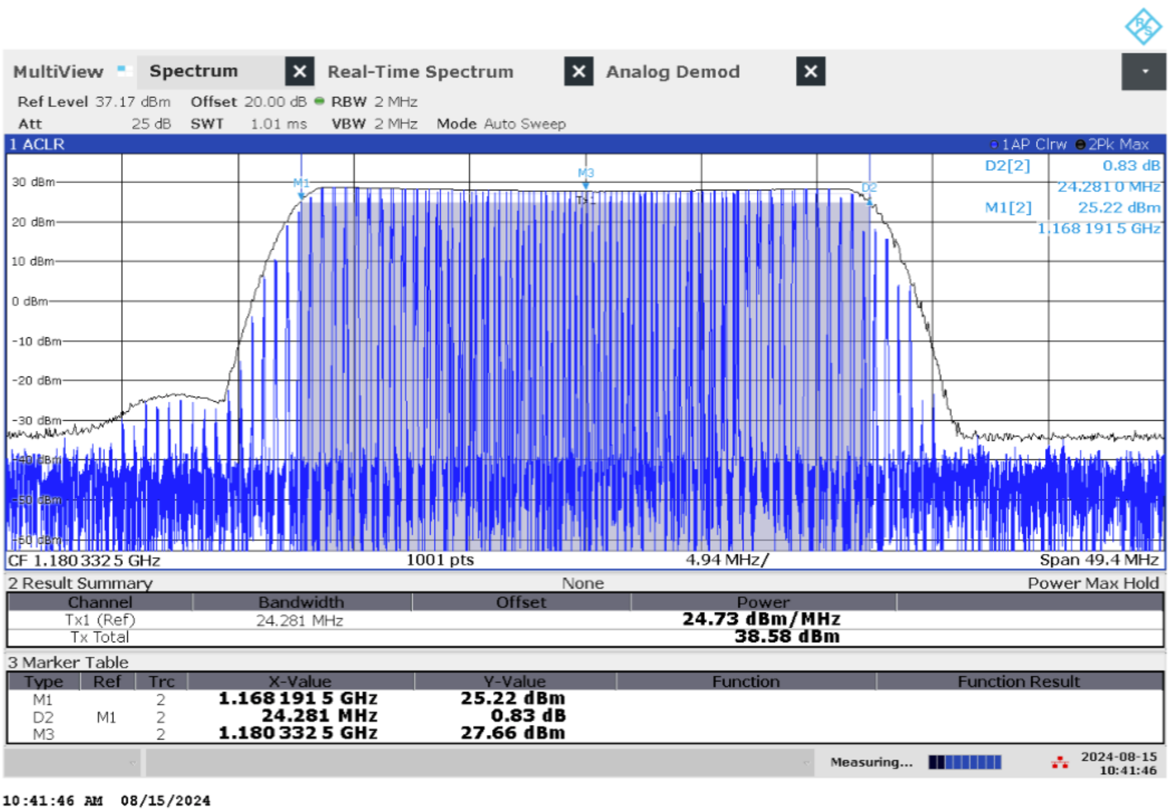

Figure 5.137: Frequency and power measurement of jammer H6.5 on antenna '1' (L5)

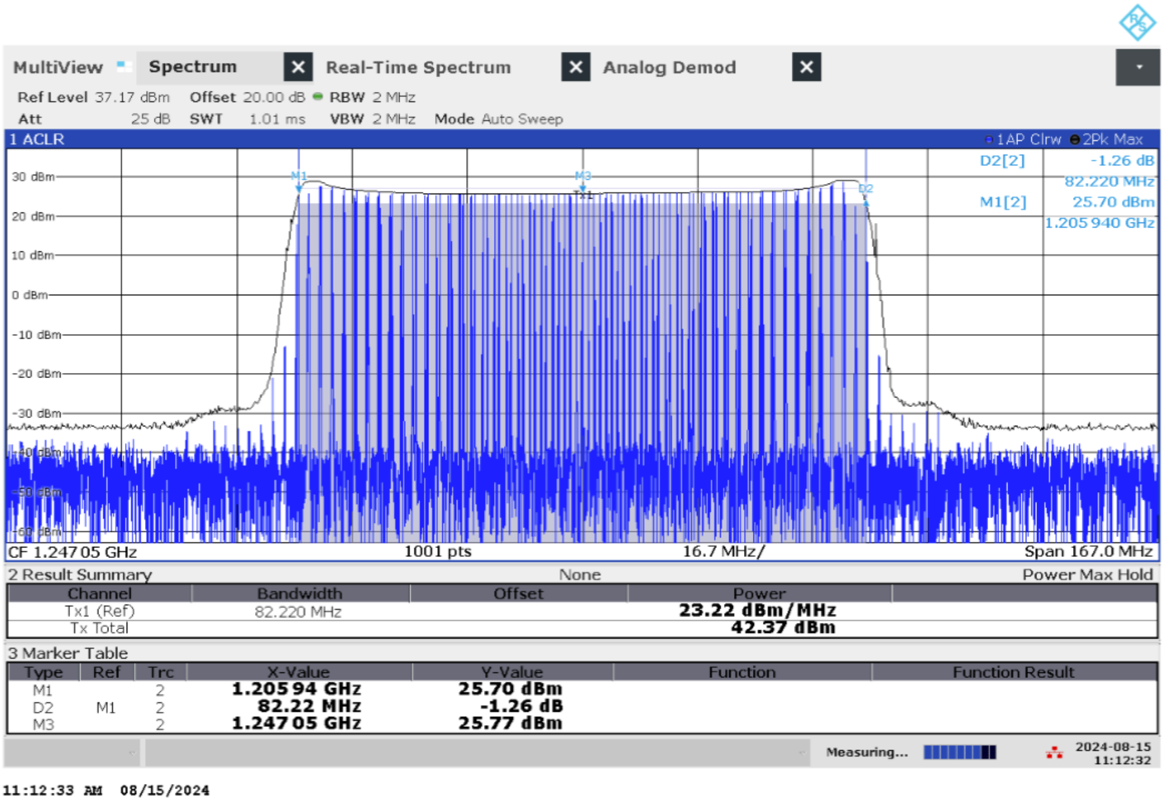

Figure 5.138: Frequency and power measurement of jammer H6.5 on antenna ’3’ (L2)

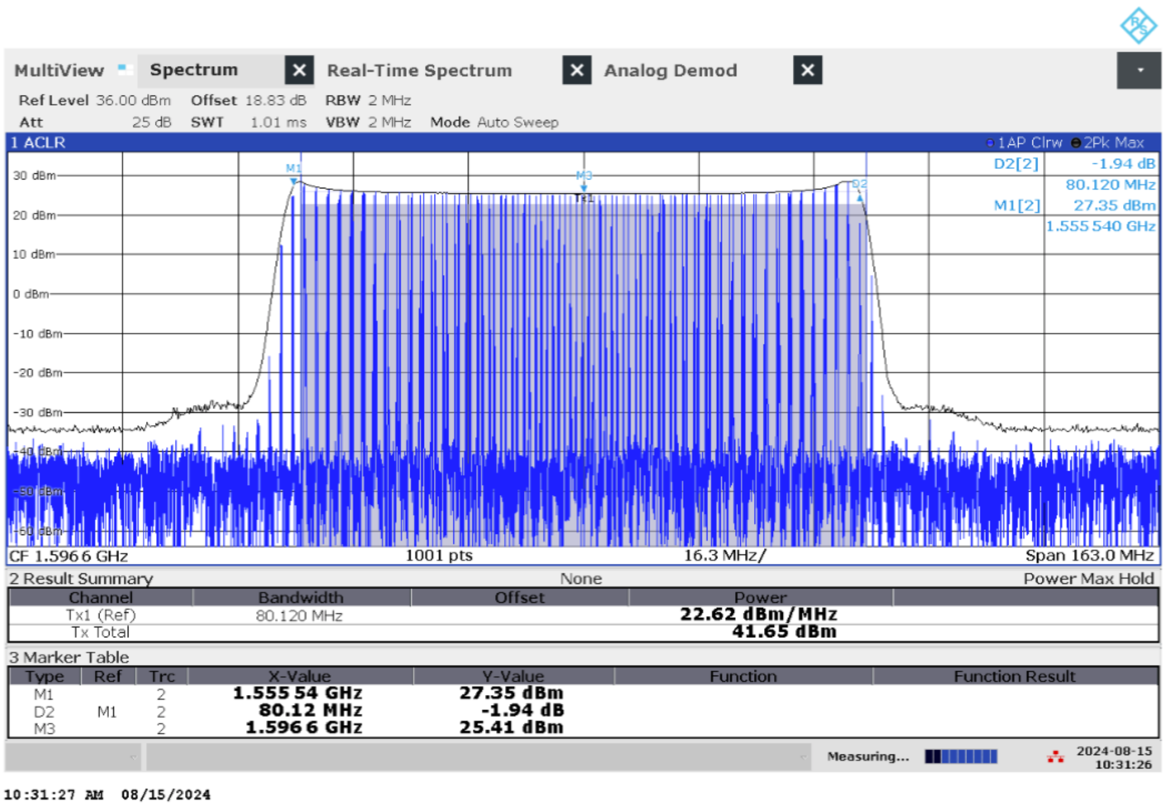

Figure 5.139: Frequency and power measurement of jammer H6.5 on antenna ’5’ (L1)

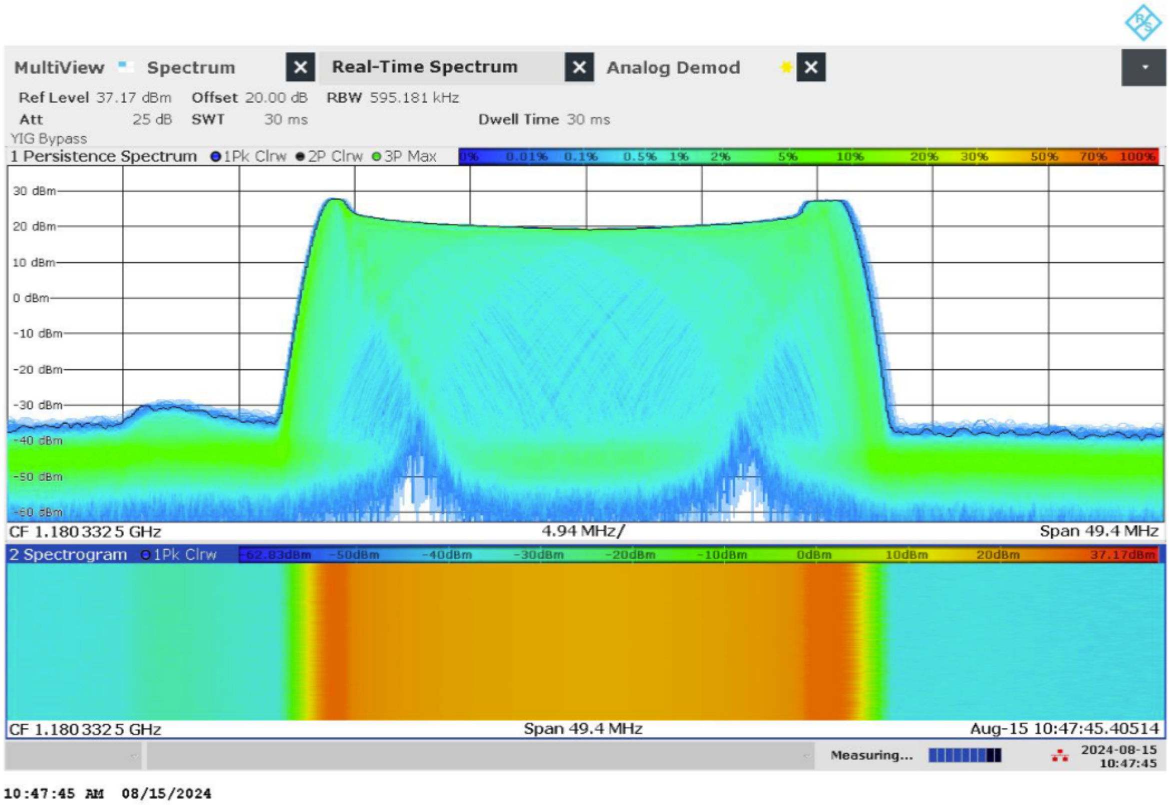

Figure 5.140: Real-time persistence and spectrogram measurement of jammer H6.5 on antenna '1' (L5)

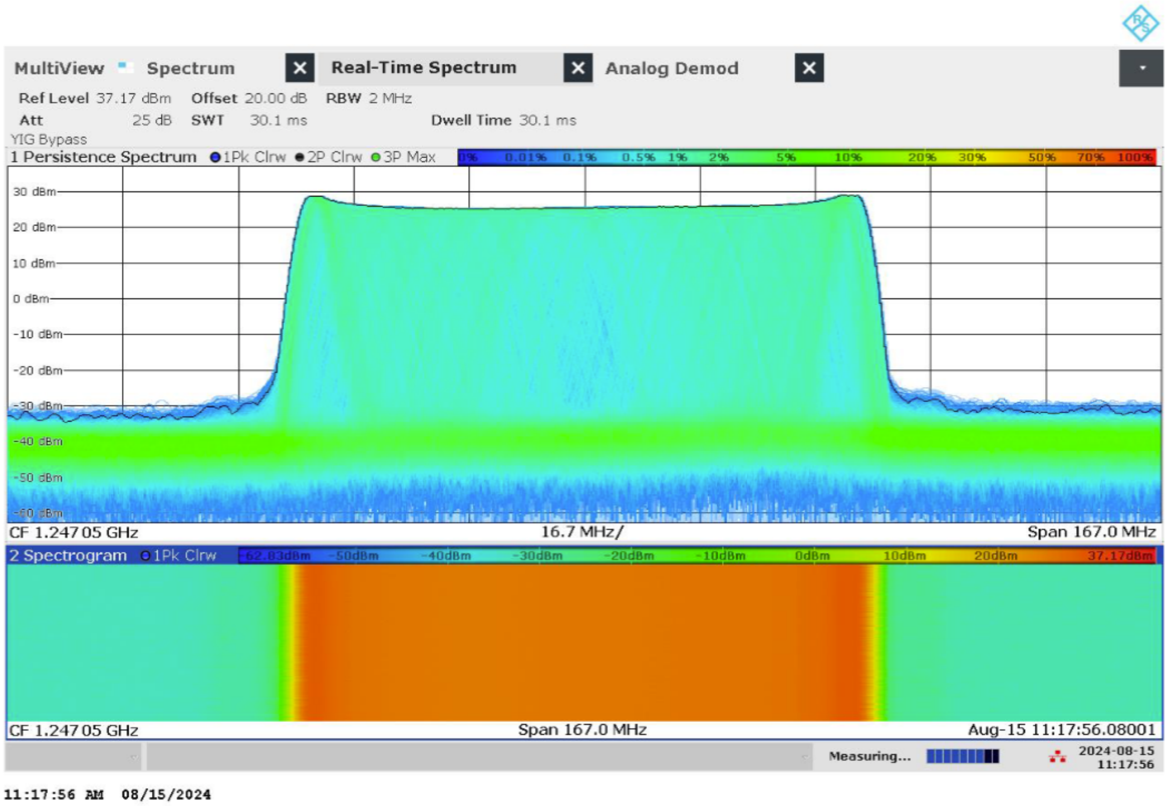

Figure 5.141: Real-time persistence and spectrogram measurement of jammer H6.5 on antenna '3' (L2)

