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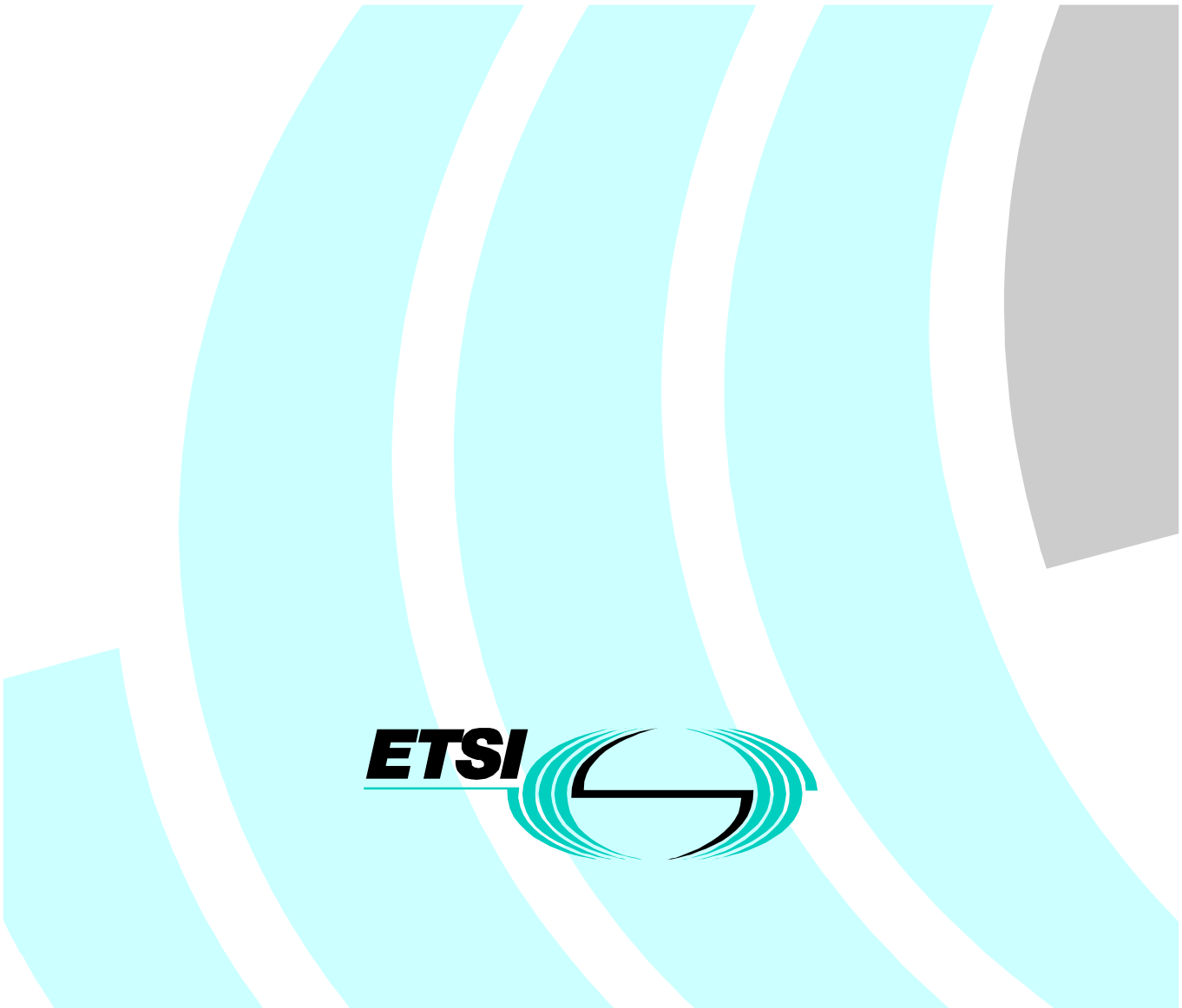
Technical Specification

Terrestrial Trunked Radio (TETRA);
TMO Repeaters
Part 1: Requirements, test methods and limits



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Contents

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Foreword

This Technical Specification (TS) has been produced by ETSI Project Terrestrial Trunked Radio (TETRA).

The present document is part 1 of a multi-part TS covering TETRA TMO Repeaters, as identified below:

Part 1: "Requirements, test methods and limits";

Part 2: "Functional specification";

1 Scope

The present document specifies the technical characteristics, test methods, limits and the requirements for TMO repeater equipment. The present document is applicable to TETRA systems operating at radio frequencies in the range 300 MHz to 1 GHz.

