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**Air Traffic Control Surveillance Radar Sensors;
Secondary Surveillance Radar (SSR);
Harmonised Standard for access to radio spectrum;
Part 1: SSR Interrogator**

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Foreword

This Harmonised European Standard (EN) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.2] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.1].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in Table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive, and associated EFTA regulations.

The present document is part 1 of a multi-part deliverable covering ATC Secondary Surveillance Radar systems for civil air navigation operating in the frequencies 1 030 MHz and 1 090 MHz, as identified below:

Part 1: "SSR Interrogator";

Part 2: "Far Field Monitor (FFM)".

National transposition dates	
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Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Introduction

The SSR system provides ground-based surveillance of transponder fitted aircraft and in addition may allow data link communication between ground stations and aircraft, where both are fitted with appropriate equipment.

Secondary Radar surveillance is exploited through two essential elements: the SSR interrogator, normally ground-based, and the aircraft SSR transponder. When aircraft are within the antenna beam of the ground station, its interrogations elicit replies from transponders.

Civil use systems have different modes of interrogation/reply: Mode A, Mode C, Mode S and intermode. Mode A, Mode C and Intermode interrogations consist of Pulse Amplitude Modulated (PAM) signals, Mode-S interrogations have an additional pulse, with Differential Phase Shift Keying (DPSK) modulation.

Ground stations will be either Mode A/C ground stations, which can interrogate and receive replies on Mode A/C only, or Mode S ground stations, for which the present standard founds its applicability, which can interrogate and receive replies on all modes. On the other side, there are two classes of transponders: Mode A/C transponders, which can respond to Mode A, Mode C and Intermode interrogations only, and Mode S transponders, which can respond to all modes. Mode-S interrogation/replies have different data block depending on the information they have to support.

As far as Mode S is concerned, for the purpose of the present document it is assumed that the SSR can transmit interrogations at least in the uplink formats (UF) UF11, UF4 and UF5 and can process replies in the downlink formats (DF) DF11, DF4, DF20, DF5 and DF21.

The replies to all modes of interrogation are used to determine aircraft 2D position by measurement of the range and bearing of the reply. The performance towards the radar parameters are determined on the basis of the number of correct and validated replies received and decoded, in the operating environment.

Performances are affected by interference effects, which can result in a degradation of the signal causing lost or wrong information. RF signals on either uplink or downlink can be distorted by other overlapping RF signals, which can make correct decoding of wanted signals impossible. The degree of degradation is a function of the channel loading.

The SSR system requires a 3 dB receiver bandwidth of approximately 8 MHz centered on 1 030 MHz and 1 090 MHz for the airborne transponder and ground SSR receiver respectively. This bandwidth is sufficient to permit significant co-channel interference from transmitters operating on adjacent frequencies.

This interference can be minimized by ensuring adequate frequency or spatial separation between the interfering transmitters and the SSR receivers. In this specific case, two air traffic service systems, DME and primary radars, can be the cause of interference.

1 Scope

The present document specifies technical characteristics and methods of measurements for the following equipment used in ground-based ATC Secondary Surveillance Radar systems for civil air navigation.

Secondary Surveillance Radar (SSR) with Mode S capabilities which includes mode A/C, transmitting in the 1 030 MHz band with a power not exceeding 4 kW (66 dBm), and receiving in the 1 090 MHz band, used for air traffic control and connected to a rotating antenna. The SSR Interrogator transmits interrogations to aircraft equipped with transponder, receives the corresponding replies, and operates in the frequency bands as indicated in Table 1.

Table 1: SSR interrogator service frequency bands

Signals	Service frequency bands
Transmitted signals	1 030 MHz
Received signals	1 090 MHz

NOTE 1: The relationship between the present document and essential requirements of article 3.2 of Directive 2014/53/EU [i.1] is given in Annex A.

NOTE 2: Systems making use of an electronic scanned antenna are not covered by the present document.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments).

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The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

[i.2] Commission Implementing Decision C(2015) 5376 final of 4.8.2015 on a standardisation request to the European Committee for Electrotechnical Standardisation and to the European Telecommunications Standards Institute as regards radio equipment in support of Directive 2014/53/EU of the European Parliament and of the Council.

[i.3] ECC/Recommendation (02)05 (2012): "Unwanted emissions".

[i.4] ETSI EG 203 336: "Guide for the selection of technical parameters for the production of Harmonised Standards covering article 3.1(b) and article 3.2 of Directive 2014/53/EU".

[i.5] ICAO Annex 10, Volume IV: "Surveillance and Collision Avoidance Systems", 5th edition, 16th July 2018, including amendments up to amendment 90.

