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*Technical Specification*

## **Digital cellular telecommunications system (Phase 2+); GSM Repeater Equipment Specification (3GPP TS 51.026 version 6.0.0 Release 6)**



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## Foreword

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# Foreword

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Version x.y.z

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- z the third digit is incremented when editorial only changes have been incorporated in the document.

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# 1 Scope

The present document describes the Radio Frequency (RF) tests for GSM 450, GSM 480, GSM 900 and DCS 1800 repeaters which receive, amplify, and retransmit a received Mobile Station (MS) signal in the GSM MS transmit band and simultaneously receive, amplify and retransmit a received Base Transceiver Station (BTS) RF signal in the GSM BTS transmit band.

The present document is applicable to repeaters meeting the requirements of either GSM Phase 2 or GSM Phase 2+. Unless otherwise stated, all tests are applicable to repeaters meeting Phase 2 and/or Phase 2+ GSM requirements, because the requirements of the Phase 2 and Phase 2+ core GSM specifications which are referenced in the test are consistent. Most differences between Phase 2 and Phase 2+ requirements represent Phase 2+ features which are optional for the BSS to support.

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# 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. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] ETR 350 (GSM 01.04): "Digital cellular telecommunication system (Phase 2+); Abbreviations and acronyms".
- [2] ETS 300 019-1-0: "Equipment Engineering (EE): Environmental conditions and environmental tests for telecommunications equipment Part 1-0; Classification of environmental conditions; Introduction".
- [3] ETS 300 019-1-3: "Equipment Engineering (EE): Environmental conditions and environmental tests for telecommunications equipment Part 1-3; Classification of environmental conditions, Stationary use at weather-protected locations".
- [4] ETS 300 019-1-4: "Equipment Engineering (EE): Environmental conditions and environmental tests for telecommunications equipment Part 1-4; Classification of environmental conditions, Stationary use at non-weather-protected locations".
- [5] 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".
- [6] ETS 300 910 (GSM 05.05): "Digital cellular telecommunication system (Phase 2+); Radio transmission and reception".
- [7] IEC 68-2: "Basic environmental testing procedures: Part 2 Tests".
- [8] IEC 721: "Classification of environmental conditions".
- [9] ETS 300 607-1 (GSM 11.10-1): "Digital cellular telecommunication system (Phase 2); Mobile Station (MS) conformance specification; Part 1: Conformance specification".
- [10] ETS 300 609-1 (GSM 11.21): "Digital cellular telecommunication system (Phase 2); Base Station System (BSS) equipment specification; Part 1: Radio aspects".
- [11] ETR 027: "Methods of measurement for private mobile radio equipment".

[12] ETR 028: "Uncertainties in the measurement of mobile radio equipment characteristics".

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## 3 Definitions and abbreviations

### 3.1 Definitions

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

**broadband repeater:** repeater which is designed for operation on any combination of ARFCNs (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 ARFCNs within the operating band of the repeater. The subset of ARFCNs may be determined during the manufacture of the repeater, or may be programmable.

**repeater system using frequency shift:** frequency shifting repeater consists of two different elements, a master unit close to the BTS and at least one remote unit close to the area to be covered. The master unit amplifies the channels from the BTS and shifts them to different GSM channels. In the remote unit the shifted channels from the master unit will be transferred back to the original channels and amplified. This is valid for the downlink signals as well as for the uplink signals.**GSM:** Unless otherwise specified, references to GSM include both GSM450, GSM 480, GSM 900 and DCS 1800.

**repeater:** bi-directional Radio Frequency (RF) amplifier which can amplify and transmit a received Mobile Station (MS) signal in the GSM MS transmit band, simultaneously it can amplify and transmit a received Base Transceiver Station (BTS) RF signal in the GSM BTS transmit band.

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

### 3.2 Abbreviations

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

BTS	Base Transceiver Station
MS	Mobile Station
RF	Radio Frequency

Abbreviations used within the GSM specifications are given in ETR 350 (GSM 01.04) [1].

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## 4 General

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.

### 4.1 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 BTS signal in the BTS transmit band. The relevant MS and BTS transmit bands for the present document, which is a subset of the MS and BTS transmit bands as defined in GSM 05.05 [6], are given in table 1.