These specifications do not necessarily include all the characteristics which may be required by a user of equipment, nor do they necessarily represent the optimum performance achievable.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] ETSI ETS 300 394-1: "Terrestrial Trunked Radio (TETRA); Conformance testing specification; Part 1: Radio".

[2] ETSI ETS 300 392-2: "Terrestrial Trunked Radio (TETRA) Voice plus Data (V+D) Part 2: Air Interface (AI)".

[3] ETSI ETS 300 113: "Radio Equipment and Systems (RES); Land mobile service; Technical characteristics and test conditions for radio equipment intended for the transmission of data (and speech) and having an antenna connector".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following definitions apply:

Broadband repeater: repeater which is designed for operation on any combination of TETRA carriers (up to a specified maximum number) within the operating band of the repeater

Channelized repeater: repeater which is designed for operation on a specified subset of TETRA carriers within the operating band of the repeater. The subset of the TETRA channels may be determined during the manufacture of the repeater, or may be programmable

Repeater: bi-directional Radio Frequency (RF) amplifier which can amplify and transmit a received Mobile Station (MS) signal in the TETRA MS transmit band, simultaneously it can amplify and transmit a received Base Station (BS) RF signal in the TETRA BS transmit band

Spurious emissions: emissions at frequencies other than those of the carrier and sidebands associated with normal modulation and switching

Channel: for the purpose of the present document a "channel" shall refer to a complete TETRA carrier

Trunked Mode operation: mode of operation where a network is used for communication

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACP	
BS	Base Station
dBc	Decibels relative to carrier power
dBm	Decibels relative to one mW
MS	Mobile Station
RF	Radio Frequency
TMO	Trunked Mode Operation

4 Requirements

4.1 Introduction

A repeater can be designed to amplify the whole transmit RF band or just a part of the band. In the latter case the repeater can be either broadband, with frequency band selective filtering, or channelized, with channel selective filtering. The repeater shall operate within the frequency bands defined in ETS 300 392-2 [2], subclause 6.2 and clause F.2.

4.2 Requirements

4.2.1 Spurious emissions and Wideband noise

The requirement of ETS 300 392-2 [2], subclauses 6.4.2.3 and 6.4.3 apply with the following modification:

Table 1: Wideband noise limits

Frequency offset	Maximum Wideband Noise
100 kHz – 250 kHz	- 75 dBc
250 kHz – 500 kHz	- 80 dBc
500 kHz - f_{rb}	- 80 dBc
> f_{rb}	- 100 dBc
frb denotes the frequency offset corresponding to the near edge of the receiver band or 5 MHz (10 MHz for frequencies above 520 MHz) whichever is greater. All levels are expressed in dBc.	

All levels in table 1 are expressed in dBc relative to the actual transmitted power level, and in any case no limit tighter than -55 dBm for offsets < f_{rb} or -70 dBm for offsets > f_{rb} shall apply.

Conducted emissions

For equipment only capable of operating at frequencies below 470 MHz, the maximum level of spurious emission shall not be greater than -36 dBm in the frequency range 9 kHz to 14 GHz, and -30 dBm in the range 1 GHz to 4 GHz. For equipment capable of operating at frequencies above 470 MHz, the maximum level of spurious emission shall not be greater than -36 dBm in the frequency range 9 kHz to 1 GHz, the maximum level of spurious emission shall not be greater than -30 dBm in the frequency range 1 GHz to 12,75 GHz.

Radiated emissions

For equipment only capable of operating at frequencies below 470 MHz, the maximum level of spurious emission shall not be greater than -36 dBm in the frequency range 30 MHz to 1 GHz, and -30 dBm in the range 1 GHz to 4 GHz. For equipment capable of operating at frequencies above 470 MHz, the maximum level of spurious emission shall not be greater than -36 dBm in the frequency range 30 MHz to 1 GHz, the maximum level of spurious emission shall not be greater than -30 dBm in the frequency range 1 GHz to 12,75 GHz.

4.2.2 Intermodulation attenuation

The requirement of ETS 300 392-2 [2], subclause 6.4.6.3 shall apply.

4.2.3 Out of band gain

4.2.3.1 Definition

Out of band gain refers to the nominal gain of the repeater outside the relevant transmit bands.

4.2.3.2 Requirement

For units with an operating frequency band of 1 MHz or less the limits detailed in table 2 shall not be exceeded.