[i.6] Eurocontrol SUR/MODES/EMS/SPE-01: "European Mode S Station Functional Specification", edition 3.11, 9th May 2005.

[i.7] ERC/Recommendation 74-01 (2019): "Unwanted emissions in spurious domain".

[i.8] ITU Radio Regulations (2020).

[i.9] ICAO DOC-9924: "Aeronautical Surveillance Manual", edition 2, 2017.

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

all-call: intermode interrogations (Mode A/C/S all-call) or Mode S interrogations (Mode S only all-call) or Mode S only all-call replies

Binary Pulse Position Modulation (BPPM): modulation used in the reply data block of a Mode S reply

NOTE: Within a Mode S reply data bit interval, a pulse transmitted in the first half of the interval represents a binary ONE and a pulse transmitted in the second half represents a binary ZERO.

carrier frequency: radio frequency, i.e. 1 030 MHz for an SSR Interrogator, which has no "modulation" imposed on it (yet)

chip: carrier interval in a Mode S interrogation within the pulse P6 with a duration of 0,25 microseconds and located after the synchro phase reversal

control: RF path between the SSR interrogator and the SSR antenna allowing sidelobe suppression

NOTE: Control path is also called OMNI (as it is derived from an omnidirectional antenna beam) or OMEGA path and identified with Greek letter Ω.

difference: RF path between the SSR interrogator and the SSR antenna allowing the monopulse function

NOTE: Monopulse difference path is also called DELTA path and identified with Greek letter Δ.

Differential Phase Shift Keying (DPSK): phase modulation used in the P6 pulse of Mode S interrogations

NOTE: The aforementioned modulation uses phase reversal preceding chips to code binary ONEs and the absence of phase reversal to code binary ZEROs.

downlink: direction of the signals transmitted on the 1 090 MHz frequency band from aircraft transponder or FFM to SSR

Downlink Format (DF): data coding format of a Mode S reply

NOTE: DF11 denotes the format of a Mode S all-call reply.
DF4 denotes the format of a Mode S selective reply of type "surveillance altitude reply".
DF5 denotes the format of a Mode S selective reply of type "surveillance identity reply".
DF20 denotes the format of a Mode S selective reply of type "Comm-B altitude reply".
DF21 denotes the format of a Mode S selective reply of type "Comm-B identity reply".
Comm-B denotes a Mode S selective reply containing supplementary data.

Far Field Monitor (FFM): fixed ground based system allowing the monitoring of the uplink and/or downlink performance of an SSR system, located at a pre-determined position from the radar (far field)

NOTE: The FFM is interrogated by the SSR, and its replies are evaluated by the secondary radar for calibration and self-test purposes. A FFM with Mode S capability has Mode A and Mode C capabilities too.

False Replies Unsynchronized In Time (FRUITs): replies received by an interrogator but not triggered by own interrogations

NOTE: They overlap to requested replies and are to be considered as interfering signals.

idle state: entire period between transmissions, less 10-microsecond transition periods preceding the first pulse and following the last pulse of the transmission

NOTE: The word "inactive" instead of "idle" is used in ICAO Annex 10 Volume IV [i.5] and Eurocontrol SUR/MODES/EMS/SPE-01 [i.6].

intermode: interrogation triggering replies from SSR transponders and eventually replies from Mode S transponders in case of Mode A/C/S all-call interrogations

NOTE: Two types of intermode interrogations exist. The first type consists of Mode A or Mode C only all-call interrogations to which transponders with Mode A and Mode C capabilities only reply and to which Mode S transponders do not reply. The second type consists of Mode A/C/S all-call interrogations to which all transponders reply. Intermode interrogations consist of P1, P3 and P4 pulses transmitted on the sum port of the SSR interrogator and a P2 pulse transmitted on the control port of the SSR interrogator.

mode A: interrogation triggering a Mode A reply allowing the identification of aircraft

NOTE 1: A Mode A interrogation consists of P1 and P3 pulses transmitted on the sum port of the SSR interrogator and a P2 pulse transmitted on the control port of the SSR interrogator (P2 is called a sidelobe suppression pulse). The interval between P1 and P3 determines the Mode A interrogation type.

NOTE 2: A Mode A reply consists of framing pulses (F1 and F2) and up to 12 pulses between F1 and F2. The absence or presence of each of the 12 pulses determines the Mode A code.

mode C: interrogation triggering a Mode C reply containing encoded pressure-altitude information

NOTE 1: A Mode C interrogation consists of P1 and P3 pulses transmitted on the sum port of the SSR interrogator and a P2 pulse transmitted on the control port of the SSR interrogator. The interval between P1 and P3 determines the Mode C interrogation type.