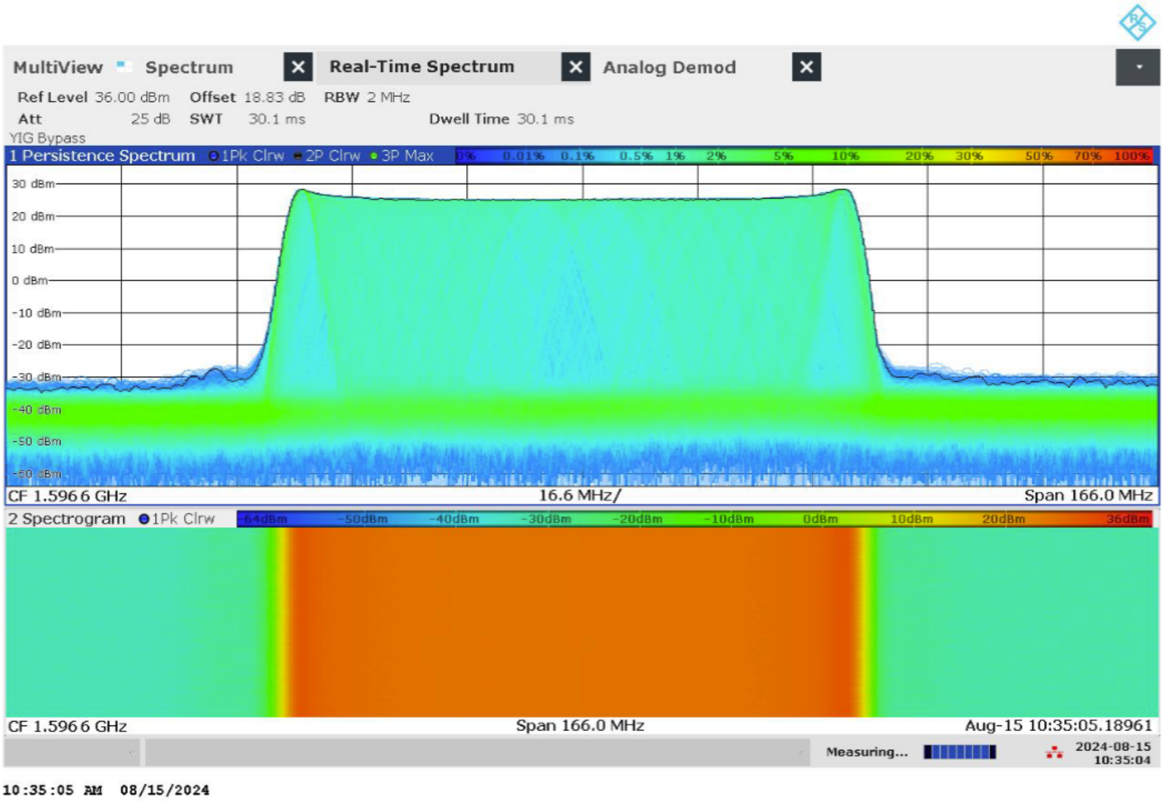

Figure 5.142: Real-time persistence and spectrogram measurement of jammer H6.5 on antenna '5' (L1)

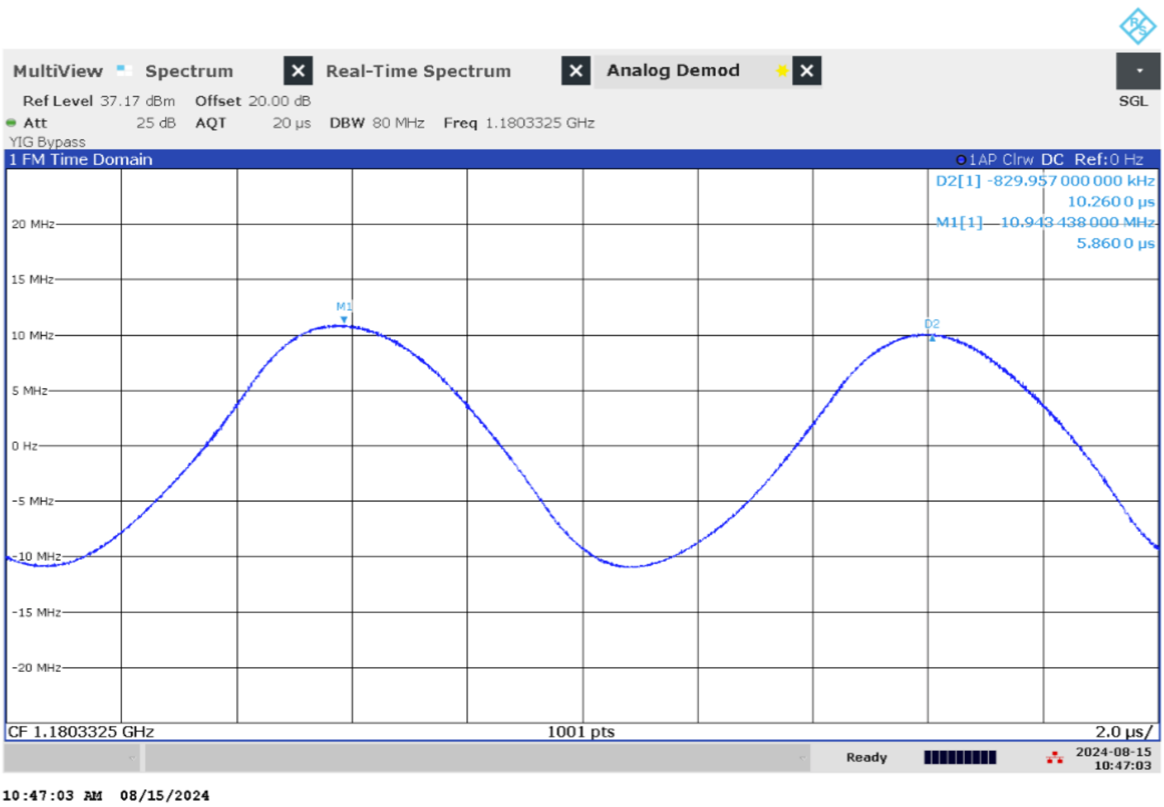

Figure 5.143: Time domain (analog demod) measurement of jammer H6.5 on antenna '1' (L5)

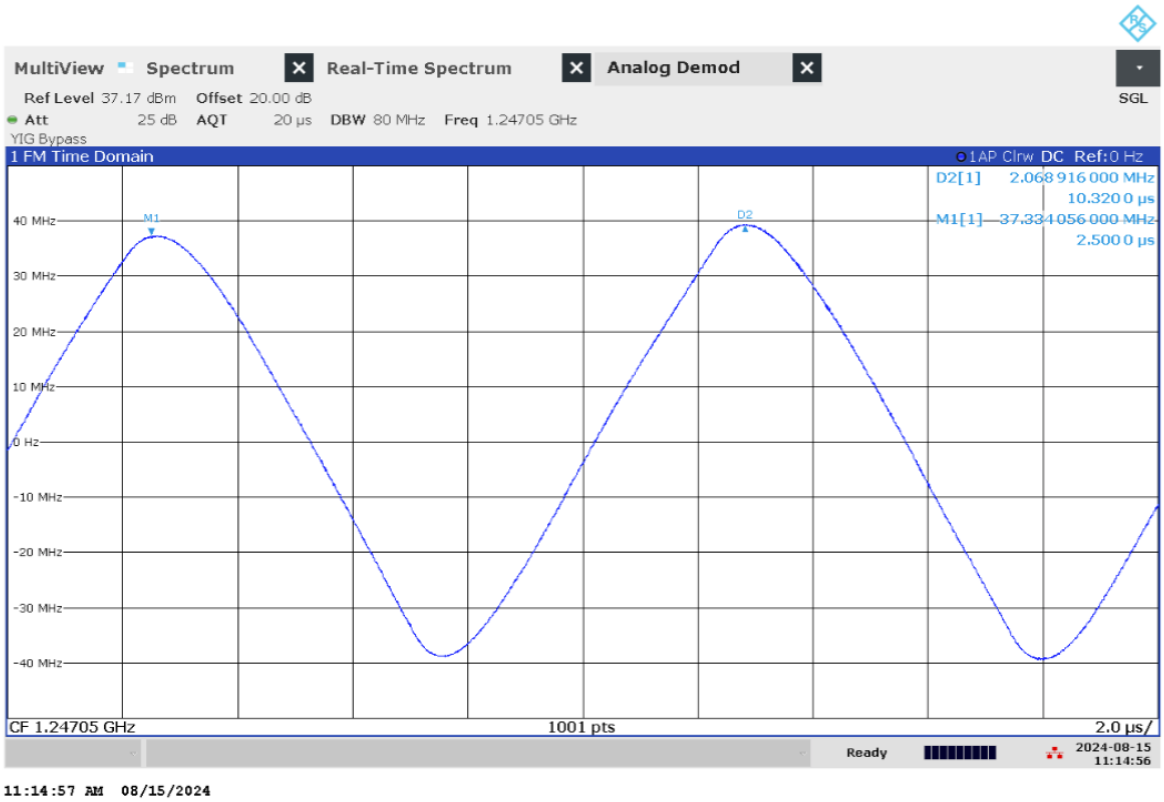

Figure 5.144: Time domain (analog demod) measurement of jammer H6.5 on antenna '3' (L2)

Figure 5.145: Time domain (analog demod) measurement of jammer H6.5 on antenna '5' (L1)

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 peration, 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).

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

Table 5.22: Technical characteristics of H6.6 jammer

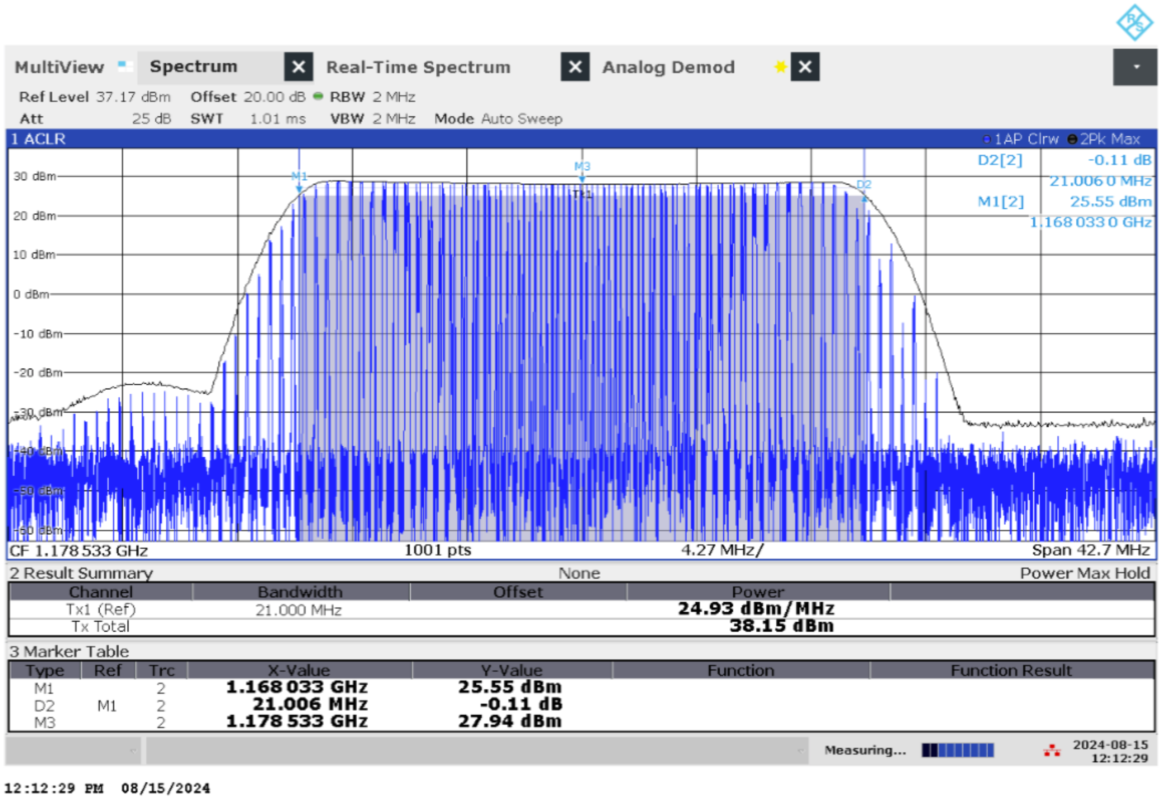

Figure 5.146: Frequency and power measurement of jammer H6.6 on antenna ’1’ (L5)

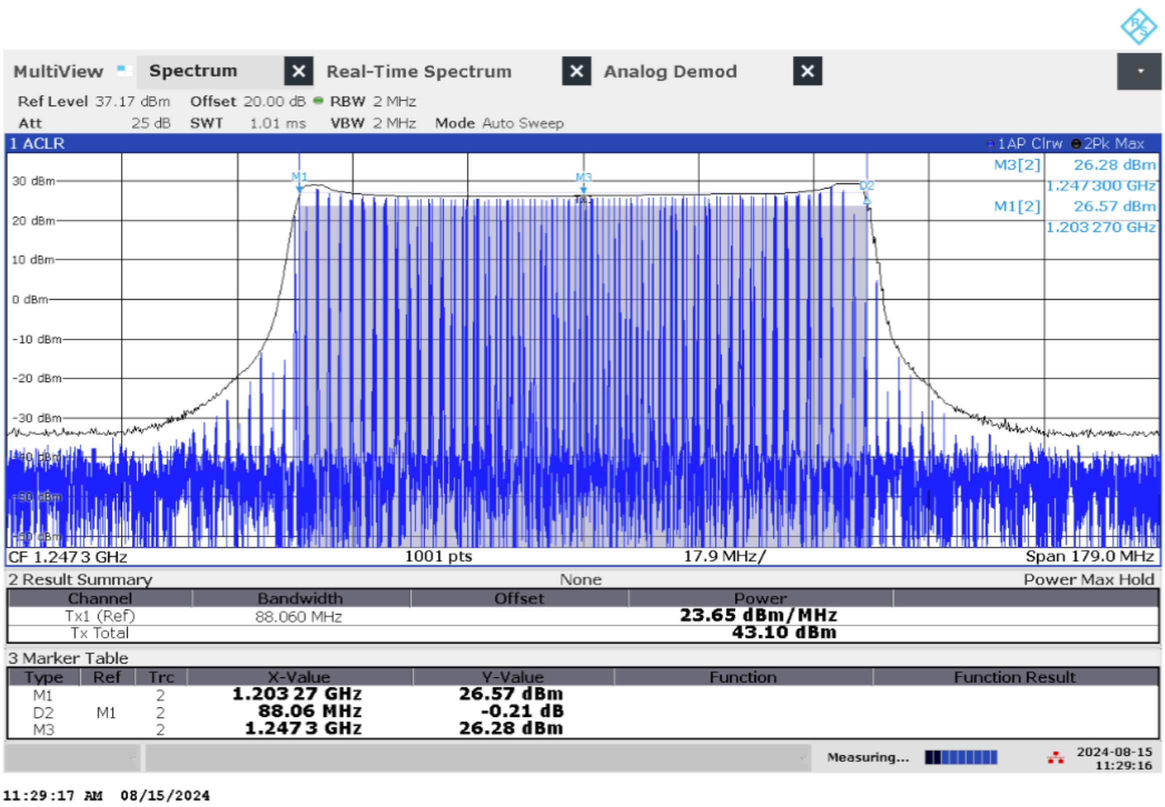

Figure 5.147: Frequency and power measurement of jammer H6.6 on antenna ’3’ (L2)

