

ERTMS/ETCS

Test Specification for Euroloop

REF : SUBSET-103

ISSUE : 1.1.0

DATE : 2012-02-29

Company	Technical Approval	Management Approval
ALSTOM		
ANSALDO		
BOMBARDIER		
INVENSYS		
SIEMENS		
THALES		



MODIFICATION HISTORY

Issue Number Date	Section number	Modification / Description	Author
0.0.1 / 2005-10-07	all	First draft	Thor Thorvaldsson
0.0.2 / 2006-01-10	all	Resolution of UNISIG comments for chapters 1 through 5	Ernst Zollinger
0.0.3 / 2006-01-31	all	Resolution of comments from UNISIG meeting on Jan. 17/18, 2006	Ernst Zollinger
0.0.4 / 2006-03-01	Chap. 6 & Annexes D – G	Resolution of comments from UNISIG related to test specifications of On-board part (chap. 6)	Ernst Zollinger
0.0.5 / 2006-03-17	all	Resolution of comments from UNISIG meeting of March 14/15 2006.	Ernst Zollinger
0.0.6 / 2006-06-09	all	Resolution of comments from UNISIG meeting of Mai 9/10 2006.	Ernst Zollinger
0.0.7 / 2006-12-15	All	Resolution of comments from UNISIG meeting of Sept. 12/13 2006	Ernst Zollinger, Max Loder
0.0.8 / 2007-02-02	all	Resolution of comments from UNISIG of 2007-01-18	Max Loder
0.0.9 / 2007-02-22	all	Resolution of comments from UNISIG Meeting of 2007-02-07	Max Loder
0.0.10/ 2007-11-15	all	Resolution of comments from UNISIG Meeting of 2007-10-03	Max Loder
0.0.11/ 2008-01-16	all	Resolution of comments from UNISIG Meeting of 2007-12-12	Max Loder
0.1.0 / 2008-02-05	all	Resolution of comments from UNISIG Meeting of 2008-02-05	Max Loder
1.0.0 / 2008-10-06		Issue corrected to 1.0.0	R.Baumann
1.0.0 / 2009-04-02		New template only	David Gillan
1.0.1 / 2011-09-06		Update after review by UNISIG	Bernhard Stamm
1.0.2 / 2011-11-07		Update for release to ERA	Bernhard Stamm
1.0.3 / 2012-01-06		Update after discussion of open questions	Bernhard Stamm
1.0.4 / 2012-01-31		Final update for delivery	Bernhard Stamm
1.0.5 / 2012-02-28		'Class 1' removed from cover sheet, 2.2 and H.1.3.17	Bernhard Stamm

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1.1.0 / 2012-02-29		Release for Baseline 3	Sibylle Maier
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1 INTRODUCTION

1.1 Foreword

The main body of this Norm, and the relevant Annexes designated as “normative”, constitute the mandatory requirements for test methods and tools for verification of compliance with the mandatory requirements of SUBSET-044 [N1]. Annexes designated as “informative”, either provide background information, or outline non-mandatory requirements and optional features.

1.2 Scope

This part of the Norm defines the specific set of verifications required for certification of conformity and suitability for use for all the Euroloop Subsystem (ELS) data transmission products, as specified in SUBSET-044 [N1].

These constituents of the ELS are the Trackside Equipment and the On-board Equipment integrated with the transmission functionality of the overall On-board ATP/ATC equipment.

The verifications dealt within this Norm are aimed at ensuring full and safe interoperability between Trackside and On-board equipment of any supplier. For this purpose, this part of the Norm mostly addresses all those requirements that are not specifically stated as “informative” in SUBSET-044 [N1].

Some interesting non-mandatory requirements (defined as recommended, preferred, or optional solutions) are also considered. This is for the purposes of supporting product inter-changeability and maintainability.

The “Euroloop” denomination can only identify those commercial products that have got certification of conformity compliance, based on the test requirements of the present Norm, by an officially recognized body.

This Norm specifies:

- detailed functional and non-functional test requirements for the ELS, identified as a basic trackside constituent of interoperability. A special focus is given to the air-gap interface, where the ELS Trackside Equipment interacts with the On-board Equipment. The air-gap requirements for the ELS have been defined in all needed details in SUBSET-044 [N1]. The interface of the Euroloop's Trackside Equipment with the other wayside equipment (i.e. the Lineside Electronic Unit, LEU) is also considered, mainly for the purpose of inter-changeability of wayside components.
- a set of functional and non-functional test requirements for the transmission parts of the On-board Equipment that is deemed indispensable for the purpose of interoperability. Also in this case, a special focus is given to the air-gap interfaces, where the On-board Antenna Unit interacts with the trackside ELC. Compared with the trackside case, only a minimum set of mandatory test requirements has been defined for the On-board Equipment. This allows any kind of optimisation, in cost and performance, for the overall architecture of the On-board system, while still ensuring interoperability.



The specific test set-ups presented herein are recommendations only, and should primarily be regarded of principal nature. However, they are detailed enough to provide a solid basis for designing actual test set-ups, and they do include hints on important properties. Modifications are allowed as long as the measurement accuracy is maintained, the same results are obtained, and the same properties are explored. There might in some cases be a need for additional precautions not to destroy specific instruments (due to high power levels).

2 REFERENCES

2.1 General

This Norm incorporates, by dated or undated references, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to, or revisions of, any of these publications apply to this Norm only when incorporated herein by amendment or revision. For undated references, the latest edition of the publication referred to apply. The reference numbers of the normative references start with an “N” (e.g. [N1]).

2.2 Normative References

- [N1] UNISIG SUBSET-044: ERTSM/ETCS, “FFFIS for Euroloop”.
- [N2] UNISIG SUBSET-023: “Glossary of Terms and Abbreviations”.
- [N3] UNISIG SUBSET-036: ERTMS/ETCS, “FFFIS for Eurobalise”.
- [N4] UNISIG SUBSET-085: ERTMS/ETCS, “Test Specification for Eurobalise FFFIS”.

3 ABBREVIATIONS AND DEFINITIONS

3.1 Introduction

Terms and abbreviations defined by reference [N2], although used in this document, may not be mentioned in the following lists. If listed, they are in agreement with [N2].

Further abbreviations and definitions commonly used for Euroloop are added and used in this document.

Further abbreviations and definitions explicitly used for Eurobalise, although used in this document, may not be mentioned in the following lists. If listed, they are in agreement with [N3].

3.2 Abbreviations

Abbreviation	Explanation
ATC	Automatic Train Control
ATP	Automatic Train Protection
AWG	Arbitrary Waveform Generator
Balun	Balanced – unbalanced transformer
BER	Bit Error Rate
CW	Continuous Wave
DSO	Digital Storage Oscilloscope
ELC	Euroloop Leaky Cable
ERT	ELC Reference Tool
ERT-ILA	ERT Interference signal Loop Antenna
LNA	Low Noise Amplifier
LPF	Low Pass Filter
BPF	Band Pass Filter
NWA	Network Analyser
RSRL	Reduced Size Reference Loop
SA	Spectrum Analyser
SG	Signal Generator
SS	Signal Source
TER	Telegram Error Ratio
VSWR	Voltage Standing Wave Ratio

Table 3-1: Abbreviations

3.3 Definitions

Term	Definition
Availability	Ability of a product to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval assuming that the required external resources are provided
Compatibility	Compatibility between two systems means that they can coexist under defined conditions without interfering with each other as to specified limits.
Field strength	The term “field strength” is applied to the Root Mean Square (RMS) of the field.
Interoperability	Interoperability between two systems means that they can operate mutually at a specified time and place as to specified limits.
Data symbol	A logical 1 or logical 0 data bit as defined in sub-clause 6.3.4.1 of SUBSET-044 [N1].
Test pattern	Sequence of data symbols.

Table 3-2: Definitions

4 BASICS ON TESTING

4.1 Means of Verification

Equipment of the Euroloop subsystem is tested on different levels of integration, dependent on the property to be tested and the relevant interface.

The functions of the Euroloop Trackside and On-board Equipment are verified through one or several of

- laboratory test,
- field test, or
- other means such as by inspection, documentation, declaration (such as the quality system of the manufacturer)

dependent on the requirement to be verified.

4.2 Test Conditions

4.2.1 Environmental Conditions

4.2.1.1 General

Tests defined in this specification shall be carried out at representative points within the boundary limits of the declared operational environmental profile.

Where technical performance varies due to environmental conditions, tests shall be mandatorily carried out also under conditions as defined by referenced standards and being within the boundary limits of the declared operational environmental profile in order to give confidence of compliance for the affected technical requirements.

During testing at the extreme environmental conditions according to SUBSET-044 [[N1]] the correct function has to be shown. If not otherwise mentioned herein, the normal conditions as defined in sub-clause 4.2.1.2 may be applied unless specific design choices require extended testing. The applied environmental condition shall be reported in the test report for every test-case.

4.2.1.2 Normal Environmental Conditions

Nominal temperature and humidity conditions for tests shall be any convenient combination of temperature and relative humidity within the following ranges:

- temperature: +15 °C to +35 °C;
- relative humidity: 20 % to 75 %.

4.2.2 Steady State of Device Under Test

The Device Under Test (DUT) shall have reached its steady state condition before triggering any measurement, e.g. after

- applying a new stimuli to Interface 'C_L1',
- changing the Q_SSCODE within the Trackside- or On-board Equipment,
- activating the Trackside Equipment.

4.2.3 Verification of Measurement Arrangement of Trackside Equipment

Measurement arrangements of the Trackside Equipment involving radiated signals shall be verified once before conducting the measurements. The aim is to keep unwanted signal leakage into the measurement setup small enough to prevent erroneous measurements. For this purpose the radiating elements, i.e. the antennas, shall be replaced by a termination matching the characteristic impedance of the corresponding radiating element. Then record the signal's amplitude to be measured and verify that this signal's amplitude is at least 20 dB below value to be expected in case the radiating element is used.

4.2.4 General Test and Calibration Setup Notes

The following aspects shall be respected for all test set-ups except stated otherwise. For some set-ups all aspects apply, but for others only some apply. The applicability is evident from the recommended test set-ups presented herein.

1. A spectrum analyser or similar equipment may substitute any power meter. However, this device shall be calibrated against a power meter prior to the test.
2. It shall be verified that all harmonics are suppressed by at least 20 dB if power meters are used. Otherwise, sufficient filtering shall be performed.
3. It shall be verified that the level of signals to be measured are at least 10 dB above the noise floor.
4. Use a Low Noise Amplifier (LNA) to increase the level of the signal to be measured where needed. Verify that its VSWR does not compromise the required measurement accuracy of the signal level. If the VSWR compromises the required measurement accuracy, use an appropriate attenuator at the respective port of the LNA to improve the VSWR as needed.
5. Appropriate filters and/or attenuators shall be used where needed to protect signal generating devices from interfering signals that are present at their output ports to avoid degradation of the required performance.
6. RMS values are applicable unless otherwise explicitly stated.
7. All distances are in millimetres unless explicitly otherwise stated.
8. Unless otherwise expressed, the length of the Interface C_L1 cable shall be 10 m ± 0.1 m.

4.3 Test Signals

The Test Signals for testing the Trackside Equipment (TSTE) and the On-board Equipment (TSOE) are identified in sub-clause 6.12.2, and 7.10.2 of SUBSET-044 [N1], respectively. They are defined in Annex H of this document.

For each test signal, a file is provided that contains the samples of the test signal, the specification of the sampling rate, and the required vertical resolution of the samples.

4.4 Requirements for Test Tools

4.4.1 General

All measurement instruments (e.g., digital storage oscilloscope and network analyser) shall comply with the applicable minimum requirements stated in sub-clauses 4.4.2 through 4.4.23. Furthermore, the instruments shall be used only after they have warmed up. The minimum warm up duration is usually specified in the manual of the equipment. If this is not the case, a warm up time of at least half an hour shall be considered. In some high power applications it may be needed to wait for warm-up after the signal has been applied to the test equipment.

The test signals shall comply with the requirements stated in Annex H of this document. The requirements associated with a specific test signal shall be verified before applying it to the device under test.

The proper operation of the test instruments shall be checked before their usage.

The measured quantities shall comply with requirements stated in Table 4-1.

Sub-clauses 4.4.2 through 4.4.23 provide minimum requirements of the test instruments intended to ease the selection of suitable equipment.

An informative list of suitable test equipment is found in Annex J.

4.4.2 Signal Generator (SG1)

Signal generator (SG1) is an Arbitrary Waveform Generator used to generate the Interface C_{L1} signals. Together with a Balun as specified in sub-clause 4.4.21 it generates signals meeting the requirements stated in sub-clause 6.3 of SUBSET-044 [N1]. Subsequent minimum requirements for the signal generator are:

- Internal reference frequency stability: $\leq \pm 3$ ppm between 19 °C and 29 °C
- MTIE $< t_{ob} * 10$ ppm + 30 ns
- Amplitude of output voltage(peak to peak value into 50 Ω assuming loss-less 50 Ω to 120 Ω transformation): $> 11.7V_{PP}$
- Output impedance: 50 Ω
- VSWR (max.): 1.5



- Interpolation Filter: ¹

$f_t = 1 \text{ MHz}$

¹ The basic function of an Arbitrary Waveform Generator generates an output waveform like a step function. To interpolate these steps to a smooth waveform, lowpass filtering shall be applied by the SG1.

4.4.3 Signal Sources (SS1 and SS2)

Signal sources (SS1 and SS2) are Arbitrary Waveform Generators used to generate the Interface A_L1 signals. The subsequent minimum requirements shall apply for the utilised Arbitrary Waveform Generator.

- Sampling clock range (min.): 6 kSamples/s to 100 MSamples/s
- Sample clock resolution: ≤ 1 Hz
- Sample clock accuracy: Same as reference used
- Sample clock stability: Same as reference used
- Internal reference frequency stability: $\leq \pm 3$ ppm between 19 °C and 29 °C
- MTIE $< t_{ob} * 3$ ppm + 5 ns
- Analogue bandwidth: ≥ 30 MHz (-3 dB point, widest bandwidth)
- Amplitude resolution: ≥ 12 bits
- Waveform memory: ≥ 16 MSamples
- Output impedance: 50 Ω
- VSWR (max.): 1.5
- Output power (into 50 Ω): 10 dBm

4.4.4 Signal Source (SS3)

The subsequent minimum requirements apply for the utilised Signal Source (SS3).

- Frequency range: 4 MHz – 30 MHz
- Frequency resolution: ≤ 50 Hz
- Frequency stability: ± 10 ppm
- Output impedance: 50 Ω
- VSWR (max.): 1.5
- Output power (into 50 Ω): 10 dBm

4.4.5 Linear Power Amplifier (PA1)

The subsequent minimum requirements shall apply for the linear power amplifier.

- Min. frequency range : 1 MHz to 50 MHz
- Nominal characteristic impedance: 50 Ω
- VSWR (input, max.): 1.5
- VSWR (output, max.): 2.5
- Output Power (min.): 45 dBm
- OIP3 (3rd order output intercept point): 53 dBm (typical)

4.4.6 Network Analyser (NWA1)

The minimum requirements for the NWA1 are:

- Min. frequency range: 300 kHz to 50 MHz
- Frequency resolution: ≤ 50 Hz
- Dynamic range (with calibration): ≥ 70 dB
- Reference frequency accuracy (source): ± 10 ppm
- Output power range: -50 dBm to +10 dBm
- Output level accuracy ± 1 dB
- Nominal impedance: 50Ω
- Return loss: > 15 dB
- Tolerable input signal from the unit under test² : > 20 dBm

Before usage the NWA1 shall be calibrated for the quantity to be measured within the proper frequency range applying standard calibration procedures using open, short, load, and through from a calibration kit as specified by the manufacturer of the equipment.

4.4.7 Network Analyser (NWA2)

The minimum requirements for the NWA2 are:

- Min. frequency range: 50 kHz to 10 MHz
- Frequency resolution: ≤ 50 Hz
- Dynamic range (with calibration): ≥ 70 dB
- Reference frequency accuracy (source): ± 10 ppm
- Output power range: -50 dBm to -5 dBm
- Output level accuracy ± 1 dB
- Nominal impedance: 50Ω
- Return loss : > 15 dB

Before usage the NWA2 shall be calibrated for the quantity to be measured within the proper frequency range applying standard calibration procedures using open, short, load, and through from a calibration kit as specified by the manufacturer of the equipment.

² To measure the return loss of an amplifier that is producing an output signal during the measurement requires an analyser which can tolerate at its input a foreign, for the analyser unwanted, signal. The measurement errors shall not exceed the specified tolerance due to the presence of such an external signal.

4.4.8 Spectrum Analyser (SA)

The minimum requirements for the SA are:

- Min. frequency range: 1 MHz to 100 MHz
- Frequency resolution: ≤ 50 Hz
- Resolution bandwidth 10 kHz
- Dynamic range ≥ 60 dB
- Nominal impedance: 50Ω
- Return loss (frequency <200 MHz): >15 dB

4.4.9 Digital Storage Oscilloscope (DSO)

The subsequent minimum requirements shall apply for the utilised DSO.

- Sampling clock: ≥ 500 MSamples/s
- Sample clock resolution: ≤ 1 Hz
- Internal reference frequency stability: $\leq \pm 10$ ppm between 10°C and 30°C
- Analogue bandwidth: ≥ 250 MHz (-3 dB point, widest bandwidth)
- Effective Dynamic range: ≥ 50 dB
- Waveform memory: ≥ 1 Msample
- Input impedance: $50 \Omega \pm 5\%$, except where indicated otherwise

4.4.10 RF Power Meter (PM)

The subsequent minimum requirements shall apply for RF signal power measurements.

- Frequency range : 10 MHz – 30 MHz
- Input VSWR at 50Ω nominal impedance: <1.2
- Power measurement range : -60 dBm – +20 dBm
- CW measurement uncertainty: <0.15 dB
- WCDMA modulation influence ³⁾: <0.07 dB
- Time window for average power measurement: 20 ms

RF signal power measurements shall not be performed before warm-up of the RF power sensor and the RF power meter. The warm-up duration is usually specified in the manual of the instrument. If this is not the case the instrument shall be allowed for a warm-up time of at least half an hour.

The RF power sensor and RF power meter shall be calibrated and zeroed before usage according to the requirements and the procedure specified in the manual of the instrument.

The RF power sensor shall be kept within a sufficiently narrow temperature range, such as to maintain the accuracy of the measurement set up.

4.4.11 RF Power Combiner (RFPC)

All RF combiners used within the measurement arrangements and set-ups shall provide coaxial connectors at all ports and feature within the frequency range they are used the subsequent minimum specifications.

- Nominal impedance (each port): 50 Ω
- VSWR (each port): < 1.3
- Isolation between input ports: ≥ 6 dB
- Amplitude unbalance: < 1 dB

4.4.12 Attenuators (A1)

The subsequent minimum requirements shall apply for the two pieces of attenuators type A1 utilized:

- Frequency range: 2 MHz – 100 MHz
- Attenuation: 10 dB ±0.5 dB
- Power dissipation: > 20 W

³⁾ 3-GPP TS25.141 (ARIB STD-T63-25.141, Base station conformance testing) Test Model 1 with 64 channels describes a multicarrier HF-test signal for communication systems. The superposition of 64 carrier signals with different frequencies results in an extreme variation of the envelope of the signal. The amplitude is nearly normal distributed.



- Nominal impedance (each port): 50 Ω
- VSWR (each port): < 1.2

4.4.13 Attenuators (A2)

The subsequent minimum requirements shall apply for the attenuators utilized:

- Frequency range: 2 MHz – 100 MHz
- Attenuation: 6 dB \pm 0.5 dB⁴
- Power dissipation: > 1 W
- Nominal impedance (each port): 50 Ω
- VSWR (each port): < 1.2

4.4.14 General Requirements for RF Cables

All RF cables including their connectors at both ends used within the measurement arrangements and set ups shall be of coaxial type featuring within the frequency range they are used the subsequent minimum specification.

- Nominal characteristic impedance: 50 Ω
- VSWR (both ports): < 1.3
- Shielding attenuation: \geq 75 dB

Coaxial cables exposed to radiated fields of the measurement arrangement or carrying a low level signal shall be equipped

- at both ends with at least
 - three ferrite clamp filters mounted back-to-back or
 - one ferrite core filter through which the coaxial cable passes two times and
- at distances of 2 m along the cable's length with at least
 - four ferrite clamp filter or
 - one ferrite core filter through which the cable passes two times.

The impedance of the ferrite material of both, the ferrite clamp filters and the ferrite core filters, shall be \geq 80 Ω between 10 MHz and 100 MHz. This impedance is specified for a straight solder plated copper wire whose diameter amounts to 1 mm that passes once through these filters.

All RF cables shall be suitably routed.

⁴ The required attenuation depends on the maximum output power of the connected equipment.

4.4.15 Directional Couplers (DC1 and DC2)

The subsequent minimum requirements shall apply for the utilised directional couplers within the frequency range they are used.

- Frequency range: 1 MHz – 30 MHz
- Insertion loss: ≤ 1.2 dB
- Coupling loss: 10 dB – 15 dB
- Directivity: ≥ 30 dB
- Return loss (all ports): ≥ 15 dB
- Nominal impedance (all ports): 50 Ω
- Input Power > 2 W

4.4.16 Low Noise Amplifier (LNA)

The subsequent minimum specifications apply for the utilised low noise amplifier.

- Frequency range: 5 MHz – 30 MHz
- Gain
(to be calibrated, see sub-clause 4.6.2) $\sim 25 - 30$ dB
- 1 dB output compression point: ≥ 5 dBm
- Flatness ≤ 0.5 dB
- Noise Figure: < 5 dB
- VSWR at in- and output: ≤ 1.8
- Nominal impedance at in- and output: 50 Ω

4.4.17 Phase Noise Measurement Equipment (PNME)

The subsequent minimum requirements shall apply for the utilised phase noise measurement equipment.

- Frequency range: 13 MHz – 14 MHz
- Nominal impedance: 50 Ω
- Return loss: ≥ 12 dB
- Noise floor (residual noise):
-100 dBc/Hz @ 1 kHz offset
-145 dBc/Hz @ 100 kHz offset

4.4.18 Common Mode Choke (CMC)

The subsequent minimum requirements shall apply for the utilised common mode choke.

- Frequency Range 9 MHz – 18 MHz
- Insertion Loss (symmetrical S21) < 0.5 dB
- Return Loss (symmetrical S11) > 15 dB



- Common mode insertion loss (asymmetrical S21) > 23 dB
- Nominal Impedance: 50 Ω

4.4.19 Current Meter (CM)

The subsequent minimum requirements shall apply for the utilised Current Meter.

- Measurement range: 1 mA to 1 A or depending on product specification

4.4.20 Volt Meter (VM)

The subsequent minimum requirements shall apply for the utilised Volt Meter.

- Measurement range: 3 V to 30 V or depending on product specification

4.4.21 Balun (BLN)

The subsequent minimum requirements shall apply for the utilised Balun.

- Asymmetrical Input Port Impedance: 50 Ω
- Symmetrical Output Port Impedance: 120 Ω
- Return Loss: ≥ 15 dB (10 kHz to 0.5 MHz)
- Insertion Loss < 1 dB

4.4.22 Reduced Size Reference Loop (RSRL)

As specified in [N4] Annex H2 with Balun as specified in [N4] Annex H5.3

4.4.23 Band-Pass Filter (BPF)

The subsequent minimum requirements shall apply for the utilised Band-Pass Filter (BPF).

- Centre frequency: f_c according to sub-clause 6.7.5 of SUBSET-044 [N1].
- 3 dB Bandwidth: 4.5 MHz $\left\{ \begin{array}{l} +10\% \\ -0\% \end{array} \right.$
- Type of filter: Chebyshev, 0.05dB pass band ripple
- Order of filter: 4
- Impedance (nominal) both ports: 50 Ω
- Return Loss: ≥ 15 dB (pass band)
- Maximum power 20 dBm

4.5 Bit Error Ratio Measurements

The direct way of measuring Bit Error Ratio (BER) requires the possibility to generate and receive a continuous bit stream of significant length. The fraction of erroneous bits out of the total number of received bits is the BER. This approach uses standard laboratory equipment for BER measurement.

The fraction of erroneous telegrams out of the total number of telegrams, which is called the TER, allows estimating the error rate assuming that bit errors are uniformly distributed.

Assuming uniformly distributed and statistically independent occurrence of bit errors the following relations exist between TER (telegram error rate) and total number M of logical data bits⁵ per telegrams.

$$TER = 1 - (1 - BER)^M,$$

$$BER = 1 - 10^{\frac{\log(1-TER)}{M}} = 1 - \sqrt[M]{1-TER}.$$

The number N of bits to be tested to verify that the Bit Error Rate is below the upper limit BER is⁶:

$$N = \frac{1}{BER} \left[-\ln(1 - CL) + \ln \left(\sum_{k=0}^E \frac{(N \times BER)^k}{k!} \right) \right]$$

- BER: Upper limit of Bit Error Rate
- CL: Confidence Level
- E: Number of erroneous bits detected

⁵ The logical 1 and logical 0 data bits are defined in sub-clause 6.3.4.1 of SUBSET-044 [N1].

⁶ J. Redd, "Calculating Statistical Confidence Levels for Error-Probability Estimates," Lightwave Magazine, pp. 110-114, April 2000.

4.6 Measurement Uncertainty

4.6.1 General Measurement Uncertainty

The accumulated measurement uncertainties of the parameters to be measured with the measurement arrangements specified in this document shall not exceed those given in Table 4-1, if not otherwise specified in the test procedure, to ensure that the measurements remain within an acceptable accuracy. In order to achieve this (or better), specific test set-up calibrations, or more accurate equipment than those specified, may apply.

Table 4-1: Absolute Measurement Uncertainty

Parameter	Uncertainty
RF power (conducted)	$\leq \pm 0.5$ dB
Magnetic field strength ⁷ (laboratory)	$\leq \pm 2$ dB
Magnetic field strength ⁷ (near field tests)	$\leq \pm 1$ dB
Magnetic field strength ⁷ (field tests @10m)	$\leq \pm 5$ dB
RF frequency (relative)	$\leq \pm 3 \cdot 10^{-6}$
Bit Error Ratio (BER) Confidential Level	99 %
DC current	≤ 5 % of reading
DC voltage	≤ 5 % of reading

In consideration of worst-case combinations of measurement uncertainties at laboratory – and near field magnetic field strength measurements the limits of some tests are set by the amount of measurement uncertainties tougher than specified in SUBSET-044 [N1].

⁷ Including the required power measurement.

4.6.2 Calibration of Fieldstrength measurement equipment

The signal path MFP – BPF – LNA might introduce considerable error due to mismatch losses. An appropriate calibration shall eliminate this error.

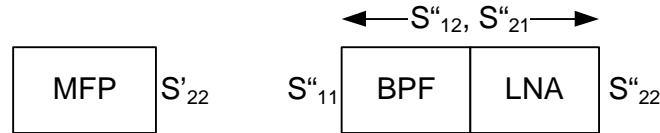


Figure 4-1: Measurement of LNA gain

1. Measure with NWA1 S_{22} of the MFP.
2. Measure with NWA1 the S parameters of the cascaded block BPF-LNA with an uncertainty of ≤ 0.3 dB.
3. Calculate from these S parameters the resulting gain G of the combination BPF-LNA-BPF under the conditions MFP as source and nominal termination (Power Meter):

$$G = \left| S''_{21} \cdot \frac{1}{1 - S'_{22} \cdot S''_{11}} \right|$$

5 TESTING OF TRACKSIDE EQUIPMENT

5.1 LOOMO Output Signal: Spectrum Mask

This test shall be performed with the LOOMO also under extreme environmental conditions declared by the manufacturer in accordance with SUBSET-044 [N1].

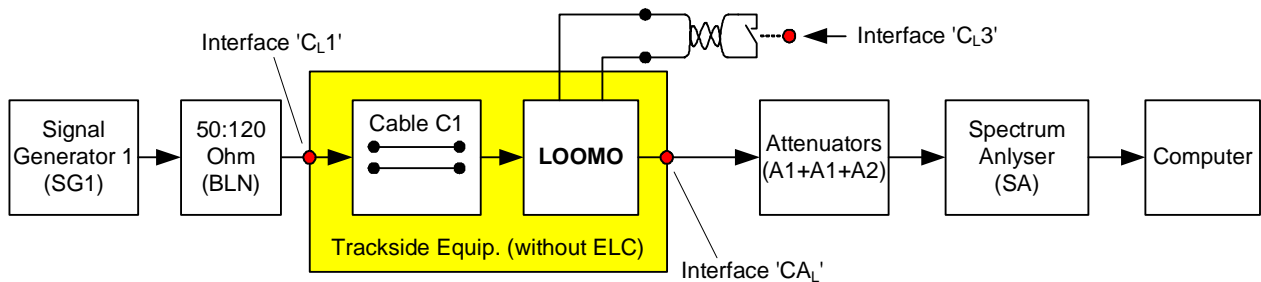


Figure 5-1: Measurement Setup Spectrum Mask

1. Set up the measurement arrangement according to Figure 5-1. Set the nominal input impedance of the SA's input channels to 50 Ω or use external 50 Ω feed-through terminators. Use a suitable attenuator to guarantee that the SA operates within its range of specifications.
2. Program the Signal Generator 1 (SG1) to generate a nominal test signal "TSTE_nom" specified in Annex H and complying with the amplitude and timing specifications detailed in Figure 6-8 and Table 6-2, both of SUBSET-044 [N1]. The test signals shall utilise the "logical data bit" sequence consisting of only logical ones ("1"). See sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term "logical data bit". Use the nominal data rate R_d as defined in sub-clause 6.3.2 of SUBSET-044 [N1].
3. Instruct the LOOMO to use Q_SSCODE 00, or code according to step 11, as defined in Table F-1 of Annex F in [N1].
4. Activate the LOOMO by switching Interface 'C_L3' to its low impedance state.
5. Check that the Euroloop signal is present on Interface 'C_A_L'.
6. Program the Spectrum Analyser (SA) for a Span of DC to 100 MHz and Resolution – and Video-Bandwidth of 10 kHz. Select the Normal Detector and Average 5 times.
7. Take the power spectrum $S_P(m\Delta f)$ from the Spectrum Analyser
8. Determine $S_{P_{max}} = \max_m (S_P(m\Delta f))$
9. Compute the normalised spectrum $\underline{S}_N(m\Delta f) = \underline{S}_P(m\Delta f) / \underline{S}_{P_{max}}$.
10. Verify that the specification for the **spectrum mask** is met. The limits lines of the spectrum mask of the Euroloop signal shall not exceed the values given in Figure 6-18 of [N1] and Table 6-6 of [N1] within the frequency range between 1 MHz and 100 MHz. Report the result in the test report.
11. Repeat steps 3 through 10 using one by one Q_SSCODE 01 to 15 within the LOOMO.

5.2 LOOMO Output Signal: Q_SSCODE and Centre Frequency

This test shall be performed with the LOOMO also under extreme environmental conditions declared by the manufacturer in accordance with SUBSET-044 [N1].

1. Set up the measurement arrangement according to Figure 5-2. Use a suitable attenuator to guarantee that the DSO operates within its range of specifications.

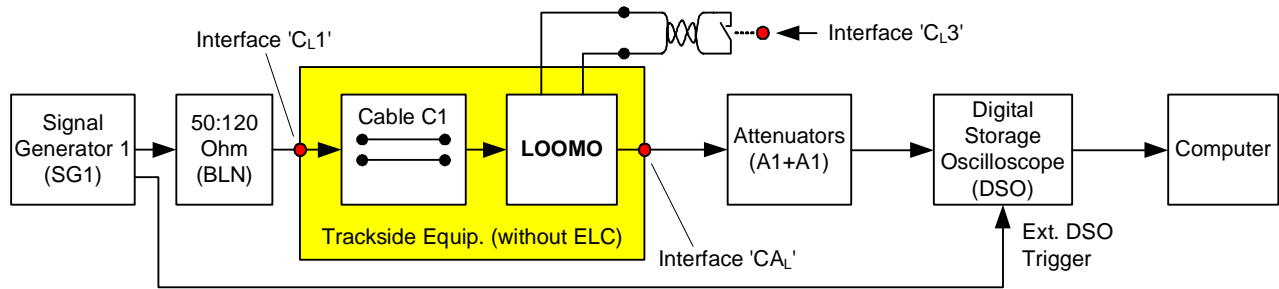


Figure 5-2: Measurement Setup centre frequency and Q_SSCODE

2. Program the Signal Generator 1 (SG1) to generate a nominal test signal “TSTE_nom” specified in Annex H and complying with the amplitude and timing specifications detailed in Figure 6-8 and Table 6-2, both of SUBSET-044 [N1]. The test signals shall utilise the “logical data bit” sequence consisting of only logical ones (“1”). See sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term “logical data bit”. Use the nominal data rate R_d as defined in sub-clause 6.3.2 of SUBSET-044 [N1].
3. Instruct the LOOMO to use Q_SSCODE 00, or code according to step 8, as defined in Table F-1 of Annex F in [N1].
4. Activate the LOOMO by switching Interface ‘CL3’ to its low impedance state.
5. Check that the Euroloop signal is present on Interface ‘CA_L’.
6. Follow Annex A.3, which defines the detailed signal processing procedure to determine the utilised Q_SSCODE from the sampled waveform.
7. Verify that the **Q_SSCODE** determined in step 6 above equals the one used in step 3 for Q_SSCODE = 00 and in step 8 for Q_SSCODE 01 through 15 and report the result in the test report.
8. Repeat steps 3 through 7 using one by one Q_SSCODE 01 to 15 within the LOOMO.
9. Instruct the LOOMO to use Q_SSCODE 15 as defined in Table F-1 of Annex F in [N1]. Then follow Annex A.2 which defines the detailed signal processing procedure to determine the centre frequency f_c from the sampled waveform.
10. Verify that the specification of the **centre frequency** f_c specified in sub-clause 6.7.5 of SUBSET-044 [N1] is met.
11. Test finished.

5.3 Quality of the LOOMO Output Signal

This test shall be performed with the LOOMO also under extreme environmental conditions declared by the manufacturer in accordance with SUBSET-044 [N1].