Table 2: Maximum gain

Frequency offset from the – 6 dB point	Maximum gain
50 kHz	63 dB
75 kHz	50 dB
125 kHz	30 dB
250 kHz	20 dB
≥ 500 kHz	10 dB

For units with an operating frequency band greater than 1 MHz the limits detailed in table 3 shall not be exceeded.

Table 3: Maximum gain

Frequency offset from the – 6 dB point	Maximum gain
50 kHz	75 dB
75 kHz	70 dB
125 kHz	65 dB
250 kHz	32 dB
≥ 500 kHz	28 dB

4.2.4 Output Power

The output shall be declared by the manufacture and be in accordance with the definition in ETS 300 392-2 [2], subclause 6.4.1.

4.2.5 Adjacent channel power

The requirement of ETS 300 392-2 [2], subclauses 6.4.2.2.1 and 6.4.2.2.2 shall apply.

4.2.6 Modulation accuracy

The requirements of ETS 300 392-2 [2], subclauses 5.2 and 6.6.1 shall apply.

5 Test specification

5.1 Radio frequency bands

A repeater, as a bi-directional amplifier, can amplify and transmit a received MS signal in the MS transmit band, simultaneously it can amplify and transmit a received BS signal in the BS transmit band. The relevant MS and BS transmit bands, as defined in ETS 300 392-2 [2].

5.2 Manufacturers declarations

The manufacturer shall declare:

a) The operating band or bands of the repeater.

b) The maximum rated output power per channel.

c) The number of channels supported by the repeater.

5.3 Test system

The test system shall conform to the requirements of ETS 300 394-1 [1], Annex B.

5.4 Test environments

For each test in the present document, the environmental conditions under which the repeater is to be tested are defined in ETS 300 394-1 [1], clause 6.

5.5 Repeater test specification

5.5.1 Spurious emissions and Wideband noise

5.5.1.1 Test purpose

The purpose of this test is to establish the level of conducted spurious emissions and wideband noise (see subclause 3.1) at the antenna ports and the effective power of spurious emissions radiated by the cabinet and structure.

5.5.1.2 Test case

The repeater shall be set to maximum gain. All measurement steps, as described in this subclause, apply to all antenna ports of the repeater.

a) Spurious emissions from the antenna port: one antenna port of the repeater shall be connected to a selective RF measurement device presenting to the repeater a load with an impedance of 50 Ω. An average power measurement of spurious emissions shall be performed for frequency offsets from the carrier frequency greater than 600 kHz under the following two conditions:

   i) Without any RF input signal. The relevant input antenna port of the repeater shall be terminated with 50 Ω;

   ii) With a RF input signal. The relevant antenna input port of the repeater shall be connected to a RF signal generator. A continuous sinusoidal RF signal shall be fed to the input of the repeater and increased, until the maximum rated output power per channel, as declared by the manufacturer, is reached. The RF input signal shall be set to the centre frequency of the repeaters operating band. In the case of a channelized repeater, the RF input signal shall be set to the centre of the supported TETRA channel closest to the centre of the range of the channels supported by the repeater.

b) Wideband noise: one antenna port of the repeater shall be connected to a selective RF measurement device presenting to the repeater a load with an impedance of 50 Ω. A measurement of wideband noise shall be conducted in accordance with the offsets defined in table 4. The measurement shall be conducted under the conditions outlined in subclause 5.5.1.2 item a), parts i) and ii), of the present document.

c) Radiated spurious emissions: a test site fulfilling the requirements of ETS 300 113 [3] shall be used, except when it conflicts with the present document. The repeater shall be placed on a non-conducting support and shall be operated from a power source as recommended by the manufacturer via an RF filter, to prevent the power source or cable from influencing the result of the measurement.

The relevant output antenna port of the repeater shall be terminated with 50 Ω. The relevant antenna input port of the repeater shall be connected to a RF signal generator in such a way that the connection does not influence the result of the measurement. The RF input signal shall be set to the centre frequency of the repeaters operating band. A continuous sinusoidal RF signal shall be input at a level, which will result in the maximum rated output power per channel, as declared by the manufacturer. The output level shall be confirmed by measurement.

An average RF power measurement shall be performed for frequency offsets from the carrier frequency greater than 600 kHz over the frequency range 30 MHz to 4 GHz. The repeater shall be rotated through 360° in the horizontal plane and the test antenna shall be raised or lowered until the maximum spurious signal level is detected. The effective radiated power of each spurious component shall be determined by a substitution measurement. The alternative test site as defined in ETS 300 112 [3] may also be used.

The measurements shall be repeated with orthogonal polarization of the test antenna.