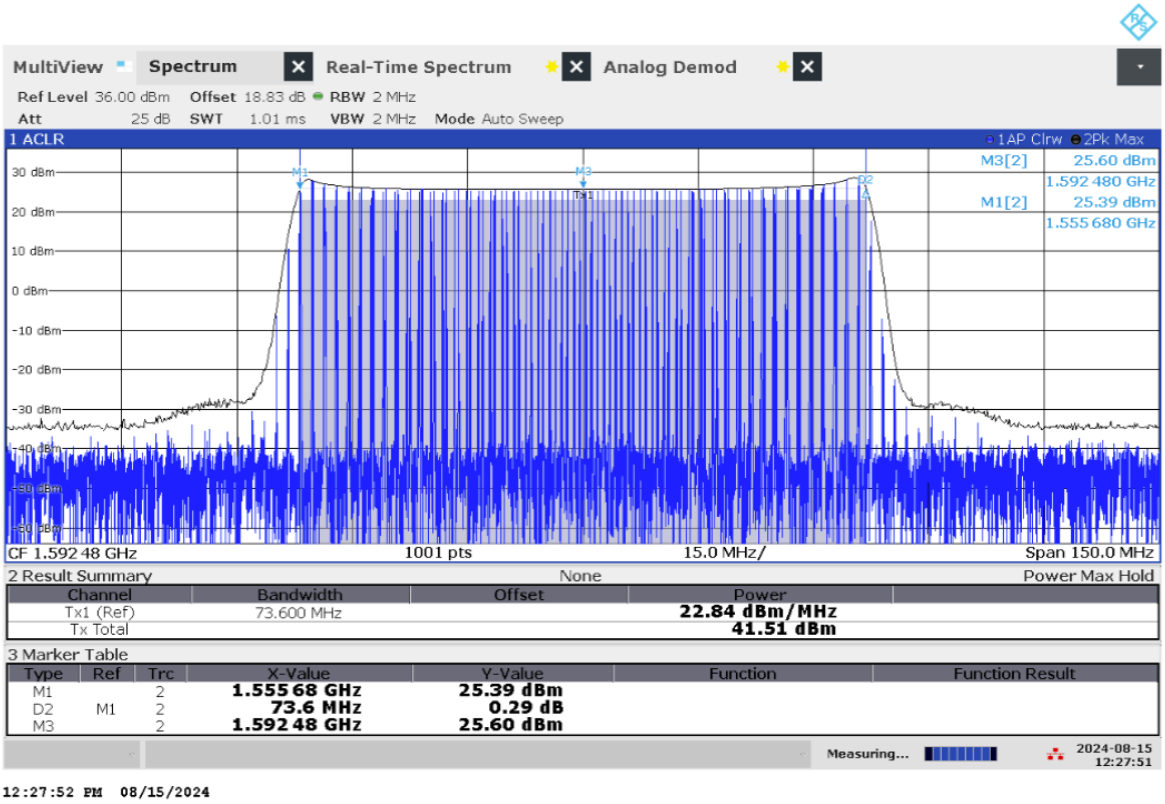

Figure 5.148: Frequency and power measurement of jammer H6.6 on antenna ’5’ (L1)

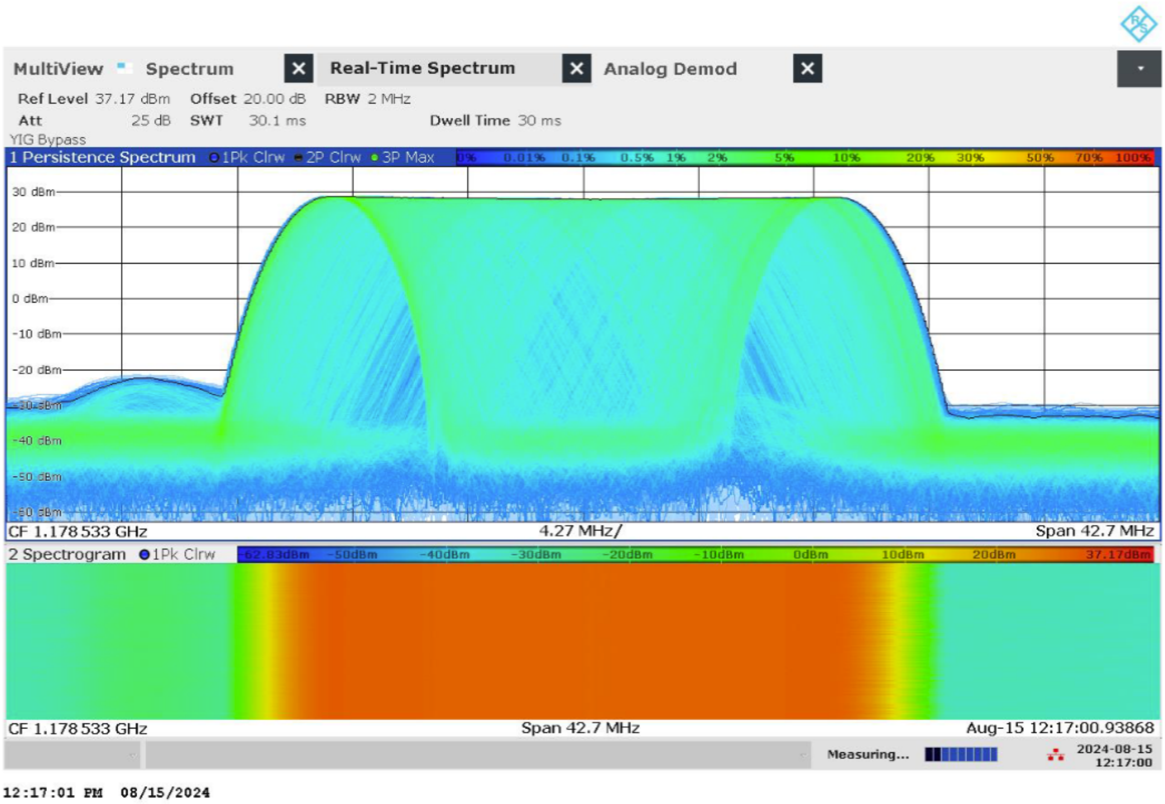

Figure 5.149: Real-time persistence and spectrogram measurement of jammer H6.6 on antenna ’1’ (L5)

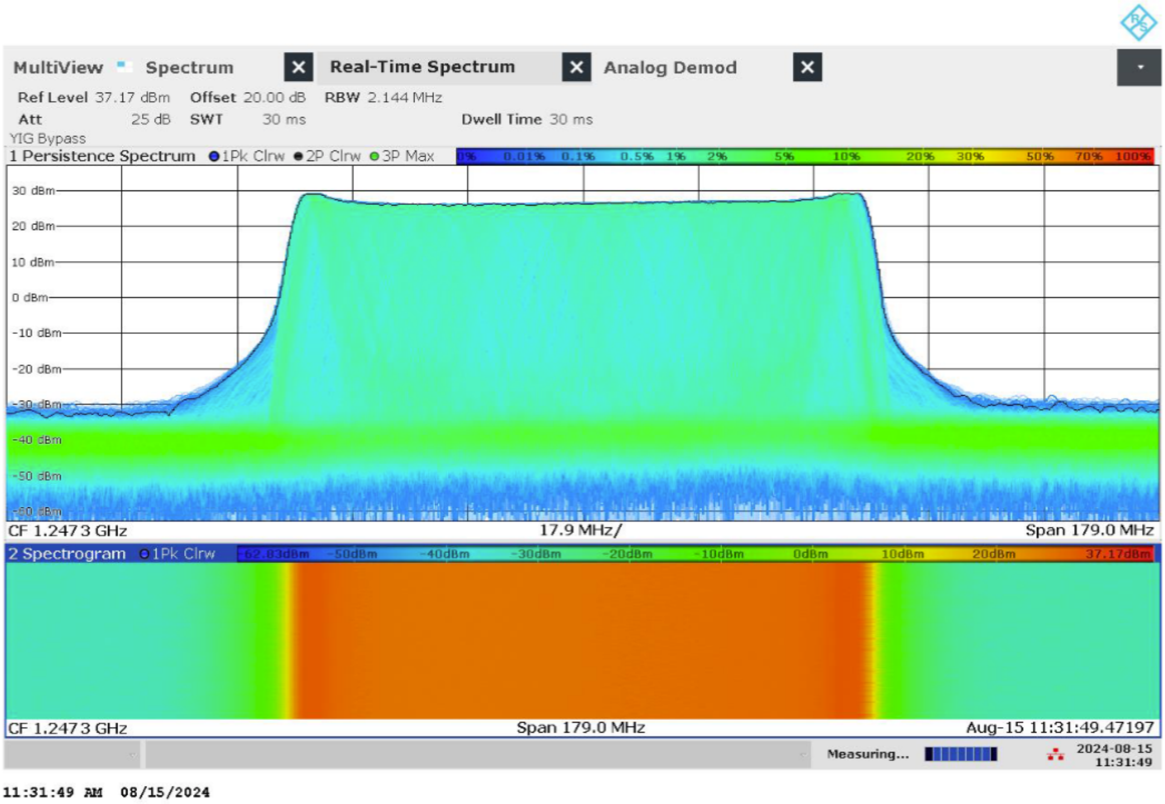

Figure 5.150: Real-time persistence and spectrogram measurement of jammer H6.6 on antenna '3' (L2)

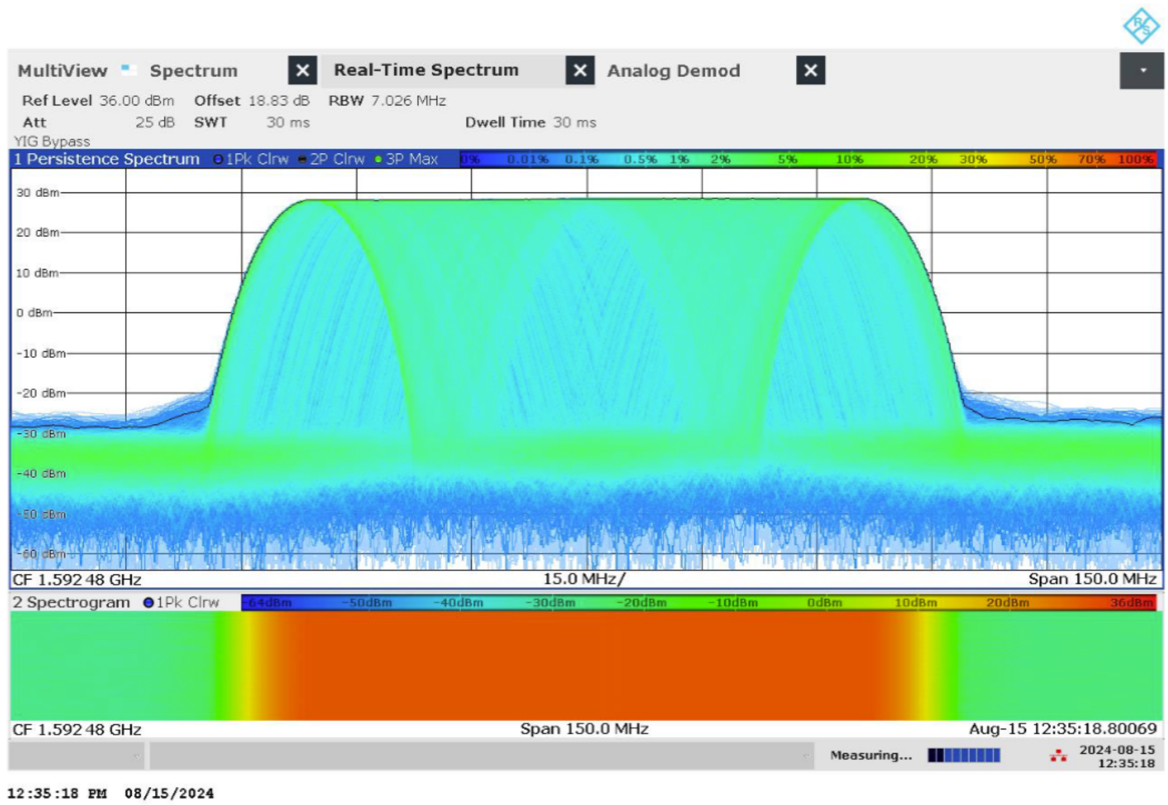

Figure 5.151: Real-time persistence and spectrogram measurement of jammer H6.6 on antenna '5' (L1)

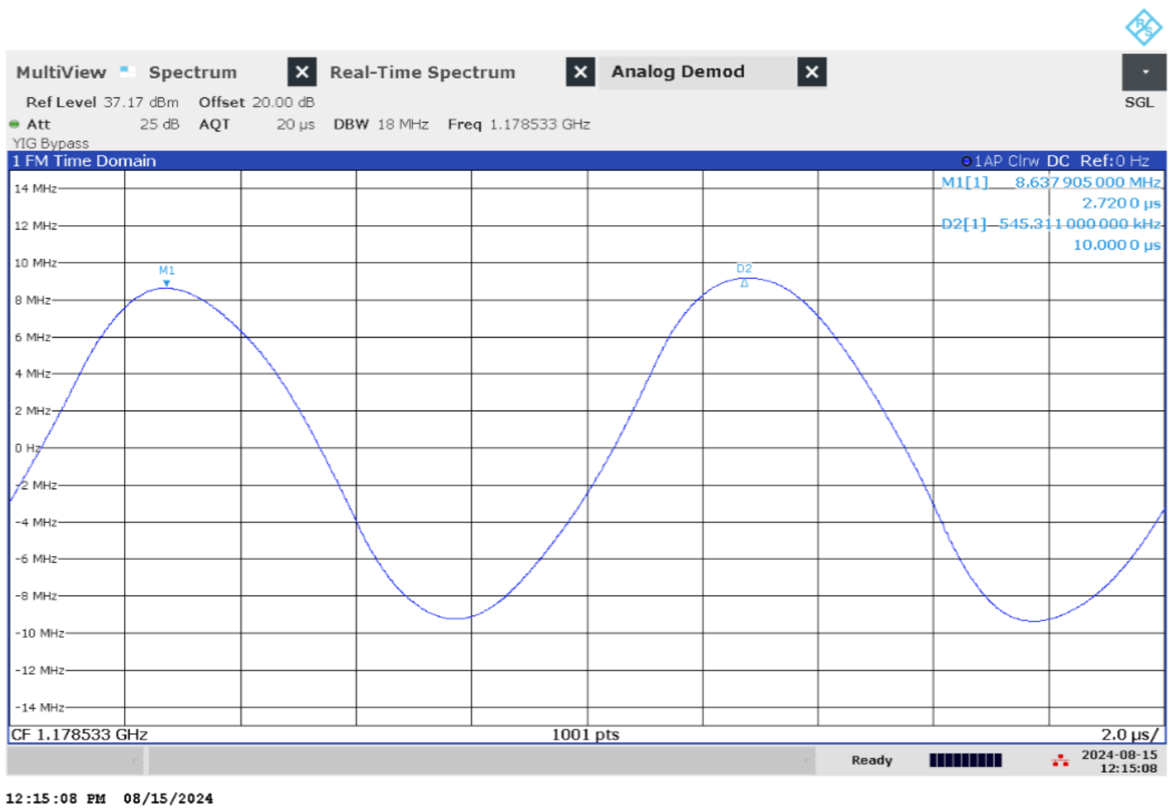

Figure 5.152: Time domain (analog demod) measurement of jammer H6.6 on antenna '1' (L5)