1. Set up the measurement arrangement according to Figure 5-2. Set the nominal input impedance of the DSO's input channels to 50Ω or use external 50Ω feed-through terminators. Use a suitable attenuator to guarantee that the DSO operates within its range of specifications.
2. Program the Signal Generator 1 (SG1) to generate a nominal test signal "TSTE_nom" specified in Annex H and complying with the amplitude and timing specifications detailed in Figure 6-8 and Table 6-2, both of SUBSET-044 [N1]. The test signals shall utilise the "logical data bit" sequence consisting of only logical ones ("1"). See sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term "logical data bit". Use the nominal data rate R_d as defined in sub-clause 6.3.2 of SUBSET-044 [N1].
3. Set the LOOMO to use an SSCode with Q_SSCODE 15 as defined in Table F-1 of Annex F in [N1].
4. Activate the LOOMO by switching Interface 'C_L3' to its low impedance state.
5. Check that the Euroloop signal is present on Interface 'CA_L'.
6. Follow steps 1 to 12 of Annex B, which defines the detailed signal processing procedure for evaluating and extracting the quality of LOOMO's output signal.
7. Verify that $CCF(n \Delta t)$ and $NCF(n \Delta t)$ comply with the requirements stated in sub-clause 6.7.6 of SUBSET-044 [N1] and report the result in the test report.
8. For the purpose of verifying the unwanted amplitude modulation verify that the single value of $H_{AM} > 0.35 \cdot K$ and report the result in the test report.

5.4 MTIE of the Modulation Signal on Interface 'CA_L'

1. Set up the measurement arrangement according to Figure 5-2. The purpose of the measurement is to test the influence of phase distortions and frequency deviation of the modulation signal generated in LOOMO. Set the nominal input impedance of the DSO's input channels to 50 Ω or use external 50 Ω feed-through terminators. Use a suitable attenuator to guarantee that the DSO operates within its range of specifications.
2. Instruct the LOOMO to use Q_SSCODE 00 as defined in Table F-1 of Annex F in [N1].
3. Activate the LOOMO by switching Interface 'C_{L3}' to its low impedance state.
4. Program the Signal Generator 1 (SG1) to generate the distorted test signal "TSTE_step+" specified in Annex H. The test signal shall utilise the "logical data bit" sequence consisting of only logical ones ("1"). See sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term "logical data bit". The basic common parameters for the specification of the test signal are given in Figure 6-8 and Table 6-2, both of SUBSET-044 [N1]. Use the nominal data rate R_d as defined in sub-clause 6.3.2 of SUBSET-044 [N1].
5. Check that the Euroloop signal is present on Interface 'CA_L'.
6. Follow steps 1 to 6 of Annex C, which defines the detailed signal processing procedure for evaluating and extracting on a computer the MTIE (Maximum Time Interval Error) from the sampled waveform. The required sample set shall be taken at $t_m = -0.25$ ms after (in this case 0.25 ms before) the phase step of the test signal. Report the measured MTIE in the test report together with the Q_SSCODE and the test signal used.
7. Repeat step 4 through 6 with $t_m = 5$ ms, 20 ms, 200 ms, 500 ms, 1 s, 2 s and 4 s.
8. Repeat step 4 through 7 generating test signal "TSTE_step-" specified in Annex H with SG1.
9. Repeat step 4 through 7 generating test signal "TSTE_step+R-" specified in Annex H with SG1 using the minimum data rate.
10. Repeat step 4 through 7 generating test signal "TSTE_step-R+" specified in Annex H with SG1 using the maximum data rate.
11. Repeat step 4 through 7 generating test signal "TSTE_alt-phase_110" specified in Annex H with SG1. In steps 6 through 7 the required sample sets shall be taken at $t_m = 11$ s, 12 s, 13 s and 14 s after applying the test signal.
12. Repeat steps 4 through 11 using one by one Q_SSCODE 01 to 15 within the LOOMO.
13. Set the LOOMO to use an SSCode with Q_SSCODE 15 as defined in Table F-1 of Annex F in [N1].
14. Adjust the time base of the Signal Generator 1 (SG1) such that the underlying data rate of the generated Test Signal "TSTE_nom" specified in Annex H becomes detuned by -70 ppm.
15. Carry out steps 1 to 6 of Annex C and record the values of MTIE in the test report.
16. Adjust the time base of the Signal Generator 1 (SG1) such that the underlying data rate of the generated Test Signal TSTE_nom specified in Annex H becomes detuned by +70 ppm.
17. Carry out steps 1 to 6 of Annex C and record the values of MTIE in the test report.



18. Test finished.

5.5 Distortion Immunity of Signal on Interface 'C_{L1}'

1. Set up the measurement arrangement according to Figure 5-2. Set the nominal input impedance of the DSO's input channels to 50 Ω or use external 50 Ω feed-through terminators.
2. Program the Signal Generator 1 (SG1) to repetitively generate distorted test signals given below.
3. The test signals shall utilise the "logical data bit" sequence 110...110. See sub-clause 6.3.4.1 of SUBSET-044 [N1] for coding of every "logical data bit" into 11 Bit Barker codes as required on the interface 'C_{L1}'.
4. Adjust the time base of SG1 such that the data rate R_d of the generated Test Signal becomes detuned by -70 ppm from its nominal value specified in sub-clause 6.3.2 of [N1].
5. Set the LOOMO to use a SSCode with Q_SSCODE $n = 00$ as defined in Table F-1 of Annex F in [N1] and where n stands for the 16 codes ranging from 00 to 15.
6. Activate the LOOMO by switching Interface 'C_{L3}' to its low impedance state.
7. Apply the test signal "TSTE_minmax" specified by Figure H- 4 to Interface 'C_{L1}'.
8. Follow steps 1 to 21 of Annex A, which defines the detailed signal processing procedure to determine the "logical data bit" sequence from the sampled waveform.
9. Verify that the "logical data bit" values of the reconstructed data signal match the "logical data bit" sequence 110...110 used for generating the test signal on Interface 'C_{L1}'.
10. Repeat steps 8 and 9 for the distorted test signal "TSTE_alt-phase" specified by Figure H-5.
11. Repeat steps 7 through 10 using Q_SSCODE $n = 01$ to 15 within the LOOMO.
12. Adjust the time base of SG1 such that the data rate R_d of the generated test signal becomes detuned by +70 ppm from its nominal value specified in sub-clause 6.3.2 of [N1].
13. Repeat steps 5 through 11.
14. Test finished

5.6 Single Sideband Phase Noise

1. Set up the measurement arrangement according to Figure 5-3. The attenuation of the Attenuator depends on the input characteristics of the Phase Noise Measurement Equipment.
2. Program the Signal Generator 1 (SG1) to repetitively generate a nominal test signal "TSTE_nom" specified in Annex H complying with the amplitude and timing specifications detailed in Figure 6-8 and Table 6-2, both of SUBSET-044 [N1].
3. The test signals shall utilise the "logical data bit" sequence consisting of only logical ones ("1"). See sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term "logical data bit". Use the nominal data rate R_d as defined in sub-clause 6.3.2 of SUBSET-044 [N1].
4. Set LOOMO to its test mode as described in sub-clause 6.12.4 of SUBSET-044 [N1] i.e. the modulation signal is switched off and only the carrier frequency specified in sub-clause 6.7.5 of [N1] is transmitted.
5. Connect Phase Noise Measurement Equipment to Interface 'CA_L' using a suitable attenuator to guarantee the Equipment's operation with its range of specifications.
6. Measure the Single Sideband (SSB) Phase Noise at Interface 'CA_L' with the Phase Noise Measurement Equipment at 10 kHz, 100 kHz, 300 kHz and 10 MHz offset from the frequency of the raw carrier and record the values.
7. Verify that the measured values comply with the specifications for the SSB Phase Noise as given in Fig.6.16 of SUBSET-044 [N1].
8. Test finished.

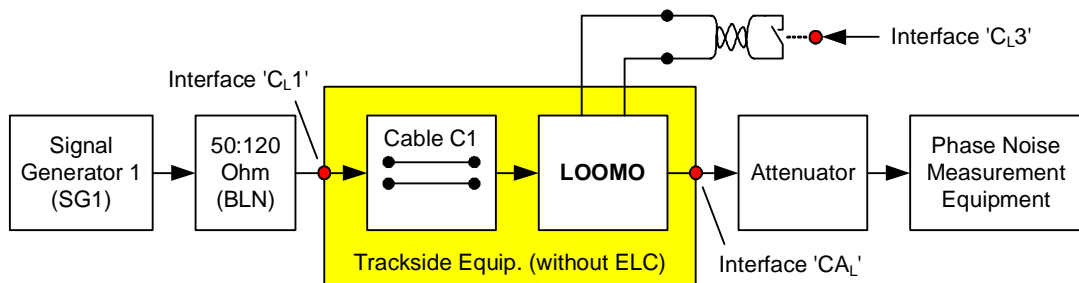


Figure 5-3: Phase Noise Measurement Setup

5.7 Return Loss at Interface 'CA_L'

1. Set up the measurement arrangement according to Figure 5-4. Program the Signal Generator 1 (SG1) to repetitively generate a nominal test signal "TSTE_nom" complying with the amplitude and timing specifications detailed in Figure 6-8 and Table 6-2, both of SUBSET-044 [N1], and Figure H- 3.
2. The test signals shall utilise the "logical data bit" sequence consisting of only logical ones ("1"). See sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term "logical data bit". Use the nominal data rate R_d as defined in sub-clause 6.3.2 of SUBSET-044 [N1].
3. Protect port 1 of the Network Analyser (NWA1) using an attenuator of suitable attenuation. Make sure that the NWA1's calibration is performed with this attenuator attached to its test port, i.e. at Interface 'CA_L' (see Figure 5-4). The attenuation of the Attenuator depends on the input characteristics of the Network Analyser.
4. Set the LOOMO to its test mode as described in sub-clause 6.12.4 of SUBSET-044 [N1] i.e. the modulation signal is switched off and only the carrier frequency specified in sub-clause 6.7.5 of [N1] is transmitted.
5. Activate the LOOMO by switching Interface 'C_{L3}' to its low impedance state.
6. Set the frequency range of the NWA1 to 27.095 MHz \pm 5 kHz.
7. Measure the reflection coefficient S_{11} at Interface 'CA_L' into the LOOMO with a resolution of \leq 100 Hz.
8. Verify that the return loss values ($20 \log_{10}|S_{11}|$) recorded in step 7 above comply with specifications limits in Table 6-7 of SUBSET-044 [N1] assuming a nominal impedance of 50 Ω at Interface 'CA_L'.
9. Confirm that the mean power return loss⁸ in the frequency range of 11 MHz to 16 MHz of the ELC is in accordance with sub-clause 6.10.6 of SUBSET-044 [N1] assuming a nominal impedance of 50 Ω at Interface 'CA_L'.
10. Measure the mean power return loss⁸ in the frequency range of 11 MHz to 16 MHz in both directions (based on S_{11} and S_{22}) of the optional Common Mode Choke with the network analyser NWA1.
11. Verify that the return losses complies with sub-clause 6.10.6 of SUBSET-044 [N1] assuming a nominal impedance of 50 Ω at Interface 'CA_L'.
12. Measure the mean power return loss⁸ the in the frequency range of 11 MHz to 16 MHz (based on S_{11}) of the Euroloop Termination with the network analyser NWA1.
13. Verify that the return loss complies with sub-clause 6.10.6 of SUBSET-044 [N1] assuming a nominal impedance of 50 Ω at Interface 'CA_L'.
14. Report the results in the test report.
15. Test finished.

$${}^8 RL_1 = 10 \cdot \log \left(\frac{1}{f_2 - f_1} \cdot \int_{f_1}^{f_2} |S_{11}|^2 \cdot df \right) \quad RL_2 = 10 \cdot \log \left(\frac{1}{f_2 - f_1} \cdot \int_{f_1}^{f_2} |S_{22}|^2 \cdot df \right)$$

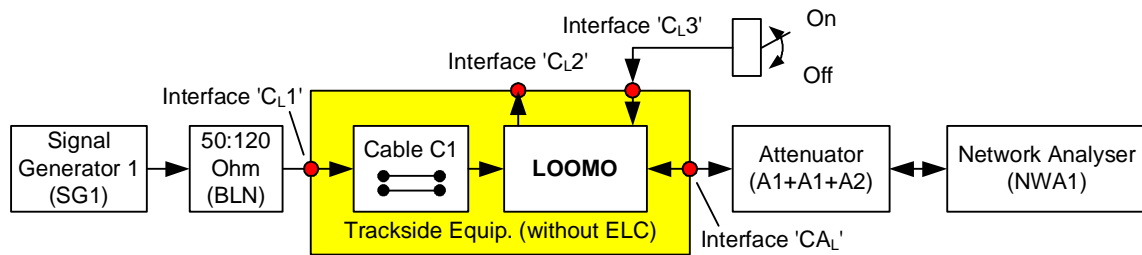


Figure 5-4: Measurement of the LOMO Return Loss at Interface 'CA_L'

5.8 Activation and Deactivation of LOOMO by Activation Signal

The Spectrum Analyser shall be calibrated against a power meter before usage.

1. Set up the measurement arrangement according to Figure 5-5 using the Activation Antenna compliant with SUBSET-085 [N4]. Free air conditions apply during this measurement. Distances and rotation angle refer to the so called "reference marks" of the antenna.
2. The cable connecting the Activation Antenna with the Signal Source SS3 shall be of double shielded low loss type (e.g., RG 214). Furthermore, the cable shall be "de-bugged" using suitable ferrite clamps evenly spaced along the cable at distances of less than 70 cm.
3. Use the Reduced Size Reference Loop (RSRL) specified in Annex H2.1 of SUBSET-085 [N4] connected via the Reference Loop Balun (RLB) specified in Annex H5 of SUBSET-085 [N4] to the Spectrum Analyser (SA) to measure the magnitude of the magnetic flux at the nominal installation position of the ELC in the outer foot of the rail (see Figure 5-5 and sub-clause 6.10.7 of SUBSET-044 [N1]). The plane of the loop of the RSRL shall be located
 - in the xy-plane, i.e. parallel to the plane of the loop of the Activation Antenna, to measure the z-component Φ_{TEz} of the magnetic flux. The RSRL shall be oriented with the longest side of its loop parallel to the x-axis as indicated in Figure 5-6.
 - in the yz-plane to measure the x-component Φ_{TEx} of the magnetic flux. The RSRL shall be oriented with the longest side of its loop parallel to the z-axis as indicated in Figure 5-6.
 - in the xz-plane to measure the y-component Φ_{TEy} of the magnetic flux. The RSRL shall be oriented with the longest side of its loop parallel to the z-axis as indicated in Figure 5-6.

The reference mark of the RSRL shall be vertically (z-direction) displaced by 550 mm ± 5 mm below the one of the geometrical centre of the Activation Antenna with an accuracy of ± 5 mm in x-direction and ± 5 mm in y-direction.

4. Switch on SS3.
5. Program Signal Source SS3 to generate a CW signal of frequency $f_{TP} = 27.095$ MHz with a tolerance of ± 5 kHz.
6. Adjust the output power of SS3 such that the magnitude of the magnetic flux $\Phi_{TE} = \sqrt{\Phi_{TEx}^2 + \Phi_{TEy}^2 + \Phi_{TEz}^2}$ received by the RSRL within a resolution bandwidth of 1 kHz centred at the actual 27.095 MHz signal frequency complies with the requirement stated in sub-clause 6.8.2.3 of SUBSET-044 [N1]. For this purpose, convert the signal power measured by the Spectrum Analyser SA into the equivalent magnetic flux value considering the properties of the RSRL antenna. The conversion of the power P_{PM2} into the magnetic flux Φ_{TE} shall be in accordance with the formula stated under point 2 within sub-clause 4.2.3.2.3 of SUBSET-085 [N4] with P_{PM2} replacing P_L and Φ_{TE} replacing Φ_{d1} in this formula. Record the value of Φ_{TE} together with the signal power P_{TP} measured by the Power Meter PM at the output of the Activation Antenna's current sense transformer in the test report.

7. Replace the RSRL and RLB with the ELC Reference Tool (ERT) specified in Annex D in such a way that the geometrical relation between the Activation Antenna and the ELC at the position of the outer foot of the rail model of the ERT is maintained. For this purpose, align the centre of the ELC's cross section in the outer foot of the ERT's rail model with the reference mark of the RSRL. See also Figure 5-7 below.
 8. Verify that the signal power P_{TP} measured by the Power Meter PM at the output of the Activation Antenna's current sense transformer at 27.095 MHz does not change by more than ± 0.1 dB relative to its value recorded in step 6 above. If not, readjust the signal power generated by SS3 accordingly to compensate for the deviation.
 9. Rotate the ELC within the ERT in its axial direction through 360° in steps of 30° . and fix it in the position yielding the smallest signal power P_2 measured with the Spectrum Analyser SA within a resolution bandwidth of 1 kHz centred at the actual 27.095 MHz signal frequency. Determine from P_2 the minimum power P_{Min} at the connector of the ERT taking into account the overall loss A of all components between the connector of the ERT and the input of the Spectrum Analyser SA.

$$P_{Min} = P_2 \cdot A$$

The value of P_{Min} is only relevant for the purposes stated in sub-clause 5.11.

Report P_2 and P_{Min} in the test report. Denote the minimum of both measurements, ELC at outer – and inner foot of the rail as required at step 7 and 27, for later use.

10. Switch off the output signal of Signal Source SS3.
11. Repeat steps 4 through 10 with a tilt of the Activation Antenna in the x axis by 15° such that the aperture of the antenna becomes facing the reference loop or the cable segment of ERT. Observe that tilting is made around an axes centred to the test antenna loop in parallel with the x-axes (if necessary readjust the y and z position). From now on use the antenna direction and ELC rotation angle which has given the lowest signal level determined from tilted or non-tilted antenna respectively.
12. Replace the Spectrum Analyser SA shown in Figure 5-7 by the measurement arrangement specified in Figure 5-8. Place the MFP 50 mm above the "sleepers" at a position of $y = 0$ mm and $x \geq 1000$ mm within the ERT.
13. Set the nominal input impedance of the DSO's input channels to 50Ω or use external 50Ω feed-through terminators.
14. Program the Signal Generator SG1 shown in Figure 5-8 to generate a nominal test signal "TSTE_nom" specified in Annex H simultaneously complying with the amplitude and timing specifications detailed in Figure 6-8 and Table 6-2, both of SUBSET-044 [N1]. This test signal shall contain only logical 0 data bits. See sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term "logical data bit". Use the nominal data rate R_d as defined in sub-clause 6.3.2 of SUBSET-044 [N1].
15. Set switch SW1 shown in Figure 5-8 to its position 0 and verify the presence of the test signal on Interface 'C_L1' using the Digital Storage Oscilloscope (DSO).
16. Set switch SW1 to its position 1.
17. Set the input of Interface 'C_L3' to its inactive state, i.e. the switch has to be opened (high impedance state).
18. Set the LOOMO to use the SSCode corresponding to the Q_SSCODE 15.



19. Set the DSO in a mode that it simultaneously records the signals on channel 1 (CH1) and channel 2 (CH2) as indicated in Figure 5-8.

20. Readjust the current output power P_{SS3} of SS3 such that the current signal power measured by the Power Meter PM is increased by the loss A_{CC1} of the coaxial cable CC1 and reduced by the measurement unaccuracy 2.2 dB. Then switch on the output signal of SS3.
21. Verify with the DSO that the LOOMO becomes activated within the time frame t_{start} as specified in sub-clause 6.8.2.3 of SUBSET-044 [N1] after the time instant of the appearance of the activation signal on Interface 'CA_L'. Record the result in the test report.
22. Measure the duration t_{on} from the activation to the deactivation of the LOOMO. Report the result in the test report.
23. Verify with the DSO that the LOOMO becomes re-activated within the time frame t_{start} as specified in sub-clause 6.8.2.3 of SUBSET-044 [N1] after it became deactivate in step 22 above. Record the result in the test report.
24. Switch off SS3 within a time frame <50 s after the re-activation of the LOOMO in step 23 above. The LOOMO shall now become deactivated within a time frame specified in sub-clause 6.8.2.3 of SUBSET_044 [N1].
25. Verify that the LOOMO stops transmitting the Euroloop signal after t_{on} elapsed.
26. Repeat steps 4 through 25 with toggling pulse modulation of SS3 as specified in Annex B1 of SUBSET_036 [N3]
27. Repeat steps 4 through 26 with the ELC in steps 7 now positioned in the inner foot of the aluminium bar of the ERT.

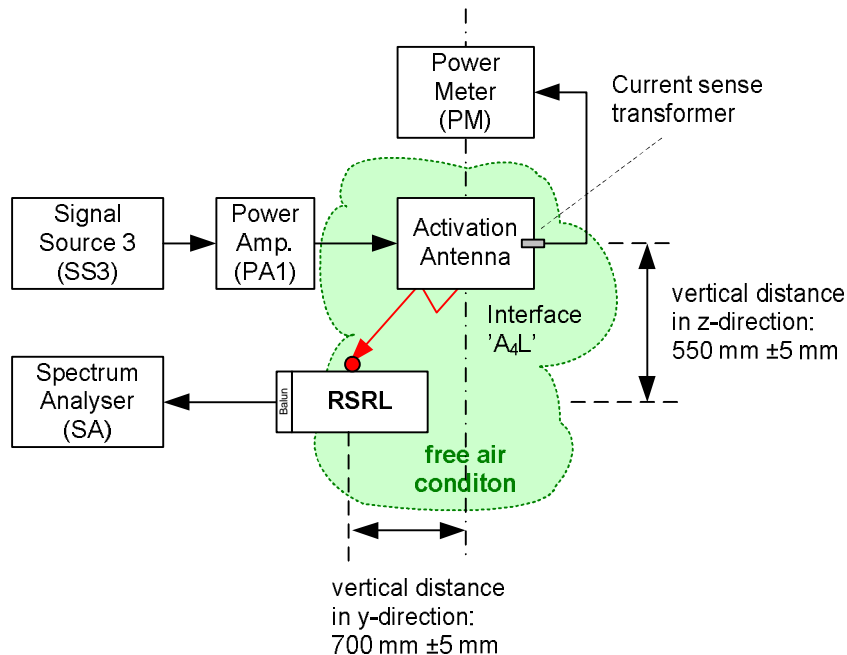


Figure 5-5: Measurement Setup for Generating Magnetic Flux of Activation Signal in Air Gap

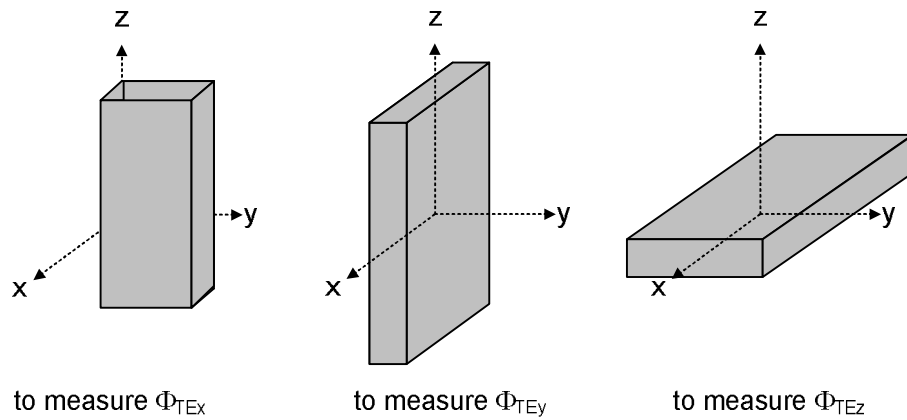


Figure 5-6: Orientations of the RSRL to measure x-, y-, and z-component of the magnetic flux Φ_{TE}

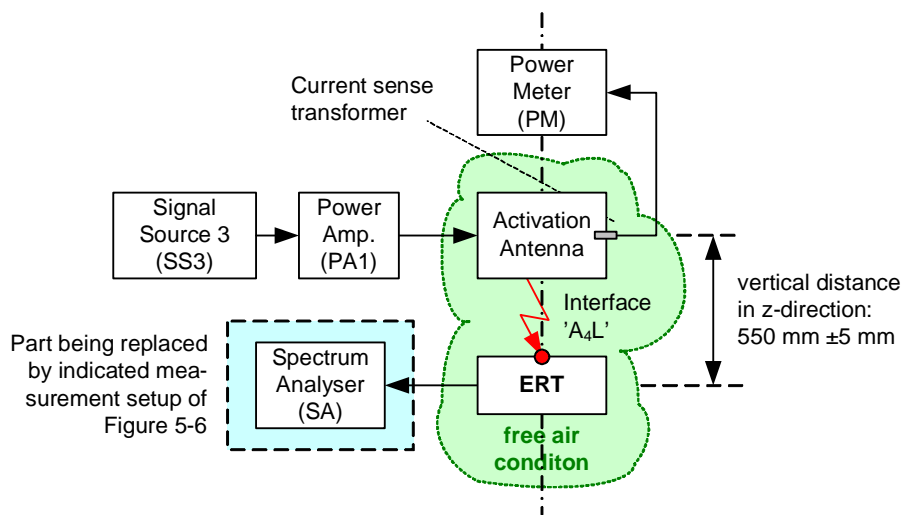


Figure 5-7: Measurement Setup to Evaluate the Worst Case Orientation of the ELC in the ERT

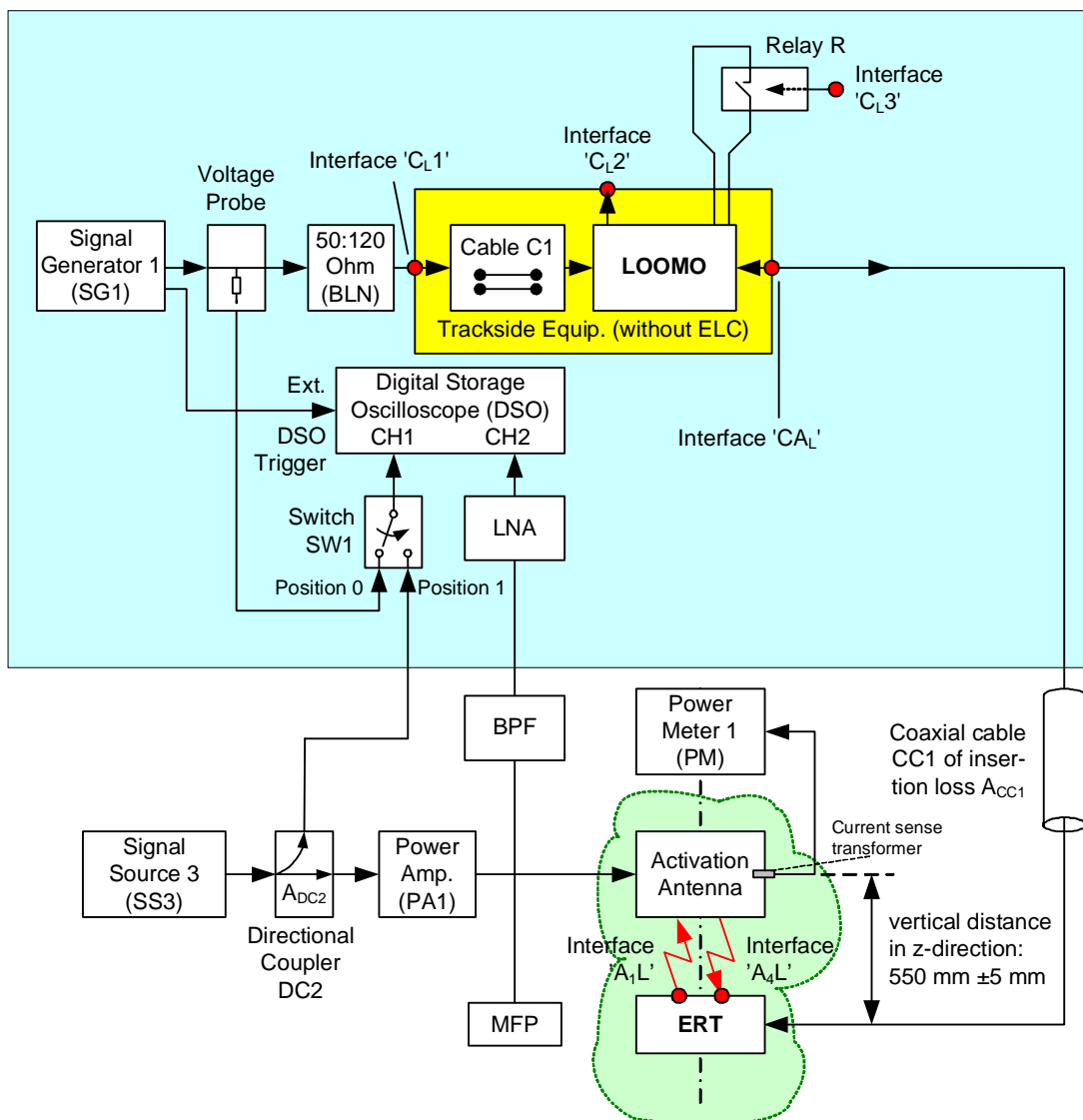


Figure 5-8: Measurement Setup for Activation & Deactivation Test of LOOMO



5.9 Activation and Deactivation Principles

1. Perform steps 1 through 21 of sub-clause 5.8.
2. Switch off the output of SG1, i.e. switch off the input signal to the LOOMO on Interface 'C_L1'.
3. Verify that the LOOMO is not transmitting an Euroloop signal by inspecting channel 2 (CH2) of the DSO. Report the result in the test report.
4. Set the input of Interface 'C_L3' to its active state, i.e. try to activate the LOOMO using Interface 'C_L3'. Repeat step 3 above. Then set the input of Interface 'C_L3' to its inactive state again.
5. Switch off the output of SS3, i.e. switch off the activation signal. Repeat step 3 above.
6. Switch on the output of SG1, i.e. switch on the input signal to the LOOMO on Interface 'C_L1'. Repeat step 3 above.
7. Set the input of Interface 'C_L3' to its active state, i.e. try to activate the LOOMO using Interface 'C_L3'. Verify that the LOOMO is transmitting an Euroloop signal by inspecting channel 2 (CH2) of the DSO. Report the result in the test report. Then set the input of Interface 'C_L3' to its inactive state again.
8. Switch on the output of SS3, i.e. switch on the activation signal. Verify that the LOOMO is transmitting an Euroloop signal by inspecting channel 2 (CH2) of the DSO.
9. Program the SG1 shown in Figure 5-8 to generate a nominal test signal "TSTE_nom" specified in Annex H simultaneously complying with the amplitude and timing specifications detailed in Figure 6-8 and Table 6-2, both of SUBSET-044 [N1]. This test signal shall contain only logical "1" data bits. See sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term "logical data bit", i.e., instruct SG1 to transmit the Deactivation Bit Pattern. Repeat step 3 above.
10. Set the input of Interface 'C_L3' to its active state, i.e. activate the LOOMO using Interface 'C_L3'. Switch off the output of SS3, i.e. switch off the activation signal. Verify that the LOOMO is transmitting an Euroloop signal by inspecting channel 2 (CH2) of the DSO.

5.10 Testing Error Indication of LOOMO – Interface ‘C_{L2}’

The triggering conditions for the error indication can be product specific.

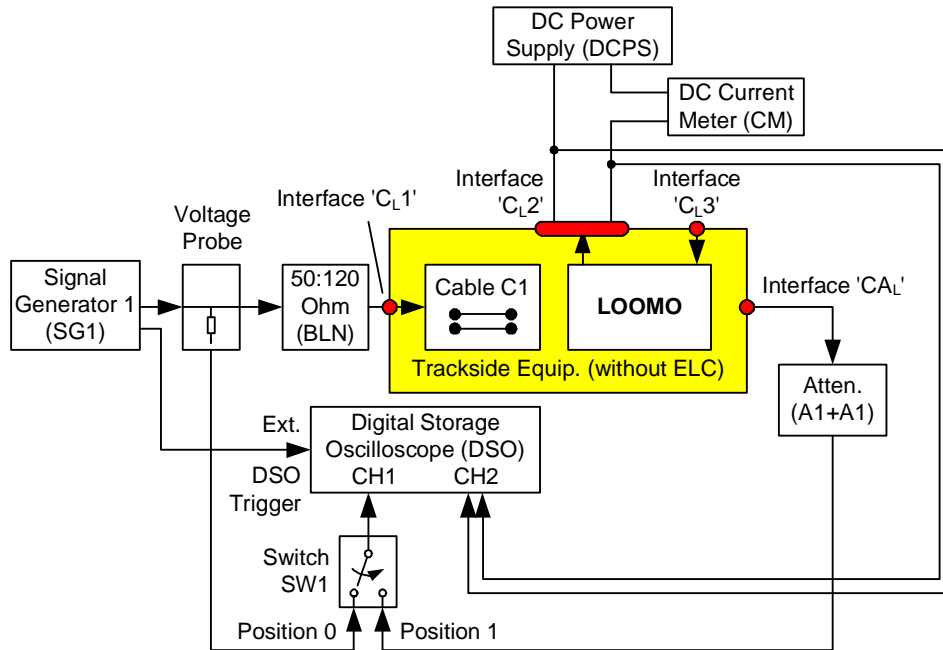


Figure 5-9: Measurement Setup for Testing Interface ‘C_{L2}’

1. Set up measurement arrangement according to Figure 5-9 using an attenuator A1 of appropriate attenuation to protect to input of the Digital Storage Oscilloscope (DSO).
2. Set the nominal input impedance of the DSO’s channel 1 (CH1) to 50 Ω or use an external 50 Ω feed-through terminator and set the input impedance of the DSO’s channel 2 (CH2) to its high impedance state.
3. Set the Current Meter (CM) to a range that allows the measurement of currents of at least 1 A.
4. Program the DC power supply DCPS to generate 5 V DC $\begin{matrix} +0.5 \text{ V DC} \\ -0.0 \text{ V DC} \end{matrix}$ and limit its output the current I to 10mA (use internal current limiting or an appropriate resistor).
5. Program the SG1 to generate the test signal “TSTE-nom” specified in Annex H and by Figure 6-8 and Table 6-2, both of SUBSET-044 [N1], and Figure H- 3. The test signals shall utilise the “logical data bit” sequence containing only logical ones (“1”). See sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term “logical data bit”. Use the nominal data rate R_d as defined in sub-clause 6.3.2 of SUBSET-044 [N1].
6. Instruct the LOOMO to use Q_SSCODE 15.

7. Switch the output signal of SG1 on.
8. Verify on CH1 of the DSO the presence of the test signal “TSTE-nom” on Interface ‘C_{L1}’.
9. Switch the output of the DC power supply DCPS on.
10. Verify with the DSO that Interface ‘C_{L2}’ is in its low impedance state, i.e., indicating no error. The voltage drop at Interface ‘C_{L2}’ shall be below the value determined by the maximum resistance⁹ specified in sub-clause 6.4 of SUBSET-044 [N1] and the applied current.
11. Verify that the LOOMO is transmitting the Euroloop signal. Record the signal voltage on CH1 with the DSO at 200 MHz sampling rate over 1 ms time span. Increase the measured value by the attenuation A1+A1 to get the voltage at interface ‘C_{A1}’. Record the calculated value in the test report (will be used as reference in tests of clause 5.11).
12. Switch the output signal of SG1 off.
13. Verify with the DSO that Interface ‘C_{L2}’ reaches its high impedance state with a delay ≤ 1.0 s, i.e., indicating an error. The delay shall be measured between the instance when the signal amplitude on Interface ‘C_{L1}’ reaches 90 % of the steady-state value and the instance when the signal on Interface ‘C_{L2}’ reaches 90 % of its final value.