The measurements shall be repeated with no RF input signal, in this case the relevant antenna input port of the repeater shall be terminated with 50 Ω.

Measurement bandwidths for steps a), b) and c) shall be in accordance with ETS 300 394-1 [1], table 16.

5.5.1.3 Limit values

The measured power in test case subclause 5.5.1.2 a), as well as the effective radiated power in test case subclause 5.5.1.2 c) shall not exceed:

Conducted emissions

- -36 dBm (250 nW) in the frequency band 9 kHz to 1 GHz;
- -30 dBm (1µW) in the frequency band 1 GHz to 12,75 GHz, for equipment capable of operating below 470 MHz, for equipment capable of operating above 470 MHz, the frequency band is 1 GHz to 12,75 GHz.

Radiated emissions

- -36 dBm (250 nW) in the frequency band 30 MHz to 1 GHz;
- -30 dBm (1µW) in the frequency band 1 GHz to 4 GHz, for equipment capable of operating below 470 MHz, for equipment capable of operating above 470 MHz, the frequency band is 1 GHz to 12,75 GHz.

The wideband noise shall not exceed the following limits.

Table 4: Wideband noise limits

Frequency offset	Maximum Wideband Noise
100 kHz – 250 kHz	- 75 dBc
250 kHz – 500 kHz	- 80 dBc
500 kHz - f_{rb}	- 80 dBc
> f_{rb}	- 100 dBc
frb denotes the frequency offset corresponding to the near edge of the receiver band or 5 MHz (10 MHz for frequencies above 520 MHz) whichever is greater. All levels are expressed in dBc.	

All levels in table 4 are expressed in dBc relative to actual transmitted power level, and in any case no limit tighter than –55 dBm for offsets < f_{rb} or –70 dBm for offsets > f_{rb} shall apply.

5.5.2 Intermodulation attenuation

5.5.2.1 Test purpose

To verify that the level of intermodulation products, generated in non-linear elements of the repeater, in the presence of two RF input signals, do not exceed the specified limits.

5.5.2.2 Test case

The repeater shall be set to maximum gain. Two continuous sinusoidal RF signals shall be fed to the input antenna port of the repeater using a combining device. The frequencies of both RF signals shall be within the repeater's operating band. The spacing between both RF signals shall be the minimum possible spacing applied in a network, i.e. 200 kHz. The input signals and resulting product shall be within the operating band of the repeater.

The level of both RF input signals shall be increased, until the maximum rated output power per channel, as declared by the manufacturer, is reached.

In case of a repeater only supporting one channel, one RF input signal shall be set to the operating frequency and the other RF input signal at an offset of 100 kHz to either side successively. In this case the input signal at the repeaters operating frequency shall be increased, until the maximum rated output power per channel, as declared by the manufacturer, is reached. The second signal shall be set to the same input level.

The level of the third order intermodulation products shall be measured by means of a selective measurement device presenting to the repeater a load with an impedance of 50 Ω.

The test shall be repeated with both RF input signals increased by 10 dB each.

NOTE: In this case, the automatic gain (level) control may reduce the gain to a value less than maximum gain in order to keep the maximum rated output power per channel, as declared by the manufacturer. An average power measurement shall be performed using a bandwidth of 3 kHz.

The measurements shall apply to all antenna ports of the repeater.

Test environment: Normal

Extreme

5.5.2.3 Limit values

The level of intermodulation product shall be less than –60 dBc. In any case not requirement greater than –36 dBm shall apply.

5.5.3 Out of band gain

5.5.3.1 Test purpose

To test the net gain of the repeater outside the relevant MS or BS transmit band. This test shall also check the net gain at harmonic frequencies.

5.5.3.2 Test case

The repeater shall be set to maximum gain. In case of a channel selective repeater, two of the channel selective modules shall be set to the lowermost and the uppermost channels within the repeater's operating band.

A continuous sinusoidal RF signal shall be fed successively at frequency offsets Y from the edges of the relevant MS or BS transmit frequency band into the relevant input port of the repeater. The frequency offsets Y shall have the following values:

- 50 kHz;
- 75 kHz;
- 125 kHz;
- 250 kHz; and
- 500 kHz.

This shall be repeated with an continuous sinusoidal RF signal successively set to all harmonic frequencies of the repeaters operating band up to 12,75 GHz (i.e. multiples of the centre frequency of the repeaters operating band up to 12,75 GHz).

The power level of the RF input signal shall be at least 5 dB below the power level which would produce, when applied within the operating band, maximum rated output power, as declared by the manufacturer. This is to ensure that the equipment is operating in the linear output range.