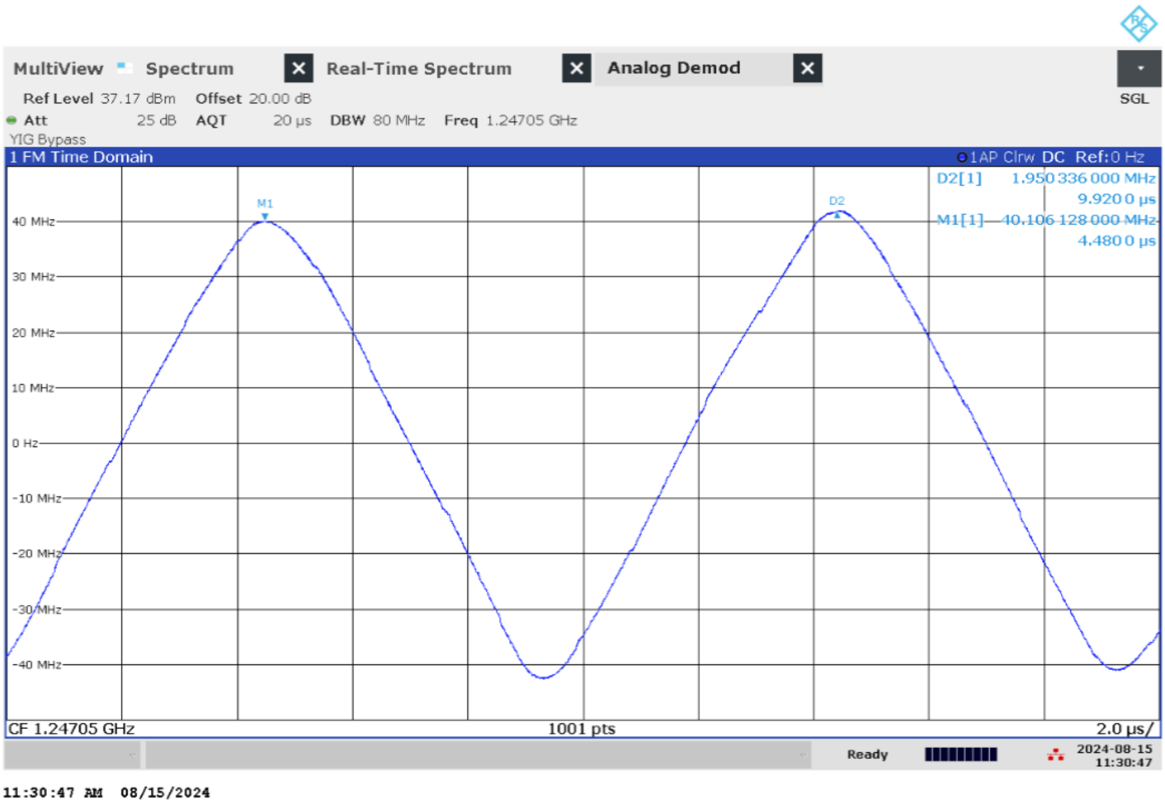

Figure 5.153: Time domain (analog demod) measurement of jammer H6.6 on antenna '3' (L2)

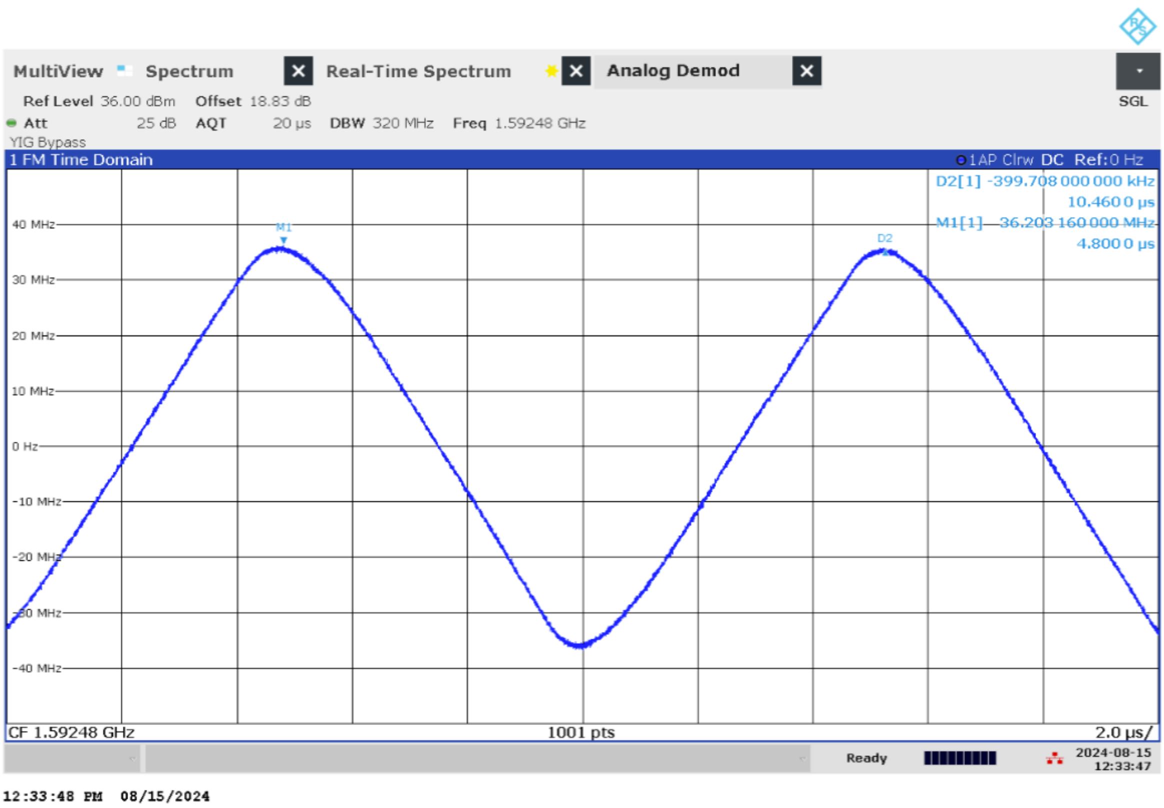

Figure 5.154: Time domain (analog demod) measurement of jammer H6.6 on antenna '5' (L1)

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-modul
'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-modul
'F6' (L5)	1177.93	16.58	24.93	37.13	18.51	5.96	sinus

Table 5.23: Technical characteristics of F6.1 jammer

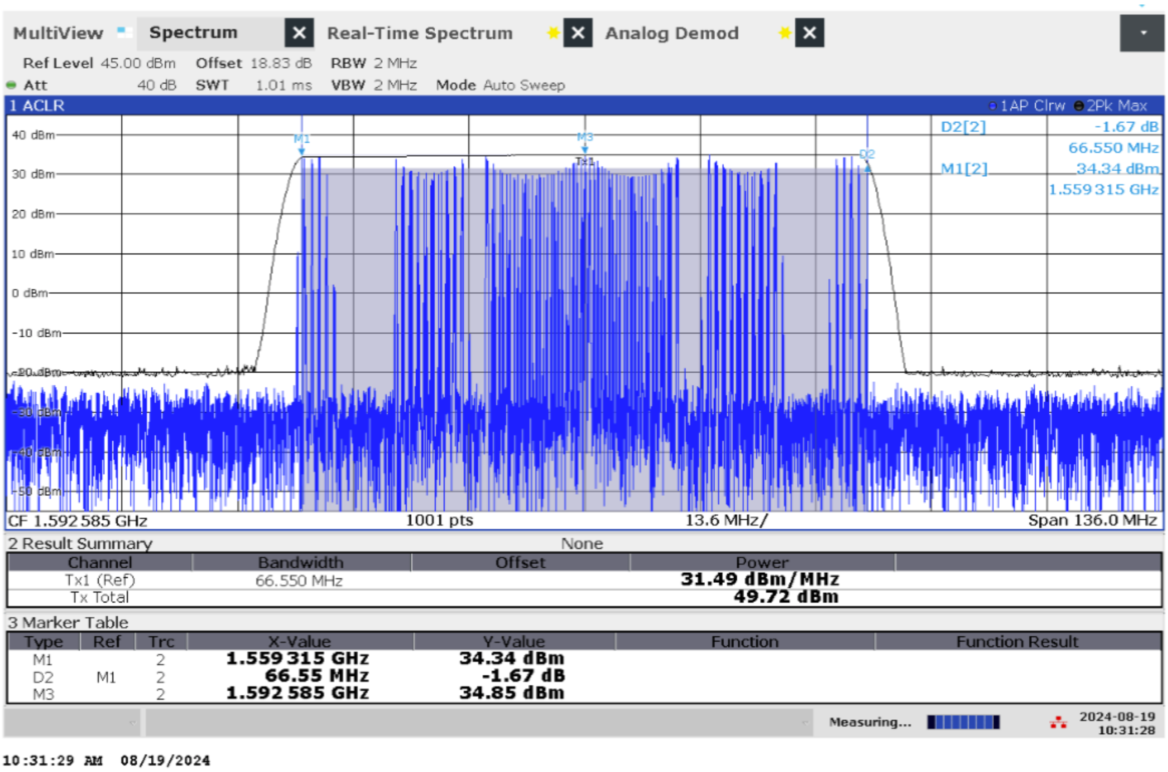

Figure 5.155: Frequency and power measurement of jammer F6.1 on antenna 'F2' (L1)

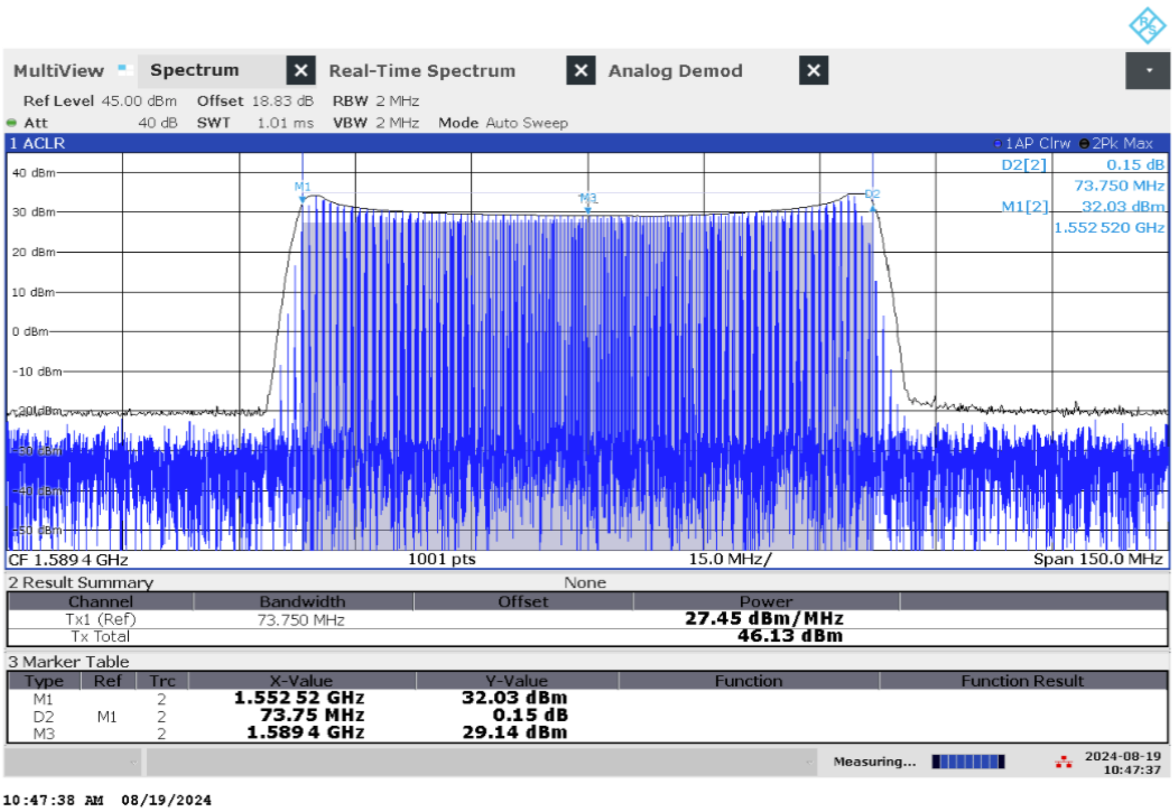

Figure 5.156: Frequency and power measurement of jammer F6.1 on antenna 'F3' (L1)

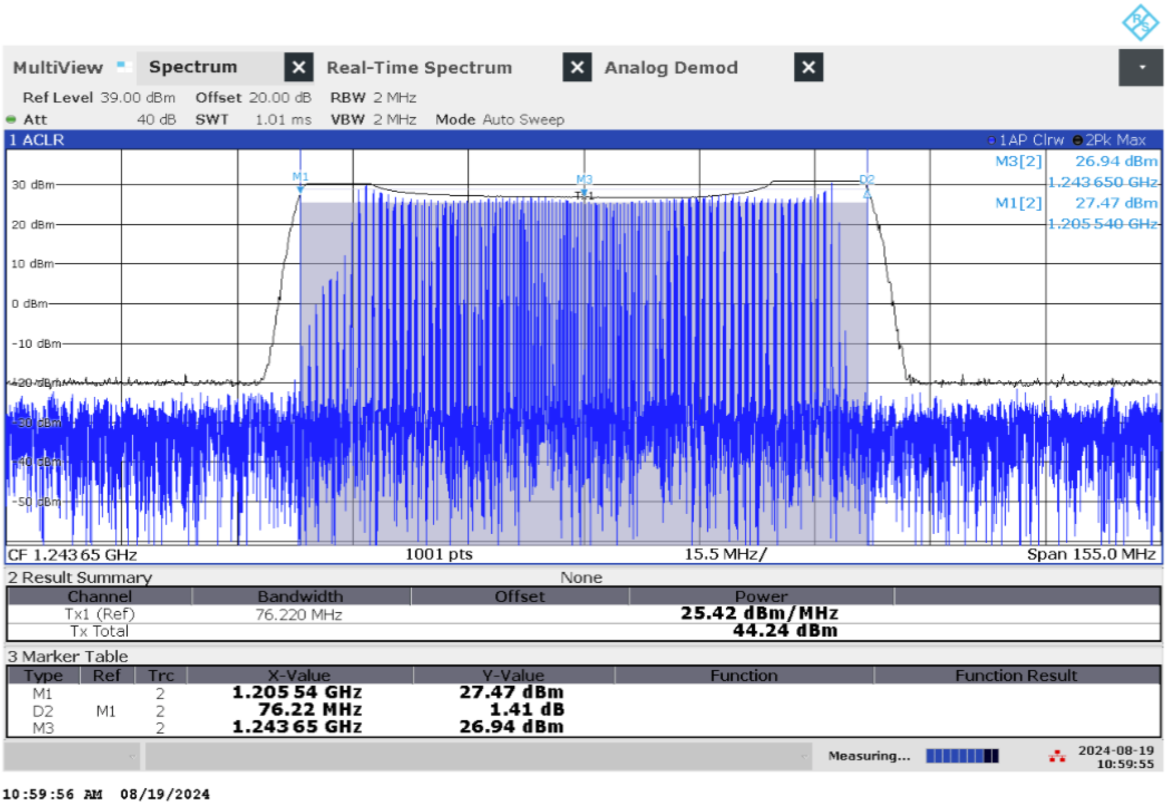

Figure 5.157: Frequency and power measurement of jammer F6.1 on antenna 'F4' (L2)