⁹ The maximum contact resistance specified in Table 6.3 of SUBSET-044 shall be interpreted as maximum resistance at minimum load current.

5.11 Maximum Activation Signal Level Testing of LOOMO

This test shall be performed with the LOOMO also under extreme environmental conditions declared by the manufacturer in accordance with SUBSET-044 [N1].

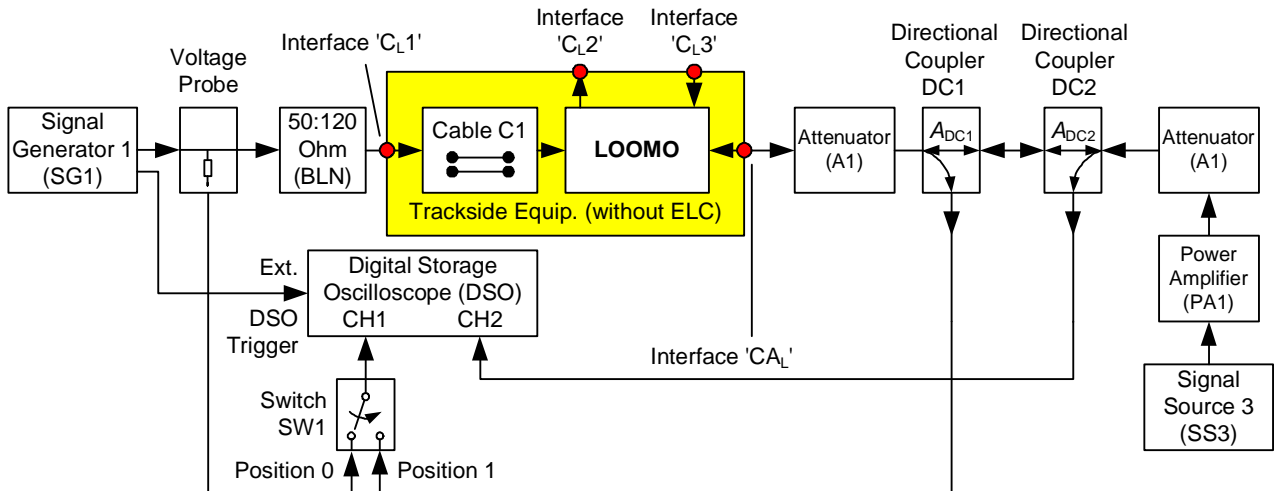


Figure 5-10: Measurement Setup for Testing of Maximum Magnetic Flux Level

1. Set up measurement arrangement according to Figure 5-10.
2. Determine the nominal value at CH1 of the DSO representing transmission from the LOOMO based on the recorded value at clause 5.10 through decreasing this value by the attenuation A1 and the coupling loss of DC1.
3. Use two attenuators A1 of attenuation values A_{Atten1} to protect the inputs of the Digital Storage Oscilloscope (DSO) and the output of Signal Source SS3. A_{Atten1} , is also improving signal source return loss and for protection of the test object.
4. Set the switch SW1 to position 0.
5. Set the nominal input impedance of the DSO's channel 1 (CH1) and channel 2 (CH2) to 50 Ω or use external 50 Ω feed-through terminators.
6. Instruct the LOOMO to use Q_SSCODE 15.
7. Set Interface 'C_L3' to its inactive state, to allow activation of the LOOMO by the activation signal from Interface 'A_L4'.
8. Switch off the output signal of SS3.
9. Program SG1 to generate the test signal "TSTE-nom" specified in Annex H and by Figure 6-8 and Table 6-2, both of SUBSET-044 [N1]. The test signals shall utilise the "logical data bit" sequence containing only logical zeros ("0"). See sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term "logical data bit". Use the nominal data rate R_d as defined in sub-clause 6.3.2 of SUBSET-044 [N1].
10. Verify with the DSO the presence of the test signal "TSTE-nom" in Interface 'C_L1'. For this purpose, check whether the signal's peak-to-peak voltage V_{2max} complies with the requirements stated in Table 6-2 of SUBSET-044 [N1]. Record the result in the test report. Then switch the output of SG1 off.
11. Set the switch SW1 to position 1.

12. Determine the equivalent signal power P_{Max} of the activation signal on interface 'CA_L' according to

$$P_{Max} = P_{Min} \left(\frac{\Phi_{Lmax}}{\Phi_{TE}} \right)^2 \cdot \varepsilon$$

where P_{Min} denotes the minimum power (in Watt) of the activation signal corresponding to the magnetic flux $\Phi_{TE} = \Phi_L / M_\Phi$ with Φ_L as specified in sub-clause 7.3.3 of SUBSET-044 [N1] and M_Φ specified in sub-clause 6.8.2.3 of SUBSET-044 [N1]. P_{Min} is the maximum measured in steps 9 and 11 of the test procedure described in sub-clause 5.8. Φ_{Lmax} is specified in sub-clause 6.8.2.2 of SUBSET-044 [N1]. $\varepsilon = 1.66$ denotes the measurement uncertainty of 2.2 dB. Please observe that for the purpose of measurement using the DSO insertion and coupling losses shall be considered.

13. Program SS3 to generate a CW signal of nominal frequency $f_{TP} = 27.095$ MHz. Adjust the power of this signal to P_{Max} determined in step 12 above and ensure that the level is set to the appropriate value such that the overall tolerance is $\leq \pm 0.5$ dB. Switch off the output of SS3.
14. Switch on the output of SG1.
15. Verify that the LOOMO is not transmitting the Euroloop signal. For this purpose, record the signal on Interface 'CA_L' with the DSO and verify that this signal's peak-to-peak amplitude remains below 10 % of the nominal value determined in step 2 above. Record the result in the test report.
16. Switch on the output of SS3.
17. Verify that the LOOMO is transmitting the Euroloop signal. For this purpose, record the signal voltage on Interface 'CA_L' with the DSO at 200 MHz sampling rate over 1 ms time span. Verify that this signal's RMS amplitude exceeds 90% of the nominal value determined in step 2 above. Record the measured value in the test report.
18. Verify with the DSO that the LOOMO becomes activated within the time frame t_{Start} as specified in sub-clause 6.8.2.3 of SUBSET-044 [N1] after the time instant of the appearance of the activation signal on Interface 'CA_L'. Record the result in the test report.
19. Wait for $10 \text{ s} \pm 1 \text{ s}$. Then repeat step 17 above.
20. Switch off the output of SS3, wait another 2 minutes, and then repeat steps 15 through 19.
21. Repeat steps 13 through 20 with toggling pulse modulation of SS3 as specified in Annex B1 of SUBSET_036 [N3].

5.12 Testing of Magnetic Field Strength Limits on Interface 'A_{L1}'

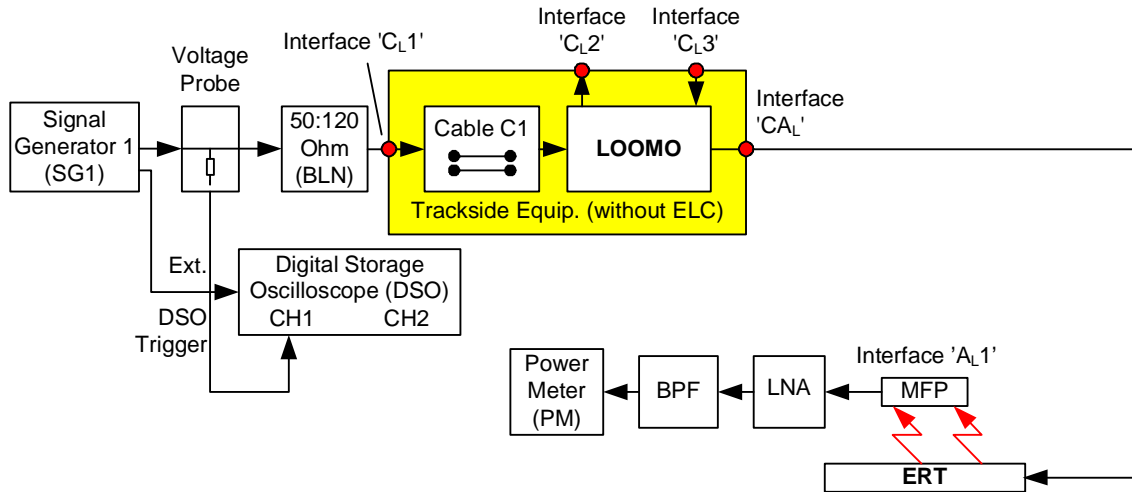


Figure 5-11: Measurement Setup for Testing Magnetic Field Strength on Interface 'A_{L1}'

1. Setup measurement arrangement according to Figure 5-11 using the ELC in the inner foot of the ERT.
2. Replace the ELC used in the ERT with the type of ELC to be used for the installation of the Euroloop the trackside environment.
3. Position the centre of the loop of MFP at the coordinates $x = 0$ m, $y = 0$ m, and $z = 300$ mm above the ERT. See Annex D for the definition of the coordinate system. Orient the MFP such that its loop lies in the x-y plane to allow for optimal reception of the z-component of the magnetic field.
4. Select a Low Noise Amplifier (LNA) in accordance with the requirements stated in sub-clause 4.4.16 featuring a suitable gain G to allow the measurement of the Euroloop signal's power with the Power Meter PM compliant with the allowed measurement uncertainty stated in Table 4-1.
5. Instruct the LOOMO to use Q_SSCODE 15.
6. Program SG1 to generate the test signal "TSTE-nom" specified in Annex H and by Figure 6-8 and Table 6-2, both of SUBSET-044 [N1]. The test signals shall utilise the "logical data bit" sequence containing only logical ones ("1"). See sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term "logical data bit". Use the nominal data rate R_d as defined in sub-clause 6.3.2 of SUBSET-044 [N1].
7. Switch the output of SG1 on.
8. Verify with the DSO the presence of a correct test signal "TSTE-nom" in Interface 'C_{L1}'.
9. Activate the LOOMO using Interface 'C_{L3}'.

10. Record the Euroloop signal power received within a 3 dB bandwidth of 4.5 MHz and a centre frequency of 13.5 MHz by the MFP in the air gap of the ERT with the Power Meter PM and determine the z-component H_z of the magnetic field strength of the Euroloop signal in the air gap Interface 'A_{L1}' taking into account the gain G of the LNA, the loss of the Band Pass Filter and the antenna factor of the MFP. Record the result in the test report. Make sure not to measure at possible instances where the LOOMO will interrupt transmitting signal for a short time according to SUBSET-044 [N1] sub-clause 6.8.2.3.
11. Verify and report that H_z is within the limits between 18 dB μ A/m and 30 dB μ A/m.

Note:

According to Figure 6-17 of SUBSET-44 [N1] the magnetic field strength H_z at the reference position in the rail is in the range of 32...67 dB μ A/m.

Based on experience, the ERT is 25.5 dB less efficient than a real installed Euroloop leaky cable. Additionally, in order to ensure compliance in the real installation, the range to be verified should also be limited. Therefore, only the range 18 dB μ A/m – 30 dB μ A/m should be verified.

5.13 Testing External Activation of LOOMO – Interface ‘C_{L3}’

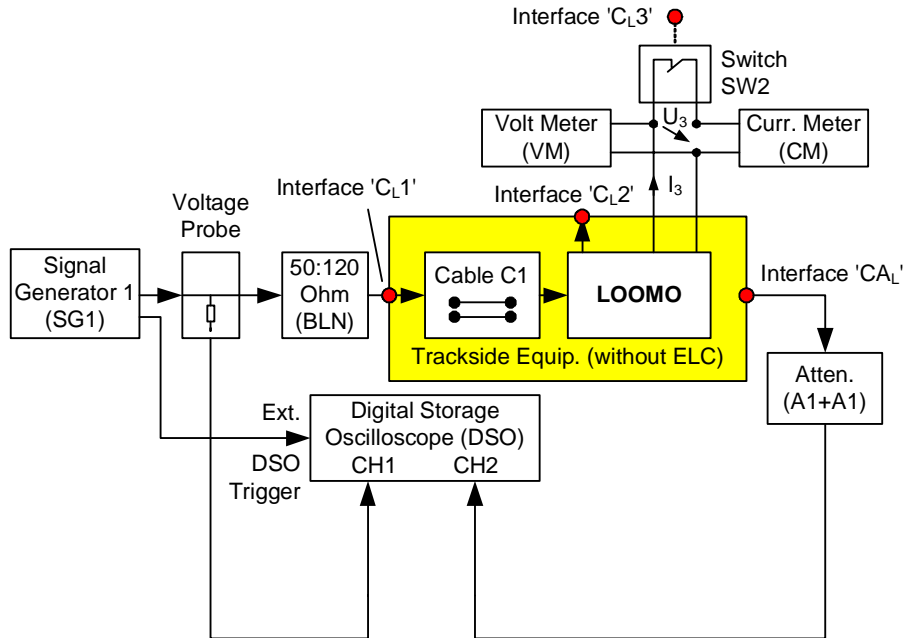


Figure 5-12: Measurement Setup for Testing Interface ‘C_{L3}’

1. Set up measurement arrangement according to Figure 5-12 using an attenuator A1 of appropriate attenuation to protect to input of the Digital Storage Oscilloscope (DSO).
2. Set the nominal input impedance of the DSO’s channel 1 (CH1) to 50 Ω or use an external 50 Ω feed-through terminator and set the input impedance of the DSO’s channel 2 (CH2) to its high impedance state.
3. Program the SG1 to generate the test signal “TSTE-nom” specified in Annex H and by Figure 6-8 and Table 6-2, both of SUBSET-044 [N1]. The test signals shall utilise only logical “1” data bits. See sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term “logical data bit”. Use the nominal data rate R_d as defined in sub-clause 6.3.2 of SUBSET-044 [N1].
4. Instruct the LOOMO to use Q_SSCODE 15.
5. Switch the output signal of SG1 on.
6. Verify on CH1 of the DSO the presence of the test signal “TSTE-nom” on Interface ‘C_{L1}’.
7. Activate the LOOMO by closing the switch SW2 using Interface ‘C_{L3}’.
8. Verify with the DC Current Meter (CM) that the current I_3 complies with the specification given in Table 6-4 of SUBSET-044 [N1].
9. Deactivate the LOOMO by opening the switch SW2 using Interface ‘C_{L3}’.
10. Verify with the DC Volt Meter (VM) that the voltage U_3 complies with the specification given in Table 6-4 of SUBSET-044 [N1].

5.14 Field Strength at Approval of Type of Installation

This test shall be performed under the actual site environmental conditions. The actual environmental conditions shall be recorded.

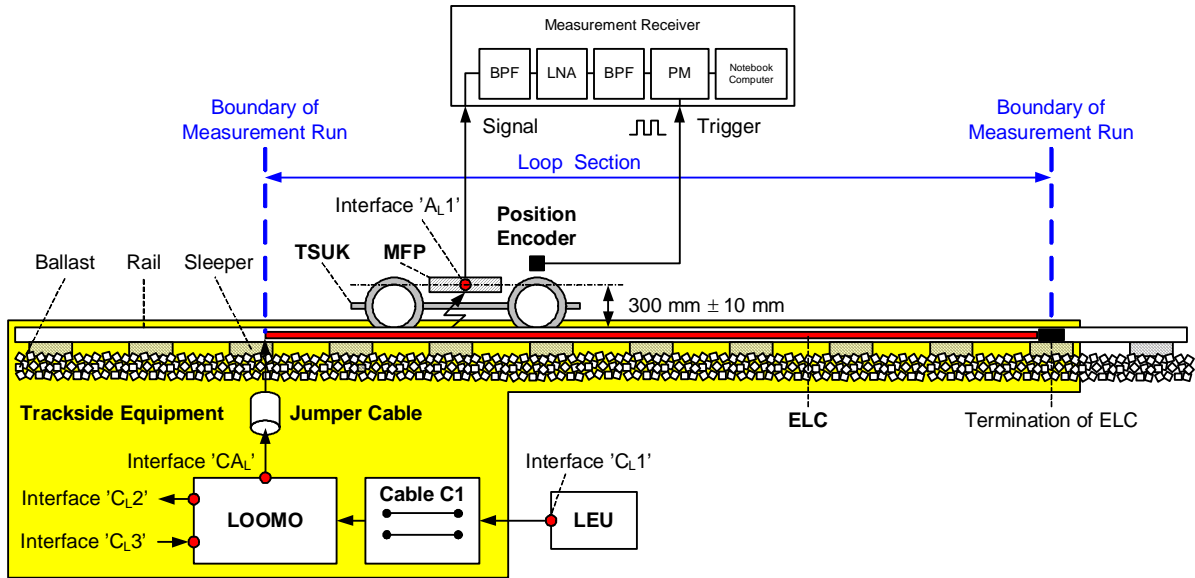


Figure 5-13: Measurement Setup for Testing Magnetic Field Strength at Approval of Installation

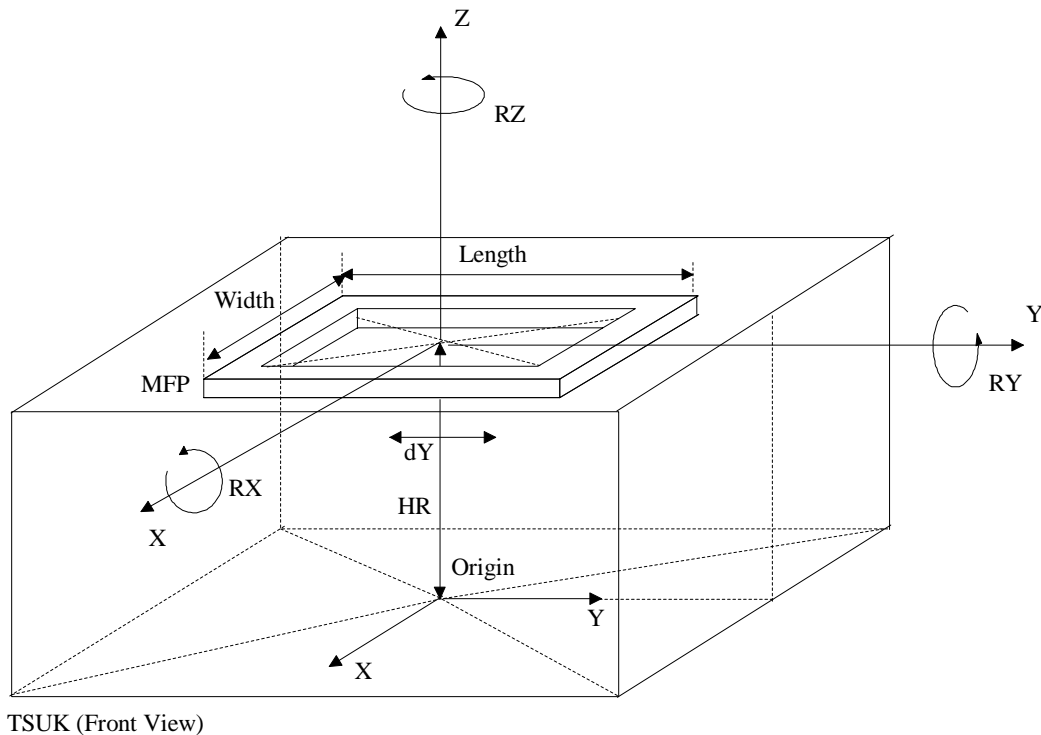


Figure 5-14: Position of the MFP with Respect to the Rail

Table 5-1: Nominal Position and Positioning Error of MFP with Respect to Rail

Parameter	Nominal Position	Accuracy
dY	0 mm	±10 mm
HR	300 mm	±10 mm
RX	0°	±5 °
RY	0°	±5 °
RZ	0°	±5 °

Table 5-2: Metal Free Volume around MFP

Parameter	Value	Condition
x-direction from geometrical centre of MFP	± 1000 mm	Except cables and measurement instruments. Measurement instruments and required cables shall be displaced in x-direction from the centre of the MFP by at least 300 mm. This does not apply for the cable connecting the MFP.
y-direction from geometrical centre of MFP	± 1000 mm	Except cables and measurement instruments. Measurement instruments and required cables shall be displaced in y-direction from the centre of the MFP by at least 300 mm. This does not apply for the cable connecting the MFP.
z-direction from geometrical centre of MFP	+1000 mm-HR	No metal objects between the top-of-sleeper (i.e. foot of rail) and stated limit except the rails, its installation materials and smaller objects like bolts or bearings of the measurement vehicle carrying the MFP.

1. Setup the measurement arrangement according to Figure 5-13. Respect the positioning of the Magnetic Field Probe (MFP) with respect to the rails as specified in Figure 5-14 and Table 5-1. Respect a metal free volume around the geometrical centre of the MFP as specified in Table 5-2 with the exception of the metal parts of the MFP itself and its feeding cable (incl. connector).
 2. Switch off the LOOMO of the Loop Section under investigation and make sure that parallel Euroloops at adjacent tracks are not active.
 3. Measure the uncorrelated power of the signal provided by the z-component H_z of the magnetic field strength at the reference position defined in sub-clause 5.5.2 of SUBSET-044 [N1] along the whole Loop Section at distance intervals of ≤ 0.2 m within a 3 dB bandwidth of 4.5 MHz centred at the centre frequency f_c defined in sub-clause 6.7.5 of SUBSET-044 [N1]. The integration time for continuous average power measurement shall be 20 ms.
 4. Determine the RMS value of the z-components $H_{zw_Euroloop}$ of the magnetic field strengths of the signal on the air gap Interface 'A_L1' along the Loop Section considering all losses and the LNA gain between the output of the MFP and the input of the measurement receiver, and the antenna factor of the MFP specified in Annex E. Record the result in the test report.
 5. Verify that the z-component H_z of the magnetic field strength determined in step 4 above complies with the requirements stated in item nr. 3 of sub-clause 4.2.4 (after step 9 has been performed) and report the result in the test report.
 6. Switch on the LOOMO of the Loop Section under investigation.
 7. Instruct the LOOMO of the Loop Section under investigation to use Q_SSCODE 15.
 8. Activate the LOOMO using Interface 'C_L3' to allow for the recording of the Euroloop signal.
 9. Repeat steps 3 and 4.
 10. Verify that the z-component H_z of the magnetic field strength determined in step 9 above complies with the limits. These limits at the approval of installation shall comply to the requirements stated in sub-clause 6.8.3.2 and sub-clause 6.10.9 of SUBSET-044 [N1]. Report the result in the test report.
 11. Verify that the requirement stated in sub-clause 6.10.5 of SUBSET-044 [N1] is met along the Loop Section of Double or Common Euroloops defined in sub-clause 6.1.3 of SUBSET-044 [N1]. For this purpose, determine the Signal-to-Interference Ratio (SIR) specified in sub-clause 6.10.5 of SUBSET-044 [N1] using the results at common x-positions obtained
 - in step 9 above for the wanted Loop Section.
 - from a corresponding measurement for the unwanted Loop Section
 12. Repeat steps 2 through 6.

5.15 Power consumption of LOOMO

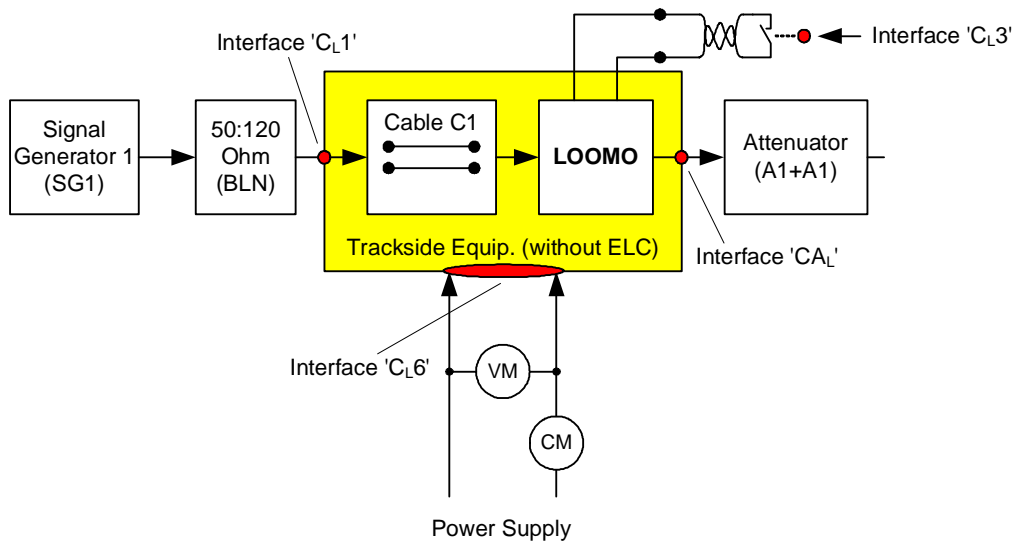


Figure 5-15: Setup to measure power consumption

1. Setup measurement arrangement according to Figure 5-15.
2. Use Attenuator (A1+A1) as termination of 'CA_L' to guarantee that the LOOMO operates within its range of specification.
3. Program the Signal Generator 1 (SG1) to generate a nominal test signal "TSTE_nom" specified in Annex H complying with the amplitude and timing specifications detailed in Figure 6-8 and Table 6-2, both of SUBSET-044 [N1]. The test signals shall utilise the "logical data bit" sequence consisting of only logical ones ("1"). See sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term "logical data bit". Use the nominal data rate R_d as defined in sub-clause 6.3.2 of SUBSET-044 [N1].
4. Instruct the LOOMO to use Q_SSCODE 00 as defined in Table F-1 of Annex F in [N1].
5. Set Power Supply to the nominal voltage specified by the supplier.
6. Read voltage U_{CL6} at VM and current I_{CL6} at CM.
7. Calculate the apparent power $P_a = U_{CL6} \cdot I_{CL6}$
8. Verify that the requirement stated in sub-clause 6.6 of SUBSET-044 [N1] is met and report the result in the test report.
9. Repeat steps 5 through 8 with maximum "power supply voltage" specified by the supplier.
10. Repeat steps 5 through 8 with minimum "power supply voltage" specified by the supplier.

5.16 Return Loss at Interface 'C_{L1}'

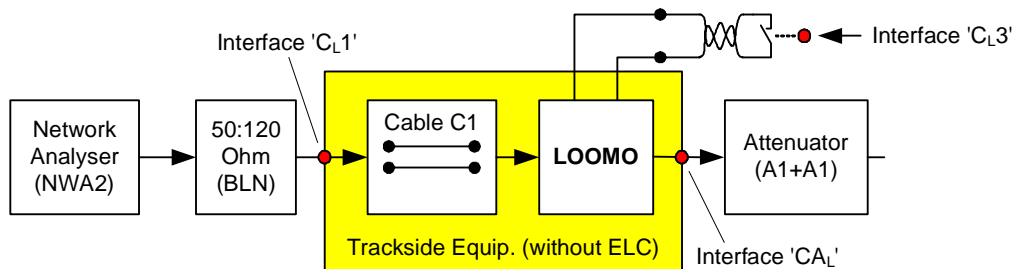


Figure 5-16: Setup to measure Return Loss at Interface 'C_{L1}'

1. Setup measurement arrangement according to Figure 5-16. The Cable C1 of the Trackside Equipment shall have a length of less than 10 m.
2. Use Attenuator (A1+A1) as termination of 'C_{A_L}' to guarantee that the LOOMO operates within its range of specification.
3. Set the frequency range of the NWA2 to the range as specified in SUBSET-044 [N1] Table 6-2.
4. Setup the NWA2 to measure S_{11} and calibrate it at the 120Ω side including the BLN.
5. Measure the reflection coefficient S_{11} at Interface 'C_{L1}' into the LOOMO.
6. Verify that the return loss values ($20 \log_{10}|S_{11}|$) recorded in step 5 above comply with the specification limits in Table 6-2 of [N1] assuming a nominal impedance of 120 Ω at Interface 'C_{L1}'.
7. Report the result in the test report.
8. Test finished.

5.17 Bit Error Ratio Measurement on Interface 'CA_L'

1. Set up the measurement arrangement according to Figure 5-2. The purpose of the measurement is to test the Bit Error Ratio of the modulated signal at Interface 'CA_L'. Set the nominal input impedance of the DSO's input channels to 50 Ω or use external 50 Ω feed-through terminators. Use a suitable attenuator to guarantee that the DSO operates within its range of specifications.
2. Use a "Cable C1" of maximum length specified by the manufacturer.
3. Instruct the LOOMO to use Q_SSCODE 00 as defined in Table F-1 of Annex F in [N1].
4. Activate the LOOMO by switching Interface 'CL3' to its low impedance state.
5. Program the Signal Generator 1 (SG1) to generate "TSTE_minmax" specified in Annex H.
6. Check that the Euroloop signal is present on Interface 'CA_L'.
7. Follow the test steps of Annex A which defines the detailed signal processing procedure for evaluating and extracting the logical data bit sequence. Contrary to specification in Annex A apply a nominal sampling interval of $\Delta t = 10$ ns. The acquired sample set comprises a time span of 9.9998 ms and the result will cover 94 data bits.
8. Compare the obtained data bit sequence with the required repetitive bit sequence "110" and record the number of erroneous bits.
9. Verify the Bit Error Ratio falls below one tenth of the BER_{DR} specified in sub-clause 7.5.2.1.1 of SUBSET-044 [N1] with the accuracy stated in sub-clause 4.6. For this purpose repeat steps 7 through 8 as many times as required to test the amount of bits specified in Annex I. Add the number of Bit Errors of all repetitions and proceed as specified in Annex I.
10. Report the result in the test report.
11. Test finished.

6 TESTING OF ON-BOARD EQUIPMENT

6.1 Interface 'A_{L4}' – Activation Signal

1. Setup the measurement instruments according to Figure 6-1, i.e. in accordance with sub-clause 5.2.7.2 of SUBSET-085 [N4] using the Reduced Size Reference Loop (RSRL) at the position defined by the coordinates $x_{RSRL} = 0$ mm, $y_{RSRL} = 700$ mm, and $z_{RSRL} = -160$ mm.

Figure 6-1 reproduces the setup for the measurement of the magnetic flux from sub-clause 5.2.7.2 of SUBSET-085 [N4] with the exception of the Reference Loop Balun (RLB).

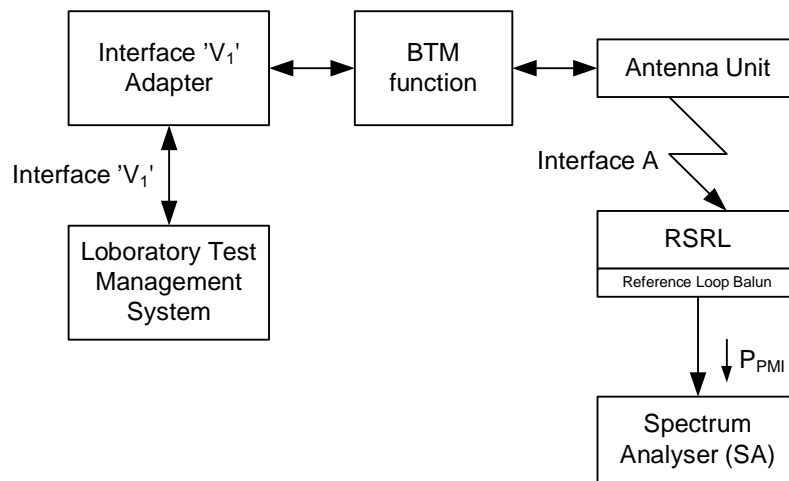


Figure 6-1: Setup for Magnetic Flux Measurements

The coordinate system and the orientation of the RSRL for the measurement of the x-, y-, and z-component of the magnetic field are defined by Figure 6-2. The origin of the coordinate system shall be in the plane of the Top of Rail (ToR) in the middle between the rails. The two rails indicated in Figure 6-2 shall not be present in the measurement setup. They simply serve as height references.

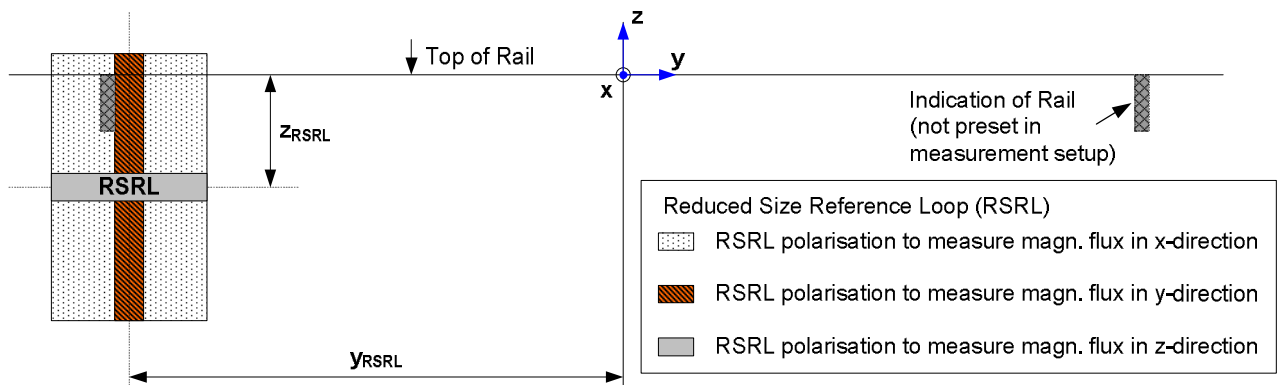


Figure 6-2: Setup for Measurement of Activation Signal

2. Use the metallic environment of the on-board AU complying with Test Case 1 specified in sub-clause B5.3.7 of SUBSET-085 (The specification of the metallic environment is for convenience reproduced from SUBSET-085 in Figure 6-3 below).