**Table 1: MS and BTS transmit RF bands**

	<b>MS transmit band</b>	<b>BTS transmit band</b>
<b>GSM 450</b>	450,4 MHz to 457,6 MHz	460,4 MHz to 467,6 MHz
<b>GSM 480</b>	478,8 MHz to 486,0 MHz	488,8 MHz to 496,0 MHz
<b>P-GSM 900</b>	890 MHz to 915 MHz	935 MHz to 960 MHz
<b>E-GSM 900</b>	880 MHz to 915 MHz	925 MHz to 960 MHz
<b>DCS 1800</b>	1 710 MHz to 1 785 MHz	1 805 MHz to 1 880 MHz
<b>R-GSM 900</b>	876 MHz to 915 MHz	921 MHz to 960 MHz

NOTE: In some circumstances, for instance when an operator (or more than one operator who co-ordinate the use of repeaters), is not allocated a complete band as defined in table 1, it may be necessary to restrict the frequency range of operations of repeaters. In these circumstances, the test of "Gain outside operating band" in annex A may be used to verify the performance of the repeater.

## 4.2 Test environments

For each test in the present document, the environmental conditions under which the repeater is to be tested are defined.

### 4.2.1 Normal test environment

When a normal test environment is specified for a test, the test should be performed under any combination of conditions between the minimum and maximum limits stated in table 2.

**Table 2: Limits of conditions for Normal Test Environment**

<b>Condition</b>	<b>Minimum</b>	<b>Maximum</b>
Barometric pressure	86 kPa	106 kPa
Temperature	15°C	30°C
Relative Humidity	20 %	85 %
Power supply	Nominal, as declared by the manufacturer	
Vibration	Negligible	

The ranges of barometric pressure, temperature and humidity represent the maximum variation expected in the uncontrolled environment of a test laboratory. If it is not possible to maintain these parameters within the specified limits, the actual values shall be recorded in the test report.

NOTE: This may, for instance, be the case for measurements of radiated emissions performed on an open field test site.

### 4.2.2 Extreme test environment

The manufacturer shall declare one of the following:

- the equipment class for the equipment under test, as defined in ETS 300 019-1-3 [3];
- the equipment class for the equipment under test, as defined in ETS 300 019-1-4 [4];
- for equipment that does not comply to an ETS 300 019-1 [2] class, the relevant classes from IEC 721 [8] documentation for temperature, humidity and vibration shall be declared.

NOTE: Reduced functionality for conditions that fall out side of the standard operational conditions are not tested in the present document. These may be stated and tested separately.

### 4.2.3 Extreme temperature

When an extreme temperature test environment is specified for a test, the test shall be performed at the standard minimum and maximum operating temperatures defined by the manufacturer's declaration for the equipment under test.

Minimum temperature:

- the test shall be performed with the environmental test equipment and methods of inducing the required environmental phenomena into the equipment, conforming to the test procedure of IEC 68-2-1 [7]. The equipment shall be maintained at the stabilized condition for the duration of the test sequence.

Maximum temperature:

- the test shall be performed with the environmental test equipment and methods of inducing the required environmental phenomena into the equipment, conforming to the test procedure of IEC 68-2-2 [7]. The equipment shall be maintained at the stabilized condition for the duration of the test sequence.

NOTE: It is recommended that the equipment is made fully operational prior to the equipment being taken to its lower operating temperature.

## 4.3 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;
- d) the supported modulation methods.

## 4.4 Methods of measurement

The general methods of measurement and measurement uncertainty shall be according to ETR 027 [11] and ETR 028 [12] except where they conflict with the present document.

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# 5 Spurious emissions

## 5.1 Test purpose

This test measures the conducted spurious emissions (see clause 3.1) at the antenna ports and the effective power of spurious emissions radiated by the cabinet and structure.

## 5.2 Test case

The repeater shall be set to maximum gain. All measurement steps, as described in this clause, 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 ohms. 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 ohms;
    - ii) with an RF input signal. The relevant antenna input port of the repeater shall be connected to an RF signal generator. A continuous sinusoidal RF signal shall be input at a level which will result, when measured, in the maximum rated RF output power per channel, as declared by the manufacturer. 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 ARFCN closest to the centre of the range of ARFCNs supported by the repeater.

b) Radiated spurious emissions:

- a test site fulfilling the requirements of ETS 300 113 [5] 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 ohms. 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, when measured, in the maximum rated output power per channel, as declared by the manufacturer.
- 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 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 ohms.