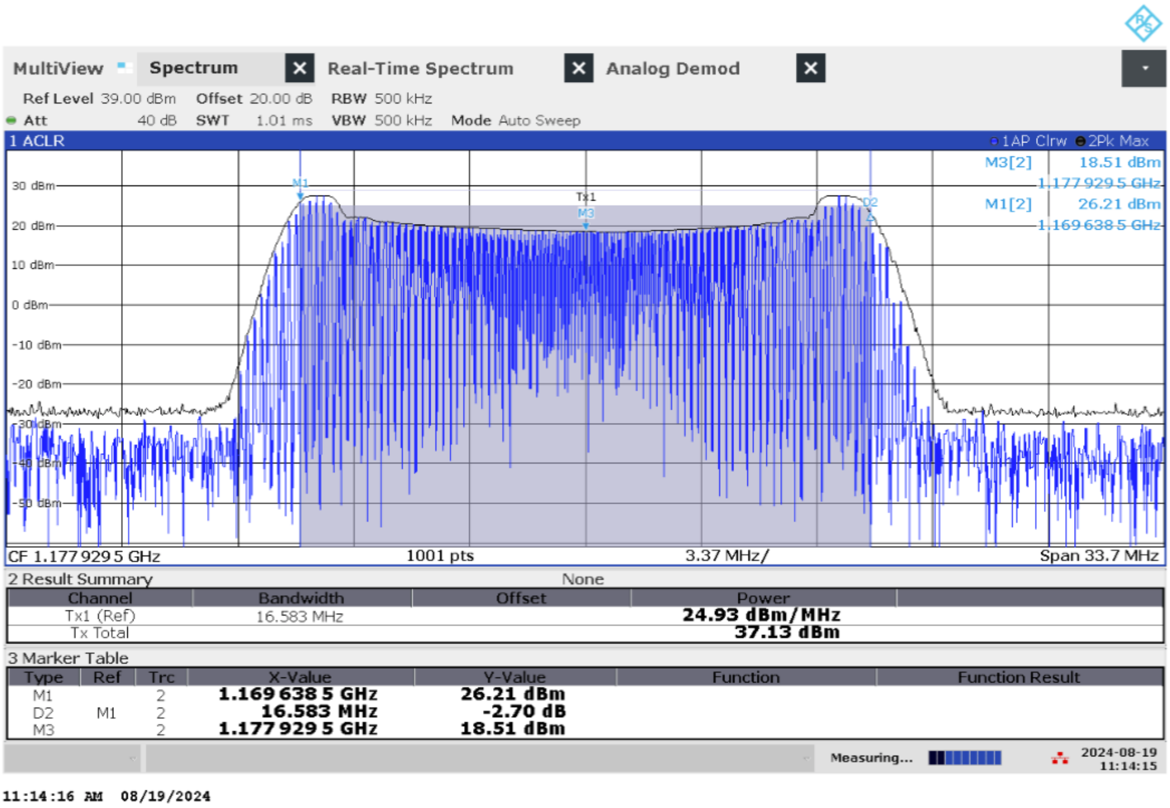

Figure 5.158: Frequency and power measurement of jammer F6.1 on antenna 'F6' (L5)

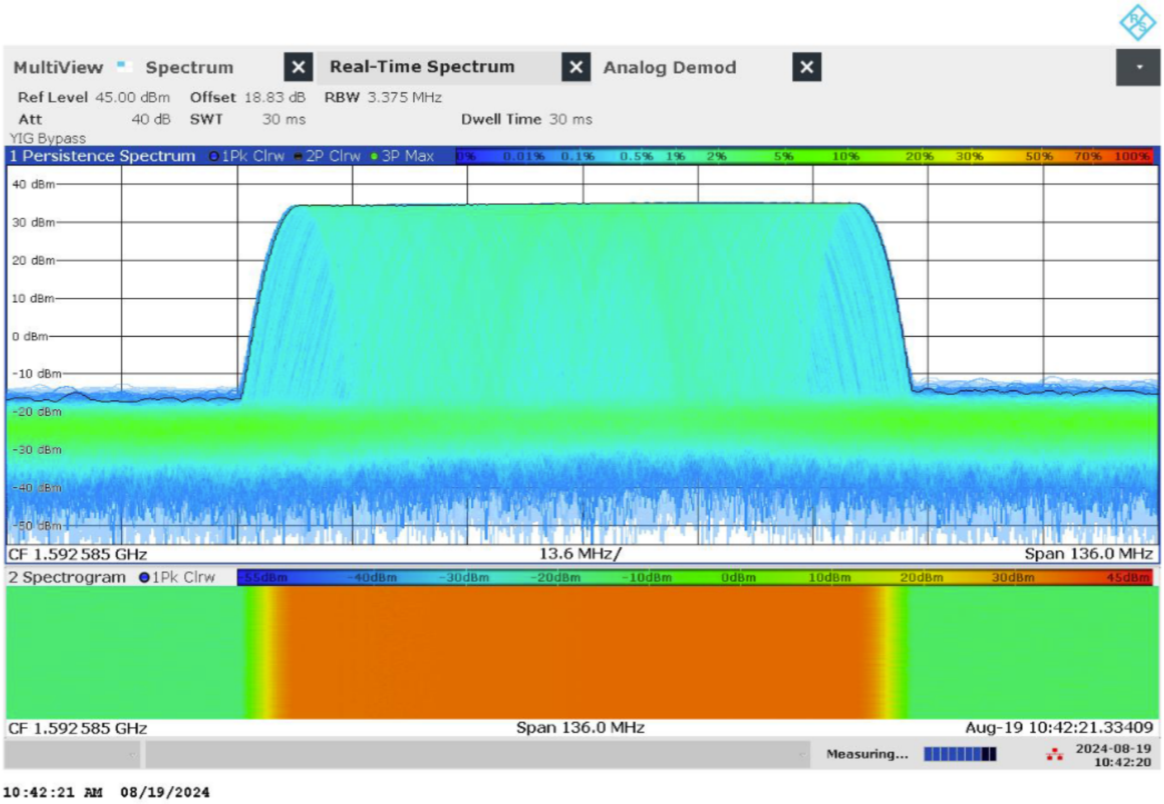

Figure 5.159: Real-time persistence and spectrogram measurement of jammer F6.1 on antenna 'F2' (L1)

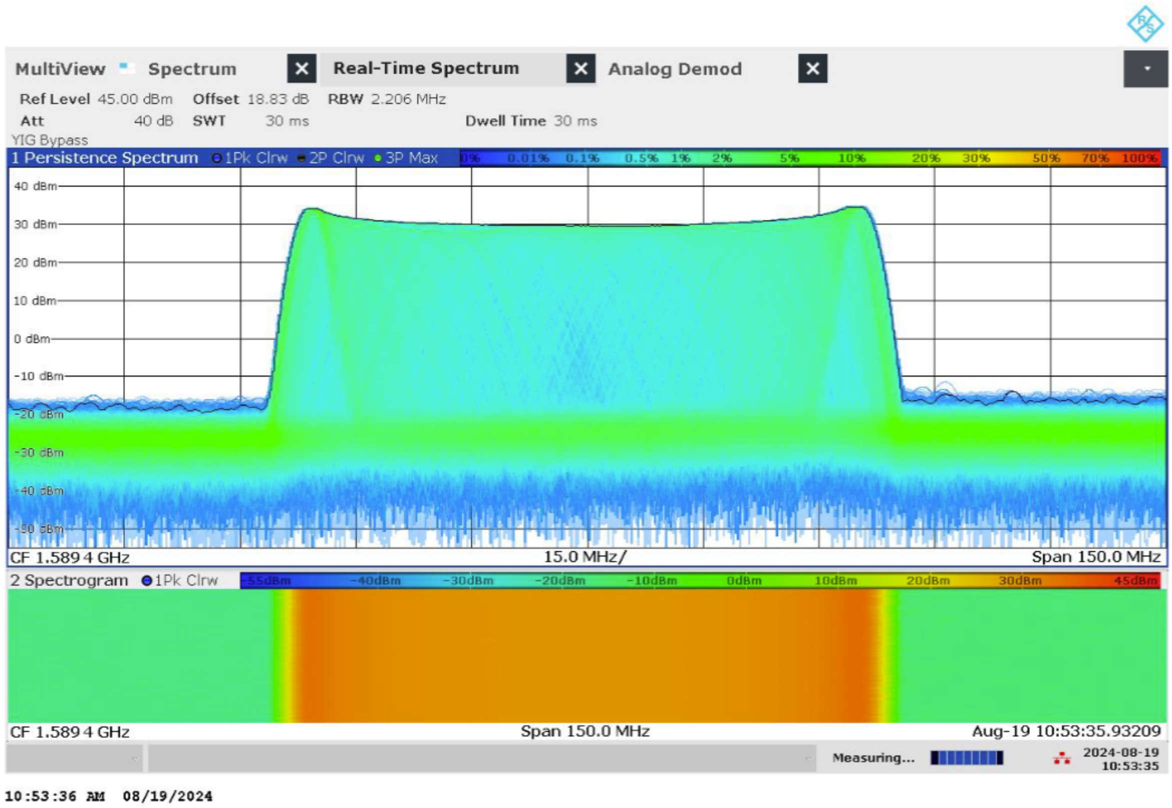

Figure 5.160: Real-time persistence and spectrogram measurement of jammer F6.1 on antenna 'F3' (L1)

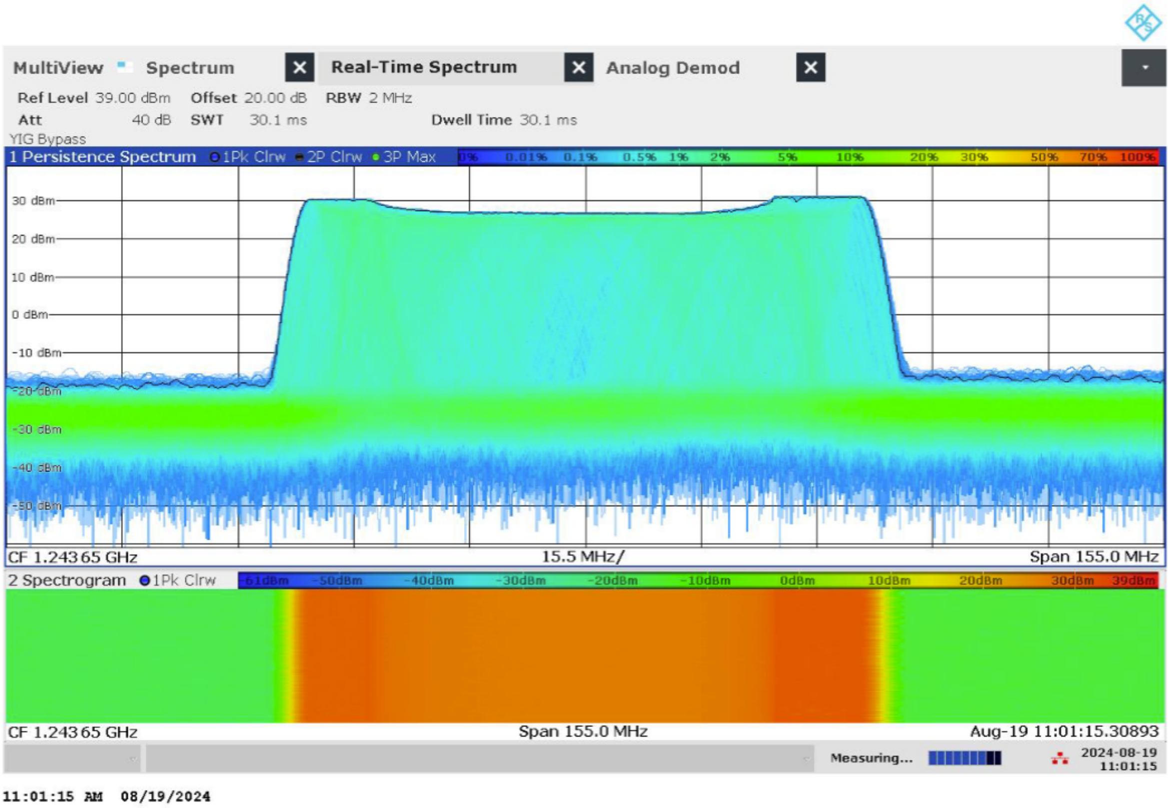

Figure 5.161: Real-time persistence and spectrogram measurement of jammer F6.1 on antenna 'F4' (L2)

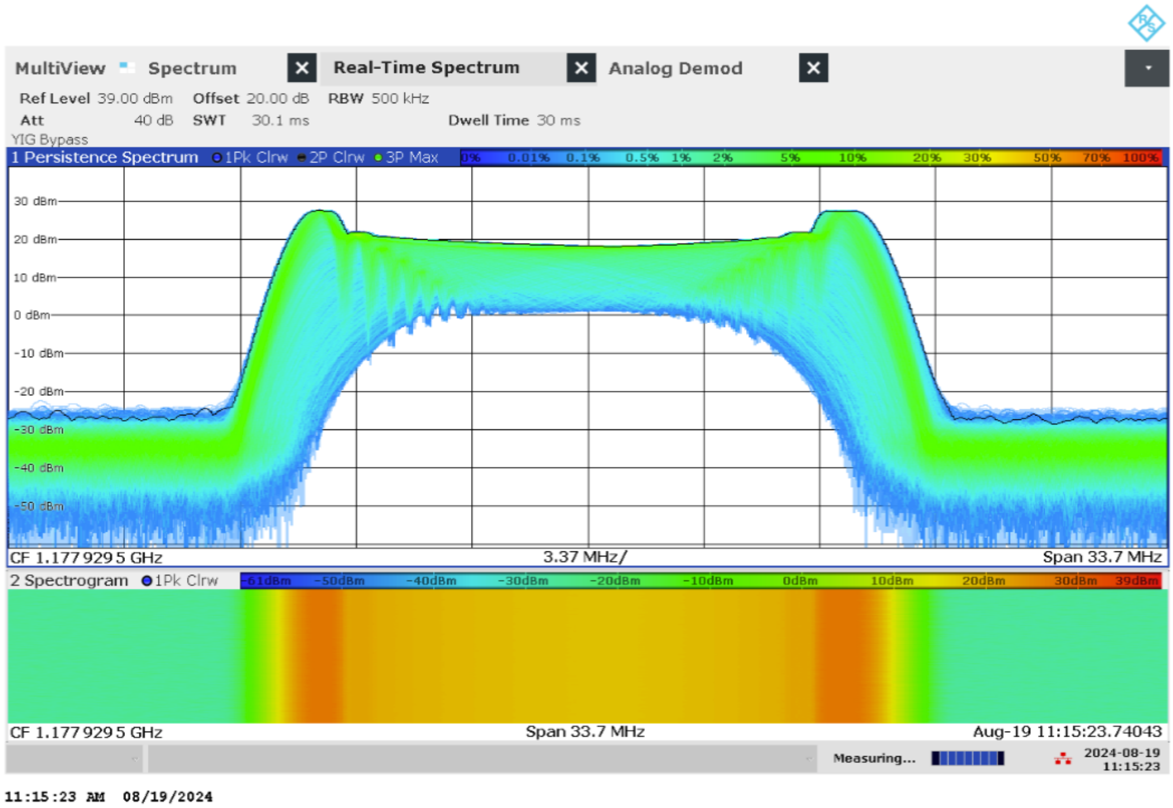

Figure 5.162: Real-time persistence and spectrogram measurement of jammer F6.1 on antenna 'F6' (L5)