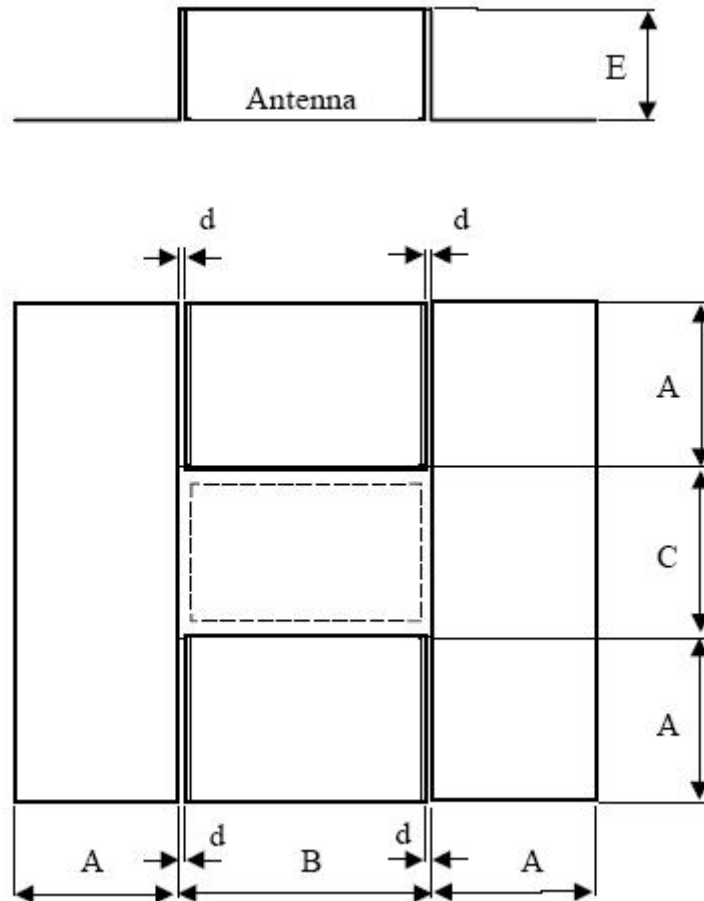


Figure 6-3: Metallic Box Around the On-board Antenna Unit

Note: The distance 'A' amounts to 300 mm. The distances 'B', 'C', 'E', and 'd' are manufacturer specific. For the measurements, manufacturer specific values specified for the antenna under test of the parameters 'B', 'C', 'E', and 'd' shall be chosen that result in the magnitude $|\vec{\Phi}_L| = \sqrt{\Phi_{Lx}^2 + \Phi_{Ly}^2 + \Phi_{Lz}^2}$ of the magnetic flux measured with the RSRL. Φ_{Lx} , Φ_{Ly} , and Φ_{Lz} denote, the respectively x-, y-, and z-components of the magnetic flux $\vec{\Phi}_L$.

3. Use the Reduced Size Reference Loop (RSRL) of size 200 mm × 390 mm as specified in SUBSET-085 [N4] in longitudinal position to measure the x-, y-, and z-component of the magnetic flux. The longitudinal position is defined by the longest side of the RSRL to be parallel to
 - the x-axis for measurements of the z-component of the magnetic flux,
 - the z-axis for measurement of the x- and y-component of the magnetic flux.
 Orient the plane of the loop of the RSRL parallel to the
 - yz-plane to measure the x-component of the magnetic flux.
 - xz-plane to measure the y-component of the magnetic flux.
 - xy-plane to measure the z-component of the magnetic flux.
4. Locate the on-board AU within manufacturer specific ranges of allowed positions as outlined in sub-clause 6.5.4 of SUBSET-036 [N3].
5. Switch on the BTM function to provide the transmission of the activation signal from the on-board AU.
6. Explore the manufacturer specific ranges of the on-board AU installation as outlined in sub-clause 6.5.4 of SUBSET-036 [N3] including
 - its vertical distance dz_{AU} from Top of Rail (ToR),
 - its lateral deviation dy_{AU} y-direction,
 - its tilt angle α_t ,

to determine its orientation that minimises the magnitude $|\Phi_L|$ of the magnetic flux Φ_L . Respect the requirements stated in step 3 above while measuring the x-, y-, and z-component of the magnetic flux Φ_L . The determination of Φ_{Lx} , Φ_{Ly} , and Φ_{Lz} shall be based on the power P_{PM} of the activation signal measured with the Spectrum Analyser SA (see Figure 6-1) for each orientation of the RSRL within the resolution bandwidth of 1 kHz centred at the actual 27.095 MHz signal frequency. The conversion of the power P_{PM} into magnetic flux shall be in accordance with sub-clause 4.2.3.2.3 of SUBSET-085 [N4].

Note: The Spectrum Analyser SA shall be calibrated against a power meter before usage.

7. Report the magnitude $|\vec{\Phi}_L|$ of the minimum magnetic flux $\vec{\Phi}_L$ in the test report and verify that it exceeds the limit stated in sub-clause 7.3.3 of SUBSET-044 [N1].
8. Repeat steps 6 and 7 above provided that the RSRL is located at the position $x_{RSRL} = 0$ mm, $y_{RSRL} = 750$ mm, and $z_{RSRL} = -160$ mm.
9. Repeat steps 6 through 8 with toggling pulse modulation of BTM function as specified in Annex B1 of SUBSET_036 [N3]

6.2 Transfer of Spreading Code Number to Loop Receiver

1. Setup the measurement arrangement according to Figure 6-4 and Figure 6-5. Make sure that the On-board Equipment is set to its operational state. Use a Balun at the inputs of the DSO to terminate the Data and Clock lines into nominal 120 Ω.

Position the reference marks of the Antenna Unit (AU) at the co-ordinates $x_{AU} = 0$ m, $y_{AU} = 0$ m, and $z_{AU} = 300$ mm above the ELC Reference Tool (ERT, see Annex D for the definition of the co-ordinate system).

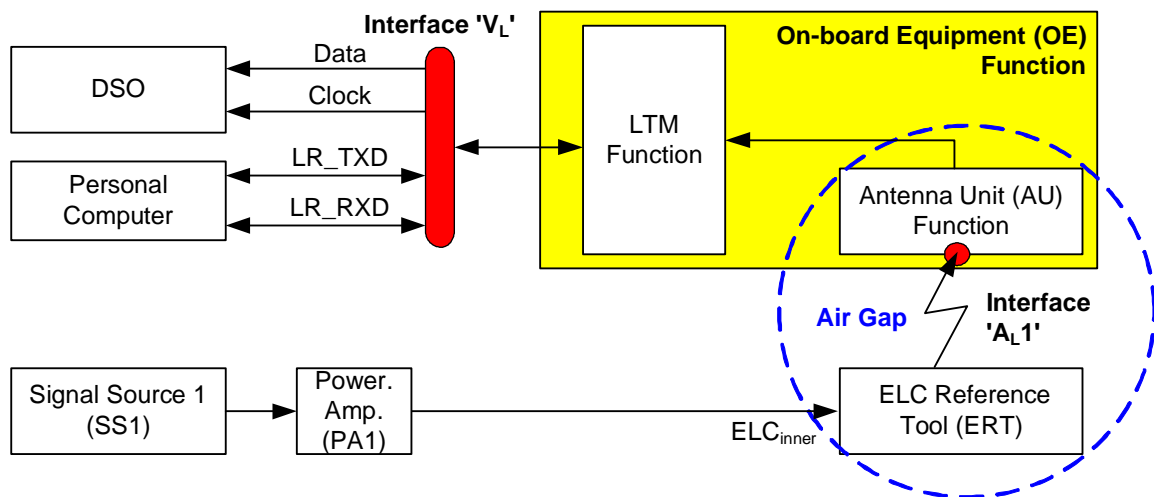


Figure 6-4: Measurement Setup with one Signal Source for Testing On-board Equipment

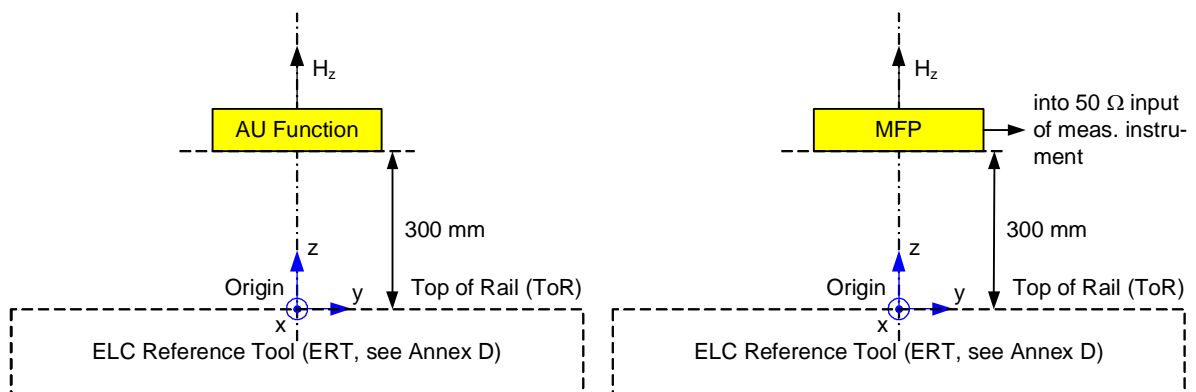


Figure 6-5: Arrangements of ELC Reference Tool (ERT) with a) Antenna Unit (left side) and b) Magnetic Field Probe (right side).

2. Command the On-board-Equipment (OE) through Interface 'V_L' to use the spreading code Q_SSCODE 15.

3. Set the SS1 to generate the Test Signal TSOE1 specified in Annex H.1.3.2 using spreading code Q_SSCODE 00 and adjust the output level of SS1 such as to generate a z-component of the magnetic field strength specified in sub-clause 7.5.2.1.2 of SUBSET-044 [N1] at the mounting position of the AU specified in step 1 and Figure 6-5a above. For this purpose, replace the AU by the MFP as indicated in Figure 6-5b and measure the power of Test Signal TSOE1 at the output of the MFP into a 50Ω load ($V_{SWR} < 1.3$) within a 3 dB-bandwidth of 4.5 MHz centred at the centre frequency f_c defined in sub-clause 6.7.5 of SUBSET-044 [N1]. Convert this signal power into magnetic field strength RMS value using the antenna factor of the MFP detailed in Annex E to adjust the magnetic field strength RMS value at the location of the AU to the required value.
4. Verify that the On-board Equipment did not receive the correct Q_SSCODE by verifying that no demodulated output data are provided by the Loop Receiver (LR) on the "Data" line of Interface 'V_L'. For this purpose, check for the presence of the clock signal on the "Clock" line of Interface 'V_L'. According to Annex F.2.4.1, this clock signal is not toggling until valid data is available on the corresponding "Data" line of Interface 'V_L'. Therefore, check whether the voltage provided on the "Clock" line remains below the minimum voltage U_{Diff} specified in Table F- 1 of Annex F.2.2. Record this fact together with the Q_SSCODE used in the Test Signal TSOE1 and the LR in the test report.
5. Command the On-board-Equipment (OE) through Interface 'V_L' to use the spreading code Q_SSCODE 00.
6. Verify that the On-board Equipment received the correct Q_SSCODE by verifying that the demodulated output data on the "Data" line of Interface 'V_L' of the Loop Receiver (LR) coincide with the ones used to generate the Test Signal TSOE1. For this purpose, record at least 100 logical data bits from the "Data" line of Interface 'V_L' at the rising edges of the corresponding clock signal. Verify that these logical data bits coincide with the ones used to generate the Test Signal TSOE1. Be aware that the data is recorded asynchronously to the repetitive test pattern of logical "1" and "0" data bits specified in **Fehler! Verweisquelle konnte nicht gefunden werden.** for the TSOE1. Record the result together with the Q_SSCODE used in the Test Signal TSOE1 and the LR in the test report.
7. Repeat step 3 through 6 increasing the Q_SSCODE number first in step 3 and after completion of step 4 also in step 5, by one (1) until the Q_SSCODE exceeds 15.

6.3 Dynamic Range of the Receiver

This test shall also be performed with the Loop Transmission Module (LTM) at the extreme environmental conditions declared by the manufacturer in accordance with SUBSET-044 [N1].

1. Setup the measurement arrangement according to Figure 6-4 and Figure 6-5. Make sure that the On-board Equipment is set to its operational state. Use a Balun at the inputs of the DSO to terminate the Data and Clock lines into nominal 120 Ω .

Position the reference marks of the Antenna Unit (AU) at the co-ordinates $x_{AU} = 0$ m, $y_{AU} = 0$ m, and $z_{AU} = 300$ mm above the ELC Reference Tool (ERT, see Annex D for the definition of the co-ordinate system).

2. Temporarily replace the AU within the setup shown in Figure 6-4 by the Magnetic Field Probe (MFP), the Band-Pass Filter (BPF) and the Power Meter PM as shown in Figure 6-6 below.
3. Orient the MFP such that the plane of its loop antenna is parallel to the xy-plane to allow the measurement of the z-component of the magnetic field.

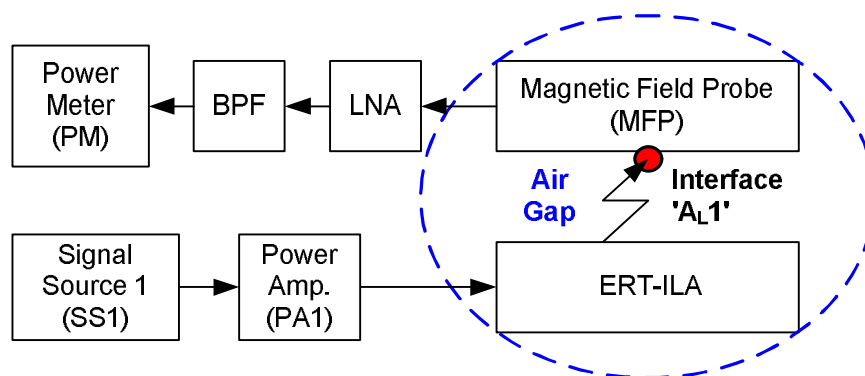


Figure 6-6: Setup for Calibration of Magnetic Field Strength of one Signal Source in the Air Gap

4. Adjust the output level of SS1 such that the z-component $H_{zw-Euroloop}$ of the corresponding magnetic field strength of the generated Test Signal TSOE2 specified in Annex H.1.3.3 with Q_SSCODE 00 amounts to the sensitivity limit specified in sub-clause 7.5.2.1.2 of SUBSET-044 [N1] reduced by measurement uncertainty of 2.2 dB. For this purpose measure the signal power at the output of the MFP with the 3 dB-bandwidth of 4.5 MHz centred at the centre frequency f_c (see sub-clause 6.7.5 of SUBSET-044 [N1]) into a 50 Ω load. Convert this signal power to the corresponding magnetic field strength RMS value using the antenna factor of the MFP as detailed in Annex E to adjust the magnetic field strength RMS value as specified above.
5. Revert to the set-up of Figure 6-4 with the reference marks of the AU at the same position as the geometrical centre for the MFP.
6. Set Signal Source SS1 to generate the Test Signal TSOE2 specified in Annex H.1.3.3 using Q_SSCODE 00.
7. Command the Onboard-Equipment (OE) through Interface 'V_L' to use the Q_SSCODE 00.
8. Record the demodulated output data of the Loop Receiver on Interface 'V_L' for a sufficiently long period of time to allow the determination of Bit Error Ratio BER_{DR} specified in sub-clause 7.5.2.1.1 of SUBSET-044 [N1] with the accuracy stated in sub-clause 4.6. For this



purpose, record the data bits from the “Data” line at successive rising edges of the clock signal on the “Clock” line of Interface ‘V_L’ and proceed as specified in Annex I.

9. Document in the test report
 - the results determined in step 8 above.
 - the Test Signal name (i.e., TSOE2) and its the magnetic field strength at the reference position as measured in step 4 above, and
 - the Q_SSCODE used with the Test Signal (i.e., Q_SSCODE 00).
10. Repeat steps 6 through 9 using in step 6 one by one all other Q_SSCODEs listed in Annex F of SUBSET-044 [N1].
11. Repeat steps 2 through 10 but instead using in step 4 the upper limit of the dynamic range of the On-board Equipment specified in sub-clause 7.5.2.1.3 of SUBSET-044 [N1] increased by measurement uncertainty (including standingwave phenomena between LNA and MFP) of 2.2 dB. To generate the high required field strength the ERT has to be replaced by the ERT-ILA. Setup the measurement arrangement according to Figure 6-6 and Figure 6-8.

Position the reference marks of the Antenna Unit (AU) at the co-ordinates $x_{AU} = 0$ m, $y_{AU} = 0$ m, and $z_{AU} = 300$ mm above the ERT-ILA (see Annex D for the definition of the coordinate system).

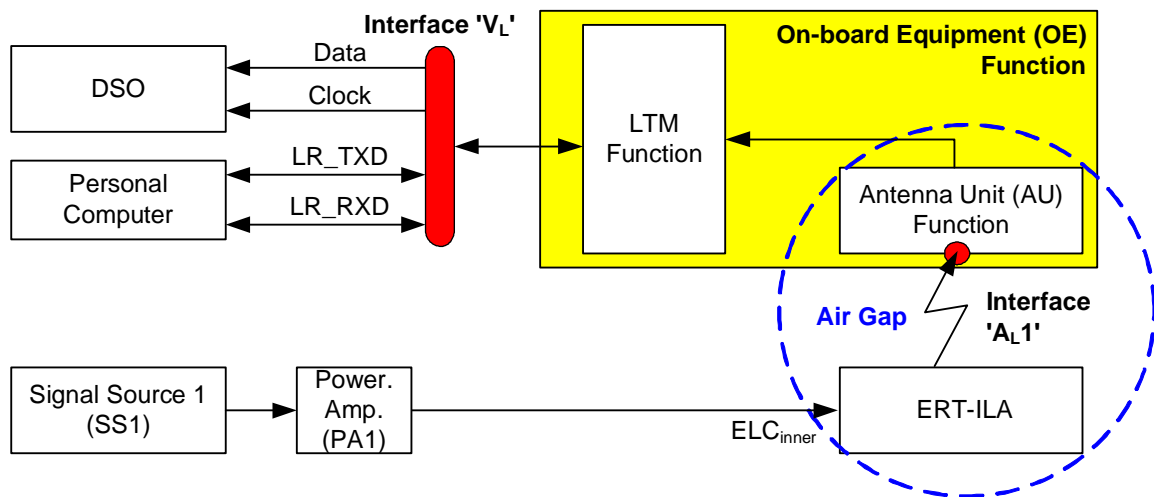


Figure 6-7: Measurement Setup with ERT-ILA for Testing On-board Equipment

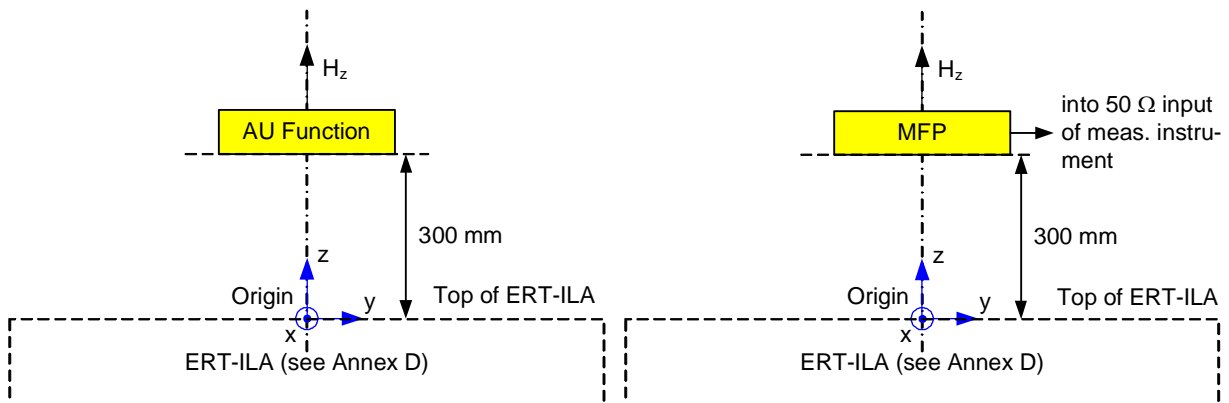


Figure 6-8: Arrangements of ERT-ILA with a) Antenna Unit (left side) and b) Magnetic Field Probe (right side).

6.4 Doppler Immunity

1. Perform the test procedure specified in sub-clause 6.3 using instead of the Test Signal TSOE2 first the Test Signals TSOE3, and then the Test Signal TSOE4 (each generated by SS1) specified in Annexes H.1.3.4, and H.1.3.5, respectively. Additionally replace in steps 8 through 9 the limit BER_{DR} by the limit BER_{DI} specified in sub-clause 7.5.2.2 of SUBSET-044 [N1].

6.5 Inter-modulation Immunity

1. Setup the measurement arrangement according to Figure 6-9 and Figure 6-8. Use a Balun at the inputs of the DSO to terminate the Data and Clock lines into nominal 120 Ω .

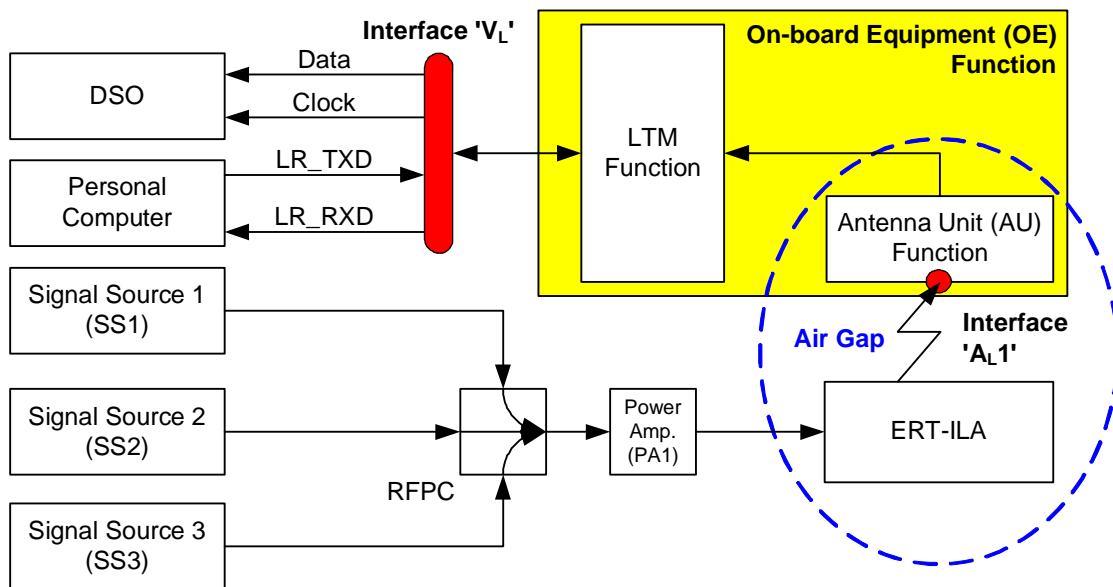


Figure 6-9: Measurement Setup with three Signal Sources for Testing On-board Equipment

2. Switch off the outputs of the Signal Sources SS1, SS2, and SS3.
3. Temporary replace the Antenna Unit (AU) function shown in Figure 6-9 by the Magnetic Field Probe (MFP), the Band-Pass Filter (BPF) and the Power Meter PM as shown in Figure 6-10 below.

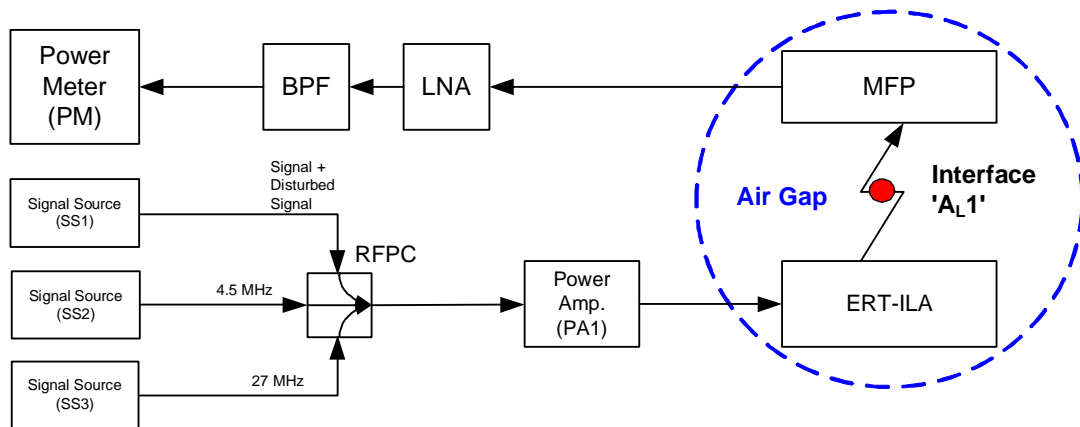


Figure 6-10: Setup for Calibration of the Magnetic Field Strengths of 3 Signal Sources in the Air Gap

4. Orient the MFP such that the plane of its loop antenna is parallel to the xy-plane to allow the measurement of the z-component of the magnetic field.
5. Set SS2 to generate a monochromatic signal of nominal frequency 4.5 MHz, i.e. Test Signal TSOE5a as specified in Annex H.1.3.6.1.
6. Switch on the output of SS2.
7. Adjust the output level of SS2 such that the z-component $H_{zu,IM}$ of the corresponding magnetic field strength RMS value of this unwanted monochromatic Test Signal TSOE5a amounts to as the level specified in sub-clause 7.5.2.3 of SUBSET-044 [N1]. For this purpose, measure the power of the Test Signal TSOE5a at the output of the MFP into a load of 50Ω within a 3 dB-bandwidth of 10 kHz centred at 4.5 MHz. Then convert this signal power to the corresponding magnetic field strength RMS value using the antenna factor of the MFP as detailed in Annex E and adjust the magnetic field strength RMS value as specified above.
8. Switch off the output of SS2.
9. Instruct SS3 to generate a monochromatic signal of nominal frequency 27.095 MHz, i.e. Test Signal TSOE5b as specified in Annex H.1.3.6.2.
10. Switch on the output of SS3.
11. Adjust the output level of SS3 such that the z-component $H_{zu,IM}$ of the corresponding magnetic field strength RMS value of this unwanted monochromatic Test Signal TSOE5b amounts to the value specified in sub-clause 7.5.2.3 of SUBSET-044 [N1]. For this purpose, measure the power of the Test Signal TSOE5b at the output of the MFP into a resistive load of 50Ω within a 3 dB-bandwidth of 30 kHz centred at 27.095 MHz. Then convert this signal power to the corresponding magnetic field strength RMS value using the antenna factor of the MFP as detailed in Annex E.
12. Switch off the output of SS3.
13. Set $N = 00$.
14. Instruct SS1 to generate the Test Signal TSOE2 specified in Annex H.1.3.3 using $Q_SSCODE N$.

15. Switch on the output of SS1.
16. Adjust the output level of SS1 such that the z-component $H_{z\text{-Euroloop}}$ of the corresponding magnetic field strength RMS value of the wanted Euroloop Test Signal TSOE2 amounts to sensitivity limit specified in sub-clause 7.5.2.1.2 of SUBSET-044 [N1]. For this purpose, measure the power of the Test Signal TSOE2 at the output of the MFP into a resistive load of 50Ω within a 3 dB-bandwidth of 4.5 MHz centred at the centre frequency f_c defined in sub-clause 6.7.5 of SUBSET-044 [N1]. Then convert this signal power to the corresponding magnetic field strength RMS value using the antenna factor of the MFP as detailed in Annex E.
17. Switch off the output of SS1.
18. Replace the MFP by the Antenna Unit (AU) function used to receive the up-link signal from Interface 'A_L1'. Orient the plane of the loop of this physical part of the AU in the xy-plane to receive the z-component of the magnetic field.
19. Instruct the Onboard-Equipment (OE) through Interface 'V_L' to use the Q_SSCODE N.
20. Switch on the outputs of SS1, SS2, and SS3.
21. Record the demodulated output data of the Loop Receiver (LR) on Interface 'V_L' for a sufficiently long period of time to allow the determination of Bit Error Ratio BER_{IMI} specified in sub-clause 7.5.2.3 of SUBSET-044 [N1] with the accuracy stated in sub-clause 4.6. For this purpose, record the data bits from the "Data" line at successive rising edges of the clock signal on the "Clock" line of Interface 'V_L' and proceed as specified in Annex I.
22. Document in the test report
 - the BER_{IMI} verified in step 21 above together with the limit for the BER_{IMI} as stated in sub-clause 7.5.2.3 of SUBSET-044 [N1].
 - the magnetic field strengths RMS value of the signal levels adjusted in step 7, 11, and 16 above at the reference position, and
 - the Q_SSCODE together with the names of the Test Signals used.
23. If $N < 15$ increase N by one (1).
24. Instruct SS1 to generate the Test Signal TSOE2 as specified in Annex H.1.3.3 using Q_SSCODE N.
25. Instruct the On-board Equipment (OE) through Interface 'V_L' to use the Q_SSCODE N.
26. Repeat steps 21 through 25 while $N \leq 15$.
27. Repeat steps 2 through 26 using in step 16 instead of the sensitivity limit the upper limit of the dynamic rang of the On-board Equipment specified in sub-clause 7.5.2.1.3 of SUBSET-044 [N1].

6.6 Co-Channel Rejection for Narrowband Signal

1. Setup the measurement arrangement according to Figure 6-11 and Figure 6-5. Use a Balun at the inputs of the DSO to terminate the Data and Clock lines into nominal 120 Ω .

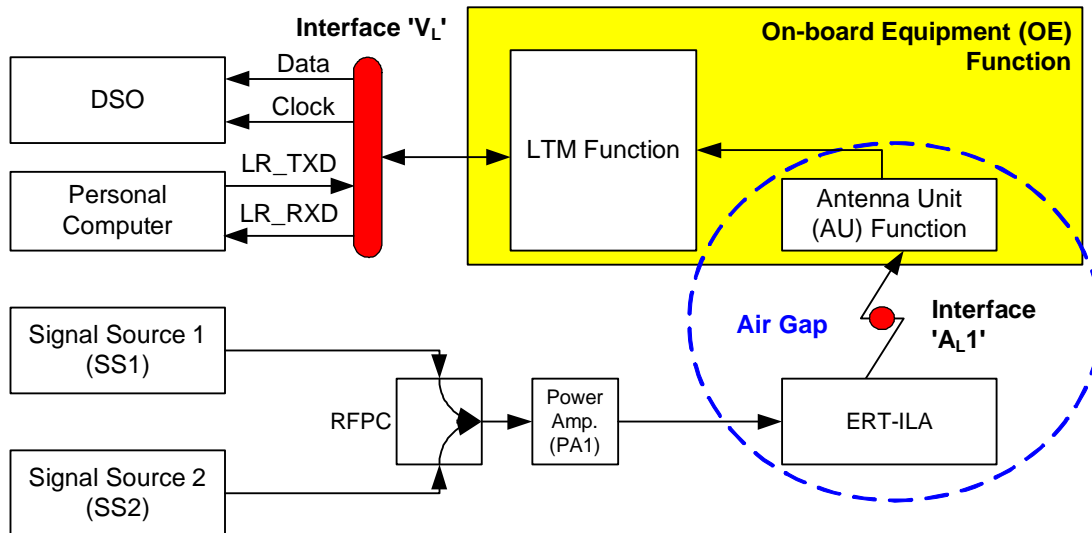


Figure 6-11: Measurement Setup with two Signal Sources for Testing On-board Equipment

2. Switch off the outputs of the Signal Sources SS1 and SS2.
3. Temporary replace the Antenna Unit (AU) function shown in Figure 6-11 by the Magnetic Field Probe (MFP), the Band-Pass Filter (BPF) and the Power Meter PM as shown in Figure 6-12 below.

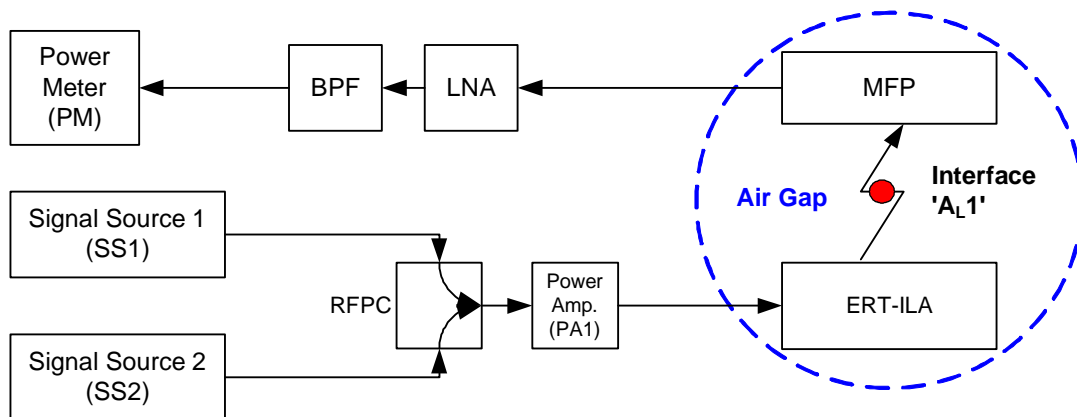


Figure 6-12: Setup for Calibration of the Magnetic Field Strength of 2 Signal Sources in the Air Gap

4. Orient the MFP such that the plane of its loop antenna is parallel to the xy-plane to allow the measurement of the z-component of the magnetic field.
5. Set SS2 to generate a monochromatic Test Signal TSOE6 of nominal centre frequency f_c (defined in sub-clause 6.7.5 of SUBSET-044 [N1]) as specified in Annex H.1.3.7.
6. Switch on the output of SS2.

7. Adjust the output level of SS2 such that the z-component $H_{z_u,CRNB}$ of the corresponding magnetic field strength RMS value of this unwanted monochromatic Test Signal TSOE6 complies with sub-clause 7.5.2.4.2 of SUBSET-044 [N1] considering that the z-component $H_{z_w,CRNB}$ of the magnetic field strength of the wanted Euroloop signal complies with sub-clause 7.5.2.1.2 of SUBSET-044 [N1]. For this purpose, measure the power of the Test Signal TSOE6 at the output of the MFP into a load of 50Ω within a 3 dB-bandwidth of 10 kHz centred at the centre frequency f_c defined in sub-clause 6.7.5 of SUBSET-044 [N1]. Then convert this signal power to the corresponding magnetic field strength RMS value using the antenna factor of the MFP as detailed in Annex E.
8. Switch off the output of SS2.
9. Set $N = 00$.
10. Instruct SS1 to generate the Test Signal TSOE2 as specified in Annex H.1.3.3 using $Q_SSCODE N$.
11. Switch on the output of SS1.
12. Adjust the output level of SS1 such that the z-component $H_{z_w-Euroloop}$ of the corresponding magnetic field strength RMS value of the wanted Euroloop Test Signal TSOE2 amount to the sensitivity limit specified in sub-clause 7.5.2.1.2 of SUBSET-044 [N1]. For this purpose, measure the power of the Test Signal TSOE2 at the output of the MFP into a resistive 50Ω load with a 3 dB-bandwidth of 4.5 MHz centred at the centre frequency f_c defined in sub-clause 6.7.5 of SUBSET-044 [N1]. Then convert this signal power to the corresponding magnetic field strength RMS value using the antenna factor of the MFP as detailed in Annex E.
13. Switch off the output of SS1.
14. Replace the MFP by the Antenna Unit (AU) function used to receive the up-link signal from Interface 'A_L1'. Orient the plane of the loop of this physical part of the AU in the xy-plane to receive the z-component of the magnetic field.
15. Switch on the outputs of SS1 and SS2.
16. Instruct the Onboard-Equipment (OE) through Interface 'V_L' to use the $Q_SSCODE N$.
17. Record the demodulated output data of the Loop Receiver (LR) on Interface 'V_L' for a sufficiently long period of time to allow the determination of Bit Error Ratio BER_{CRNB} specified in sub-clause 7.5.2.4.2 of SUBSET-044 [N1] with the accuracy stated in sub-clause 4.6. For this purpose, record the data bits from the "Data" line at successive rising edges of the clock signal on the "Clock" line of Interface 'V_L' and proceed as specified in Annex I.