NOTE 2: A Mode C reply consists of framing pulses (F1 and F2) and up to 12 pulses between F1 and F2. The absence or presence of each of the 12 pulses determines the Mode C code.

mode S: enhanced SSR mode allowing the addressing of individual aircraft and the retrieving of information with higher integrity

NOTE 1: A Mode S interrogation consists of P1, P2 and P6 pulses transmitted on the sum port of the SSR interrogator and a P5 pulse transmitted on the control port of the SSR interrogator (P5 is called a sidelobe suppression pulse). A Mode S reply consists of a four-pulse preamble followed by a reply data block.

NOTE 2: Mode S stands for "Mode Select".

NOTE 3: The addressing method consists of a unique 24 bit Mode-S address for each individual aircraft transponder, assigned by ICAO and using a country prefix scheme. The Mode S address is used by SSR Interrogator in the interrogations, and by transponders and FFM in their correlated replies.

monopulse: technique used to determine the direction of a RF signal by comparison of different RF antenna paths

necessary bandwidth: width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions

out-of-band domain: frequency range, immediately outside the necessary bandwidth but excluding the spurious domain, in which out-of-band emissions generally predominate

NOTE 1: Out-of-band emissions, defined based on their source, occur in the out-of-band domain and, to a lesser extent, in the spurious domain. Spurious emissions likewise may occur in the out-of-band domain as well as in the spurious domain.

NOTE 2: This definition is taken from ITU Radio Regulation [i.8].

out-of-band emissions: emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions

NOTE: This definition is taken from ITU Radio Regulation [i.8].

peak envelope power: average power supplied to the antenna transmission line by a transmitter during one radio frequency cycle at the crest of the modulation envelope taken under normal operating conditions

NOTE: This definition is taken from ITU Radio Regulation [i.8].

phase reversal: 180-degree change of the phase of the uplink frequency carrier

NOTE: Phase reversal is a characteristics of the Differential Phase Shift Keying (DPSK) modulation used for the uplink transmission of the Mode S signals.

Pulse Amplitude Modulation (PAM): modulation used for Mode A, Mode C, intermode interrogations, pulses P1 and P2 of Mode S interrogations as well as Mode A, Mode C replies and the preamble pulses of Mode S replies

pulse decay time: time taken for the trailing edge of the pulse to decrease from 90 % to 10 % of the maximum amplitude (voltage)

pulse duration: time between the 50 % amplitude (voltage) points on the leading and trailing edge of the pulse envelope

pulse rise time: time taken for the leading edge of the pulse to increase from 10 % to 90 % of the maximum amplitude (voltage)

roll-call: selective Mode S interrogations addressed to an individual aircraft or selective Mode S replies received from an individual aircraft

Secondary Surveillance Radar (SSR): radio-determination system based on the comparison of reference signals with radio signals retransmitted from the position to be determined

NOTE 1: This definition is taken from ITU Radio Regulation [i.8].

NOTE 2: The SSR provides ground-based radar surveillance of targets equipped with transponder, and of far field monitors.

spurious domain: frequency range beyond the out-of-band domain in which spurious emissions generally predominate

NOTE: This definition is taken from ITU Radio Regulation [i.8].

spurious emissions: emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information

NOTE 1: Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

NOTE 2: This definition is taken from ITU Radio Regulation [i.8].

sum: RF path between the SSR interrogator and the SSR antenna allowing the transmission and reception of RF signals through the main directional beam of the SSR antenna

NOTE: Monopulse sum path is also called SIGMA path and identified with Greek letter Σ

uplink: direction of the signals transmitted on the 1 030 MHz frequency band from SSR interrogator to aircraft transponder or FFM

Uplink Format (UF): data coding format of a Mode S interrogation

NOTE: UF11 denotes the format of a Mode S only all-call interrogation.
UF4 denotes the format of a Mode S selective interrogation of type "surveillance altitude request".
UF5 denotes the format of a Mode S selective interrogation of type "surveillance identity request".

3.2 Symbols

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

B_{-40}	-40 dB bandwidth
B_N	Necessary bandwidth
B_{res}	3 dB resolution bandwidth of transceiver
dB	decibel
dB/dec	dB per decade
dBm	dB with respect to 1 milliwatt
dBpep	dB with respect to peak envelope power
k	Boltzmann's constant
kW	Kilowatt
NF	Noise Figure
NM	Nautical mile
P_d	Probability of detection
$P_{d\ 1090}$	Probability of detection at 1 090 MHz
$P_{d\ offset}$	Probability of detection at a frequency offset from 1 090 MHz
P_t	Pulse power of transmission
RF	Radio Frequency
t	Time
t_p	Pulse duration
t_r	Pulse rise time
T_0	Temperature in Kelvin
λ	Wavelength