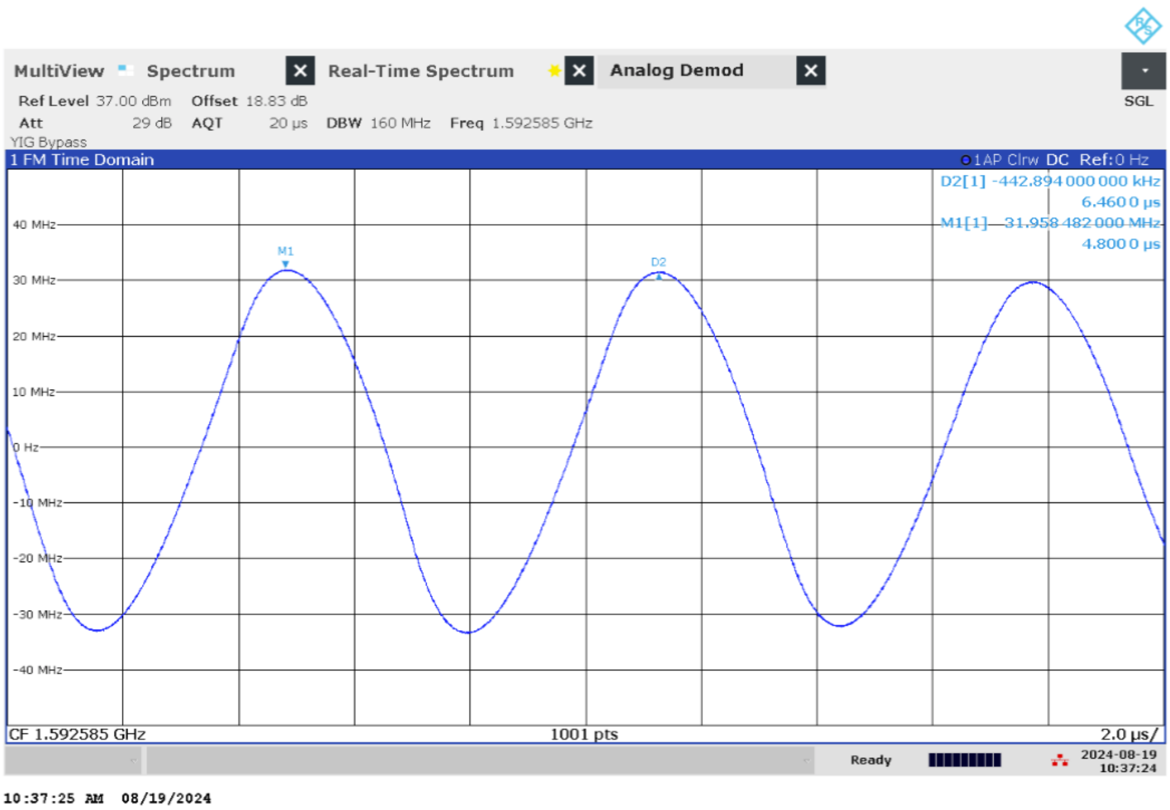

Figure 5.163: Time domain (analog demod) measurement of jammer F6.1 on antenna 'F2' (L1)

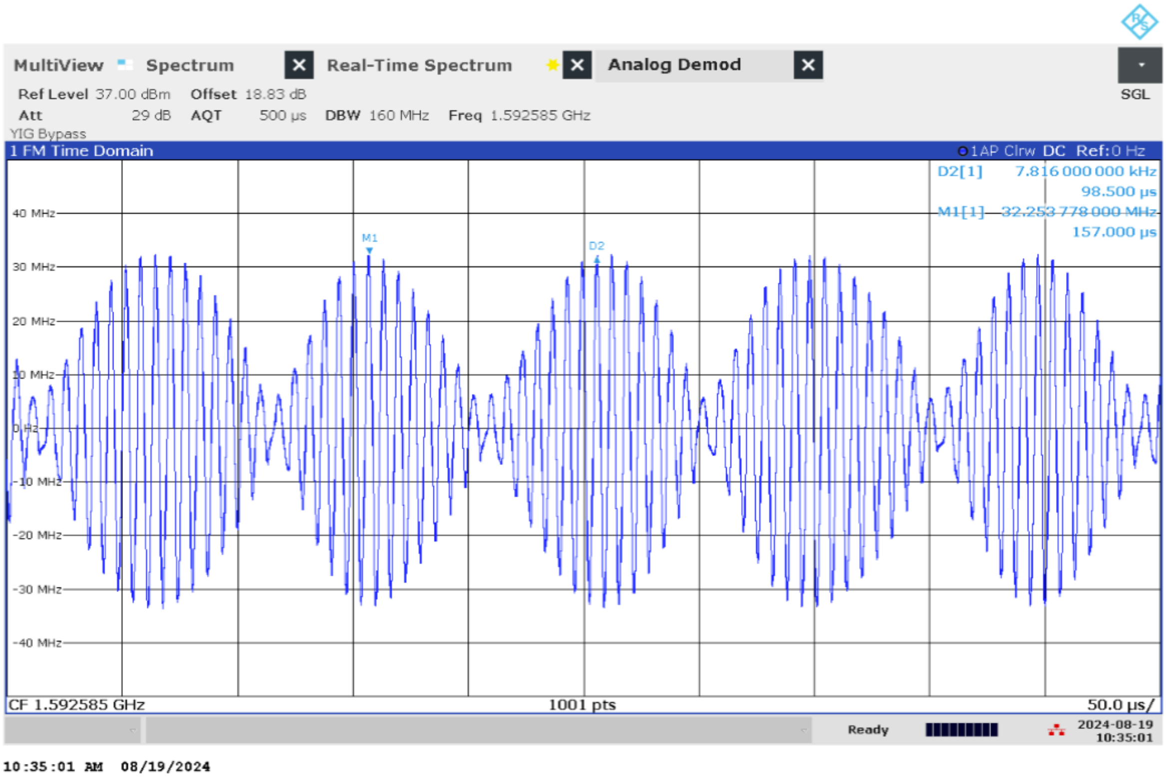

Figure 5.164: Time domain (analog demod) measurement with wider span of jammer F6.1 on antenna 'F2' (L1)

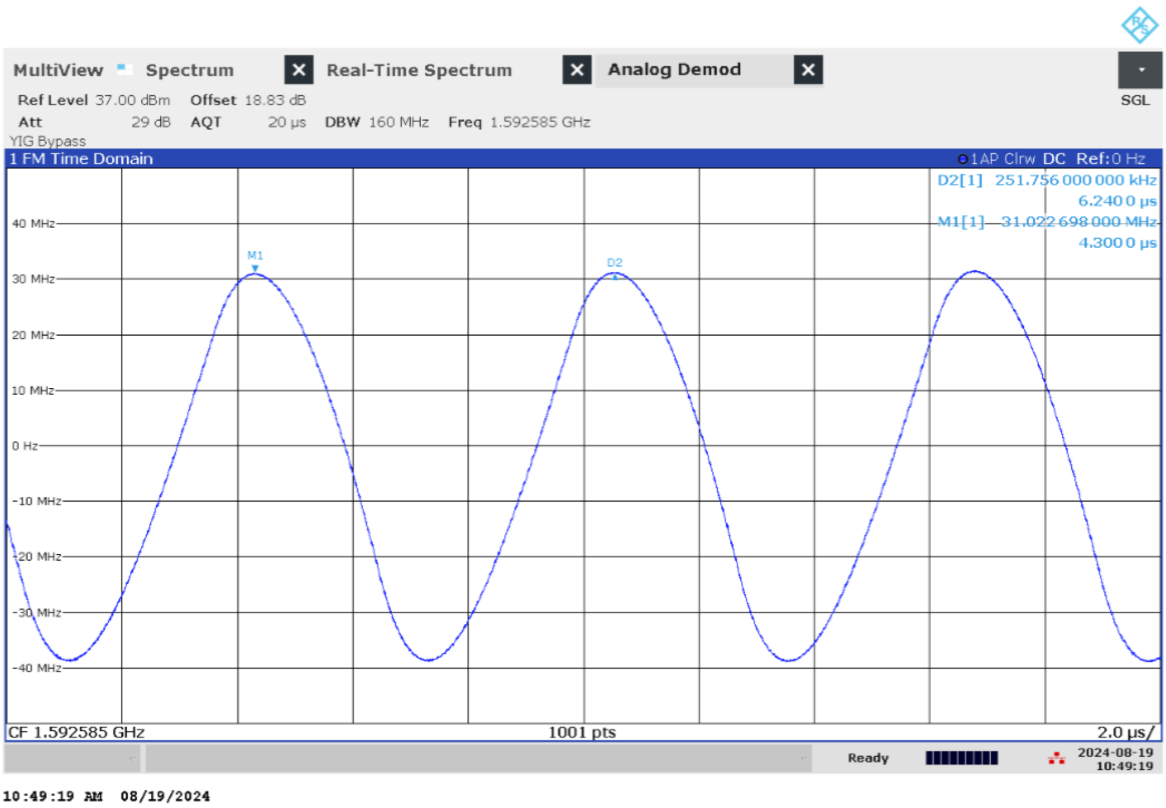

Figure 5.165: Time domain (analog demod) measurement of jammer F6.1 on antenna 'F3' (L1)

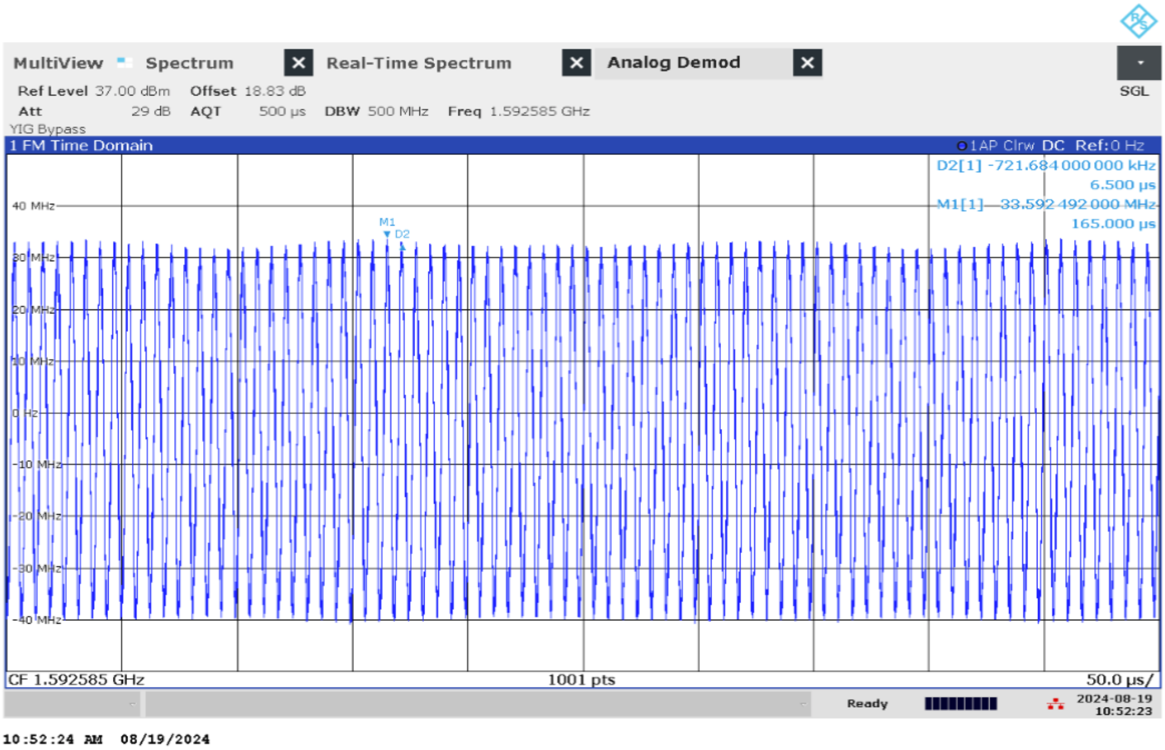

Figure 5.166: Time domain (analog demod) measurement with wider span of jammer F6.1 on antenna 'F3' (L1)

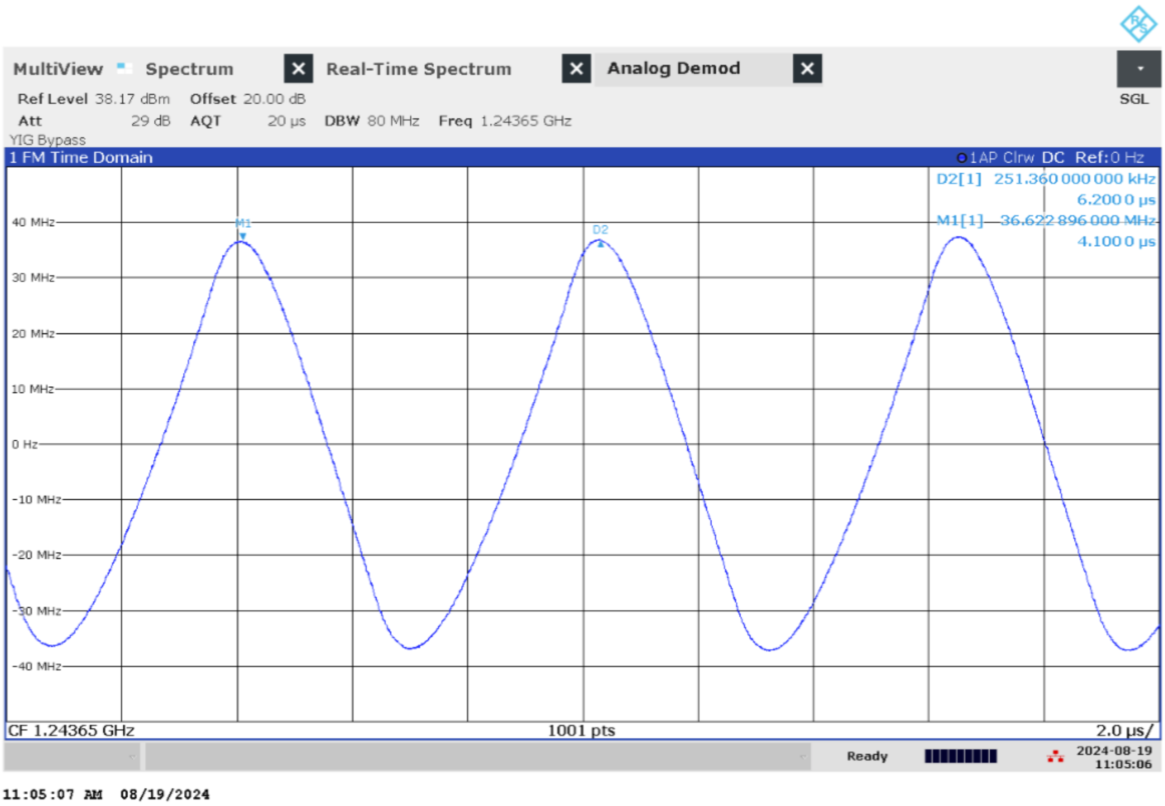

Figure 5.167: Time domain (analog demod) measurement of jammer F6.1 on antenna 'F4' (L2)