18. Document in the test report

- the BER_{CRNB} verified in step 17 above together with the limit for the BER_{CRNB} as stated in sub-clause 7.5.2.4.2 of SUBSET-044 [N1].
- the magnetic field strengths RMS value of the signal levels adjusted in step 7 and 12 above at the reference position, and
- the Q_SSCODE together with the names of the Test Signal TSOE2 used.

19. If $N < 15$ increase the N by one (1), otherwise repeat the test beginning at step 7 applying 12 dB stronger signals TSOE2 and TSOE6. If this repetition at higher levels has been done the test is finished.

20. Instruct SS1 to generate the Test Signal TSOE2 as specified in Annex H.1.3.3 using Q_SSCODE N.

21. Go to step 16.

6.7 Co-Channel Rejection of Other Euroloop Signal

1. Perform the test step 1 specified in sub-clause 6.6
2. Perform the test step 2 specified in sub-clause 6.6
3. Perform the test step 3 specified in sub-clause 6.6
4. Perform the test step 4 specified in sub-clause 6.6
5. Set SS2 to generate Euroloop signal TSOE7 as specified in Annex 0 using the SSCode with Q_SSCODE M = 05.
6. Switch on the output of SS2.
7. Adjust the output level of SS2 such that:
 - the z-component $H_{z_u, Euroloop}$ of the corresponding magnetic field strength RMS value of this Euroloop Test Signal TSOE7 amounts to the value specified in sub-clause 7.5.2.4.3 of SUBSET-044 [N1]
 - the z-component of the magnetic field strength RMS value $H_{z_w, Euroloop}$ of the Euroloop signal takes on the value specified in sub-clause 7.5.2.1.2 of SUBSET-044 [N1].

For this purpose, measure the power of the Test Signal TSOE7 at the output of the MFP into a load of 50Ω within a 3 dB-bandwidth of 4.5 MHz centred at the centre frequency f_c defined in sub-clause 6.7.5 of SUBSET-044 [N1]. Then convert this signal power to the corresponding magnetic field strength RMS value using the antenna factor of the MFP as detailed in Annex E.

8. Switch off the output of SS2.
9. Instruct SS1 to generate the Test Signal TSOE2 as specified in Annex H.1.3.3 using Q_SSCODE N = 00.
10. Switch on the output of SS1.
11. Adjust the output level of SS1 such that the z-component $H_{z_w, Euroloop}$ of the corresponding magnetic field strength RMS value of the Euroloop Test Signal TSOE2 amount to the sensitivity limit specified in sub-clause 7.5.2.1.2 of SUBSET-044 [N1]. For this purpose, measure the power of the Test Signal TSOE2 at the output of the MFP into a resistive 50Ω load with a 3 dB-bandwidth of 4.5 MHz centred at the centre frequency f_c defined in sub-clause 6.7.5 of SUBSET-044 [N1]. Then convert this signal power to the corresponding magnetic field strength RMS value using the antenna factor of the MFP as detailed in Annex E.
12. Switch off the output of SS1.
13. Replace the MFP by the Antenna Unit (AU) function used to receive the up-link signal from Interface 'A_L1'. Orient the plane of the loop of this physical part of the AU in the xy-plane to receive the z-component of the magnetic field.
14. Switch on the outputs of SS1 and SS2.
15. Instruct the Onboard-Equipment (OE) through Interface 'V_L' to use the Q_SSCODE N.

16. Record the demodulated output data of the Loop Receiver (LR) on Interface 'V_L' for a sufficiently long period of time to allow the determination of Bit Error Ratio BER_{CRWB} specified in sub-clause 7.5.2.4.3 of SUBSET-044 [N1] with the accuracy stated in sub-clause 4.6. For this purpose, record the data bits from the "Data" line at successive rising edges of the clock signal on the "Clock" line of Interface 'V_L' and proceed as specified in Annex I.
17. Document in the test report
 - the BER_{CRWB} verified in step 16 above together with the limit for the BER_{CRWB} as stated in sub-clause 7.5.2.4.3 of SUBSET-044 [N1].
 - the magnetic field strengths RMS value of the signal levels adjusted in step 7 and 11 above at the reference position, and
 - the Q_SSCODE's together with the names of the Test Signal TSOE's used.
18. Set SS2 to generate unwanted Euroloop signal TSOE7 as specified in Annex 0 using the SSSCode with Q_SSCODE M = 14.
19. Instruct SS1 to generate the Test Signal TSOE2 as specified in Annex H.1.3.3 using Q_SSCODE N =02.
20. Instruct the Onboard-Equipment (OE) through Interface 'V_L' to use the Q_SSCODE N.
21. Repeat steps 16 through 17.
22. Set SS2 to generate unwanted Euroloop signal TSOE7 as specified in Annex 0 using the SSSCode with Q_SSCODE M = 04.
23. Instruct SS1 to generate the Test Signal TSOE2 as specified in Annex H.1.3.3 using Q_SSCODE N =06.
24. Instruct the Onboard-Equipment (OE) through Interface 'V_L' to use the Q_SSCODE N.
25. Repeat steps 16 through 17.
26. Set SS2 to generate unwanted Euroloop signal TSOE7 as specified in Annex 0 using the SSSCode with Q_SSCODE M = 08.
27. Instruct SS1 to generate the Test Signal TSOE2 as specified in Annex H.1.3.3 using Q_SSCODE N =11.
28. Instruct the Onboard-Equipment (OE) through Interface 'V_L' to use the Q_SSCODE N.
29. Repeat steps 16 through 17.
30. Repeat steps 5 through 29. In step 7 adjust the output level of SS1 such that the z-component H_{zw-Euroloop} of the corresponding magnetic field strength RMS value of the wanted Euroloop Test Signal TSOE2 amount to the level specified in sub-clause 7.5.2.1.3 of SUBSET-044 [N1].

6.8 Blocking

1. Perform the test step 1 specified in sub-clause 6.6
2. Perform the test step 2 specified in sub-clause 6.6
3. Perform the test step 3 specified in sub-clause 6.6
4. Perform the test step 4 specified in sub-clause 6.6
5. Set SS2 to generate unwanted monochromatic Test Signal TSOE8a specified in Annex H.1.3.9.
6. Switch on the output of SS2.
7. Adjust the output level of SS2 such that the z-component $H_{zu,Blocking}$ of the corresponding magnetic field strength RMS value of this unwanted monochromatic nominal Test Signal TSOE8 amounts to the value specified in sub-clause 7.5.2.5 of SUBSET-044 [N1]. For this purpose, measure the power of the Test Signal TSOE8 at the output of the MFP into a load of 50Ω within a 3 dB-bandwidth of 10 kHz centred at 27.115 MHz (or the other frequencies defined by TSOE when repeating the test according to step 23). Then convert this signal power to the corresponding magnetic field strength RMS value using the antenna factor of the MFP as detailed in Annex E.
8. Switch off the output of SS2.
9. Set $N = 00$.
10. Instruct SS1 to generate the Test Signal TSOE2 as specified in Annex H.1.3.3 using $Q_SSCODE N$.
11. Switch on the output of SS1.
12. Adjust the output level of SS1 such that the z-component $H_{zw-Euroloop}$ of the corresponding magnetic field strength RMS value of the wanted Euroloop Test Signal TSOE2 amount to the sensitivity limit specified in sub-clause 7.5.2.1.2 of SUBSET-044 [N1]. For this purpose, measure the power of the Test Signal TSOE2 at the output of the MFP into a resistive 50Ω load with a 3 dB-bandwidth of 4.5 MHz centred at the centre frequency f_c defined in sub-clause 6.7.5 of SUBSET-044 [N1]. Then convert this signal power to the corresponding magnetic field strength RMS value using the antenna factor of the MFP as detailed in Annex E.
13. Switch off the output of SS1.
14. Replace the MFP by the Antenna Unit (AU) function used to receive the up-link signal from Interface 'AL1'. Orient the plane of the loop of this physical part of the AU in the xy-plane to receive the z-component of the magnetic field.
15. Switch on the outputs of SS1 and SS2.

16. Instruct the Onboard-Equipment (OE) through Interface 'VL' to use the Q_SSCODE N.
17. Record the demodulated output data of the Loop Receiver (LR) on Interface 'VL' for a sufficiently long period of time to allow the determination of Bit Error Ratio BER_{Blocking} specified in sub-clause 7.5.2.5 of SUBSET-044 [N1] with the accuracy stated in sub-clause 4.6. For this purpose, record data bits from the "Data" line at successive rising edges of the clock signal on the "Clock" line of Interface 'VL' and proceed as specified in Annex I.
18. Document in the test report
 - the BER_{Blocking} verified in step 17 above together with the limit for the BER_{Blocking} as stated in sub-clause 7.5.2.5 of SUBSET-044 [N1].
 - the magnetic field strengths RMS value of the signal levels adjusted in step 7 and 12 above at the reference position, and
 - the Q_SSCODE together with the names of the Test Signal TSOE2 used.
19. If $N < 15$ increase the N by one (1), otherwise continue with step 22.
20. Instruct SS1 to generate the Test Signal TSOE2 as specified in Annex H.1.3.3 using Q_SSCODE N.
21. Repeat steps 16 through 21.
22. Repeat steps 2 through 21 ignoring steps 6 through 8 and using in step 12 the upper limit of the z-component of the wanted Euroloop magnetic field strength RMS value specified in sub-clause 7.5.2.1.3 of SUBSET-044 [N1].
23. Repeat steps 5 through 22 for each of the three additional test frequencies of Test Signals TSOE8b to TSOE8d specified in Annex H.1.3.9

6.9 Dynamic Receiver Performance

1. Perform the test steps 1 through 11 specified in sub-clause 6.3 using instead of Test Signal TSOE2 the Test Signal TSOE9 specified in Annex H.1.3.10. Replace in steps 8 through 9 the limit BER_{DR} by the limit BER_{DRP} specified in sub-clause 7.5.2.6 of SUBSET-044 [N1].

6.10 Multi path Dynamic Performance

1. Perform the test steps 1 through 11 specified in sub-clause 6.3 using instead of the Test Signal TSOE2 the Test Signal TSOE10 specified in Annex H.1.3.11. Replace in steps 8 through 9 the limit BER_{DR} by the limit BER_{DRP} specified in sub-clause 7.5.2.7 of SUBSET-044 [N1].



6.11 Tolerable Centre Frequency combined with MTIE Error

This test shall be performed with the Loop Transmission Module (LTM) also at the temperature extremes declared by the manufacturer in accordance with SUBSET-044 [N1].

1. Perform the test procedure specified in sub-clause 6.3 twice using instead of the Test Signals TSOE2 the Test Signals TSOE11, and TSOE12 specified in Annexes H.1.3.12 and H.1.3.13 respectively. Replace in steps 8 through 9 the limit BER_{DR} by the limit BER_{TCFE} specified in sub-clause 7.5.2.8 of SUBSET-044 [N1].

6.12 Tolerable Chip Rate Error

1. Perform the test steps 1 through 11 specified in sub-clause 6.3 twice using instead of the Test Signals TSOE2 the Test Signals TSOE13, and TSOE14 specified in Annexes H.1.3.14 and H.1.3.15, respectively. Replace in steps 8 through 9 the limit BER_{DR} by the limit BER_{TCRE} specified in sub-clause 7.5.2.9 of SUBSET-044 [N1].

6.13 Tolerable MTIE of the Chip Rate

1. Perform the test steps 1 through 11 specified in sub-clause 6.3 using instead of Test Signal TSOE2 the Test Signal TSOE15 specified in Annex H.1.3.16. Replace in steps 8 through 9 the limit BER_{DR} by the limit BER_{TCRE} specified in sub-clause 7.5.2.10 of SUBSET-044 [N1].

6.14 Fundamental Function of the Loop Receiver

1. Setup the measurement arrangement according to Figure 6-13 and Figure 6-5.

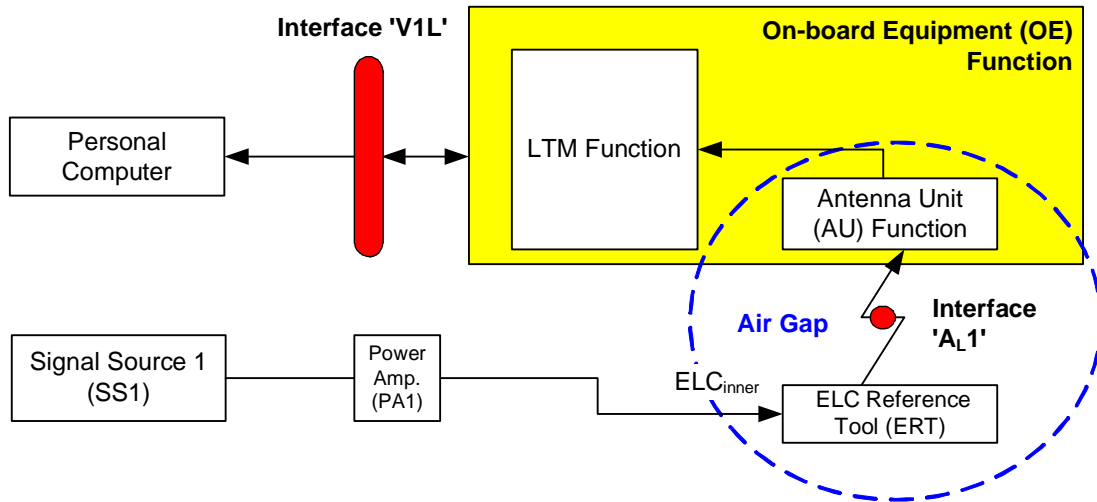


Figure 6-13: Measurement Setup for Testing of Fundamental Function

2. Switch off the outputs of the Signal Source SS1.
3. Temporary replace the Antenna Unit (AU) function shown in Figure 6-13 by the Magnetic Field Probe (MFP), the Band-Pass Filter (BPF) and the Power Meter PM as shown in Figure 6-14 below.

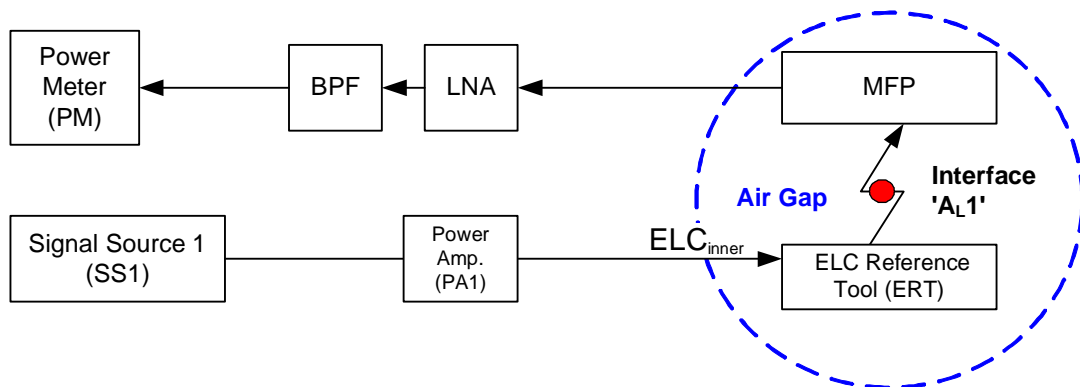


Figure 6-14: Measurement Setup for Calibration of Fundamental Function

4. Orient the MFP such that the plane of its loop antenna is parallel to the xy-plane to allow the measurement of the z-component of the magnetic field.



5. Instruct SS1 to generate the Test Signal TSOE16 as specified in Annex H.1.3.17 using Q_SSCODE 00.
6. Switch on the output of SS1.
7. Adjust the output level of SS1 such that the z-component $H_{zw-Euroloop}$ of the corresponding magnetic field strength RMS value of the wanted Euroloop Test Signal TSOE16 amount to the sensitivity limit specified in sub-clause 7.5.2.1.2 of SUBSET-044 [N1]. For this purpose, measure the power of the Test Signal TSOE16 at the output of the MFP into a resistive 50Ω load with a 3 dB-bandwidth of 4.5 MHz centred at the centre frequency f_c defined in sub-clause 6.7.5 of SUBSET-044 [N1]. Then convert this signal power to the corresponding magnetic field strength RMS value using the antenna factor of the MFP as detailed in Annex E.
8. Switch off the output of SS1.
9. Replace the MFP by the Antenna Unit (AU) function used to receive the up-link signal from Interface 'A_L1'. Orient the plane of the loop of this physical part of the AU in the xy-plane to receive the z-component of the magnetic field.
10. Instruct the Onboard-Equipment (OE) through Interface 'V1L' to use the Q_SSCODE N and wait for at least 3 s such that the LTM has adapted to the Q_SSCODE.
11. Record the data output of Interface 'V1L'.
12. Switch on the output of SS1.
13. Verify the data recorded in step 11 above for conformance to the telegram content specified in Annex H.1.3.17. Verify also that the LTM starts transmitting correct data no later than 250 ms after step 12 above.
14. Instruct SS1 to generate the Test Signal TSOE17-S1 as specified in Annex H.1.3.18 using Q_SSCODE 00. Verify that the reported results comply with SUBSET-085 [N4] chapter 5.2.14.3. Repeat this test with all other variants TSOE17-S2 to TSOE17-S8.
15. Report all results in the test report.

Annex A THE LOOMO OUTPUT SIGNAL: SSCORE, LOGICAL DATA BIT SEQUENCE AND CENTRE FREQUENCY

A.1 Overview

This annex aims at determining the centre frequency (Annex A.2), the Q_SSCORE (Annex A.3), and the “logical data bit” sequence (Annex A.4) of the Euroloop signal based on the output signal of the LOOMO on Interface ‘CA_L’.

A.2 Centre Frequency

1. Let $s(t)$ denote the output signal of the LOOMO on Interface ‘CA_L’ and t the time. Pass $s(t)$ through a low-pass (LP) filter featuring a 3 dB cut-off frequency of 200 MHz \pm 20 MHz to obtain the signal $s_{LP}(t)$.
2. Use the DSO to sample $s_{LP}(t)$ over a time period $T = N \Delta t \pm \Delta t/2 = 0.5 \text{ ms} \pm \Delta t/2$ utilising a nominal sampling interval of $\Delta t = 2 \text{ ns}$ and $n \in \{0, 1, 2, \dots, (N - 1)\}$ with $N = 250'000$. The sampled signal is denoted by $s_{LP}(n \Delta t)$.

$$s_{LP}(n\Delta t) = \int_{-\infty}^{\infty} s_{LP}(t) \delta(t - n\Delta t) dt .$$

The distribution $\delta(\cdot)$ of the enclosed argument denotes the Dirac-function. To keep the mathematical notation concise, $s_{LP}(n \Delta t)$ and $s_{LP}(n)$ shall denote the same sequence of signal samples. Figure A- 1 shows an example of a section of the waveform recorded on Interface ‘CA_L’.

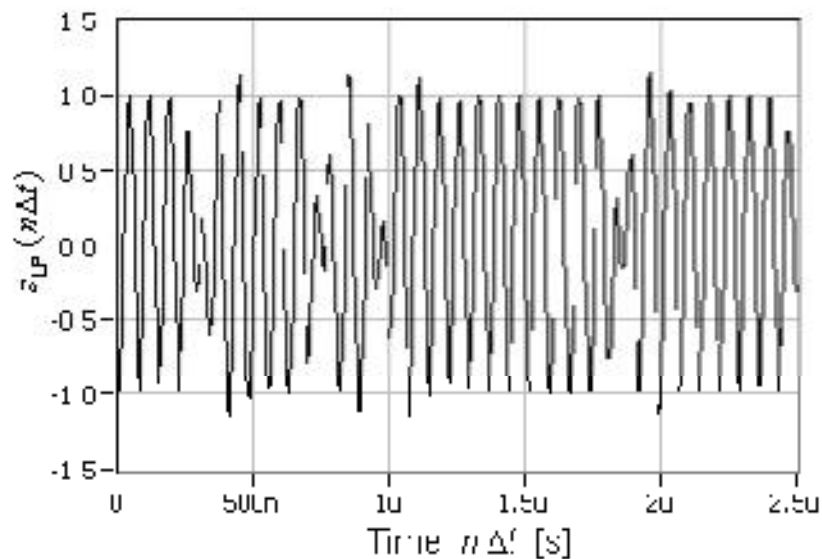


Figure A- 1: Example of Section of Sampled Waveform on Interface ‘CA_L’ as a Function of Time

3. Compute the spectrum $\underline{S}_{LP}(n \Delta f_n)$ with $\Delta f_n = 1 / (N \Delta t)$ of the signal $s_{LP}(n \Delta t)$ determined in step 2 above using the DFT.

$$\underline{S}_{LP}(n \Delta f_n) = \sum_{k=0}^{N-1} s_{LP}(k \Delta t) e^{-j \frac{2\pi n k}{N}} \text{ for } n \in \{0, 1, 2, \dots, (N-1)\}.$$

4. Set, i.e. gate, the spectrum $\underline{S}_{LP}(n \Delta f_n)$ outside the frequency range $(f_c - HBW) \leq n \Delta f_n \leq (f_c + HBW)$ to zero. f_c denotes the centre frequency according to sub-clause 6.7.5 of SUBSET-044 [N1], the Half Band Width $HBW = f_{TP} / 3$, and $f_{TP} = 27.095$ MHz. This yields the spectrum $\underline{S}_G(n \Delta f_n)$. An example of the magnitude of this spectrum is shown in Figure A- 2.

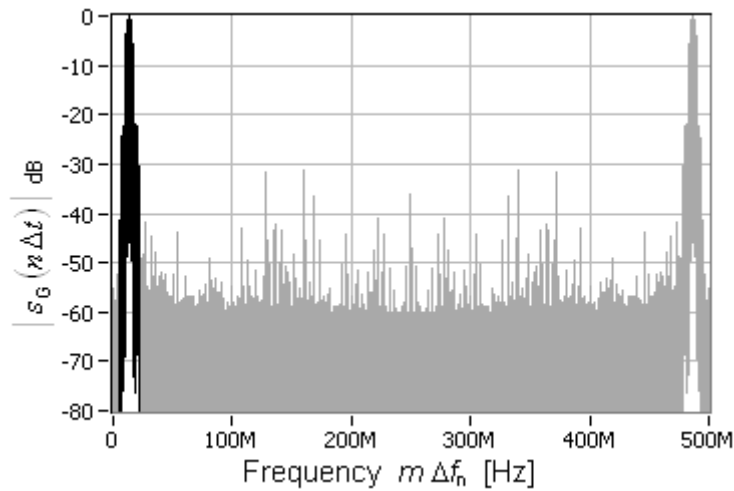


Figure A- 2: Example of the Magnitude of Normalised Gated Spectrum $\underline{S}_G(n \Delta f_n)$ (Black Line) with Indication of Suppressed Spectral Part (Grey Line)

5. Compute the Inverse Discrete Fourier Transform (IDFT) of the spectrum $\underline{S}_G(n \Delta f_n)$ to obtain the corresponding complex time domain signal $\underline{s}_G(n \Delta t)$.

$$\underline{s}_G(n \Delta t) = \frac{2}{N} \sum_{k=0}^{N-1} \underline{S}_G(k \Delta f_n) e^{j \frac{2\pi n k}{N}}.$$

The factor two (2) in the above equation accounts for the loss of signal power caused by the suppression of the conjugated spectral part of the signal (grey part of spectrum in Figure A- 2) due to the gating performed in step 4 above.

6. Determine

$$s_{Sq}(n \Delta t) = [\Re(\underline{s}_G(n \Delta t))]^2 \text{ for } n \in \{0, 1, 2, \dots, (N-1)\}$$

with $\Re(\cdot)$ denoting the real part of the enclosed argument. Figure A- 3 depicts an example of a section of the squared waveform shown in Figure A- 1.

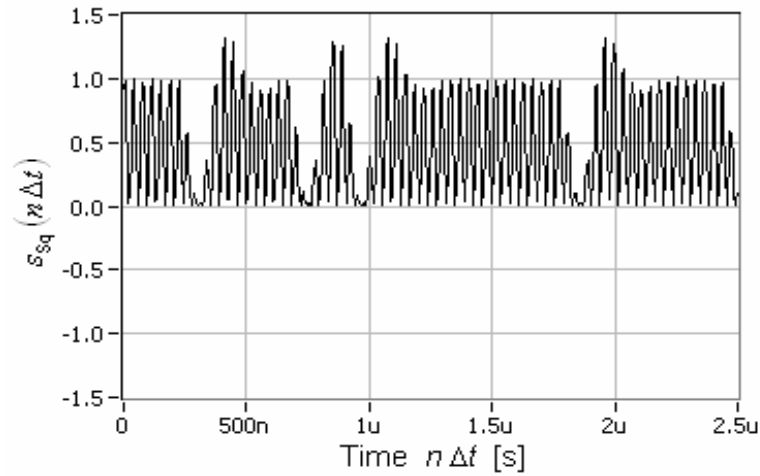


Figure A- 3: Example of Section of the Squared Signal Waveform $s_{Sq}(n \Delta t)$ Shown in Figure A- 1

7. Computer the spectrum $\underline{S}_{Sq}(n \Delta f_n)$ of the signal $\underline{s}_{Sq}(n \Delta t)$ using the DFT.

$$\underline{S}_{Sq}(n \Delta f_n) = \sum_{k=0}^{N-1} s_{Sq}(k \Delta t) e^{-j \frac{2\pi n k}{N}}$$

8. Set, i.e. gate, the spectrum $\underline{S}_{Sq}(n \Delta f_n)$ outside the frequency range $(f_{TP} - NB) \leq n \Delta f_n \leq (f_{TP} + NB)$ to zero. Use $NB = 25$ kHz, and $f_{TP} = 27.095$ MHz. This yields the spectrum $\underline{S}_{SqG}(n \Delta f_n)$. An example of the magnitude of this spectrum shown in Figure A- 4.

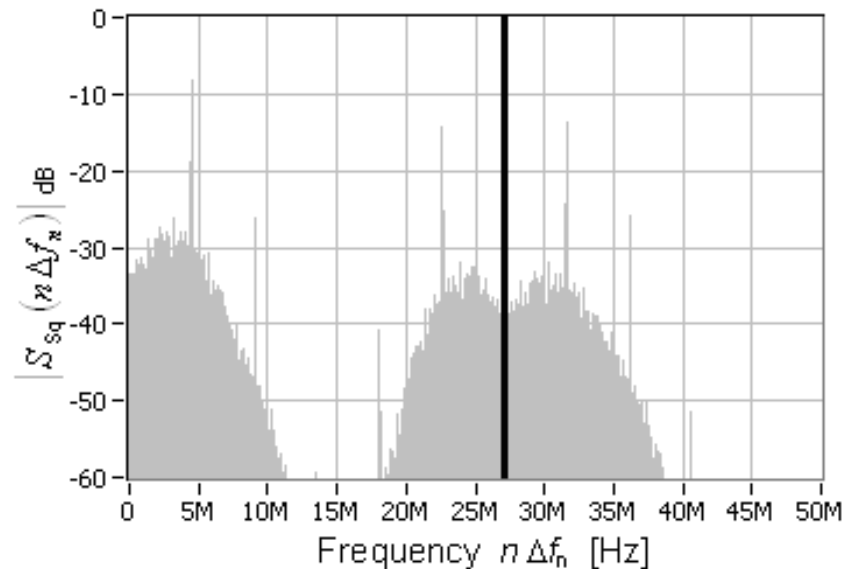


Figure A- 4: Example of Gated Spectrum of the Squared Waveform $s_{Sq}(n \Delta t)$ (Black line) with Indication of Suppressed (gated) Spectral Part (Grey Lines)

9. Compute the Inverse Discrete Fourier Transform (IDFT) of the spectrum $\underline{S}_{SqG}(n \Delta f_n)$ to obtain the corresponding complex time domain signal $\underline{s}_{SqG}(n \Delta t)$.

$$\underline{s}_{\text{sqG}}(n \Delta t) = \frac{1}{N} \sum_{k=0}^{N-1} \underline{s}_{\text{sqG}}(k \Delta f_n) e^{\frac{j 2 \pi n k}{N}}$$

10. Determine the phase

$$\varphi(n \Delta t) = \frac{1}{2} \arctan \left[\frac{\Im(\underline{s}_{\text{sqG}}(n \Delta t))}{\Re(\underline{s}_{\text{sqG}}(n \Delta t))} \right],$$

where $\Re(\cdot)$ and $\Im(\cdot)$ denote, respectively, the real and imaginary part of the enclosed argument. Figure A- 5 shows an example of $\varphi(n \Delta t)$ as a function of time.

Note that the factor $\frac{1}{2}$ in the equation above accounts for the second harmonic frequency of the centre frequency f_c detected in step 8 above.

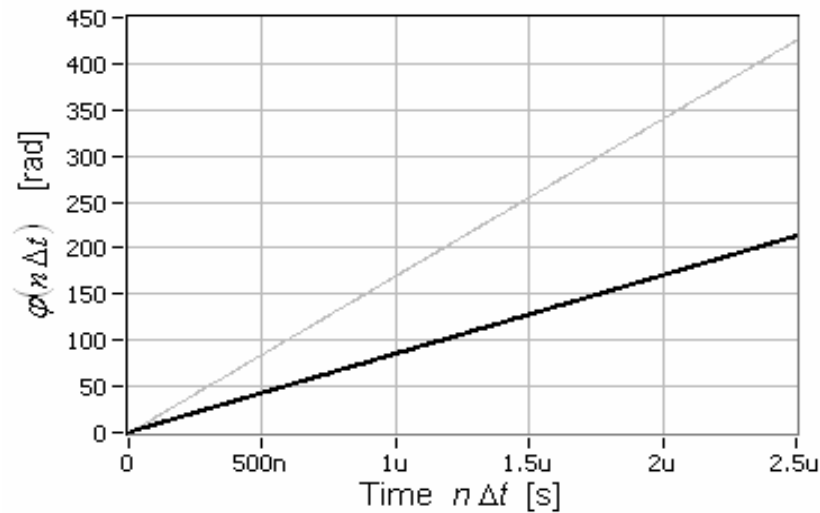


Figure A- 5: Example of Phase $\varphi(n \Delta t)$ (Black Line) as a Function of Time with Indication of the Phase vs. Time of the Second Harmonic Signal (Grey Line)

11. Compute the parameters a and b of the linear regression line

$$\varphi_{\text{LR}}(n \Delta t) = a n \Delta t + b$$

such that the quantity

$$\Delta = \sum_{n=0}^{N-1} (\varphi_{\text{LR}}(n \Delta t) - \varphi(n \Delta t))^2$$

becomes minimal within the range $60 \mu\text{s} \leq n \Delta t \leq 0.5 \text{ ms}$.

Note that this gating reduces transients present at both ends of the sampling interval of the phase $\varphi(n \Delta t)$ determined in step 10 above caused by the gating performed in step 8 above.

12. Determine the measured centre frequency

$$f_{cm} = \frac{a}{2\pi}$$

13. Verify that the **measured centre frequency** f_{cm} complies with the requirement stated in sub-clause 6.7.5 of SUBSET_044 [N1] and report the result in the test report.

A.3 Q_SSCODE

14. Determine the base band signal

$$s_B(n \Delta t) = \Re\left(|s_B(n \Delta t)| e^{j\varphi_B(n \Delta t)}\right) \text{ with}$$

$$|s_B(n \Delta t)| = |s_G(n \Delta t)| \quad \text{and} \quad \varphi_B(n \Delta t) = \arctan\left(\frac{\Im(s_G(n \Delta t))}{\Re(s_G(n \Delta t))}\right) - \varphi_{LR}(n \Delta t)$$

using the signal $s_G(n \Delta t)$ from step 5 and $\varphi_{LR}(n \Delta t)$ from step 11 above.

15. Determine the time instants of the zero crossings of the base band signal $s_B(n \Delta t)$ using linear interpolation between the two signal samples adjacent to the zero crossing point. For this purpose find the set \aleph of all values n for which

$$\aleph = \left\{ n \in \{1, 2, 3, \dots, (N-1)\} \mid \text{sign}[s_B(n \Delta t)] \neq \text{sign}[s_B((n-1)\Delta t)] \right\}.$$

Then determine the zero crossing time instants $t(k_p)$ for all $k_p \in \aleph$ with $\text{card}(\aleph) = P$. For this purpose, arrange the elements of \aleph in ascending order and number them from one (1) through P with increments of one (1) by assigning the index $p = 1$ to the smallest element, i.e.

$$k_p \in \aleph \Rightarrow \aleph = \aleph_{<k_p} \cup \aleph_{>k_p} \cup \{k_p\}, \quad \aleph_{<k_p} \cap \aleph_{>k_p} = \emptyset \text{ with}$$

$$m \in \aleph_{<k_p} \Rightarrow m < k_p \quad \text{and} \quad m \in \aleph_{>k_p} \Rightarrow m > k_p.$$

Hence, the mapping of the elements $\{k_p\}$ onto the index p with $p \in \{1, 2, 3, \dots, P\}$ is given by $k_p \rightarrow \text{card}(\aleph_{<k_p}) + 1 = p$. Then, the linear interpolated time instants $t(p)$ of the zero crossing of the edge number p is given by

$$t(p) = \Delta t \left(k_p - \frac{s_B(k_p \Delta t)}{s_B(k_p \Delta t) - s_B((k_p - 1)\Delta t)} \right).$$

Figure A- 6 and Figure A- 7 show zoomed in sections of the waveform $s_B(n \Delta t)$.