**Table 3: Measurement bandwidth for spurious emissions**

Band	Frequency offset (offset from carrier)	Measurement bandwidth
In the relevant BTS transmit Band or MS transmitt band	≥ 100 kHz	3 kHz
100 kHz to 50 MHz	-	10 kHz
50 MHz to 500 MHz outside the relevant transmit band	(offset from edge of the relevant transmit band) > 0 MHz ≥ 2 MHz ≥ 5 MHz	10 kHz 30 kHz 100 kHz
Above 500 MHz outside the Relevant transmit band	(offset from edge of the relevant transmit band) > 0 MHz ≥ 2 MHz ≥ 5 MHz ≥ 10 MHz ≥ 20 MHz ≥ 30 MHz	10 kHz 30 kHz 100 kHz 300 kHz 1 MHz 3 MHz

Test environment: Normal

### 5.3 Conformance requirement

The measured power in test case clause 5.2.a) as well as the effective radiated power in test case clause 5.2.b) shall not exceed:

- -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.

## 5.4 Reference requirement

GSM 05.05 [6], annex E.

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# 6 Intermodulation attenuation

## 6.1 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.

## 6.2 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. 600 kHz.

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 400 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 ohms.

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

## 6.3 Conformance requirement

The maximum level of intermodulation product shall be not greater than:

- -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.

## 6.4 Reference requirement

GSM 05.05 [6] annex E.

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## 7 Out of band gain

### 7.1 Test purpose

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

### 7.2 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 ARFCN 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 BTS transmit frequency band into the relevant input port of the repeater. The frequency offsets Y shall have the following values:

400 kHz, 600 kHz, 800 kHz, 1 MHz, 5 MHz, 10 MHz, 15 MHz, 20 MHz.

This shall be repeated with an RF input 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 temperature

### 7.3 Conformance requirement

The net gain in both directions through the repeater shall be less than:

- 50 dB at 400 kHz offset and greater;
- 40 dB at 600 kHz offset and greater;
- 35 dB at 1 MHz offset and greater;
- 25 dB at 5 MHz offset and greater;

from the edges of the relevant MS or BTS transmit bands.

### 7.4 Reference requirement

GSM 05.05 [6], annex E.

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## 8 Frequency error

### 8.1 Test purpose

This clause applies only to repeater systems using frequency shift and describes the test of the frequency error.

## 8.2 Test case

The repeater system shall be levelled according to the recommendations of the manufacturer. For the purpose of the frequency synchronisation of the repeater system it might be necessary to connect the system to a BTS or an equivalent test equipment like a mobile tester. In all cases an accurate frequency synchronisation source has to be used to synchronise the measurement setup.

The test of the repeater system shall be performed at the lowest and the highest ARFCN supported by the repeater system. For the measurement of the frequency error a continuous, sinusoidal and synchronised RF signal shall be fed successively at a frequency of the relevant MS or BTS transmit frequency band into the relevant input port of the repeater. 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 frequency shall be measured with a frequency counter.

The frequency error of single elements within the repeater system such as master unit or remote unit may be measured as well.

Test environment:   Normal  
                          Extreme temperature

## 8.3 Conformance requirement

The average frequency error of the repeater system shall not exceed 0,1 ppm. If tested, the average frequency error of a single repeater shall not exceed 0,05 ppm.

## 8.4 Reference requirement

GSM 05.05 [6], annex E.

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# 9 Modulation accuracy at GMSK modulation

## 9.1 Test purpose

This clause applies only to repeater systems using frequency shift and describes the test of the phase error.

## 9.2 Test case

The repeater system shall be levelled according to the recommendations of the manufacturer. For the purpose of the frequency synchronisation of the repeater system it might be necessary to connect the system to a BTS or an equivalent test equipment like a mobile tester. In all cases an accurate frequency synchronisation source has to be used to synchronise the measurement setup.

For the measurement of the phase error a continuous and synchronised GMSK signal modulated with a pseudo random bit sequence shall be fed successively at one frequency of the relevant MS or BTS transmit frequency band into the relevant input port of the repeater. 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 phase trajectory shall be measured at the equivalent output of the repeater system and the calculation of the phase error shall be performed according to GSM 11.10-1 [9] or GSM 11.21 [10].

The phase error of single elements within the repeater system such as master unit or remote unit may be measured as well.

The GMSK signal source shall have a phase error below the following values:

- 5 degrees rms;
- 20 degrees peak.

Test environment:   Normal  
                          Extreme temperature

### 9.3 Conformance requirement

The phase error of a complete repeater system shall not exceed:

- 7 degrees rms;
- 28 degrees peak.

If tested, the phase error of a single repeater unit shall not exceed:

- 6.1 degrees rms;
- 24.5 degrees peak.

### 9.4 Reference requirement

GSM 05.05 [6], annex E.