3.3 Abbreviations

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

AC	Alternating Current
ATC	Air Traffic Control
BPPM	Binary Pulse Position Modulation
CW	Continuous Wave
DC	Direct Current
DF	Downlink Format
DME	Distance Measuring Equipment
DPSK	Differential Phase Shift Keying
EFTA	European Free Trade Association
ERC	former European Radio Committee in CEPT, now ECC
EUT	Equipment Under Test
FFM	Far Field Monitor
FRUITs	False Replies Unsynchronized In Time (or to Interrogation Transmissions)
ICAO	International Civil Aviation Organization
IRF	Interrogation Repetition Frequency
ITU	International Telecommunication Union
MDL	Minimum Decode Level
NA	Not Applicable
NF	Noise Figure
OoB	Out-of-Band
PAM	Pulse Amplitude Modulation
PEP	Peak Envelope Power
PRF	Pulse Repetition Frequency
RBW	Reference BandWidth

RF	Radio Frequency
RSL	Receiver Saturation Level
RX	Receive
SSR	Secondary Surveillance Radar
TX	Transmit
UF	Uplink Format
VSWR	Voltage Standing Wave Ratio

4 Technical requirements specifications

4.1 Environmental profile

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be in accordance with its intended use, but as a minimum, shall be that specified in the test conditions contained in the present document. The equipment shall comply with all the technical requirements of the present document at all times when operating within the boundary limits of the operational environmental profile defined by its intended use.

4.2 Conformance requirements

4.2.1 Transmitter requirements

4.2.1.1 Maximum frequency deviation

4.2.1.1.1 Definition

The maximum frequency deviation is the maximum allowed departure from the carrier frequency.

4.2.1.1.2 Limits

The maximum frequency deviation for an SSR Interrogator shall not exceed 0,01 MHz for all interrogation modes and all available transmitter channels.

NOTE: This value is defined in clause 3.1.2.1.1 of ICAO Annex 10 Volume IV [i.5].

4.2.1.1.3 Conformance

The conformance tests are specified in clause 5.3.1.1.

4.2.1.2 Transmitter power

4.2.1.2.1 Definition

The transmitter power is the peak value of the transmitter pulse power during the transmission pulse (PEP).

4.2.1.2.2 Limits

The transmitter power shall not exceed 4 kW (i.e. 66 dBm).

4.2.1.2.3 Conformance

The conformance tests are specified in clause 5.3.1.2.

4.2.1.3 Transmitter power control

4.2.1.3.1 Definition

The SSR interrogator transmitter power control defines the capability to control the power of the interrogator transmitter delivered at the RF sum and control ports.

4.2.1.3.2 Limits

The SSR interrogator shall fulfil the requirements defined in Table 2.

Table 2: SSR interrogator transmitter power control

Requirement	Limit
For all transmitted interrogation modes, variation of the sum and control output powers shall be at least within a range:	From maximum power to 12 dB below maximum power (see note 1) and "no power" (see note 2)
For all transmitted interrogation modes, variation of the sum and control output powers shall be:	– incremental with a step ≤ 2 dB – with a step accuracy ≤ 1 dB
NOTE 1: The limit derives from clause 6.2.9 of Eurocontrol SUR/MODES/EMS/SPE-01 [i.6]. NOTE 2: No power is due to the fact that, in some sectors, no interrogations are performed (sector blanking).	

4.2.1.3.3 Conformance

The conformance tests are specified in clause 5.3.1.3.

4.2.1.4 Spectrum mask

4.2.1.4.1 Definition

A spectrum mask is a set of limit lines applied to a plot of a transmitter spectrum.

The purpose is to constrain emissions at frequencies in the Out-of-Band domain and spurious domain, which lie outside the intended operating channel. A spectrum mask is an alternative method to the specification of the Out-of-Band domain and spurious domain emissions.

4.2.1.4.2 Limits

The SSR interrogator transmitted signal spectrum (as measured on the sum and control ports), for Mode A, Mode C and Mode S interrogations, shall not exceed the limits shown in Table 3.

Table 3: Required SSR interrogator transmitter spectrum limits

Frequency offset from carrier frequency (MHz)	Maximum Power relative to peak (dB)
≥ 4 and < 6	-6 dB
≥ 6 and < 8	-11 dB
≥ 8 and < 10	-15 dB
≥ 10 and < 20	-19 dB
≥ 20 and < 30	-31 dB
≥ 30 and < 40	-38 dB
≥ 40 and < 50	-43 dB
≥ 50 and < 60	-47 dB
≥ 60 and < 125	-50 dB
≥ 125 MHz and down to 30 MHz (lower limit) and up to 5 150 MHz (5th harmonics, upper limit)	-(43 + 10log PEP) or -60 dB, whichever is less stringent (see note 3)