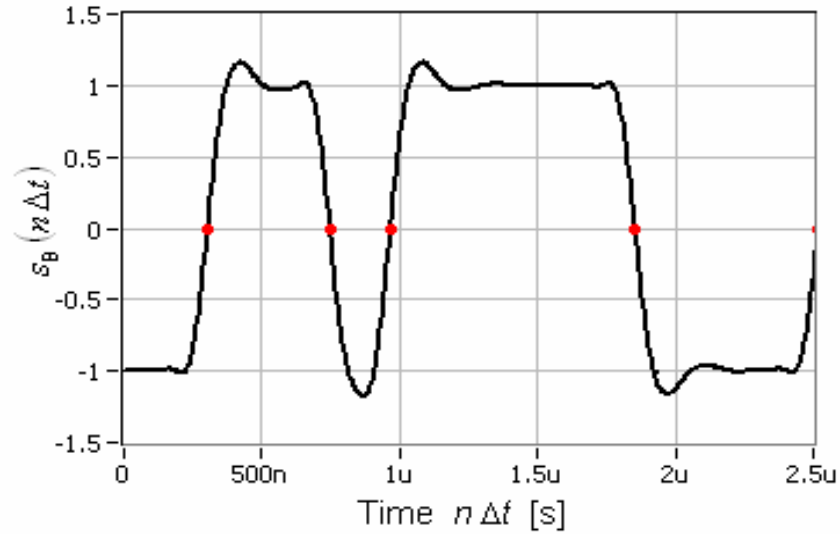


Figure A- 6: Example of Section of $s_B(n \Delta t)$ Showing Four Zero Crossing Points of the Waveform

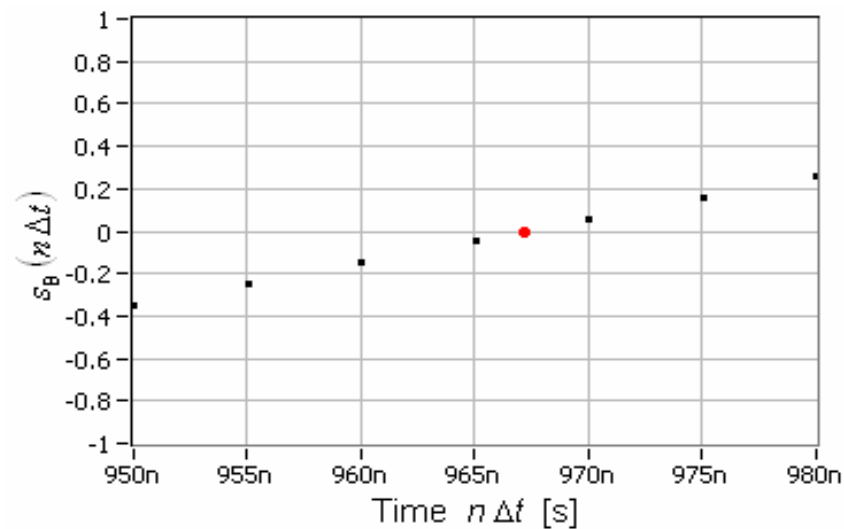


Figure A- 7: Example of Enlarged Section of $s_B(n \Delta t)$ Showing One Zero Crossing Point of the Waveform

16. Determine the number $n_c(p)$ of SSCode clock cycles between consecutive time instances $t(p)$ of zero crossings.

$$n_c(p) = \text{nint} \left(\frac{t(p) - t(p-1)}{T_c} \right)$$

with “nint(.)” denoting the “nearest integer number¹⁰” function of the enclosed argument,

¹⁰ Often called round(.).



$p \in \{2, 3, 4, \dots, P\}$, and $T_c = \frac{1}{R_c}$. R_c denotes the chip rate of the SSCode as defined in sub-clause 6.7.3.4 of SUBSET-044 [N1].

17. Synthesize the normalised sequence $s_c(k T_c)$, ($k \in \{1, 2, 3, \dots, N_k\}$, $t(p-1) < N_k T_c \leq t(P)$),

$$s_c(k T_c) = \begin{cases} +1 & \text{for } t(p) < k T_c \leq t(p+1); p \in \{1, 3, 5, \dots\}; p \leq P. \\ -1 & \text{for } t(p) < k T_c \leq t(p+1); p \in \{2, 4, 6, \dots\}; p \leq P. \end{cases}$$

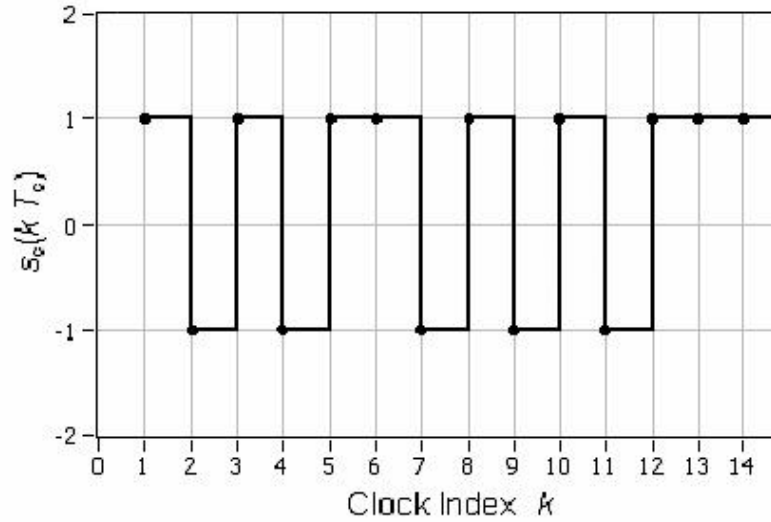


Figure A- 8: Example of Section of Normalised Sequence of SSCode Chips $s_c(k T_c)$

18. Compute the Cross-Correlation Functions $CCF_{Q_SSCODE}(k T_c)$ of the signals $s_c(k T_c)$ with all SSCode $s_{Q_SSCODE}(l T_c)$ with corresponding Q_SSCODE values specified in Annex F of SUBSET-044 [N1].

$$CCF_{Q_SSCODE}(k T_c) = \frac{1}{N_c} \sum_{l=0}^{N_c-1} s_{Q_SSCODE}(l T_c) s_c((l+k) T_c)$$

with N_c denoting the length of the SSCode specified in Annex F of SUBSET-044 [N1], l is the chip number with $l \in \{0, 1, 2, 3, \dots, (N_c - 1)\}$, $k \in \{0, 1, 2, 3, \dots, K\}$, $K = (N_k - N_c)$. Dependent on the sign of the received data bits the sign of the CCF peaks might be positive or negative.

19. Determine

$$k_1 = \min \left\{ k \mid M_{Q_SSCODE} = \max_{k \in \{1, 2, 3, \dots, K\}} \left(N_c \cdot |CCF_{Q_SSCODE}(k T_c)| \right) \right\}$$

for all values of Q_SSCODE specified in Annex F of SUBSET-044 [N1]. Figure A- 9 depicts the magnitude of the cross-correlation function of $s_c(k T_c)$ with the correct SSCode.

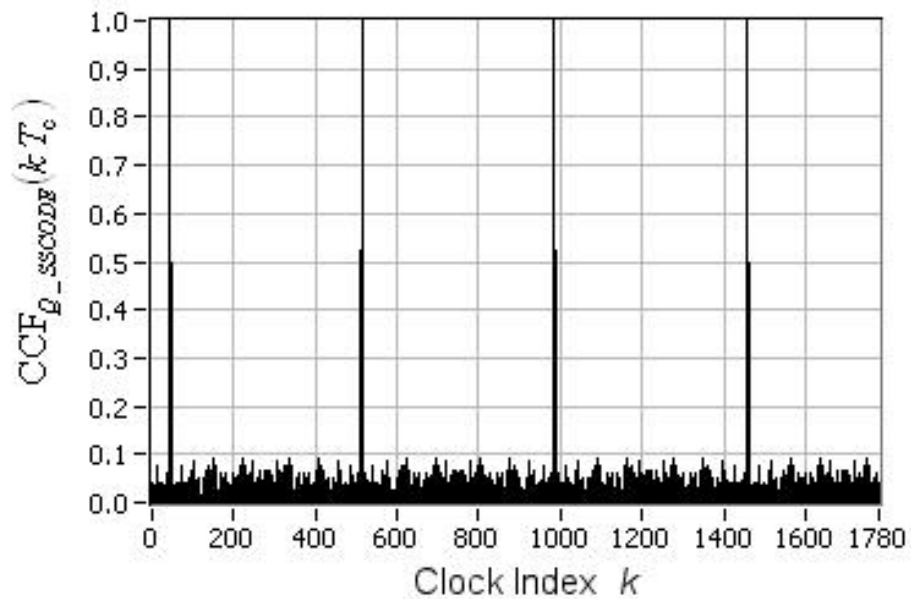


Figure A- 9: Example of Magnitude of Cross-Correlation Function with Correct SSCode

20. Check for all possible values of Q_SSCODE whether one and only one of the values of M_{Q_SSCODE} equals 472. If this is the case, the test is passed, otherwise failed. Report this result in the test report together with the value of the corresponding Q_SSCODE of the **Euroloop spread spectrum code** (i.e. SSCode).

A.4 Logical Data Bit Sequence

21. Determine the logical data bit sequence contained within the recorded signal $s_{LP}(n \Delta t)$. For this purpose

- find all values k_q with $q \in \{0, 1, 2, \dots, Q\}$ such that $|CCF_{Q_SSCODE}(k_q T_c)| = 1$ with Q denoting the number of data bits recovered from the recorded data.
- determine the differential data $DD(q T_d) = \frac{1}{2} (\text{sign}(CCF(k_q T_c)) + 1)$ with $T_d = 1/R_d$ and R_d the data rate according to sub-clause 6.3.2 of SUBSET-044 [N1] and $DD(q T_d)$ according to Figure 6-14 and sub-clause 6.7.3.2 of SUBSET-044 [N1].
- determine the logical data bit sequence $D(q T_d)$ from the differential data sequence $DD(q T_d)$ in accordance with sub-clause 6.7.3.2 of SUBSET-044 [N1].

Annex B QUALITY OF THE LOOMO OUTPUT SIGNAL

This annex aims at determining the quality of the LOOMO output signal as specified in sub-clause 6.7.6 of SUBSET-044 [N1]. For this purpose, the subsequent steps shall be performed.

1. Set the index $i = 1$.
2. Perform steps 1 through 5 of Annex A. This yields the signal¹¹ $\underline{s}_G(n \Delta t)$ with $\Delta t = 2$ ns, $n \in \{0, 1, 2, 3, \dots, (N-1)\}$, and $N = 250'000$.
3. Determine the envelope $\underline{s}_E(n \Delta t)$ of $\underline{s}_G(n \Delta t)$.

$$s_E(n \Delta t) = |\underline{s}_G(n \Delta t)|.$$

4. Normalise the amplitude of $\underline{s}_G(n \Delta t)$. For this purpose, determine

$$s_{\text{Max}} = \max_{n \in \{0, 1, 2, 3, \dots, (N-1)\}} [s_E(n \Delta t)] \quad \text{and} \quad s_{\text{Min}} = \min_{n \in \{0, 1, 2, 3, \dots, (N-1)\}} [s_E(n \Delta t)].$$

Then partition the amplitude range $s_1 = s_{\text{Max}} - s_{\text{Min}}$ into $K = 255$ equally spaced intervals $\Delta s = s_1 / K$. Then determine

- the histogram $H(k)$ with $k \in \{0, 1, 2, 3, \dots, K-1\}$ of sample amplitudes fitting into each of these K amplitude ranges $s_k = s_{\text{Min}} + k \Delta s$, i.e. the number of samples encountered within each amplitude range s_k .
- the values $H_{\text{Max}} = \max_{k \in \{1, 2, 3, \dots, K\}} [H(k)]$ and $H_{75} = 0.75 H_{\text{Max}}$.
- the average value

$$s_0 = \frac{1}{H_0} \sum_{\{k \mid H_{75} \leq H(k) \leq H_{\text{Max}}\}} H(k) (s_{\text{Min}} + k \Delta s) \quad \text{with} \quad H_0 = \sum_{\{k \mid H_{75} \leq H(k) \leq H_{\text{Max}}\}} H(k).$$

Figure B- 1 depicts on the left hand side an example of the envelope of $\underline{s}_G(n \Delta t)$ with the corresponding histogram of this signal's amplitude values on the right hand side.

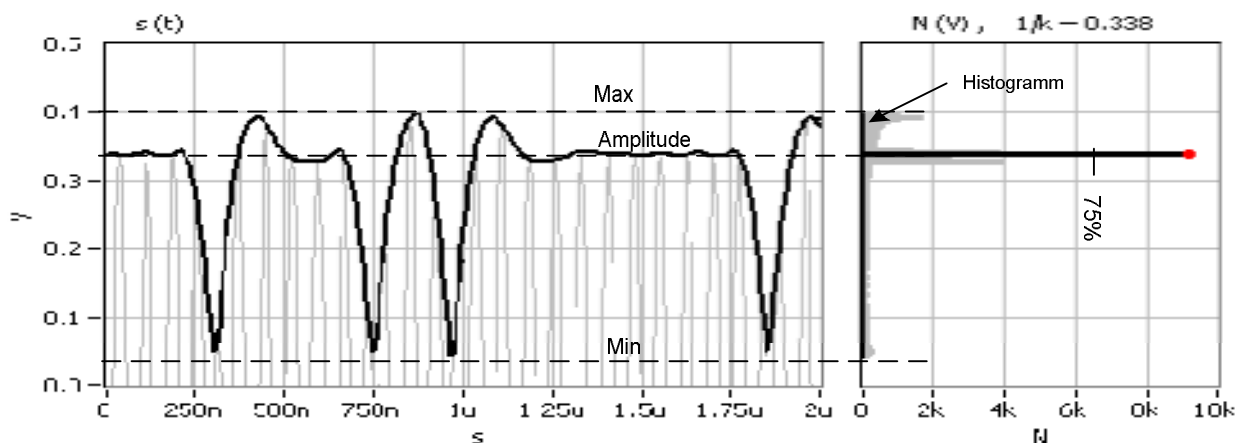


Figure B- 1: Determining the Mean Amplitude to Normalise $\underline{s}_G(n \Delta t)$

Then compute the normalised signal

$$s_N(n \Delta t) = \frac{s_{LP}(n \Delta t)}{s_0} \text{ for } n \in \{0, 1, 2, 3, \dots, (N-1)\}.$$

Figure B- 2 depicts an example of the normalised signal $\underline{s}_N(n \Delta t)$.

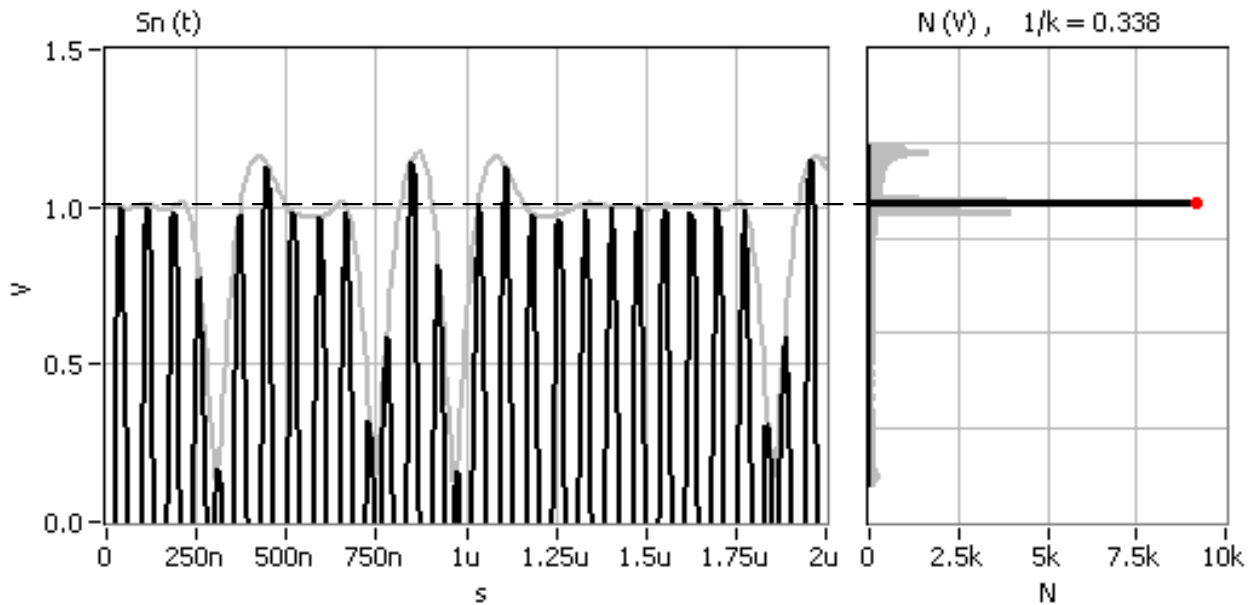


Figure B- 2: Example of Normalised Signal $\underline{s}_N(n \Delta t)$ Recorded on Interface ‘CAL’ of LOOMO

5. Convert signal $\underline{s}_N(n \Delta t)$ to its base band. For this purpose,

- calculate $\underline{s}_B(n \Delta t) = \underline{s}_N(n \Delta t) e^{j2\pi f_c n \Delta t}$ with the centre frequency f_c equal to the value determined in step 12 of Annex A.
- pass $\underline{s}_B(n \Delta t)$ through a 4th order Butterworth low-pass filter with 3 dB cut-off frequency

$$f_g = \frac{f_{TP}}{3} \cong 9.0317 \text{ MHz} \text{ with } f_{TP} = 27.095 \text{ MHz}$$

to obtain the equivalent complex base band signal $\underline{s}_{cb}(n \Delta t)$.

6. Convert, respectively, the logical “1” and “0” values of the SSCode with $Q_SSCODE = 15$ specified in Table F-1 of Annex F of SUBSET_044 [N1] to the corresponding values “1” and “-1” to obtain $C_{15}(m \Delta T)$ with $\Delta T = 6 / f_{TP}$ with $m \in \{0, 1, 2, 3, \dots, 471\}$ denoting the chip number of the SSCode.
7. Over sample $C_{15}(m \Delta T)$ using the sampling interval Δt to obtain the SSCode signal $c_{15}(r \Delta t)$ with $r \in \{0, 1, 2, 3, \dots, R-1\}$ and $R = 52'260$.

¹¹ Complex quantities are underlined.



8. Compute the Correlation Function, start with $i = 1$ (i will be incremented at step 11)

$$\underline{CF}_i(n \Delta t) = \frac{1}{R} \sum_{r=0}^{R-1} s_{cb}((n+r) \Delta t) c_{15}(r \Delta t) \text{ for } n \in \{0, 1, 2, 3, \dots, N-R\}$$

9. Find the two indexes n_l ($l \in \{1, 2\}$) of smallest value such that $|\underline{CF}_i(n_l \Delta t)| \geq 0.5$, $|\underline{CF}_i(n_l \Delta t)| \geq |\underline{CF}_i((n_l - 1) \Delta t)|$ and $|\underline{CF}_i(n_l \Delta t)| \geq |\underline{CF}_i((n_l + 1) \Delta t)|$ are met, i.e. a local maximum of $|\underline{CF}_i(n \Delta t)|$. The first local correlation peak at $n_1 \Delta t$ of \underline{CF}_i might be < 1.0 as the sampling of the underlying signal is not synchronised with the “logical data bit” sequence. The algorithm searches therefore for the next correlation peak at $n_2 \Delta t$ with $n_2 > n_1$.
10. Determine one period of the Complex Correlation Function $\underline{CCF}_i(n \Delta t)$.

$$\underline{CCF}_i(n \Delta t) = \underline{CF}_i((n_2 + n) \Delta t) \text{ for } n \in \{-26'130, -26'129, \dots, 0, \dots, 26'129, 26'130\}.$$
11. Repeat steps 2 through 10 four more times increasing each time the index i by one (1) to obtain $\underline{CCF}_1(n \Delta t)$ through $\underline{CCF}_5(n \Delta t)$.
12. Determine the parameters specified in sub-clause 6.7.6 and Table 6-5 of SUBSET-044 [N1] to determine the quality of the LOOMO output signal.
13. From the normalised signal S_N of step 4 calculate a sparse histogram H_{AM} of only one single amplitude window $W_{AM} = 0.95 \dots 1.05$.

Annex C DETERMINING MTIE ON INTERFACE 'CA_L'

This annex aims at determining the Maximum Time Interval Error (MTIE) of the modulation signal MCH (see Figure 6-13 and sub-clause 6.7.4 of SUBSET-044 [N1]) based on the Euroloop signal on Interface 'CA_L' of the LOOMO.

1. Perform steps 1 through 10, and steps 14 through 16 of Annex A to obtain with $p \in \{1, 2, 3, \dots, P\}$. Use a sampling interval $\Delta t =$ of 20 ns instead of 2 ns and $N = 500'000$:
 - the time $t(p)$ of the pulse edges of the modulating signal, and
 - the number $n_c(p)$ of SSCode clock cycles between adjacent pulse edges of the modulating signal.
2. Determine the number $n(p)$ of clock cycles of the SSCode corresponding to the time instants $t_N(p)$ of the pulse edges for $p \in \{2, 3, 4, \dots, P\}$.

$$n(p) = \sum_{q=2}^p n_c(q).$$

3. Compute the Time Interval Error $\tau(p)$ between the measured time instances $t(p)$ of the pulse edges and the corresponding time instances $n(p) T_c$ of a reference chip interval $T_c = 1/R_c$ of nominal rate R_c as specified in sub-clause 6.7.3.4 of SUBSET-044 [N1].

$$\tau(n(p)) = t(p) - n(p)T_c \quad \text{for } p \in \{2, 3, 4, \dots, P\}$$

Figure C- 1 depicts the Time Interval Error $\tau(r)$ with indication of observation time t_{ob} .

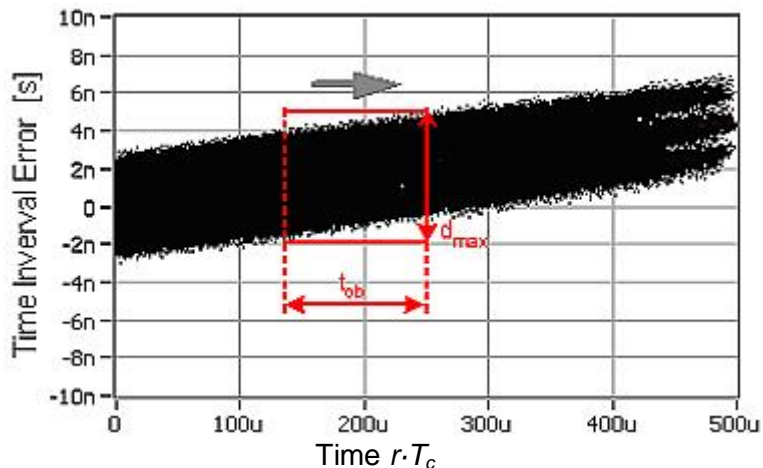


Figure C- 1: Example of Time Interval Error $\tau(r)$ with Indication of Observation Time t_{ob}

4. Compute the MTIE up to a Observation Time of 10 ms

$$MTIE(m) = \max_{i \in \{1 \dots n(P)-m\}} \left(\max_{r \in \{i \dots i+m\}} (\tau(r)) - \min_{r \in \{i \dots i+m\}} (\tau(r)) \right) \quad m \in \{1 \dots 45159\}$$

where the observation time is $t_{ob} = m \cdot T_c$. and $n(P)$ is the total number of chips. $\tau(r)$ represents the time error of the r^{th} chip.

Figure C- 2 shows an example of the MTIE with indication of the limit line according to sub-clause 6.7.4 of SUBSET-044 [N1].

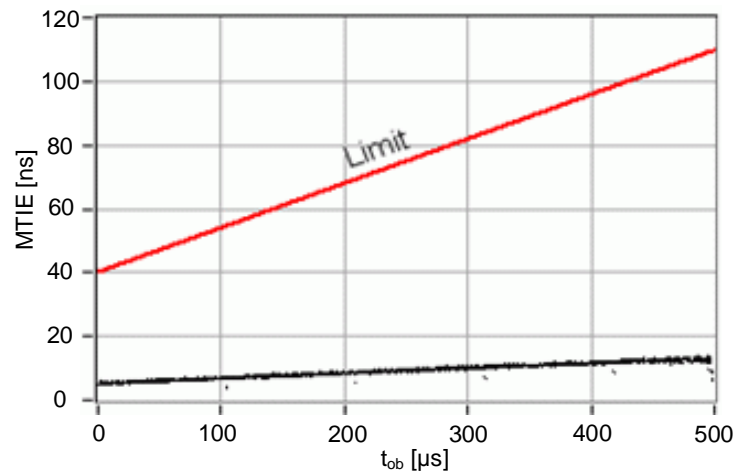


Figure C- 2: Example of MTIE (Black) vs. Observation Time t_{ob} with Indication of Corresponding Limit Line (Red).

5. Repeat steps 1 through 4 five (5) times within a time frame of ≤ 1 s.
6. Verify that each of these five (5) MTIE's determined in step 5 above complies with the corresponding requirement stated in sub-clause 6.7.4 of SUBSET-044 [N1] and report the result in the test report.

Annex D SPECIFICATION OF ELC REFERENCE TOOL (ERT)

D.1 Introduction

This Annex specifies the ELC Reference Tool (ERT) to be used for testing the activation of the Loop Modem (LOOMO) using the activation signal generated by the LTM function of the On-board Equipment. This Annex is needed for Interoperability between LOOMOs from different manufacturers. Additionally, the ERT is used to test the On-board Equipment.

In general, this Annex defines the minimum requirements of the ERT. Better accuracy is always advantageous, and will reduce necessary margins in the measurement process during Product Qualification.

The ERT shall be positioned within the test laboratory such that a clearance of at least 1 m is maintained to each of the walls and the ceiling. Additionally, the distance between aluminium plates and the floor of the test laboratory shall amount to ≥ 450 mm as specified in Figure D- 1.

D.2 ELC in Inner & Outer Foot (optional) of Aluminium Bar

The overall setup of the ERT with the ELC laid in the inner (ELC_{inner}) and outer (ELC_{outer}) foot of the aluminium bars is specified in Figure D- 1 and Figure D- 2. The origin of the coordinate system is at Top of Rail (ToR) in the middle of the track.

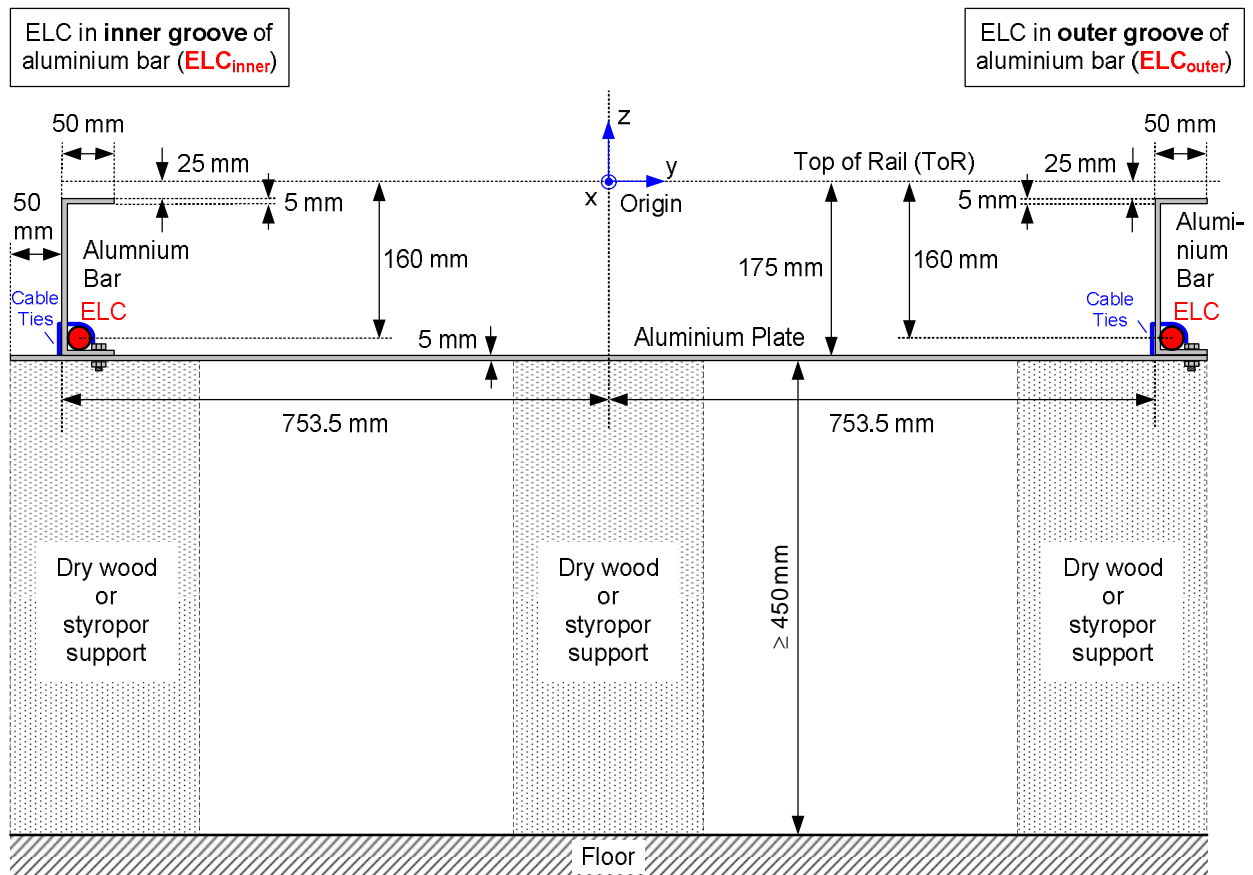


Figure D- 1: Front View of ERT with ELC in Inner and Outer Foot of Aluminium Bars



The two aluminium bars shall comply to section B5.3.1 in [N4]. Each bar shall be attached and electrically firmly connected to the aluminium plates by e.g. positive pattern type spring washers, in order to provide a low impedance path between the two aluminium bars. The aluminium bars are modelling the rails of a track.

The aluminium plates shall feature a length of 1607 mm, a width of 200 mm and a thickness of 5 mm. The aluminium plates shall be spaced 600 mm apart along the ERT as specified in Figure D- 2. The aluminium plates shown in Figure D- 1 and Figure D- 2 are modelling the sleepers of the track.

The two ELCs shall generally be of type “Andrew[®] RXL4-3A” or “Nexans **RF-LE-1/2”-CUT**”. They shall be clamped to the inner corner of the aluminium bars as indicated in Figure D- 2 and Figure D- 3 using dielectric cable ties. However, for the purpose of the tests according to sub-clause 5.12, the actually used cable type of the installation shall be used. In the latter case, it shall be rotated such that minimum reception/transmission is obtained (if applicable).

One aluminium bar shall be grounded to the environment by a low impedance line using a flat tinned or silver plated copper braid of ≥ 5.08 cm width (≥ 2 inch), ≥ 0.33 cm (≥ 0.13 inch) and ≤ 5 m length.

Each of the two ELCs shall have a length of 3.26 m measured between the contact surfaces of their connectors at both ends of the cables. One end of each ELC shall be terminated into a resistive 50Ω load. If only one ELC is used at a time, the input of the unused ELC shall be terminated into a resistive 50Ω load. The resistive loads of the terminations shall feature a return loss of ≥ 15 dB within the frequency range between 9 MHz and 27.1 MHz. A common mode choke shall be attached to the input of the ELC whose minimum requirements are provided in sub-clause 4.4.18.

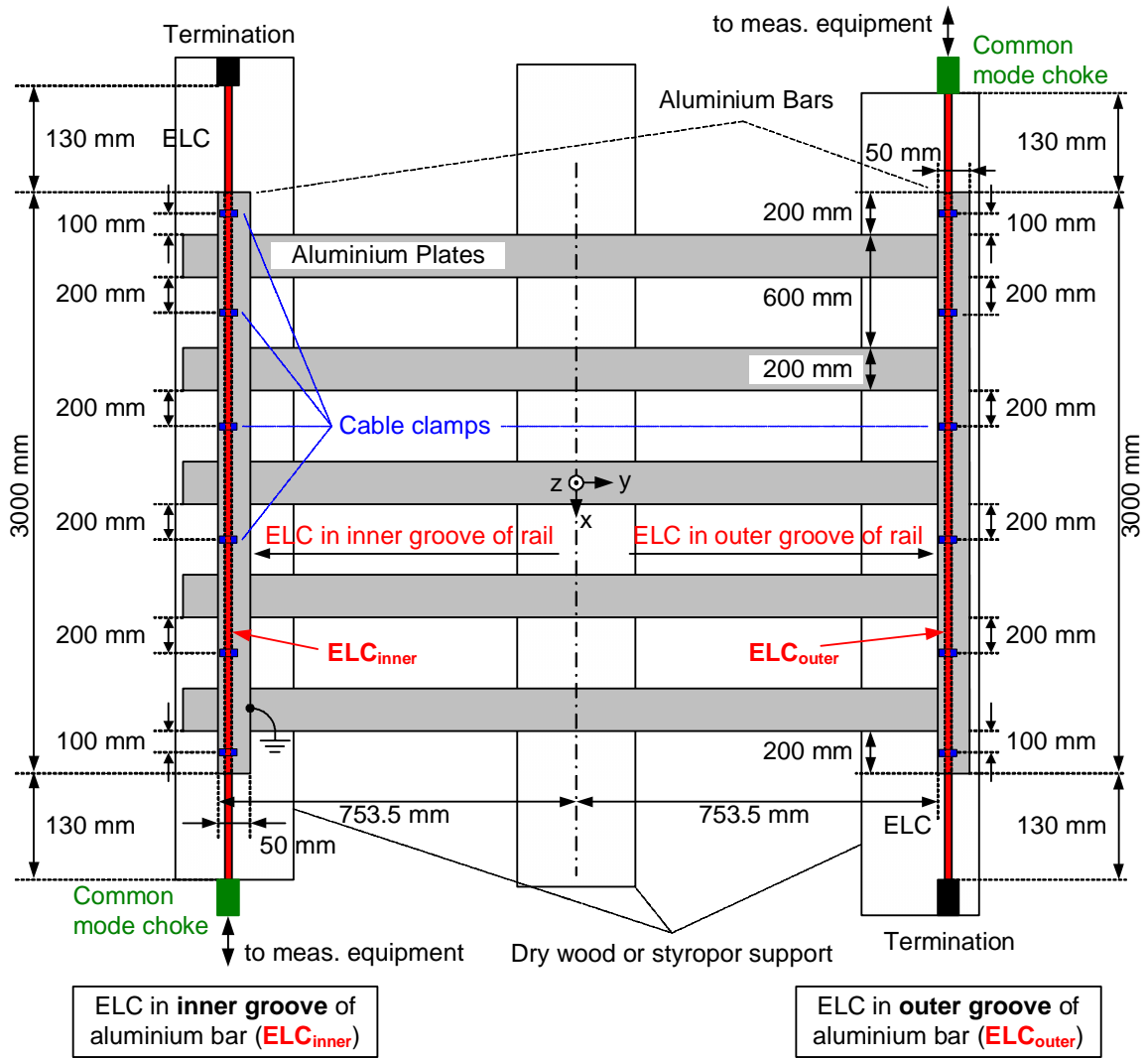


Figure D- 2: Top View of ERT with ELC in Inner and Outer Foot of Rail

D.3 Clamping of ELC to the Aluminium Bars

The ELC shall be attached to the aluminium bars in a suitable manner such as to allow it to rotate in axial direction (i.e. around the x-axis, see sub-clause 5.5.1 of SUBSET-044 [N1]) by 360°. For the attachment of the ELC to the foot of the aluminium bars, cable ties made of polyamid (i.e. nylon) shall be used as illustrated in Figure D- 3. The clamping of the ELC to the aluminium bars should be at distances of 60 cm as specified in Figure D- 2 using small holes drilled into the aluminium bars as indicated in Figure D- 3.