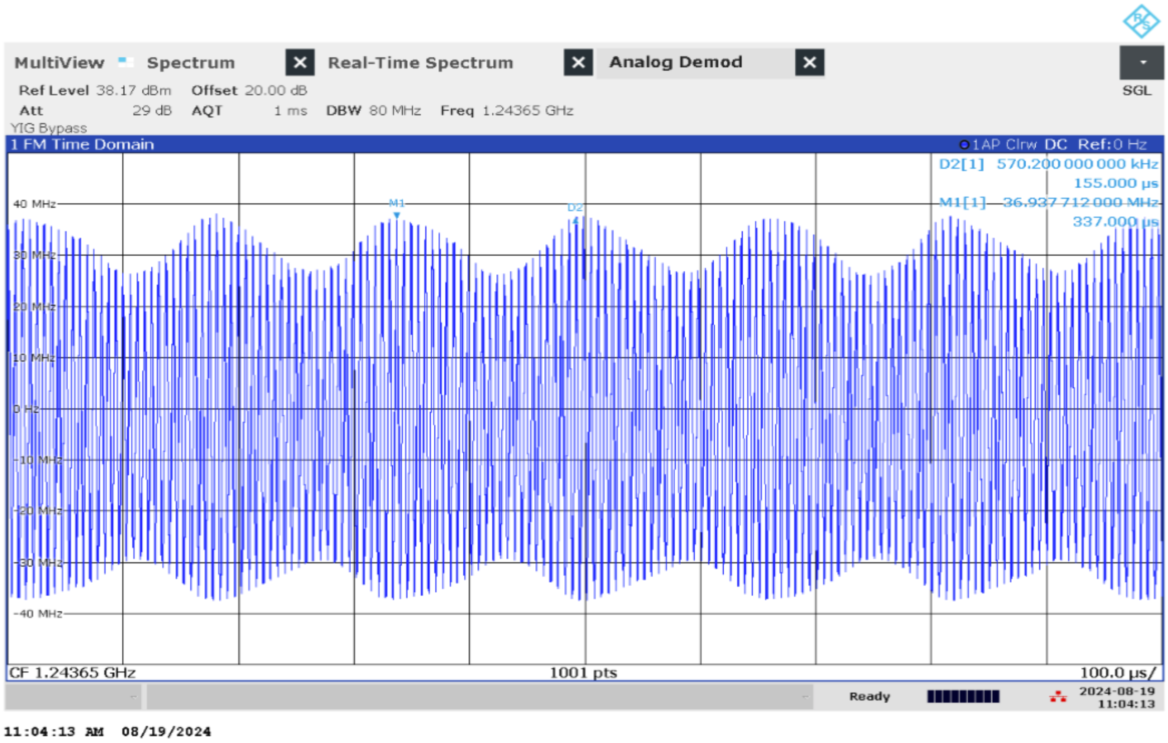

Figure 5.168: Time domain (analog demod) measurement with wider span of jammer F6.1 on antenna 'F4' (L2)

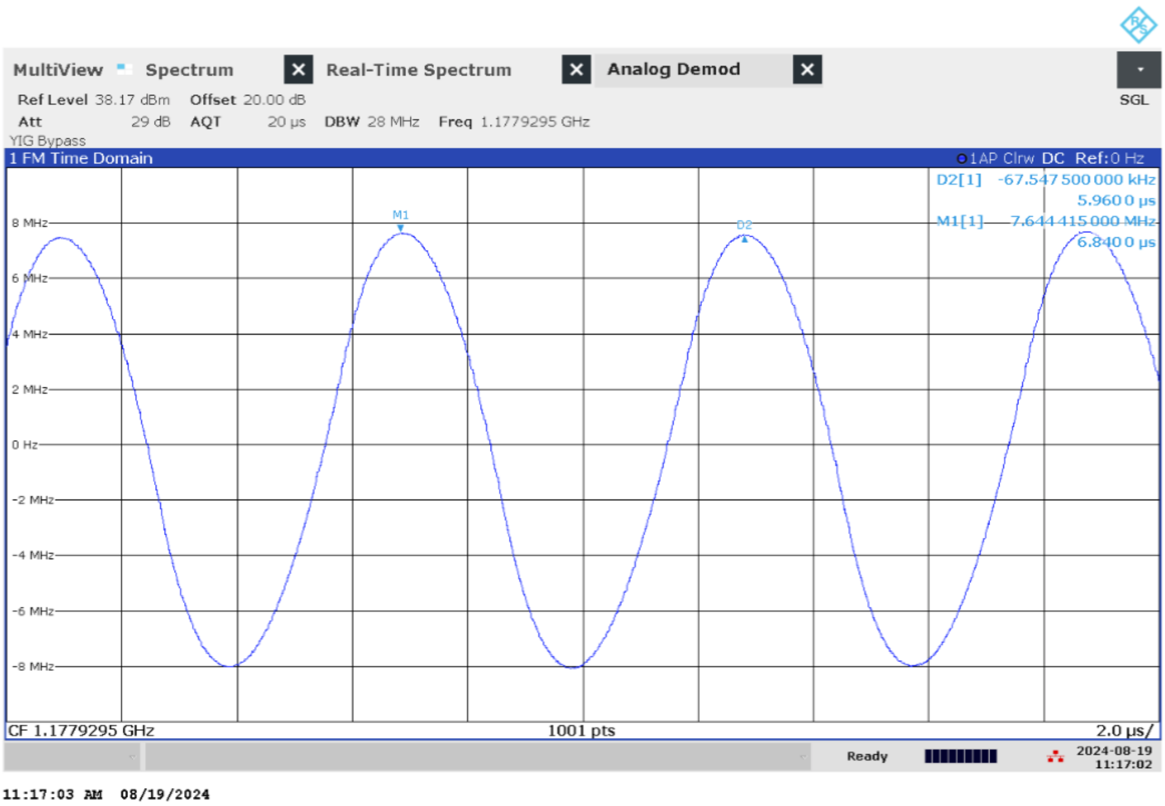

Figure 5.169: Time domain (analog demod) measurement of jammer F6.1 on antenna 'F6' (L5)

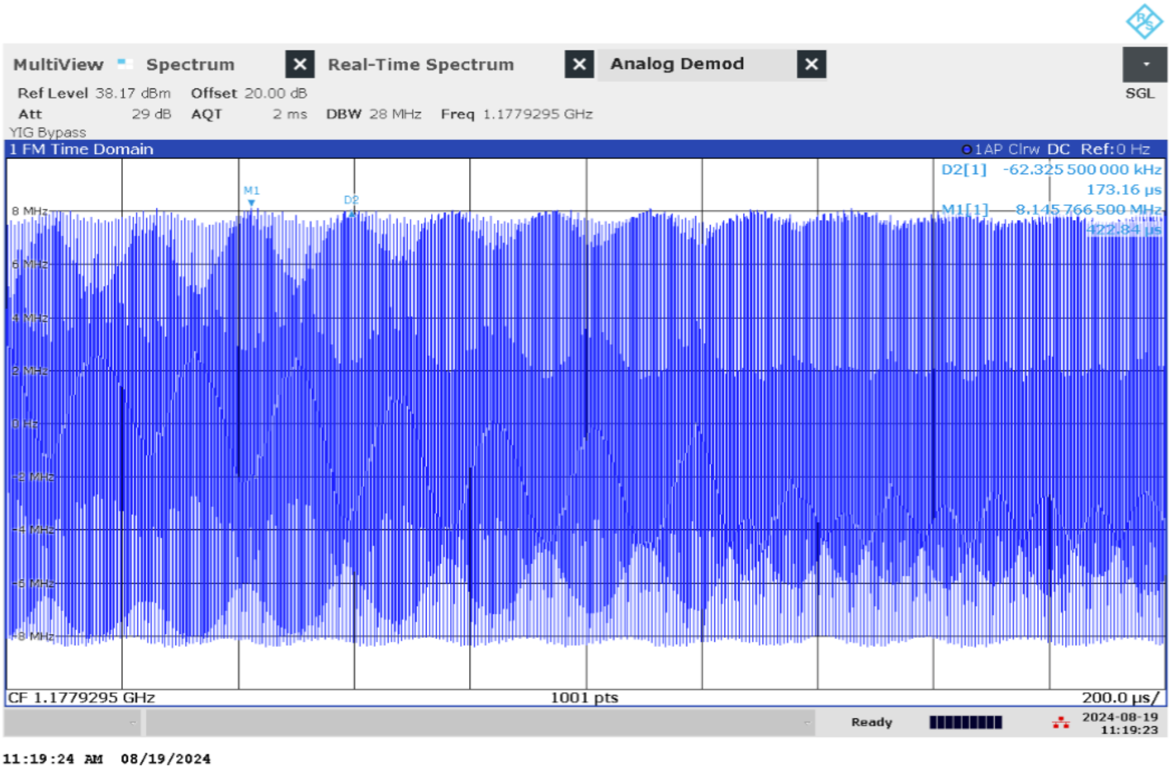

Figure 5.170: Time domain (analog demod) measurement with wider span of jammer F6.1 on antenna 'F6' (L5)

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'

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

Table 5.24: Technical characteristics of H8.1 jammer

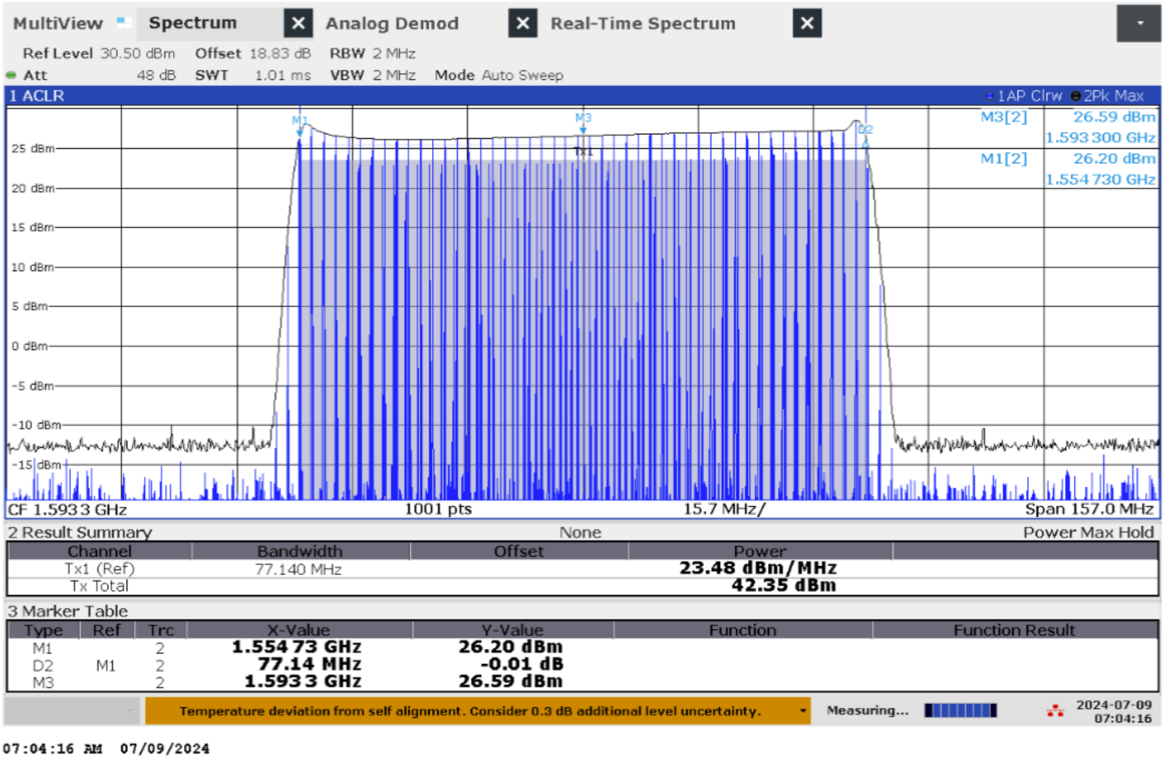

Figure 5.171: Frequency and power measurement of jammer H8.1 on antenna '6'

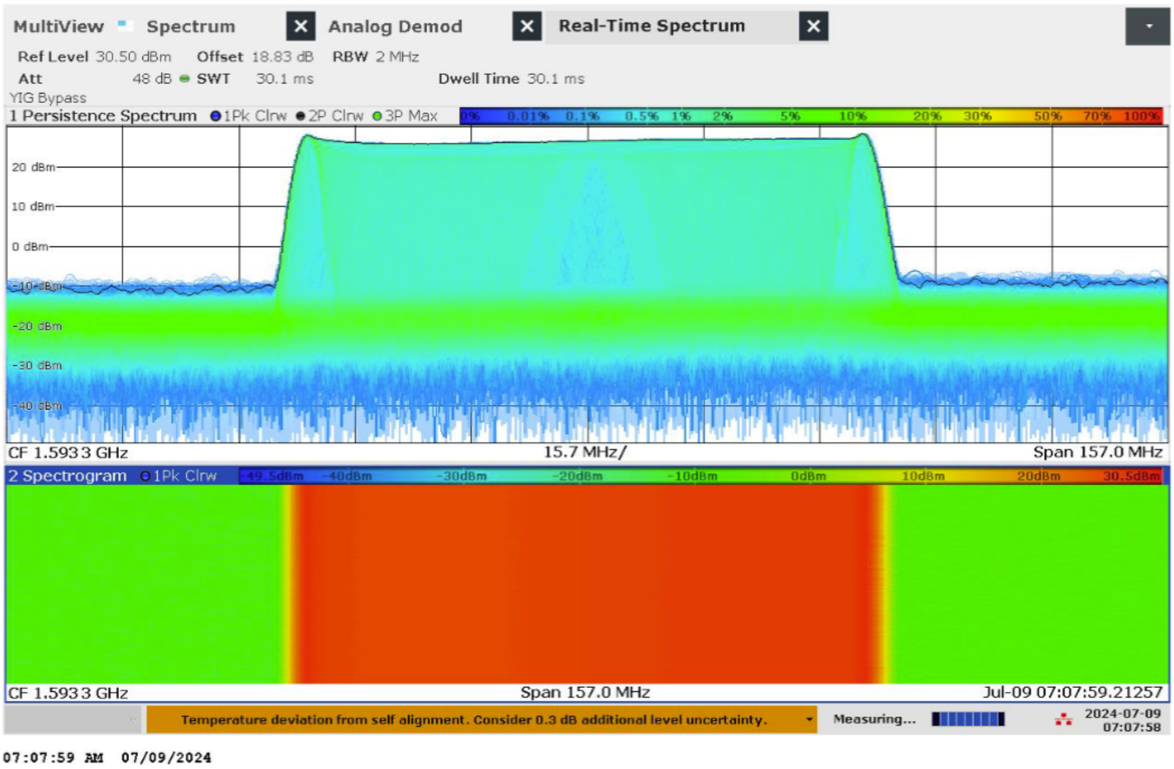

Figure 5.172: Real-time persistence and spectrogram measurement of jammer H8.1 on antenna '6'