NOTE 1: The spectrum mask derives from clause 3.1.2.1.2 and figure 3-2 of ICAO Annex 10 Volume IV [i.5].
NOTE 2: The ICAO mask was extrapolated from the last three steps to intercept the -60 dB point, reaching a value of approximately 125 MHz. This is also the point reached when extrapolating the mask from the -40 dB (i.e. 40 MHz) by -40 dB per decade, which is the design objective for the 60 dB below PEP systems reflected in Table 3 and Figure A2.1 a) ("Emission Mask for Radars") of ECC/Recommendation (02)05 [i.3], until the spurious limit is reached.
NOTE 3: These limits are also specified in ITU Radio Regulation [i.8], Volume 2, Appendix 3.

Figure 1 shows the required spectrum for an SSR interrogator transmitter.

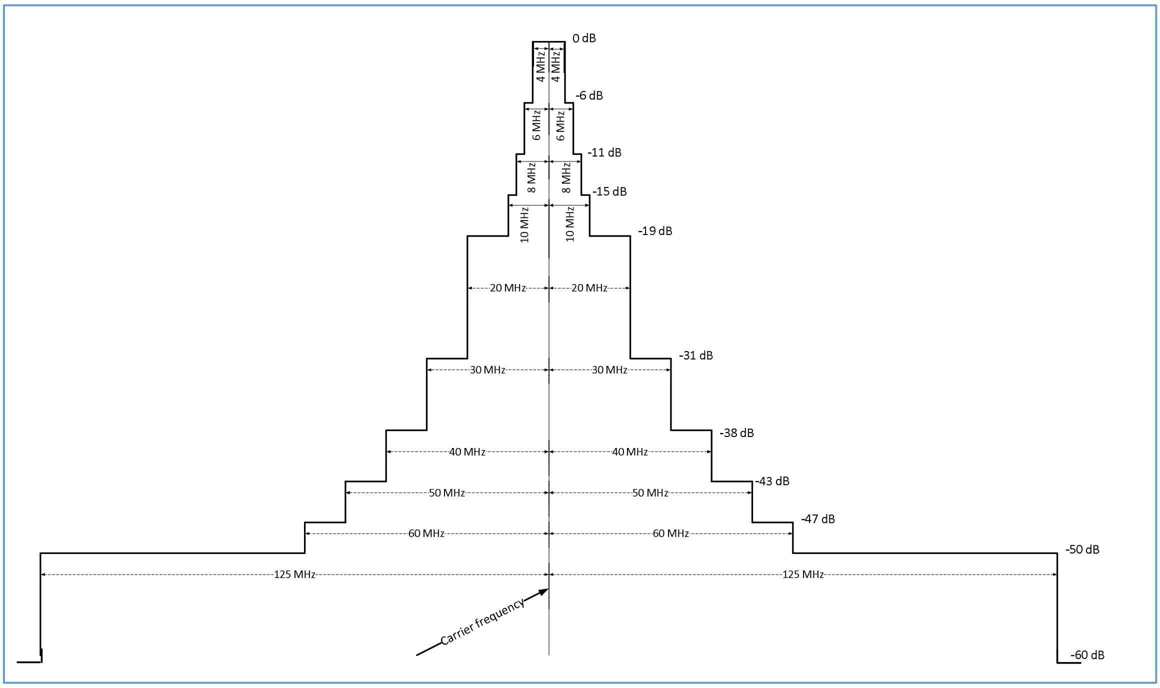

Figure 1: Required SSR interrogator transmitter spectrum

4.2.1.4.3 Conformance

The conformance tests are specified in clause 5.3.1.4.

4.2.1.5 Emissions in idle mode

4.2.1.5.1 Definition

Emissions in idle mode refer to emissions radiated during periods of non-transmission, including self-test signals, on the sum and control ports.

4.2.1.5.2 Limits

An SSR interrogator shall fulfil the requirements as indicated in Table 4.

Table 4: Emissions in idle mode related requirements for an SSR Interrogator

Frequency band	Emission Limits
30 MHz ≤ f ≤ 1 GHz	-57 dBm
1 GHz < f ≤ 5 150 MHz	-47 dBm
NOTE 1: -57 dBm and -47 dBm are defined in Annex 5, Table 15 of ERC/Recommendation 74-01 [i.7]. NOTE 2: 5 150 MHz corresponds to the 5th harmonic.	

4.2.1.5.3 Conformance

The conformance tests are specified in clause 5.3.1.5.

4.2.1.6 Transmitted waveforms

4.2.1.6.1 Definition

The SSR interrogator is able to transmit in different interrogation modes, each one consisting of a series of modulated pulses.