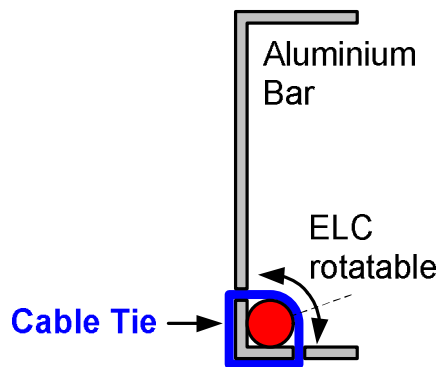


Figure D- 3: Mounting of ELC to Inner Corner of Aluminium Bar

D.4 ERT Interference-Signal Loop-Antenna (ERT-ILA)

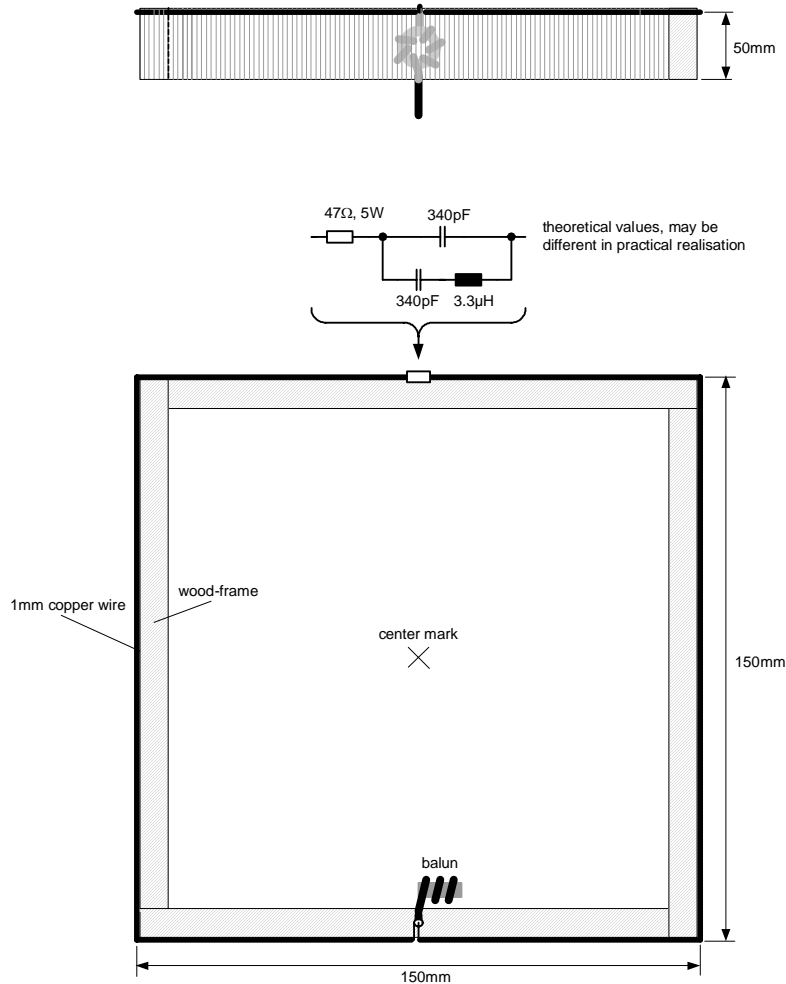


Figure D- 4: ERT Interference-Signal Loop-Antenna (ERT-ILA)

The ERT-ILA is a quadratic single turn Loop-Antenna that shall be fed by a coaxial cable. To enhance the symmetry a balun shall be realised by winding this cable 5 times through a ferrite ring Philips TX36/23/15 Grade 3F3.

At 4.5 MHz, 13.5 MHz MHz it the loop shall be inductivity compensated by an L/C circuit. The Bandwidth at 13.5 MHz shall be wide enough to transmit the Euroloop signal.

Return Loss in a 50Ω reference system	4.0 – 4.7 MHz:	>12 dB
	11.5 – 15.5 MHz:	>12 dB
	27 MHz – 30 MHz	>2.0 dB

The ERT-ILA replaces the ERT in all test cases where the required field strength is too high to be generated via the short ELC. Its position in the test environment has to be compliant to Figure D-2. The Reference point is located in a plane defined by the loop wire in the centre of the loop-square.

Annex E SPECIFICATION OF MAGNETIC FIELD PROBE (MFP)

The subsequent specification applies for the MFP.

Table E- 1: Specifications of the MFP

Parameter	Specification	Condition
Manufacturer	advanced technical solutions (adts) GmbH, Alpenstrasse 1A, CH-8800 Thalwil, Web: www.adts.ch.	
Model	LAM (Loop Antenna for Midband)	
Frequency range	4.5 MHz – 30 MHz	
Nominal impedance	50 Ω	
Return loss (min.)	9 dB	
Mechanical dimensions of encapsulation	(170 mm \pm 1 mm) \times (150 mm \pm 1 mm) \times (20 mm \pm 1 mm)	
Mechanical dimensions of the loop	(150 mm \pm 0.5 mm) \times (130 mm \pm 0.5 mm)	
Magnetic antenna factor A_{MFP}	Typical 112 dB μ A/m \pm 1 dB @ 0 dBm Calibration uncertainty \pm 0.2 dB	<ul style="list-style-type: none"> ▪ at antenna connector ▪ 4.5 MHz – 28 MHz ▪ free air condition
Cross polarisation decoupling (min.)	15 dB	
group delay distortion	< 10 ns	<ul style="list-style-type: none"> ▪ 9 MHz – 30 MHz
Temperature range	-20 $^{\circ}$ C to +80 $^{\circ}$ C	

Annex F SPECIFICATION OF INTERFACE 'V_L'

F.1 General Characteristics

Interface 'V_L' consists of two up-link signal lines, two control lines, and a ground line. The up-link signal lines consist of

1. the demodulated output data of the Loop Receiver (LR) subsequently called "Data" and
2. the corresponding clock signal subsequently called "Clock".
3. the ground line, subsequently called "Ground" (GND).

The two control lines consist of

1. the S_RXD line allowing passing commands from the Personal Computer to the LTM Function, and
2. the S_TXD line allowing passing messages from the LTM Function back to the Personal Computer.

The Data and Clock are balanced RS 422 lines to be terminated at the receiver input into 120 Ω. Connections to the Data and Clock are restricted to a closed unit with a common ground.

F.2 Up-Link Data Interface

F.2.1 Architecture

The following RS 422 connections should be considered:

DATA:	RS 422,	Data rate R_d according to sub-clause 6.3.2 of SUBSET-044 [N1]	(up-link telegram data)
CLOCK:	RS 422	Clock rate R_d according to sub-clause 6.3.2 of SUBSET-044 [N1]	(for synchronous transmission)

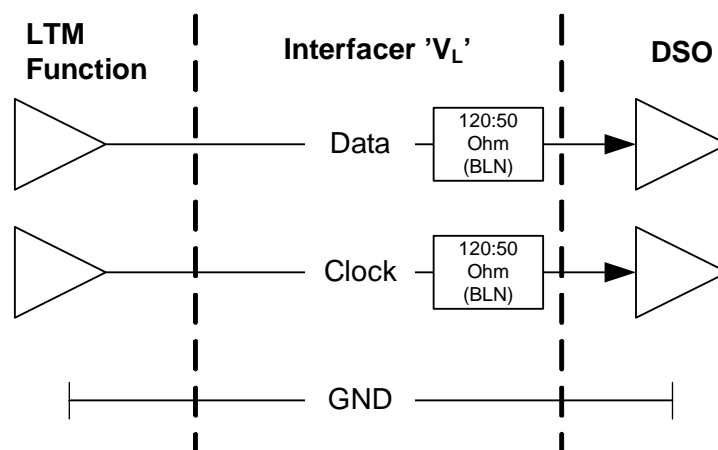




Figure F- 1: Data & Clock Line Connection between LTM Function and DSO

F.2.2 DC Characteristics

The DC characteristics of the Data and Clock are provided in Table F- 1 below.

Table F- 1: DC Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Units	Condition
Level	U_{Diff}	0.9	---	5.5	V	$R_L = 120 \Omega$
Line termination	R_L	100	120	140	Ω	---

F.2.3 AC Characteristics

The AC characteristics of the Data, and Clock lines are provided in Table F- 2, and Table F- 3 below, respectively. Figure F- 2 specifies the timing of the Data and Clock. Data bits shall be captured at the positive edge of the clock signal.

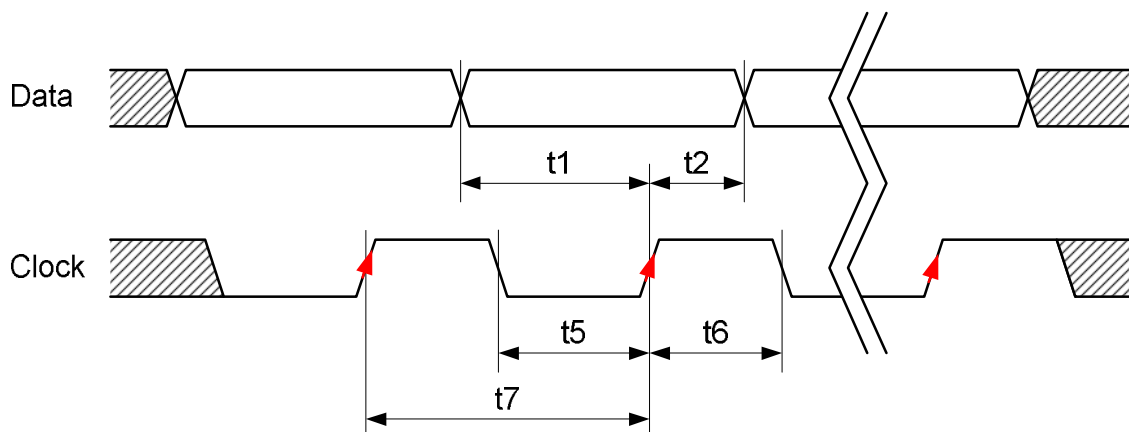


Figure F- 2: Timing Diagram

Table F- 2: Timing Specifications of the Data Signal

Parameter	Symbol	Min.	Typ.	Max.	Units	Condition
Set-up time	t1	500	---	---	ns	---
Hold time	t2	200	---	---	ns	---

Table F- 3: Timing Specifications of the Clock Signal

Parameter	Symbol	Min.	Typ.	Max.	Units	Condition
Low time	t5	800	---	---	ns	---
High time	t6	300	---	---	ns	---
Cycle time ¹²	t7	96	112	112.1	µs	---
Data rate	R _d	---	see sub-clause 6.3.2 of SUBSET-044 [N1]	---	---	---

F.2.4 Data Link Layer

F.2.4.1 CLOCK

The clock rate R_{clock} shall be synchronous to the data rate R_d . The data rate is specified in sub-clause 6.3.2 of SUBSET-044 [N1]. The clock signal shall not start toggling until the data on the “Data” line (see sub-clause F.2.4.2 below) is valid.

F.2.4.2 DATA

The data on the “Data” line shall be captured on the rising edge of the signal on the “Clock” line (see sub-clause F.2.4.1 above). The “logical data bits” available on Interface ‘A_L1’ shall propagate to Interface ‘V_L’ unchanged and in the same sequence they appear on Interface ‘A_L1’ (see sub-clause 6.3.4.1 of SUBSET-044 [N1] for a definition of the term “logical data bit”).

The data rate R_d is specified in sub-clause 6.3.2 of SUBSET-044 [N1].

¹² Mean cycle time according to Data Rate as specified in sub-clause 6.3.2 of SUBSET-044 [N1].

F.3 Control Interface

F.3.1 Control Lines

These control lines aim at transferring the data of clause F.3.2 to/from the LTM function. Its timing specifications shall be the same as those provided in Table F- 4 and Figure F- 2.

Table F- 4: Control Line Interface Specification

Parameter	Value	Comment
Type of Interface	RS 232	
Duplex Mode	Full duplex, asynchronous serial mode with Interface 'V _L ' (slave) and Personal Computer (master)	
Baud Rate	38'400 baud	
Character Frame	1 start bit, 8 data bits, 1 stop bit, and no parity bit	

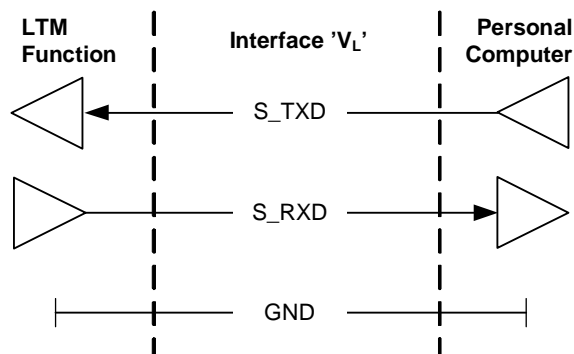


Figure F- 3: Control Line Connection between LTM Function and Personal Computer

F.3.2 Operational Data

F.3.2.1 Telegram structure

Data transmission is organized by telegram exchange. Telegrams are delimited by “non printable characters” to achieve clear synchronisation and an additional Check-Sum. The “pay-load” is called a Data-Frame.

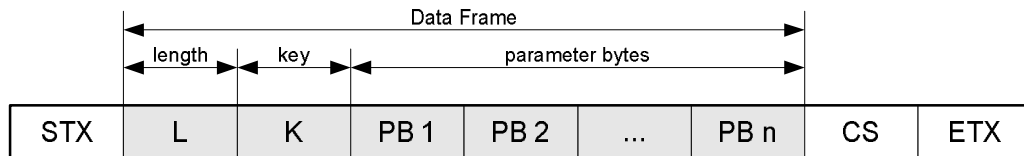


Figure F- 4: Telegram structure

- STX: STX-byte (0x02) delimiter “beginning of telegram”
- L: Length of Data Frame plus Checksum in Bytes
- K: Command key
- PB: Optional parameter
- CS: Checksum: modulo 256 sum of all bytes of a Data Frame
- ETX: ETX-byte (0x03) delimiter “end of telegram”

The length of each individual field of the telegram listed above is 8 bits. All data have to be sent in binary form. The least significant bit is transmitted first, as specified by the RS232 standard.

F.3.2.2 Protocol of telegram exchange

The LTM function is “slave” in the telegram exchange. It normally sends telegrams only as a response to every received Command Telegram. A minimum delay t_6 between a Response Telegram and the next Command Telegram prevents an overflow of the receive buffer in the LTM function.

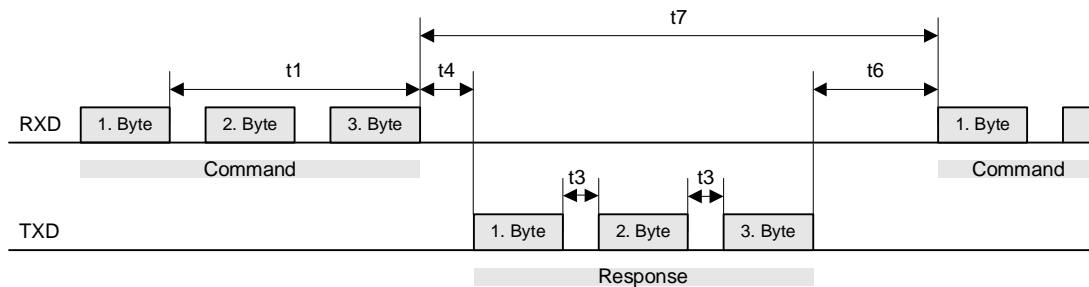


Figure F- 5: Telegram timing on the Control Lines

Parameter	Symbol	min	typ	max	Unit
Transmission time of a command telegram	t_1			20	ms
Gap between two bytes of an response telegram	t_3	0		1	ms
Processing time of the On-Board Equipment	t_4	20		#	μ s
Delay between a response and the next command	t_6	0			ms
Delay between two commands if the response fails	t_7	20			ms

#: see sub-clause F.3.3.1.

F.3.2.3 Quoting

All telegram words are 8 bits long. Control characters are defined as follows¹³ :

- STX 0x02 Beginning of telegram delimiter
- ETX 0x03 End of telegram delimiter
- DLE 0x10 Quoting character
- 0x12¹⁴
- 0x14¹⁴

If a telegram character, which is not intended to be a control character, has the same pattern as a control character then it shall be preceded by an additional DLE character and an offset of 0x80 is applied as follows.

Original telegram character:	Transformed into two transmitted characters:
0x02	0x10, 0x82
0x03	0x10, 0x83
0x10	0x10, 0x90

¹³ '0x' is a prefix used for values in hexadecimal notation.

¹⁴ Actually not used, has to be implemented for legacy reasons.



0x12
0x14

0x10, 0x92
0x10, 0x94

F.3.3 Telegram Catalogue

F.3.3.1 Overview

Command Key	Response Key	Description	Maximum processing time ¹⁵
4	154	Activate Q_SSCODE, see sub-clause F.3.2.2	10 ms
1	50	Query of Online-Test status, see sub-cl. F.3.3.3	10 ms
-	254	Error Response Telegram, see sub-cl. F.3.3.4	-

F.3.3.2 Activate Q_SSCODE

This command activates a desired Q_SSCODE in the LTM function. It shall be succeeded by a confirmation to the personal computer. After start-up, Q_SSCODE 15 (test Q_SSCODE) is active. While processing this command, the reception of Euroloop data is interrupted.

Command telegram Activate Q_SSCODE (from personal computer to LTM function)

L	K	PB
4	4	Activate Q_SSCODE

Response telegram (from LTM function to personal computer)

L	K	PB
4	154	Acknowledged Q_SSCODE

Q_SSCODE:

0 through 14: standard Q_SSCODE's

15: Test Q_SSCODE

¹⁵ Telegram transmission time is not included.

F.3.3.3 Query of Online-Test status

Query of Online-Test status (from personal computer to LTM function)

L	K
3	1

Response telegram (from LTM function to personal computer)

L	K	PB1	PB2	PB3
6	50	Error number	Response 1	Response 2

Error number:

0: Test OK
 1 through 255: Error

Response 1 and Response 2: details of error detected.

F.3.3.4 Error response Telegram

Response telegram to erroneous commands (from LTM function to personal computer)

L	K	PB1
4	254	Error number

Error number:

3: Key unknown or Parameter not in range

F.3.4 Communication Establishment and Error Handling

The PC (master) is responsible for starting all communication activities. It generates commands which then have to be answered by the LTM function (slave). The LTM function sends no messages without first having received a command from the PC.

The master shall wait until the message of the slave has been acknowledged, before sending the next command.

If the master does not receive an answer within the specified time, the command shall be repeated (max. three times).

The slave ignores all incomplete commands or commands with incorrect checksums, and should acknowledge with an error number after a timeout.

Commands with unknown keys, for example, are answered by a fault telegram.

Each command is answered either by a message or by an acknowledge telegram.



Annex G SPECIFICATION OF INTERFACE 'V1L'

G.1 General

The Interface 'V1L' defines the data exchanged between the LTMS and the LTM functionality of the On-board ERTMS/ETCS Equipment, in order to facilitate the tests defined in sub-clause 6.14. This Interface may require the use of a company specific Interface V1L Adapter in order to translate the required test data to formats and timings compatible with those internal to the equipment under test.

G.2 Physical Interface and Link Control

Physical Interface and Link Control shall be compliant with SUBSET-085 [N4] Annex E4.

G.3 Operational Data

G.3.1 General

The functionality of Interface 'V1L' shall be equivalent to the corresponding Interface 'V1' for testing Eurobalise On-board Equipment as specified in SUBSET-085 [N4] Annex E.

G.3.2 Mode Selection (TESTCONF)

Mode Selection shall be equivalent to SUBSET-085 [N4] Annex E1.2.1. Three characters shall be added, specifying the Euroloop Key-Code:

character 8: “-“

character 9: most significant decimal ASCII digit of Euroloop Key-code

character 10: least significant decimal ASCII digit of Euroloop Key-code

G.3.3 Mode Status (LTMSTAT)

Mode Status shall be equivalent to SUBSET-085 [N4] Annex E1.2.1. Three characters shall be added, reporting the Euroloop Key-Code:

character 12: “-“

character 13: most significant decimal ASCII digit of Euroloop Key-code

character 14: least significant decimal ASCII digit of Euroloop Key-code

G.3.4 Link Status (ALIVE)

Link Status shall be compliant with SUBSET-085 [N4] Annex E1.2.3.



G.3.5 Test Data

Test Data shall be equivalent to SUBSET-085 [N4] Annex E1.3. In contrast to Eurobalise Interface 'V1', the Euroloop Interface 'V1L' does report information about Euroloop and Euroloop telegrams.

Self-test Report (ANTTEST):

Compliant with SUBSET-085 [N4] Annex E1.3

Loop Passage Report (LOOP_PASS) shall be identical to Balise Passage Report (BALL_PASS), except that:

Char 214 ... 224, Balise Time Location: all set to "0"

Char 226 ... 234, Balise Distance Location: all set to "0"

All other characters shall be compliant to SUBSET-085 [N4] Annex E1.3.

As long as Euroloop data is received, the LTM function shall perform repetitive LOOP_PASS reporting at regular intervals within the range 1 s to 2 s.

Annex H TEST SIGNALS

H.1 Test Signals

H.1.1 General

This sub-clause specifies the stimuli (i.e. Test Signals) used for testing the Trackside Equipment (TSTE), and On-board Equipment (TSOE). A description of these test signals is found in sub-clause 6.12.2, and 7.10.2 of [N1]. General requirements of the TSTE and TSOE are provided in Table H- 1.

Table H- 1: General Requirements for Test Signals TSTE and TSOE

Parameter	Requirement
Data rate R_d	specified in sub-clause 6.3.2 of SUBSET-044 [N1]
Phase Noise ¹⁶	< -120 dBc/Hz @ 400 kHz
Accuracy of Data Rate R_d	± 5 ppm

H.1.2 Test Signals for Trackside Equipment (TSTE)

H.1.2.1 General Requirements

The basic common parameters for the specification of the Test Signal are given in Figure 6-8 and Table 6-2, both of SUBSET-044 [N1]. Each Test Signal of the Trackside Equipment (TSTE) comes with a file containing its samples and the specification of its nominal sampling interval, minimum sampling interval accuracy, and minimum required amplitude resolution. Coding of Logical Data Bit Pattern shall be according to sub-clause 6.3.4.1 of SUBSET-044 [N1].

Table H- 2 specifies the filenames of the TSTEs.

¹⁶ Currently not in line with the present SUBSET-044

Table H- 2: Filenames Containing the Samples of the Test Signals for Trackside Equipment (TSTE)

Test Signal	Filename	Remarks
TSTE_step+	TSTE_early.csv	Only logical one “1” data bits. Repeat TSTE_early.csv 1’000 times, and then repeat TSTE_late.csv as required by the test-procedure.
	TSTE_late.csv	
TSTE_step+R-	TSTE_earlyRm.csv	As TSTE_step+ but minimum data rate.
	TSTE_lateRm.csv	
TSTE_step-	TSTE_late.csv	Only logical one “1” data bits. Repeat TSTE_late.csv 1’000 times, and then repeat TSTE_early.csv as required by the test-procedure.
	TSTE_early.csv	
TSTE_step-R+	TSTE_lateRp.csv	As TSTE_step- but maximum data rate.
	TSTE_earlyRp.csv	
TSTE_nom	TSTE_nom_1111.csv	Only logical one “1” data bits. Repeat TSTE_nom_1111.csv as required by the test-procedure.
	TSTE_nom_0000.csv	Only logical zero “0” data bits. Repeat TSTE_nom_0000.csv as required by the test-procedure.
TSTE_minmax	TSTE_minmax_110.csv	Repetitive pattern of “110”. Repeat TSTE_minmax_110.csv as required by the test-procedure.
TSTE_alt-phase	TSTE_altphase_110.csv	Repetitive pattern of “110”. Repeat TSTE_altphase_110.csv as required by the test-procedure.

Table H- 3 specifies the general requirements for the Test Signals TSTE.

Table H- 3: General Requirements for Test Signals TSTE

Parameter	Requirement
Amplitude Resolution	≥ 7 bits
Edges	slew rate as specified below

H.1.2.2 TSTE_step+

Table H- 4 and Figure H- 1 specify the Test Signal TSTE_step+.

Table H- 4: Requirements for TSTE_step+

Parameter	Requirement
Sampling Frequency	$220 \cdot R_d = 2.1048$ MHz with the nominal value of R_d according to sub-clause 6.3.2 of SUBSET-044 [N1]
Accuracy of Sampling Frequency	± 10 ppm
Early / Late Transition	$+ 500$ ns $\begin{cases} + 50$ ns \\ $- 0$ ns \end{cases}
Slew Rate	Positive Slew Rate: 60 ns/V ± 10 ns/V Negative Slew Rate: 60 ns/V ± 10 ns/V
Amplitude	according to Figure H- 1
Accuracy of Amplitude	± 0.5 V _{pp}

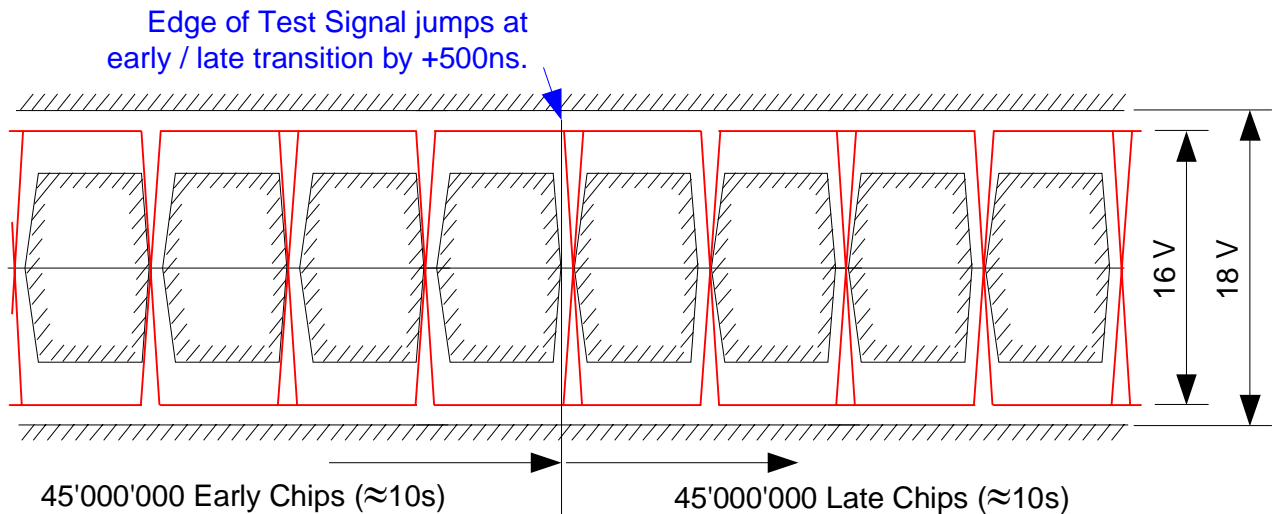


Figure H- 1: Amplitude and Timing Requirements for Test Signal “TSTE_step+”

H.1.2.3 TSTE_step+R-

Test signal TSTE_step+R- shall be identical with TSTE_step+, except that the data rate shall be at the lowest tolerable R_d according to sub-clause 6.3.2 of SUBSET-044 [N1].

H.1.2.4 TSTE_step-

Table H- 5 and Figure H- 2 specify the Test Signal TSTE_step-.

Table H- 5: Requirements for TSTE_step-

Parameter	Requirement
Sampling Frequency	$220 \cdot R_d = 2.1048$ MHz with the nominal value of R_d according to sub-clause 6.3.2 of SUBSET-044 [N1]
Accuracy of Sampling Frequency	± 10 ppm
Late / Early Transition	-500 ns $\begin{cases} +0$ ns \\ -50 ns \end{cases}
Slew Rate	Positive Slew Rate: 60 ns/V ± 10 ns/V Negative Slew Rate: 60 ns/V ± 10 ns/V
Amplitude	according to Figure H- 2
Accuracy of Amplitude	± 0.5 V _{pp}

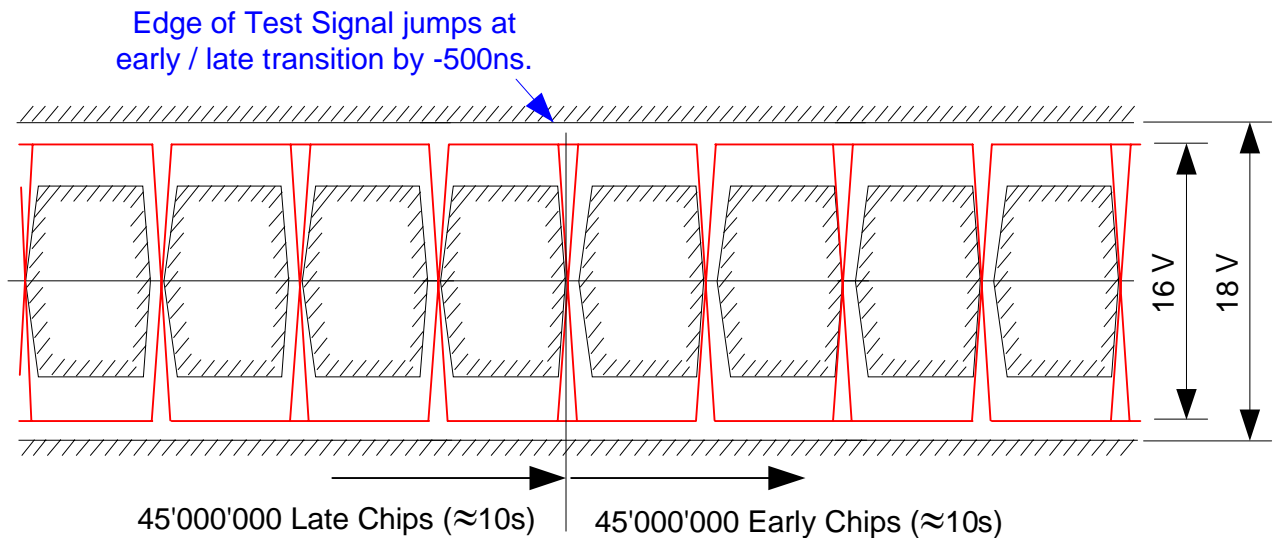


Figure H- 2: Amplitude and Timing Requirements for Test Signal “TSTE_step-”

H.1.2.5 TSTE_step-R+

Test signal TSTE_step-R+ shall be identical with TSTE_step-, except that the data rate shall be at the highest tolerable R_d according to sub-clause 6.3.2 of SUBSET-044 [N1].

H.1.2.6 TSTE_nom

Table H- 6 and Figure H- 3 specify the Test Signal TSTE_nom.

Table H- 6: Requirements for TSTE_nom

Parameter	Requirement
Sampling Frequency	$7788 \cdot R_d = 74.5113$ MHz with the nominal value of R_d according to sub-clause 6.3.2 of SUBSET-044 [N1]
Accuracy of Sampling Frequency	± 10 ppm
Slew Rate	Positive Slew Rate: $60 \text{ ns/V} \pm 10 \text{ ns/V}$ Negative Slew Rate: $60 \text{ ns/V} \pm 10 \text{ ns/V}$
Amplitude	according to Figure H- 3
Accuracy of Amplitude	$\pm 0.5 V_{pp}$

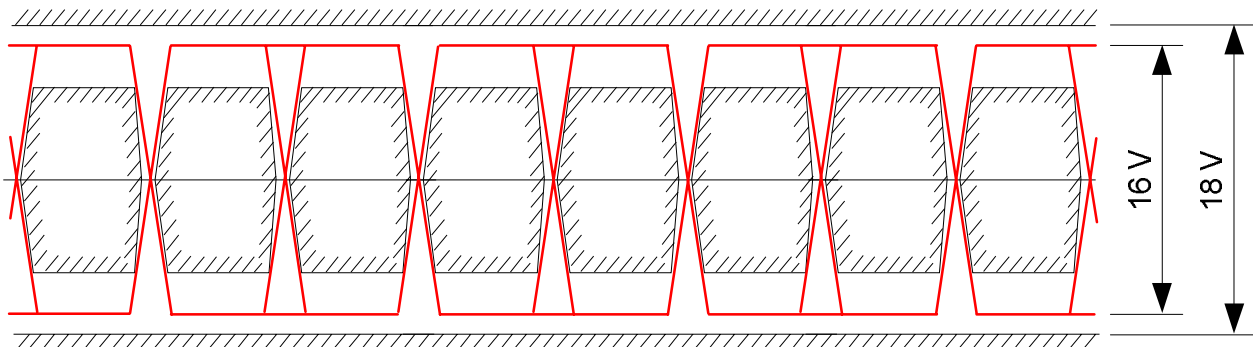


Figure H- 3: Amplitude and Timing Requirements for Test Signal "TSTE_nom"

H.1.2.7 TSTE_minmax

Table H- 7 and Figure H- 4 specify the Test Signal TSTE_minmax.