The average output power in each case shall be measured and the net gain shall be recorded.

The measurements shall apply to all antenna ports of the repeater.

Test environment: Normal

Extreme

5.5.3.3 Limit values

For units with an operating frequency band of 1 MHz or less the following limits shall not be exceeded.

Table 5: Maximum gain

Frequency offset from the – 6 dB point	Maximum gain
50 kHz	63 dB
75 kHz	50 dB
125 kHz	30 dB
250 kHz	20 dB
≥ 500 kHz	10 dB

For units with an operating frequency band greater than 1 MHz the following limits shall not be exceeded.

Table 6: Maximum gain

Frequency offset from the – 6 dB point	Maximum gain
50 kHz	75 dB
75 kHz	70 dB
125 kHz	65 dB
250 kHz	32 dB
≥ 500 kHz	28 dB

5.5.4 Output power

5.5.4.1 Test purpose

The purpose of this test is to establish the output power of the repeater.

5.5.4.2 Test case

The following measurements shall be performed in both the uplink and downlink directions. The pass criteria for all power levels declared by the manufacturer shall be met. For the practicality of measurement the tests will be conducted at maximum and minimum gain settings only.

The measurement shall be conducted on channels at the upper and lower limits of operational frequency band of the repeater, as declared by the manufacturer.

A T2 test signal shall be fed into the input of the repeater.

The output connector shall be connected to a selective RF measurement device presenting to the repeater a load with an impedance of 50 Ω.

The maximum power class of the repeater shall be defined in accordance with ETS 300 392-2 [2], subclause 6.4.1.1. It should be noted that some administrations indicate that co-ordination may apply for repeaters exceeding 1W (30 dBm).

Test environment: Normal

Extreme

5.5.5 Adjacent channel power

5.5.5.1 Test purpose

The purpose of this test is to measure the adjacent channel power performance of the repeater.

5.5.5.2 Test case

The test shall be conducted in accordance with ETS 300 394-1 [1], subclauses 7.1.3, 7.1.4, 8.3 and 8.4 with the following amendments.

a) The following measurements shall be performed in both the uplink and downlink directions.

b) A T2 test signal shall be used as the stimulus for ACP due to modulation.

c) A T4 test signal shall be used as the stimulus for the ACP due to switching.

d) The level of the input signal shall be set so that the repeater will perform at its maximum nominal output power, as declared by the manufacturer.

The T4 test signal to be used as the stimulus for ACP due to switching shall fulfil all of the following requirements:

i) T2 test signal as ETS 300 394-1 [1], subclause B.1.5.2 but not necessarily conforming to the modulating bits defined in ETS 300 394-1 [1], subclause 5.3.3.

ii) Discontinuous signal transmitted in one timeslot per frame.

iii) Conforming to RF output power time mask for Normal Uplink Burst or Normal Downlink Burst defined in ETS 300 392-2 [2], subclause 6.4.

iv) Conforming to the requirements of ETS 300 392-2 [2], subclause 6.4.2.2.2, subject to a maximum level of -60 dBc and not limited to -36 dBm.

5.5.5.3 Limit values

The limits detailed in the following table shall not be exceeded for adjacent channel power due to modulation.

Table 7: Maximum adjacent power

Frequency offset	Maximum Level
25 kHz	60 dBc
50 kHz	70 dBc
75 kHz	70 dBc

In any case not requirement greater than –36 dBm shall apply.

Switching transients

The adjacent channel peak power level shall not exceed -50 dBc. In any case, no requirement more stringent than -36 dBm shall apply for modulation due to switching transients.

5.5.6 Modulation accuracy

5.5.6.1 Test purpose

The purpose of this test is to measure the effect a repeater may have on the modulation accuracy of the amplified signal.

Modulation accuracy is defined according to ETS 300 392-2 [2], subclause 6.4.

5.5.6.2 Test case

The modulation accuracy shall be tested in accordance with ETS 300 394-1 [1], subclause 10.1.2 with the following amendments.

a) The test shall be carried out at maximum nominal gain.

b) The measurements shall apply to all antenna ports of the repeater.

c) A T2 test signal shall be applied to the repeater.

5.5.6.3 Limit values

The RMS vector error in any burst shall be less than 0,1 for any symbol.

The peak vector error magnitude shall be less than 0,3 for any symbol.

6 Measurement uncertainty

Limits for measurement uncertaninty shall be in accordance with ETS 300 394-1 [1], clause 11.

History

Document history		
V1.1.1	May 2000	Publication