Each pulse of the sequence has specific characteristics in terms of shape and timing in the sequence, depending on the transmitted mode.

4.2.1.6.2 Limits

An SSR interrogator shall fulfil the requirements as indicated in Tables 5 and 6.

Table 5: Pulse shape of transmitted pulses

Pulse	Pulse length Duration (µs)		Rise Time (µs)		Decay Time (µs)	
	Min	Max	Min	Max	Min	Max
P1, P2, P3, P5	0,71	0,89	0,05	0,1	0,05	0,2
P4 (short)	0,71	0,89	0,05	0,1	0,05	0,2
P4 (long)	1,51	1,69	0,05	0,1	0,05	0,2
P6 (short)	16,05	16,45	0,05	0,1	0,05	0,2
Phase reversal		0,08	-		-	

Table 6: Pulse spacing for transmitted modes

Pulses	SSR Mode	Pulse spacing (µs)	
		Min	Max
P2 to P1 delay	Modes A/C	1,9	2,1
P2 to P1 delay	Mode-S	1,96	2,04
P3 to P1 delay	Mode A	7,82	8,18
	Mode C	20,82	21,18
P4 to P3 delay	Inter-mode	1,96	2,04
P5 to sync. Phase Reversal delay	Mode-S	0,35	0,45
P6 to sync. Phase Reversal delay	Mode-S	1,21	1,29

NOTE: The tables above derive from paragraphs 3.1.2.1 and table 3-11 in ICAO Annex 10 Volume IV [i.5].

4.2.1.6.3 Conformance

The conformance tests are specified in clause 5.3.1.6.

4.2.2 Receiver requirements

4.2.2.1 Receiver sensitivity and flatness

4.2.2.1.1 Definition

The receiver sensitivity is defined as the Minimum Decode Level (MDL) at the receiver input of the SSR Interrogator necessary to decode Mode A, Mode C and Mode S replies while providing a pre-determined level of performance.

The receiver sensitivity flatness, or Gain flatness, is the measure of the variation of sensitivity/gain over a specified frequency range.

4.2.2.1.2 Limits

Receiver sensitivity levels are established, based on maximum range requirement and associated signal-to noise ratio to provide the required probability of signal (pulse) detection.

The receiver sensitivity shall be, for Mode A, Mode C and Mode S replies, better than -85 dBm (see note 2 and note 3), and at this level of signal the SSR Interrogator shall decode at least 90 % of received replies in response to interrogations (see note 1).

The sensitivity shall not degrade by more than 1 dB with an incoming signal offset by up to 1 MHz (see note 3). The sensitivity, based on the given definition, is to be measured only on sum channel.

NOTE 1: This value reflects a number for surveillance systems in order to support the requirements for Probability of Target Reports in Eurocontrol [i.6].

NOTE 2: 1 MHz is the maximum allowed deviation from nominal frequency for an airborne Mode-S transponder; for an airborne Mode-A/C only transponder, the deviation from the nominal frequency may differ.

NOTE 3: The sensitivity level of at least -85 dBm is specified in ICAO DOC-9924 [i.9].

4.2.2.1.3 Conformance

The conformance tests are specified in clause 5.3.2.1.

4.2.2.2 Receiver Saturation Level and Dynamic Range

4.2.2.2.1 Definition

The Receiver Saturation Level (RSL) is the level of signal at which signal compression effect occurs.

The compression effect is a non-linear behaviour of one of the receiver stages, thereby causing distortion and other effects that prevent proper operation of the receiver.

The receiver input compression level is defined as the input power when the receiver gain is reduced by 1 dB (i.e. when the receiver output is 1 dB into compression).

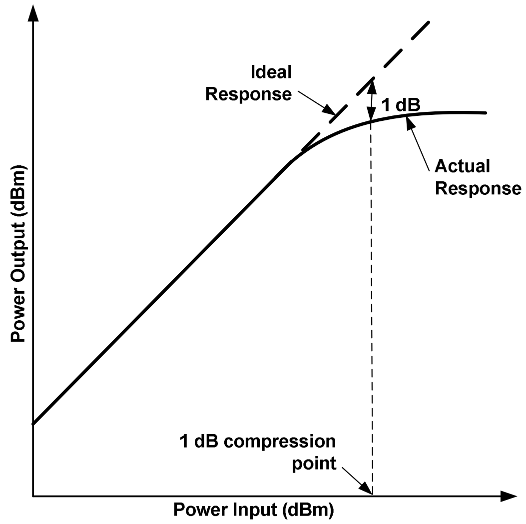

Figure 2: Illustration of finding the receiver 1 dB compression point

Considering the MDL previously defined, this allows the calculation of the Receiver Dynamic Range, as the signal interval between RSL and MDL.