Table H- 7: Requirements for TSTE_minmax

Parameter	Requirement
Sampling Frequency	$1024 \cdot R_d = 9.79706$ MHz with the nominal value of R_d according to sub-clause 6.3.2 of SUBSET-044 [N1]
Accuracy of Sampling Frequency	± 10 ppm
Slew Rate	Positive Slew Rate: 139 ns/V ± 25 ns/V Negative Slew Rate: 139 ns/V ± 25 ns/V
Amplitude	according to Figure H- 4
Accuracy of Amplitude	$\pm 0.5 V_{pp}$

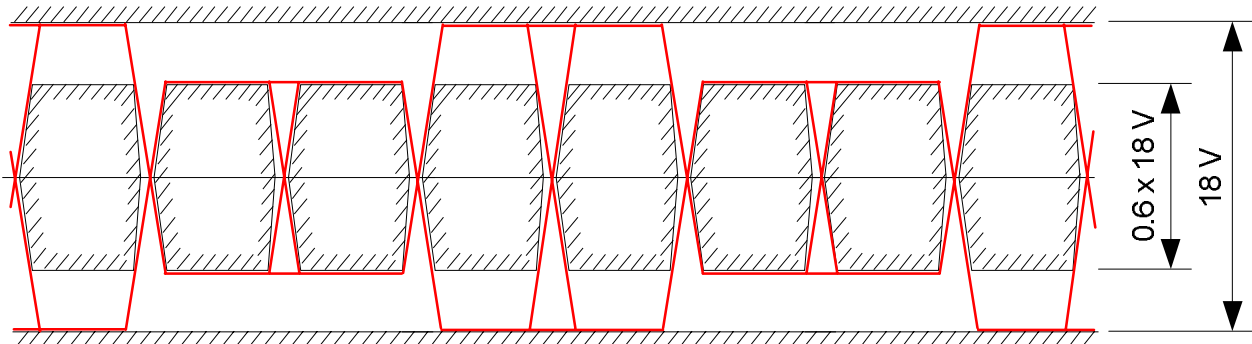


Figure H- 4: Amplitude and Timing Requirements for Test Signal "TSTE_minmax"

H.1.2.8 TSTE_alt-phase

Table H- 8 and Figure H- 5 specify the Test Signal TSTE_alt-phase.

Table H- 8: Requirements for TSTE_alt-phase

Parameter	Requirement
Sampling Frequency	$1024 \cdot R_d = 9.79706$ MHz with the nominal value of R_d according to sub-clause 6.3.2 of SUBSET-044 [N1]
Accuracy of Sampling Frequency	± 10 ppm
Early / Late Transition	$+ 500$ ns $\begin{cases} + 0$ ns \\ $- 50$ ns \end{cases}
Late / Early Transition	$- 500$ ns $\begin{cases} + 50$ ns \\ $- 0$ ns \end{cases}
Slew Rate	Positive Slew Rate: 60 ns/V ± 10 ns/V Negative Slew Rate: 60 ns/V ± 10 ns/V
Amplitude	according to Figure H- 5
Accuracy of Amplitude	± 0.5 V _{pp}

Edge of Test Signal jumps at early / late transition by +500ns or -500ns as indicated.

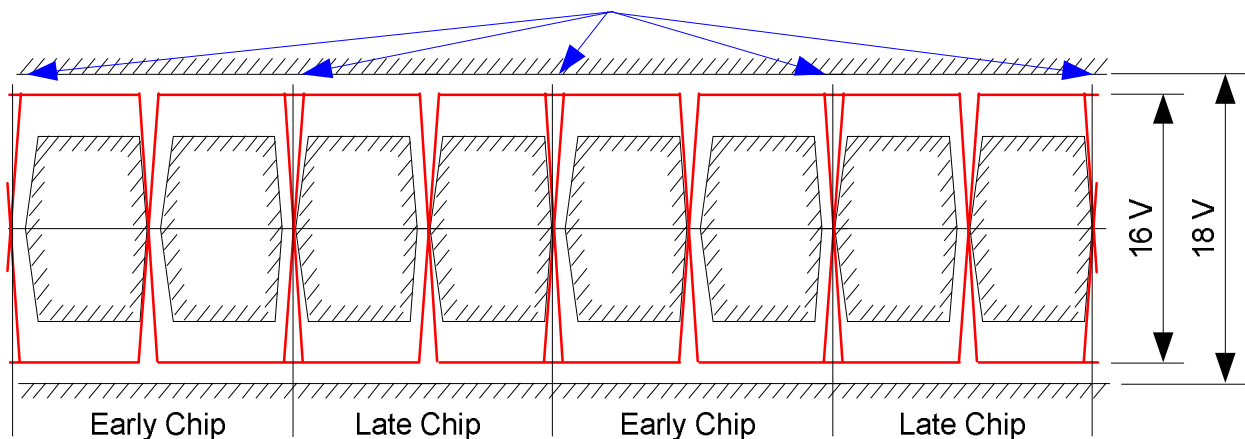


Figure H- 5: Amplitude and Timing Requirements for Test Signal “TSTE_alt-phase”

H.1.3 Test Signals for On-board Equipment (TSOE)

H.1.3.1 General Requirements

Each Test Signal of the On-board Equipment (TSOE) comes with a file containing its samples with specification of the nominal sampling interval, minimum sampling interval accuracy, and the minimum required amplitude resolution. The filenames are made up of a prefix and postfix. The prefix is identical with the name of the Test Signal, e.g. TSOE1. The postfix is made up of a two digit decimal number indicating the Q_SSCODE used with the Test Signal. Consequently, there are up to sixteen (16) Test Signals that go with each type of Test Signal. Table H- 9 specifies the filenames of the TSOEs.

General requirements for the TSOEs are provided in Table H- 10.

Table H- 9: Filenames Containing the Samples of the Test Signals for On-board Equipment (TSOE)

Test Signal	File Name
TSOE1	TSOE01_Qxx_sampling-rate.csv ¹⁷
TSOE2	TSOE02_Qxx_sampling-rate.csv
TSOE3	TSOE03_Qxx_sampling-rate.csv
TSOE4	TSOE04_Qxx_sampling-rate.csv
TSOE5	TSOE05_Qxx_sampling-rate.csv
TSOE6	TSOE06_Qxx_sampling-rate.csv
TSOE7	TSOE07_Qxx_sampling-rate.csv
TSOE8	TSOE08_Qxx_sampling-rate.csv
TSOE9	TSOE09_Qxx_sampling-rate.csv
TSOE10	TSOE10_Qxx_sampling-rate.csv
TSOE11	TSOE11_Qxx_sampling-rate.csv
TSOE12	TSOE12_Qxx_sampling-rate.csv
TSOE13	TSOE13_Qxx_sampling-rate.csv
TSOE14	TSOE14_Qxx_sampling-rate.csv
TSOE15	TSOE15_Qxx_sampling-rate.csv
TSOE16	TSOE16_Qxx_sampling-rate.csv

¹⁷ "xx": 00 ... 15 for all 16 SSCODE's, "sampling-rate"-format like: 74.999897MHz

Table H- 10: General Requirements for Test Signals TSOE

Parameter	Requirement
Centre frequency f_c	according to sub-clause 6.7.5 of SUBSET-044 [N1]
Accuracy of centre frequency f_c	± 5 ppm
MTIE	$< t_{ob} * 5$ ppm + 7 ns

A filter may be introduced at the output of the signal generator to mitigate imperfections in the generation of the test signals (such as harmonics, sampling noise, etc.). In case of applying such a filter, the test signals shall meet the characteristics specified herein.

H.1.3.2 TSOE1

The TSOE1 is an undistorted Euroloop signal complying with the specification provided in **Fehler! Verweisquelle konnte nicht gefunden werden.**

Table H- 11: Specification of TSOE1

Parameter	Requirement
Signal shape of TSOE1 in the air-gap	Nominal signal, complies with requirements stated in sub-clause 6.7 of [N1] for Interface 'CA _L '. No intended deviations from nominal data rate R_{dnom} , no intended MTIE.
Repetitive test pattern of logical 1 and logical 0 data bits as defined in sub-clause 6.7 of SUBSET-044 [N1].	1110010
Q_SSCODE	as specified in the test procedures
Amplitude	as specified in the test procedures
Sampling interval Δt	1/74.999873 MHz
Number of samples N	109747

TSOE1 shall be generated as follows:

$$TSOE1(n\Delta t) = a_{1x} \Re \left\{ TSOE1_c(n\Delta t) \times e^{j2\pi f_c n\Delta t} \right\}$$



where $TSOE1_c(n\Delta t) = \sum_{k=0}^{N-1} Pattern_{1110010}(((n-k) \bmod N)\Delta t) \times Fir(k\Delta t)$

REMARK: The term "Pattern" includes performing the differentiation operation on the bits 1110010

where $Fir(k\Delta t) = \sum_{p=1}^{11} g_{Fir}(p) \times \delta(k\Delta t - \tau_{Fir}(p))$

with :

Tap Number p	Tap Delay $\tau_{Fir}(p)$	Linear Tap Amplitude $g_{Fir}(p)$
1	Δt	1/36
2	$2\Delta t$	2/36
3	$3\Delta t$	3/36
4	$4\Delta t$	4/36
5	$5\Delta t$	5/36
6	$6\Delta t$	6/36
7	$7\Delta t$	5/36
8	$8\Delta t$	4/36
9	$9\Delta t$	3/36
10	$10\Delta t$	2/36
11	$11\Delta t$	1/36

H.1.3.3 TSOE2

The TSOE2 is a distorted Euroloop signal complying with the specification provided in Table H- 12.

Table H- 12: General Parameters of TSOE2

Parameter	Requirement
Q_SSCODE	as specified in the test procedures
Amplitude	as specified in the test procedures
Sampling interval Δt	1/74.99987 MHz
Number of samples N	109747

The complex envelope $TSOE2_c(n \cdot \Delta t)$ Test Signal TSOE2 is the discrete cyclic convolution of the complex envelope $TSOE1_c(n \cdot \Delta t)$ of the samples TSOE1($n \cdot \Delta t$) of the Test Signal TSOE1 with the complex envelope $g_{TDSLc}(n \cdot \Delta t)$ of the radio channel's impulse response at the time instance $n \cdot \Delta t$, $n \in \{1, 2, 3, \dots, N-1\}$, specified in **Fehler! Verweisquelle konnte nicht gefunden werden..**

$$TSOE2_c(n \Delta t) = \sum_{k=0}^{N-1} TSOE1_c(((n-k) \bmod N) \Delta t) \cdot g_{TDSLc}(k \Delta t).$$

N denotes the number of samples of the test signal $TSOE1_c(t)$ and Δt the sampling interval.

The complex envelope of the radio channel's impulse response is given by

$$g_{TDSLc}(n \Delta t) = \sum_{k=1}^9 g_k \cdot \delta(n \Delta t - \tau_k) \cdot e^{j 2\pi f_c \tau_k}$$

with f_c denoting the nominal centre frequency of the Euroloop signal specified in sub-clause 6.7.5 of SUBSET-044 [N1], and g_k and τ_k as specified in **Fehler! Verweisquelle konnte nicht gefunden werden..**

Finally, the Test Signal $TSOE2(n \cdot \Delta t)$ is given by

$$TSOE2(n \Delta t) = \Re \left\{ TSOE2_c(n \Delta t) \cdot e^{-j 2\pi f_c n \Delta t} \right\}$$

with $j = \sqrt{-1}$, $\Re(\cdot)$ denoting the real part of the argument.

The radio channel's impulse response $g_{TDSLc}(k \cdot \Delta t)$ is specified in Fehler! Verweisquelle konnte nicht gefunden werden.. **Table H- 13: Taped Delay Line Model of Complex Envelope of $g_{TDSLc}(n \cdot \Delta t)$**

Tap Number k	Relative Tap Delay τ_k	Relative Tap Amplitude $g_{k,dB}$	Relative Tap Amplitude g_k
-----------------	--------------------------------	--------------------------------------	---------------------------------

Tap Number k	Relative Tap Delay τ_k	Relative Tap Amplitude $g_{k,dB}$	Relative Tap Amplitude g_k
1	0 ns	-11 dB \pm 1 dB	0.282 $\begin{cases} +0.034 \\ -0.031 \end{cases}$
2	450 ns \pm 10%	0 dB \pm 1 dB	1 $\begin{cases} +0.12 \\ -0.11 \end{cases}$
3	625 ns \pm 10%	-1 dB \pm 1 dB	0.891 $\begin{cases} +0.11 \\ -0.096 \end{cases}$
4	850 ns \pm 10%	-6 dB \pm 1 dB	0.501 $\begin{cases} +0.061 \\ -0.054 \end{cases}$
5	1.05 μ s \pm 10%	-6 dB \pm 1 dB	0.501 $\begin{cases} +0.061 \\ -0.054 \end{cases}$
6	1.28 μ s \pm 10%	-9 dB \pm 1 dB	0.355 $\begin{cases} +0.043 \\ -0.039 \end{cases}$
7	1.48 μ s \pm 10%	-10 dB \pm 1 dB	0.316 $\begin{cases} +0.039 \\ -0.028 \end{cases}$
8	1.70 μ s \pm 10%	-13 dB \pm 1 dB	0.224 $\begin{cases} +0.027 \\ -0.024 \end{cases}$
9	2.00 μ s \pm 10%	-15 dB \pm 1 dB	0.178 $\begin{cases} +0.022 \\ -0.020 \end{cases}$

Note: The test signals shall be generated with the nominal values of the above listed parameters, tolerances are only specified to allow for tolerances in the test instrumentation.

H.1.3.4 TSOE3

The Test Signal TSOE3 is identical to TSOE2, except that the complex envelope of the radio channel's impulse response $g_{TDLc}(n \cdot \Delta t)$ is given by

$$g_{TDLc}(n\Delta t) = \sum_{k=1}^9 g_k \cdot \delta(n\Delta t - \tau_k) \cdot e^{j2\pi f_c \tau_k} \cdot e^{j2\pi v_0 n \Delta t}$$

with f_c denoting the nominal centre frequency of the Euroloop signal specified in sub-clause 6.7.5 of SUBSET-044 [N1], $v_0 = 4.4 \text{ Hz} \pm 0.4 \text{ Hz}$ the maximum Doppler shift accounting for the maximum train speed of 350 km/h as of sub-clause 5.3.1 of SUBSET-044 [N1], and g_k and τ_k as specified in **Fehler! Verweisquelle konnte nicht gefunden werden..**

Sampling interval Δt 1/74.99990 MHz
 Number of samples N 109747

H.1.3.5 TSOE4

The Test Signal TSOE4 is identical to the Test Signal TSOE3, except for the Doppler shift, which shall amount to $v_0 = -4.4 \text{ Hz} \pm 0.4 \text{ Hz}$.

Sampling interval Δt 1/74.99985 MHz
 Number of samples N 109747

H.1.3.6 TSOE5

H.1.3.6.1 TSOE5a

The Test Signal TSOE5a shall be a harmonic signal complying with the requirements stated in Table H- 14.

Table H- 14: Specification of TSOE5a

Parameter	Value
Fundamental frequency (nominal)	4.5 MHz
Sampling interval Δt	1/100.0 MHz
Number of samples N	40000
Frequency accuracy	± 5 ppm
Signal power level	specified in the test procedures
Tolerance of Signal power level	± 0.5 dB

H.1.3.6.2 TSOE5b

The Test Signal TSOE5b shall be a harmonic signal complying with the requirements stated in Table H- 15.

Table H- 15: Specification of TSOE5b

Parameter	Value
Fundamental frequency (nominal)	27.095 MHz
Sampling interval Δt	1/100.0 MHz
Number of samples N	40000
Frequency accuracy	± 5 ppm
Signal power level	specified in the test procedures
Tolerance of Signal power level	± 0.5 dB

H.1.3.7 TSOE6

The Test Signal TSOE6 shall be a harmonic signal complying with the requirements stated in Table H- 16.

Table H- 16: Specification of TSOE6

Parameter	Value
Frequency (nominal) f_c	see sub-clause 6.7.5 of SUBSET-044 [N1]
Sampling interval Δt	1/100.0 MHz
Number of samples N	40000
Frequency accuracy	± 5 ppm
Signal power level	specified in the test procedures
Tolerance of Signal power level	± 0.5 dB

H.1.3.8 TSOE7

The Test Signal TSOE7 is an unwanted Euroloop signal, which shall comply with TSOE2 but differing from the wanted Euroloop signal with regard to the Q_SSCODE and in addition: ¹⁸⁾

- deviation from nominal data rate R_{dnom} +55.29 ppm
- deviation from nominal carrier frequency f_c +4.89 ppm.
- sampling interval 1/7500061 MHz
- number of samples N 109742

H.1.3.9 TSOE8

Four versions of THSOE8 with different frequencies are defined: TSOE8a, ..b, ..c, ..d. The amplitude is specified in the respective test procedure.

Table H- 17: Specification of TSOE8

Parameter	Value
TSOE8a: Nominal frequency for test set-up	27.115 MHz
TSOE8b: Nominal frequency for test set-up	28.000 MHz
TSOE8c: Nominal frequency for test set-up	29.000 MHz
TSOE8d: Nominal frequency for test set-up	30.000 MHz
Sampling interval Δt	1/100.0 MHz
Number of samples N	40000
Frequency accuracy	± 20 ppm
Signal power level	specified in the test procedures
Tolerance of Signal power level	± 0.5 dB

¹⁸⁾ The deviation of data-rate is required in order to cover all phase relations between the DSSS-Code sequences during a co-channel rejection test. The exact values of both deviations are chosen such that a continuous signal results between end and begin of the repeated signal sequence.

H.1.3.10 TSOE9

The Test Signal TSOE9 coincides with the Test Signal TSOE2 except for its amplitude which fluctuates as indicated in Figure H- 6. The Field Strength variation shall be linear over time between the two limits.

Further the signal amplitude of every chip shall alternately deviate from nominal value by $\pm 10\%$ representing a 10% amplitude modulation at half the chip rate.

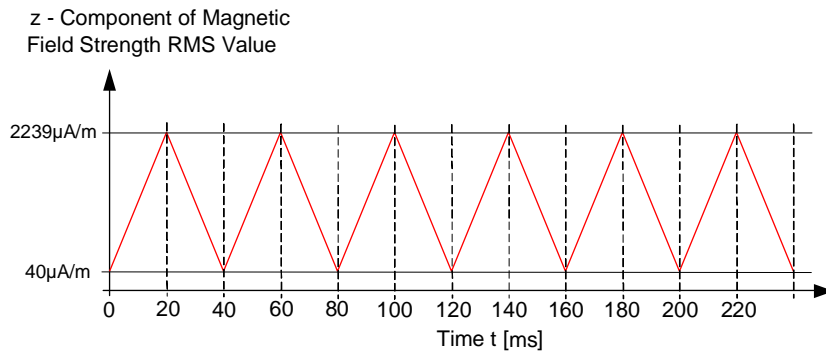


Figure H- 6: Amplitude vs. Time of TSOE9

H.1.3.11 TSOE10

The Test Signal TSOE10 shall be made up of two (2) simultaneously generated identically copies of the Test Signal TSOE2 called TSOE10 Nr. 1 and TSOE10 Nr. 2, which differ in their amplitudes vs. time and delays as specified in Figure 7.6 of SUBSET-044 [N1]. The relation of z-component of the magnetic field strengths shall be accurate to $\pm 2 \text{ dB}\mu\text{A/m}$. The relative propagation delays of the two signals shall be accurate to $\pm 50 \text{ ns}$.

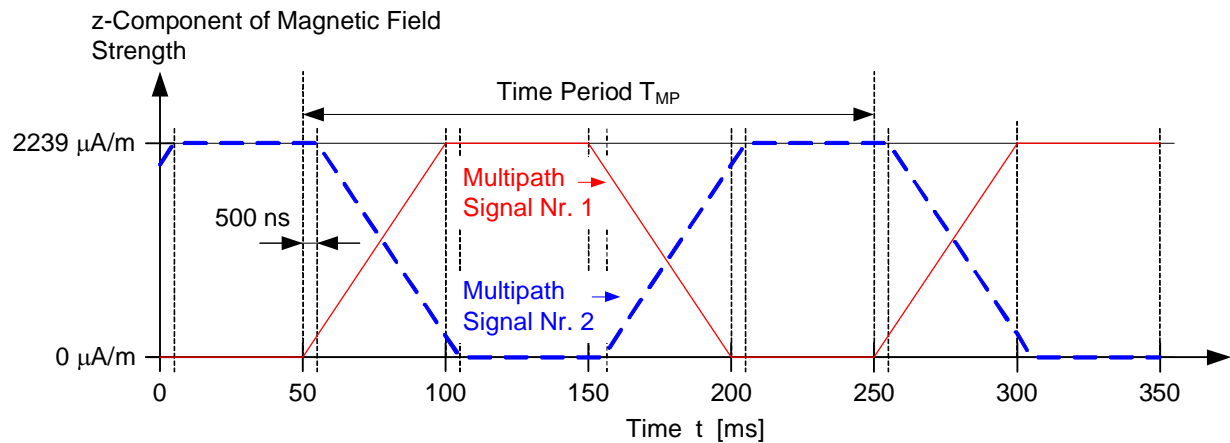


Figure H- 7: Time-Varying Multipath Signals of TSOE10

Sampling interval Δt	1/75.0 MHz
Number of samples N	1503536

H.1.3.12 TSOE11

The Test Signal TSOE11 complies with the Test Signal TSOE2, except for its centre frequency f_c , which shall be detuned by +30 ppm and shall include applied jitter as specified in TSOE15.

Sampling interval Δt	1/75.00012 MHz
Number of samples N	329243

H.1.3.13 TSOE12

The Test Signal TSOE12 complies with the Test Signal TSOE2, except for its centre frequency f_c , which shall be detuned by -30 ppm and shall include applied jitter as specified in TSOE15.

Sampling interval Δt	1/75.00008 MHz
Number of samples N	329241

H.1.3.14 TSOE13

The Test Signal TSOE13 complies with the Test Signal TSOE2, except for its chip rate R_c , which shall be detuned by +70 ppm.

Sampling interval Δt	1/75.00019 MHz
Number of samples N	329220

H.1.3.15 TSOE14

The Test Signal TSOE14 complies with the Test Signal TSOE2, except for its chip rate R_c , which shall be detuned by -70 ppm.

Sampling interval Δt	1/75.00002 MHz
Number of samples N	329264

H.1.3.16 TSOE15

The Test Signal TSOE15 is identical to the Test Signal TSOE13, except that the jitter of the edges of the chip periods of the SSCode changes alternatively by $+40\text{ ns}$ and -40 ns relative to their nominal values as indicated in Figure H- 8 below. The quantity T_c denotes the chip period of the SSCode with $T_c = 1/R_c$, where R_c is the chip rate defined in sub-clause 6.7.3.4 of SUBSET-044 [N1]. The test pattern of logical “0” and “1” data bits is defined in **Fehler! Verweisquelle konnte nicht gefunden werden.** for the Test Signal TSOE1 in sub-clause H.1.3.2. This pattern is repeated 6 times. Every two consecutive edges in the chip sequence have the same time shift of 20 ns. The sign of the time shift changes after every two edges.

Sampling interval Δt	1/75.00019 MHz
Number of samples N	329220

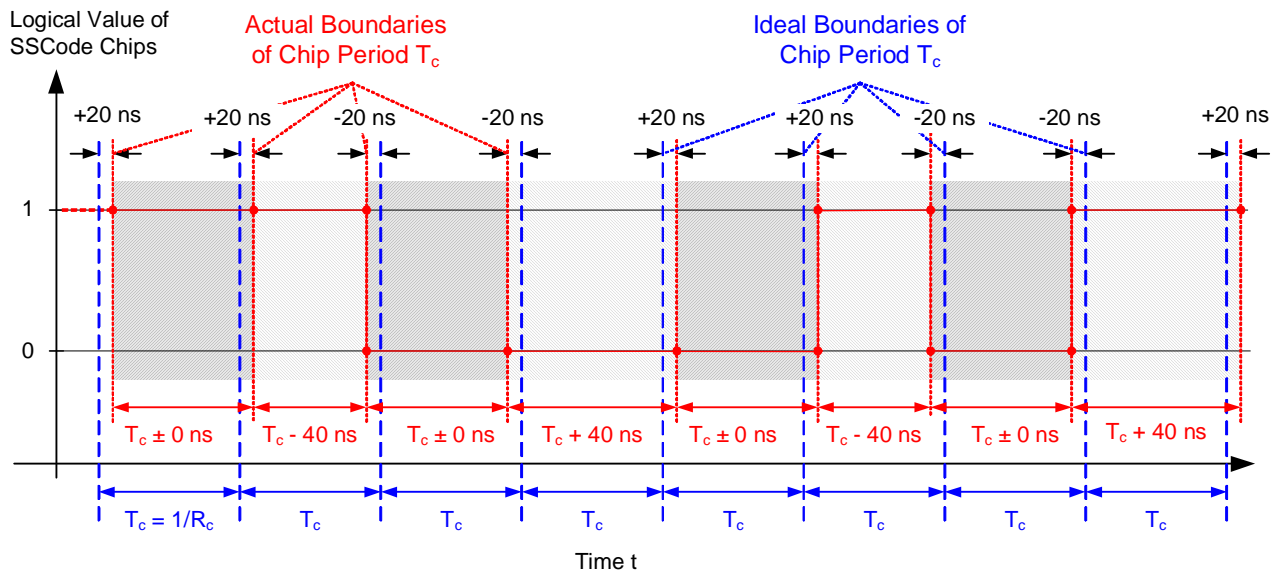


Figure H- 8: Repetitive Pattern of Logical 1 and Logical 0 Chips with Jitter



H.1.3.17 TSOE16

The parameters of the Test Signal TSOE16 are identical to the Test Signal TSOE1, except that it contains a full short Euroloop telegram.

Sampling interval Δt	1/75.0 MHz
Number of samples N	5346256

The User Bits shall be encoded in accordance with the Eurobalise Coding Strategy (see Ref. [N3]). The encoded telegram length is 341, which shall be cyclically transmitted without interruption as required by the test procedure.

The coded Telegram content, starting with the least significant bit of the first hex-value, shall be as follows:

EA862F3A9AC64B6F4913ED7D55B49115B2B559E85D0A3788752D8D16D04053A4C10D983E286159C899C297

Table H- 18: User data of TSOE16

Title	description	Value (dec.)	# of bits
Q_UPDOWN	Up link telegramm	1	1
M_VERSION	Version 1.0	16	7
Q_MEDIA	loop	1	1
NID_C	Country code	0	10
NID_LOOP	Id of loop	0	14
NID_PACKET	Plain text message	72	8
Q_DIR	Both directions	2	2
L_PACKET	Length in bits	164	13
Q_SCALE	1 m	1	2
Q_TEXTCLASS	Auxiliary information	0	2
Q_TEXTDISPLAY	No combination of conditions	0	1
D_TEXTDISPLAY	0 m	0	15
M_MODETEXTDISPLAY	No limitation by mode	15	4
M_LEVELTEXTDISPLAY	No limitation by level	5	3
L_TEXTDISPLAY	No distance limitation	32767	15
T_TEXTDISPLAY	Not limited by Time	1023	10
M_MODETEXTDISPLAY	No limitation by mode	15	4
M_LEVELTEXTDISPLAY	No limitation by level	5	3
Q_TEXTCONFIRM	No Confirmation required	0	2
L_TEXT	Length of text-string	9	8
X_TEXT	T	84	8
X_TEXT	e	101	8
X_TEXT	s	115	8
X_TEXT	t	116	8
X_TEXT	-	45	8
X_TEXT	T	84	8
X_TEXT	e	101	8
X_TEXT	l	108	8
X_TEXT	:	58	8
NID_PACKET	End of message	255	8
		Total No. Bits:	205



H.1.3.18 TSOE17

Test Signal TSOE17 occurs in 8 variants, TSOE17-S1 to TSOE17-S8, which differs only in the “telegram” content. The parameters of the Test Signals TSOE17-S1 to -S8 are identical to the Test Signal TSOE1, except that they contain corrupt Eurobalise telegrams S1 to S8 specified in SUBSET-085 [N4] chapter A3.



Annex I BIT ERROR TEST PROCEDURE

Test procedure for verification of the required BER limit of $1 \cdot 10^{-5}$, $1 \cdot 10^{-4}$ and $2 \cdot 10^{-4}$ with a confidence level of 99%. For these two BER's, different number of bits has to be tested:

BER < $1 \cdot 10^{-5}$:	N1 = 460'517	N2 = 203'318	N3 = 176'759
BER < $1 \cdot 10^{-4}$:	N1 = 46'052	N2 = 20'332	N3 = 17'676
BER < $2 \cdot 10^{-4}$:	N1 = 23'026	N2 = 10'166	N3 = 8'838

1. Test N1 bits
2. If no bit error occurred then the test is successfully finished.
3. If error occurred, test additional N2 bits.
4. If altogether no more than one bit error occurred, then the test is successfully finished.
5. If more than one error occurred, test additional N3 bits.
6. If altogether no more than two bit error occurred, then the test is successfully finished.
7. If altogether more than two bit error occurred then the test failed.

Annex J TEST TOOLS AND INSTRUMENTS (INFORMATIVE)

The following list includes examples of suitable test equipment. Other equipment with similar performance may substitute these. “Item” refers to numbers in the Test and Calibration configurations.

Table J- 1: List of Suitable Test Equipment

Item	Ref.	Equipment	Type	Comment
		Signal Sources		
SG1	4.4.2	Arbitrary Waveform Generator	LeCroy LW420A	
SS1, SS2	4.4.3	Arbitrary Waveform Generator	Tektronix AG420A	
SS3	4.4.4	HF Signal Source	HP 8668B	
		Measurement Instruments		
SA	4.4.7	Spectrum Analyser	R&S FSH 3	
NWA1	4.4.6	Network Analyser	Agilent 8753C	
NWA2	4.4.7	Network Analyser	Rohde&Schwarz ZVC	
DSO	4.4.9	Digital Storage Oscilloscope	LeCroy LT342, Opt. 1M sample	
PM	4.4.10	RF Power Meter	Power sensor: R&S NRP Z11 USB Adapter: R&S NRP-Z4	
PNME	4.4.17	Phase Noise Measurement Equipment	HP 11729B, HP 8668B	
		Auxiliary Instruments		
PA1	4.4.5	Linear Power Amplifier	ENI 550L	
LNA	4.4.16	Low Noise Amplifier	Mini-Circuits ZFL-500LN	
DCPS		DC Power Supply, 10V, 0.1A	-	
VM	4.4.20	Volt Meter	-	
CM	4.4.19	Current Meter	-	
		Antennas		
MFP	Annex E	Magnetic Field Probe	Compliant with Annex E	
ELC	Annex D	ELC Reference Tool	Compliant with Annex D	
ERT-ILA	Annex D.4	ERT Interference-Signal Loop Antenna	Compliant with Annex D.4	

Item	Ref.	Equipment	Type	Comment
		Auxiliary Equipment		
RFPC	4.4.11	RF Combiner	SUHNER 4901.01.A	
DC1, DC2	4.4.15	Directional Coupler	Mini-Circuits ZFDC-10-1	
A1	4.4.12	Attenuator	SUHNER 5910.17.0006	
A2	4.4.13	Attenuator	SUHNER 6806.17.AC	
	4.4.14	RF Cables	-	
FCF		Ferrite Clamp Filter	Würth 74271221	
FOF		Ferrite Core Filter	Philips TX36/23/15 Grade 3F3	
BLN	4.4.21	Balun	North Hills Type 0306LB	
CMC	4.4.18	Common Mode Choke	-	
SW1		Switch	-	
BPF	4.4.23	Band Pass Filter	K&L: 4LB30-13.5/T4.5-O/O	
ERT	Annex D	ELC Reference Tool	Compliant with Annex D	
		Eurobalise Equipment		
EBV1L		Interface 'V1L' Adapter	Item 34 in Annex F1 of SUB-SET-085 [N4]	
LTMS		Laboratory Test Management System	Item 38 in Annex F1 of SUB-SET-085 [N4]	
RSRL		Reduced Size Reference Loop	Item 19 in Annex F1 of SUB-SET-085 [N4]	
ENRB		Reference Loop Balun	Item 8 in Annex F1 of SUBSET-085 [N4]	
EBMB		Metal Box	Compliant to sub-clause B5.3.7 of SUBSET-085 [N4]	



Annex K CROSS CORRELATION PROPERTIES OF SSCODES

Table I- 1 provides the largest even or odd cross correlation values (i.e. worst case) among indicated SSCodes for all possible relative shifts between the two SSCodes. The SSCodes are specified in Annex F of SUBSET-044 [N1].

Table I- 1: Largest Even or Odd Cross Correlation Levels in dB Among all SSCodes from Annex F of [N1]

Q_SSCODE	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
00	0.0	-15.6	-16.6	-17.1	-16.3	-15.0	-16.8	-16.3	-16.6	-16.6	-16.8	-16.3	17.9	-15.6	-17.1	-16.1
01	----	0.0	-15.9	-17.4	-16.3	-16.3	-17.6	-16.1	-15.9	-16.8	-17.1	-15.9	-16.1	-17.6	-17.4	-16.8
02	----	----	0.0	-16.8	-16.8	-15.6	-17.6	-17.6	-16.3	-15.0	-15.2	-17.1	-16.1	-16.8	-14.2	-15.4
03	----	----	----	0.0	-16.3	-16.3	-16.6	-16.3	-17.1	-16.6	-16.3	-17.1	-16.3	-16.6	-16.6	-16.6
04	----	----	----	----	0.0	-16.3	-14.6	-16.3	-16.6	-15.6	-16.3	-16.8	-15.4	-16.1	-16.1	-17.6
05	----	----	----	----	----	0.0	-17.4	-15.9	-15.6	-16.1	-17.4	-16.6	-16.8	-17.4	-17.4	-16.6
06	----	----	----	----	----	----	0.0	-15.0	-17.6	-16.6	-15.9	-16.1	-15.4	-16.1	-16.3	-16.1
07	----	----	----	----	----	----	----	0.0	-16.6	-16.6	-16.8	-16.6	-16.8	-17.4	-17.9	-15.6
08	----	----	----	----	----	----	----	----	0.0	-17.1	-17.1	-14.6	-16.6	-16.3	-15.4	-17.1
09	----	----	----	----	----	----	----	----	----	0.0	-15.2	-17.4	-16.1	-15.9	-15.9	-17.4
10	----	----	----	----	----	----	----	----	----	----	0.0	-16.3	-16.8	-16.3	-16.3	-16.3
11	----	----	----	----	----	----	----	----	----	----	----	0.0	-16.1	-16.3	-16.3	-15.0
12	----	----	----	----	----	----	----	----	----	----	----	----	0.0	-15.6	-17.6	-17.1
13	----	----	----	----	----	----	----	----	----	----	----	----	----	0.0	-17.1	-15.0
14	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0.0	-17.4
15	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0.0

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