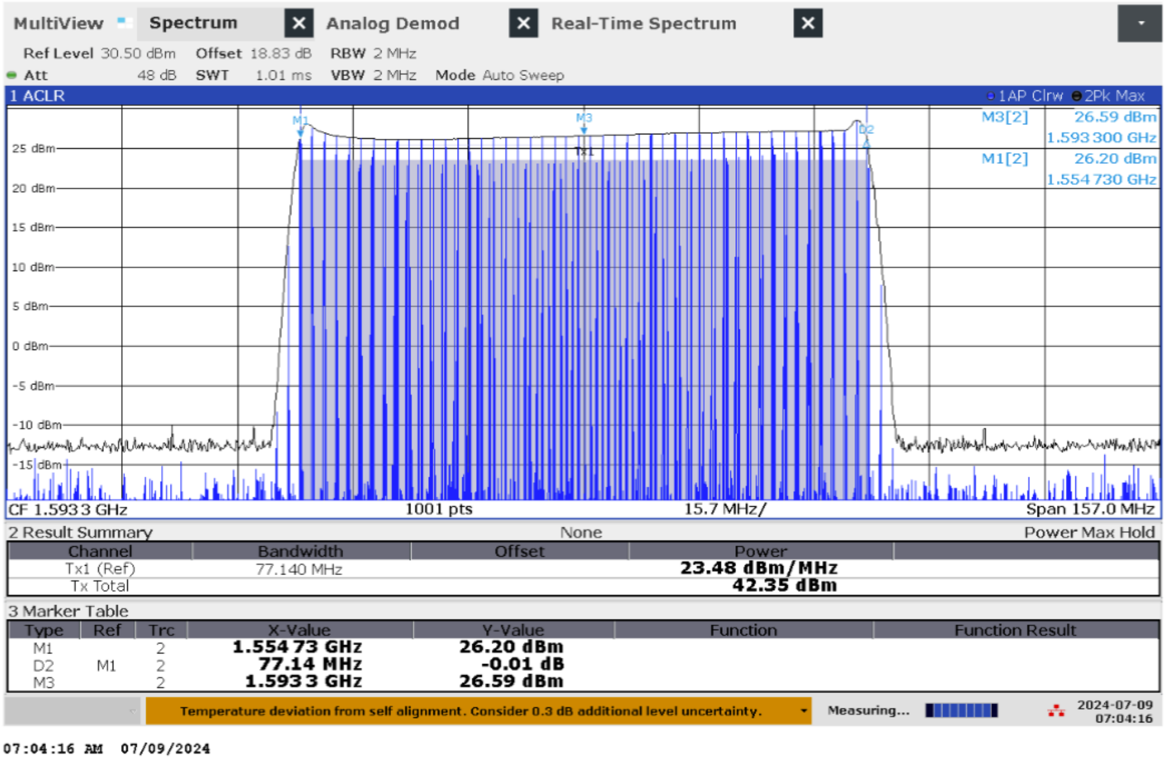

Figure 5.173: Time domain (analog demod) measurement of jammer H8.1 on antenna '6'

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.

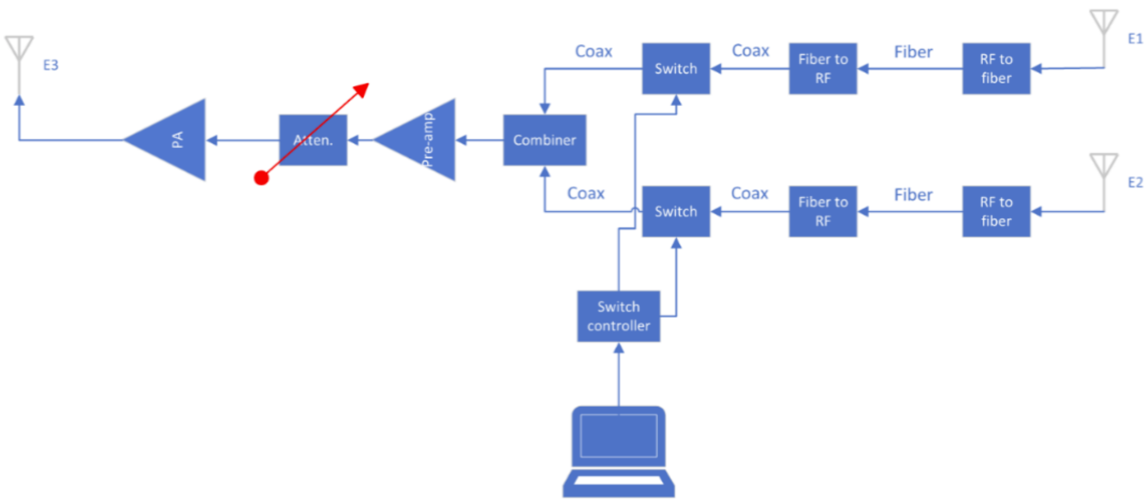

Figure 5.174: Diagram of the meaconing setup

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 5.175 is a block diagram of the high-power jammer that shows how it works in pnciple. 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.

Frequency band name	CW	PRN		Frequency sweep		
	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

Table 5.25: 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.

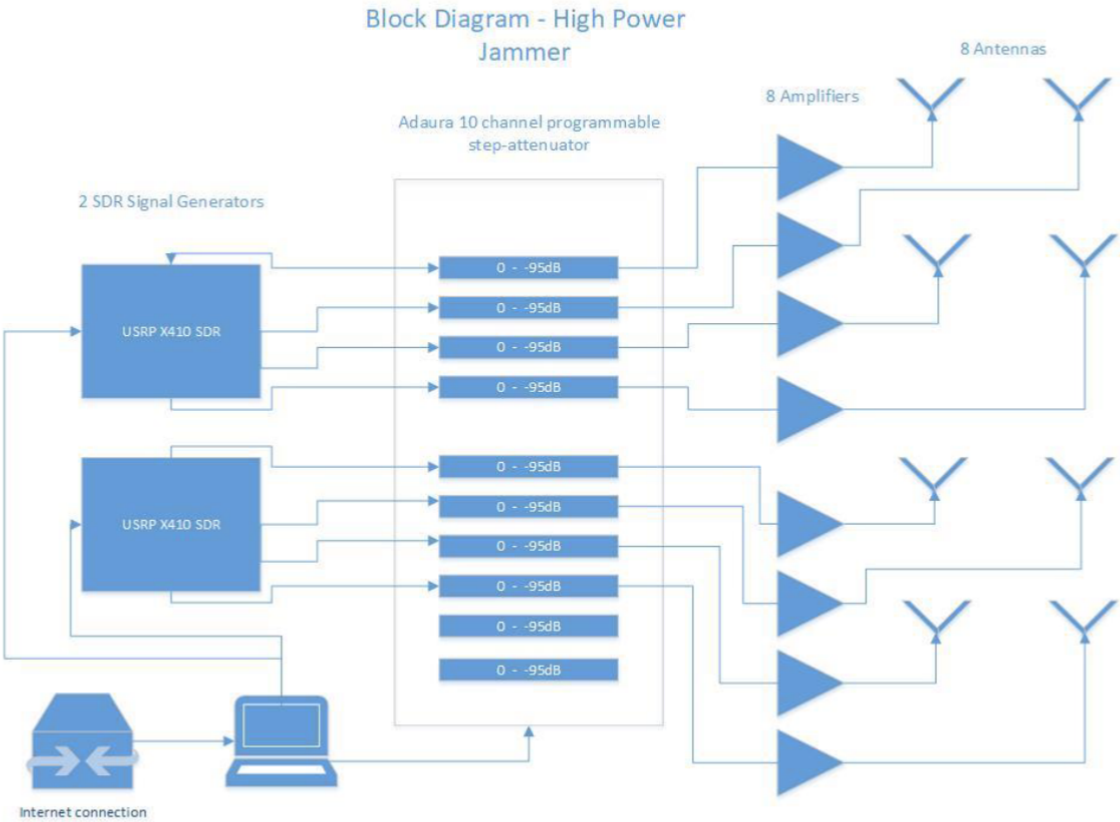

Figure 5.175: Diagram of the high-power jammer

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 ds1036-080410.pdf (european-antennas.co.uk).

Figure 5.176: Picture of the SDR without casing

The spoofed signals are GPS C/A only and may be combined with Glonass jamming (G1).

Technical details on software defined radio mobile SDR spoofer 'Winnie-the-spoof' / 'M1.1'

Winnie-the-spoof is vehicle based high-power mobile jammer and spoofer that can provide signals up to 50 W EIRP simultaneously between three and six different GNSS bands, where the maximum available power depends on the signal modulations. Figure 5.177 is a block diagram of the vehicle's equipment. To generate the signals it uses an Orolia GSG-8 simulator with four Dektec DAT-2115B SDR-cards. Each SDR has one output covering the frequency range from 32 MHz to 2.1 GHz, with maximum 72 MHz instantaneous bandwidth. The SDRs have an internal gain range of 60 dB in 1 dB steps. Final power output is controlled using step-attenuators and high power amplifiers. Each amplifier is connected to its own antenna via a 6m coax cable. The antennas are directional helical antennas with right hand circular polarization (RHCP) and 10 dB gain, vertical horn antennas (13dB gain) or an isotropic vertical radiator (0dB gain) for the spoofing, depending on the scenario. The system can simultaneously jam and spoof most combinations of bands, limited only by the intermodulation of the final amplifiers.

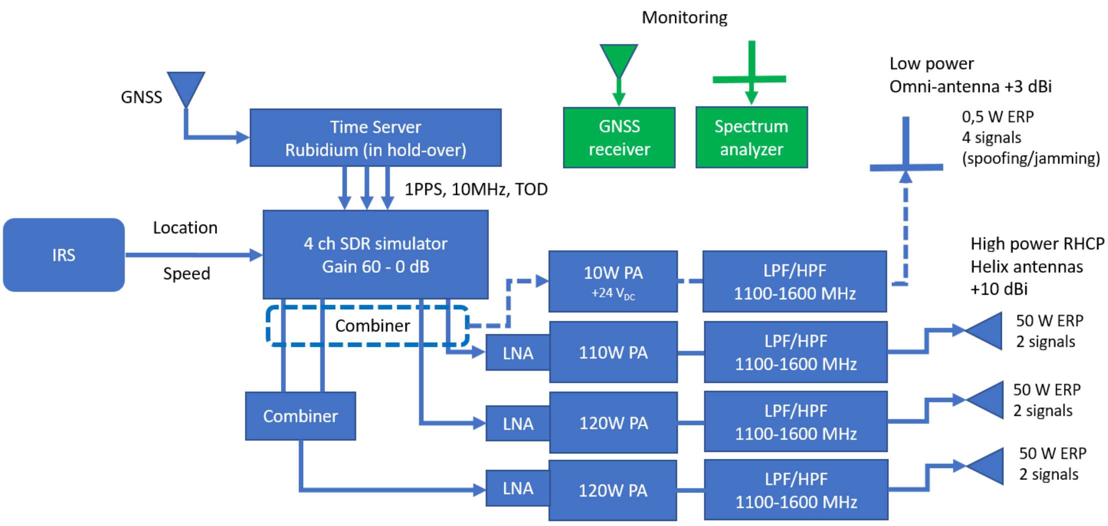

Figure 5.177: Diagram of the mobile jammer

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 (Figure 1)
- 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)

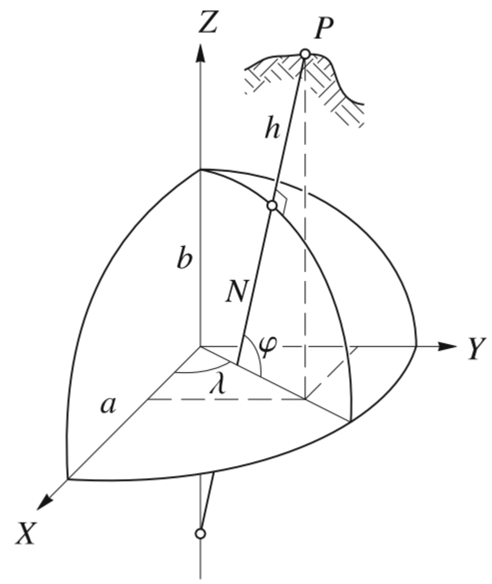

Figure 1: From [1] GNSS – Global Navigation Satellite Systems

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°.

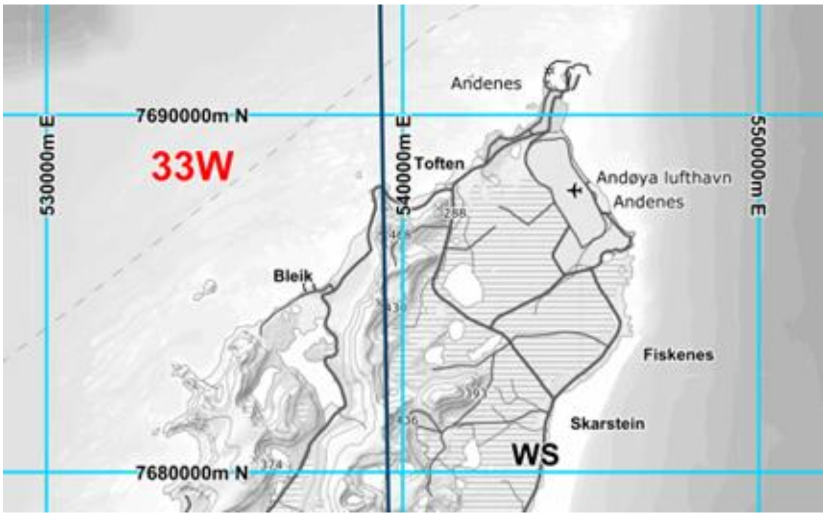

Figure 2: The UTM33 grid nearby Andøya

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 ΔE = 0.46m

$\varphi_{WGS84\ epoch2024.7} = \varphi_{EUREF89UTM33_{epoch1989.0}} + \Delta Lat$ where ΔLat =0.0000056°
$\lambda_{WGS84\ epoch2024.7} = \lambda_{EUREF89UTM33_{epoch1989.0}} + \Delta Long$ 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.

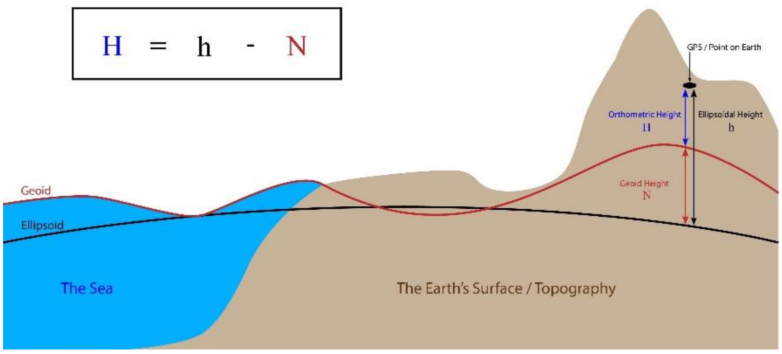

Figure 3: Ellipsoid and geoid. Credit: https://support.virtual-surveyor.com/

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] Geodetisk grunnlag [Geodetic datum] (in Norwegian language only)

[3] Referanserammer og transformasjoner [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

Kartverket
Norwegian Mapping Authority