4.2.2.2.2 Limits

The receiver saturation level shall be not less than -15 dBm (see note 1).

NOTE 1: The value is based on the maximum signal strength, associated to a close range target, on sum Channel.

The Saturation Level shall not vary by more than 1 dB with an incoming signal offset by up to 1 MHz (see note 2).

NOTE 2: This is the maximum allowed deviation from nominal frequency for an airborne Mode-S transponder.

The corresponding Dynamic Range shall be at least 70 dB.

4.2.2.2.3 Conformance

The conformance tests are specified in clause 5.3.2.2.

4.2.2.3 Receiver blocking

4.2.2.3.1 Definition

Blocking is a measure of the capability of the receiver to receive a wanted signal without exceeding a given degradation due to the presence of a strong unwanted signal.

4.2.2.3.2 Limits

The rate of correctly received and decoded wanted Mode S and Mode-A/C replies shall be reduced by no more than 5 percentage points in the presence of unwanted signals specified in Table 7.

Table 7: Unwanted signal characteristics

Frequency	Level (dB)
-78 MHz to -15 MHz relative to 1 090 MHz +15 MHz to +78 MHz relative to 1 090 MHz	20 dB above the level of a wanted signal within the dynamic range, for any interrogation mode

4.2.2.3.3 Conformance

The conformance tests are specified in clause 5.3.2.3.

4.2.2.4 Receiver selectivity

4.2.2.4.1 Definition

RF selectivity is the ability of the EUT to avoid erroneous reception of signals from outside the desired frequency band.

Limits are evaluated assuming the signal is constructed as a valid Mode S waveform except that the frequency is altered. It is important for the receiver to reject signals, which are Out-of-Band, while retaining sufficient bandwidth for acceptable detection and decoding performance levels.

4.2.2.4.2 Limits

The EUT shall reject signals such that the signal level of a valid message shall be increased by at least the value given for the frequency offset in Table 8 before the signal is received with the same Probability of detection.

EXAMPLE: The EUT receives a valid signal at 1 090 MHz with 90 % P_d at a level of -85 dBm. With a frequency offset of 10 MHz, the same probability of detection can be achieved only if the injected signal has a level of at least -65 dBm (20 dB higher). This shows that the receiver has at least 20 dB of rejection at the 10 MHz frequency offset.

Table 8: Receiver selectivity

Frequency offset (MHz) with respect to the operating frequency	Minimum Rejection level (dB)
-10 < f ≤ -5,5 and +5,5 ≤ f < +10	3
-15 < f ≤ -10 and +10 ≤ f < +15	20
-25 < f ≤ -15 and +15 ≤ f < +25	40
f ≤ -25 and f ≥ +25	60

4.2.2.4.3 Conformance

The conformance tests are specified in clause 5.3.2.4.

4.2.2.5 Inter-modulation response rejection

4.2.2.5.1 Definition

The intermodulation response rejection is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of two or more unwanted signals with a specific frequency relationship relative to the receiver frequency.

4.2.2.5.2 Limits

At any frequency combination from -78 MHz to -20 MHz and from +20 MHz to +78 MHz from the receiver frequency of 1 090 MHz, the unwanted signals shall not reduce the probability of detection by more than 5 percentage points if their signal level is 40 dB above the reference sensitivity.

4.2.2.5.3 Conformance

The conformance tests are specified in clause 5.3.2.5.

4.2.2.6 Receiver co-channel rejection

4.2.2.6.1 Definition

Co-channel rejection is the SSR receiver's ability to receive a wanted signal in the presence of an unwanted signal, with both signals being at the nominal receiver frequency.

4.2.2.6.2 Limits

An unwanted signal, with a level of at least 12 dB below the level of the wanted signal and with the same type of waveform, shall not reduce the rate of correctly received and decoded wanted signals by more than 5 percentage points.

4.2.2.6.3 Conformance

The conformance tests are specified in clause 5.3.2.6.

4.2.2.7 Receiver Noise Figure

4.2.2.7.1 Definition

The receiver Noise Figure measures the degradation of the signal-to-noise ratio, caused by components in the radio-frequency signal chain.

4.2.2.7.2 Limits

The SSR interrogator Noise Figure (NF) shall not exceed 5 dB.

4.2.2.7.3 Conformance

The conformance tests are specified in clause 5.3.2.7.

5 Testing for compliance with technical requirements

5.1 General requirements

5.1.1 Standard operation mode for testing

SSR Interrogators for ATC service can be operated in single or dual channel configuration. Single channel configuration can be used for temporary use or as a backup system. In a dual channel configuration, the equipment has redundant electronics for transmitting and receiving chains, including processing facilities.