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## 10 Modulation accuracy at 8-PSK modulation

### 10.1 Test purpose

This clause applies only to repeater systems supporting 8-PSK modulation and describes the test of the modulation accuracy.

### 10.2 Test case

The repeater system shall be levelled according to the recommendations of the manufacturer. For the purpose of the frequency synchronisation of the repeater system it might be necessary to connect the system to a BTS or an equivalent test equipment like a mobile tester. In all cases an accurate frequency synchronisation source has to be used to synchronise the measurement setup.

For the measurement of the modulation accuracy a continuous and synchronised 8-PSK signal modulated with a pseudo random bit sequence shall be fed successively at one frequency of the relevant MS or BTS transmit frequency band into the relevant input port of the repeater. 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 EVM shall be measured at the equivalent output of the repeater system and the calculation of the EVM shall be performed according to GSM 11.21 [10].

The modulation accuracy of single elements within the frequency shifting repeater system such as master unit or remote unit may be measured as well.

Test environment:   Normal  
                          Extreme temperature

## 10.3 Conformance requirement

For a single repeater with no shift in frequency the EVM shall not exceed:

- 8 % RMS.

For a complete repeater system using frequency shift the EVM shall not exceed:

- 14,5 % RMS.

If tested, the EVM of a single repeater unit in a frequency shifting repeater system shall not exceed:

- 12 % RMS.

### 10.4 Reference requirement

GSM 05.05 [6], annex E.



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## Annex A (informative): Testing of gain for part band repeaters

### A.1 Rationale for this test

The normative provisions of the present document specify the out-of band gain relative to the edge of one of the GSM bands specified in clause 4.1. The purpose of this informative annex is to define a test method which may be used to measure the out-of-band gain for a repeater which is designed to operate only over part of one of these bands. This test may be used for acceptance testing or for regulatory purposes.

Since GSM 05.05 does not specify the out-of-band gain requirements within a GSM band for a such a repeater, the performance requirements for the repeater must be agreed prior to this test being performed. Normally, the requirements for the uplink and downlink directions will be similar, but with the frequencies offset by 45 MHz or 95 MHz.

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### A.2 Gain outside operating band

#### A.2.1 Test purpose

To determine the net gain of the repeater outside its specified operating band (or bands), when this is less than a GSM band defined in clause 4.1 of the present document. The requirements of clause 7 of the present document shall always be met, whether or not this test is also performed.

This test is not a normative requirement of the present document.

#### A.2.2 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 ARFCN within the repeaters operating band.

A continuous sinusoidal RF signal shall be fed successively at each specified frequency into the relevant input port of the repeater. 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 specified 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 temperature

#### A.2.3 Conformance requirement

At each frequency specified to be measured, the gain through the repeater shall be less than the specified value.

## Annex B (informative): Change history

This annex lists all change requests approved for the present document since the first phase 2 version was approved by ETSI SMG.

SMG#	SMG tdoc	SMG8 tdoc	VERS	CR	RV	PH	CAT	SUBJECT	Resulting Version
S17	095/96		4.0.0	001		2	B	Editorial additions and changes to comply with ETSI style	4.1.0
	095/96		4.0.0	002		2	D	Addition of definition of normal and extreme conditions for testing	4.1.0
	095/96		4.0.0	003		2		Definition of test method for part band repeaters	4.1.0
S18	257/96		4.1.0	A004		2	F	Intermodulation attenuation	4.2.0
S20	606/96	58/96	4.2.0	A005		2	D	Correction of reference title	4.2.1
s23	783/97	031/97	4.2.2	A006		R96	B	Addition of references to the R-GSM band	5.0.0
s25	98-0168	98p007	5.0.1	A007		R96	F	Minimum offset for spurious emissions measurements	5.1.0
s26	98-395	98p051	5.1.0	A008		R96	B	Repeater systems using frequency shift	5.2.0
s26	98-395	98p056	5.1.0	A009		R96	D	Addition of reference to ETR 027 and ETR 028	5.2.0
			5.2.0					Version update for publication	5.2.1
s31b	P-00-190	866/00	5.2.1	A011	2	R99	B	Repeater EDGE & GSM 400 test cases	8.0.0
			8.0.1					Update to Version 8.0.2 for Publication	8.0.2

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2002-01					New version for Release 4	8.0.2	4.0.0
2002-06					New version for Release 5	4.0.0	5.0.0
2005-01					New version for Release 6	5.0.0	6.0.0

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## History

<b>Document history</b>		
V6.0.0	January 2005	Publication