All tests for transmitting and receiving chains shall be executed for each channel present in the equipment.

Only one transmitting/receiving chain can be connected to the antenna via RF cables, as the antenna has not duplicated inputs, therefore a switching device can be present inside or outside the SSR interrogator, automatically or manually controlled.

If the switching device is part of the EUT, for all input and output signals, the external RF interfaces towards test instruments will be the actual RF interfaces of the switching unit towards/from the SSR antenna, and all performance figures will include gain, losses, filtering capabilities introduced by the switching device.

If the switching device is not present, as for single channel SSR interrogators, the RF interface shall be the output of the transmitter unit and the input of the receiving unit.

During the tests, the radar equipment shall be operated in the standard operation mode (no failure present, all units powered and switched on, on both channels in dual channel configuration, if available). Furthermore, the radar shall be supplied with the necessary signals i.e. antenna azimuth encoder signal and safety loop signals to simulate normal operation at radar site.

5.2 Environmental conditions for testing

5.2.1 General Requirements

Tests defined in the present document shall be carried out at representative points within the boundary limits of the environmental profile defined by its intended use which, as a minimum, shall be that specified in the test conditions contained in the present document.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions as specified in the present document to give confidence of compliance for the affected technical requirements.

5.2.2 Test Conditions

5.2.2.1 Normal temperature and humidity

The temperature and humidity conditions for tests shall be a combination of temperature and humidity within the following ranges:

a) temperature: +15 °C to +35 °C;

b) relative humidity: not exceeding 75 %.

5.2.2.2 Normal test power supply

a) The test voltage for equipment to be connected to an AC supply shall be the nominal mains voltage declared by the manufacturer -10 % to +10 %.

b) The frequency of the test voltage shall be 50 Hz ± 1 Hz.

5.3 Test specifications

5.3.1 Transmitter related tests

5.3.1.0 General requirements

Before setting up the test bench, and at any time when disconnecting/reconnecting an RF cable, it needs to be verified that RF radiation is disabled, for any transmitting chain.

5.3.1.1 Maximum frequency deviation

5.3.1.1.1 Test conditions

The measurement setup shall be as in Figure B.1.

An RF Spectrum Analyzer shall be used.

5.3.1.1.2 Procedure

1) Set the spectrum analyser according to the following parameters:

- Central Frequency: 1 030 MHz
- Resolution Bandwidth: 1 MHz
- Video Bandwidth: 3 MHz
- Span: 1 MHz

2) Via the radar control position, set the following: Mode: A, PRF: 100 Hz, maximum power.

3) Connect cable to sum path connector.

4) Enable TX Radiation.

5) Verify that the result is according to the limits specified in clause 4.2.1.1.2.

6) Repeat above steps 1 to 4 after setting power level to -12 dB.

7) Repeat above steps 1 to 5 for Mode-C and Mode-S all-call.

8) Repeat above steps 1 to 6 for OMNI path.

9) If a second channel is available, repeat above steps 1 to 7 for this radar channel.

10) Record on a Test Data Record sheet the test results.

5.3.1.2 Transmitter power

5.3.1.2.1 Test conditions

The measurement setup shall be as in Figure B.1.

An RF Peak Power Meter shall be used.

5.3.1.2.2 Procedure

If the EUT includes two radar channels, the measurement shall be done on both channels.

The transmitter power limits shall not be exceeded, for each pulse of the different interrogation types.

1) Connect Peak Power meter instrument to sum path connector.

2) Via the radar control position, set the following: Selected Mode: A, PRF: 100 Hz.

3) Verify that the selected TX attenuation is set to 0 dB value (full power).

4) Verify that test result is according to clause 4.2.1.2.

5) Repeat step 3 to step 4 performing the following change: Selected Mode: C, PRF: 100 Hz.

6) Enable "intermode interrogation" (presence of an additional P4 pulse on sum channel):

   - P4 Pulse : Short
   - Selected Mode : A

7) Repeat step 3 to step 4.

8) Repeat step 6 to step 7 with the following change:

   - P4 Pulse : Long

9) Via the radar control position, set the following: Selected Mode : Mode-S Only (i.e. all-call interrogations), PRF: 100 Hz.

10) Repeat step 3 to step 4.

11) Connect Peak Power meter instrument to OMNI path (via the Coupler and the RF Attenuator) and repeat step 2 to 10.

12) If a second channel is available, repeat the sequence 2 to 11 above and verify the expected test result for this channel.

13) Record on a Test Data Record sheet the test results.

5.3.1.3 Transmitter power control

5.3.1.3.1 Test conditions

The measurement setup shall be as in Figure B.1. An RF Peak Power Meter shall be used.

If the EUT includes two radar channels, the measurement shall be done on both channels.

5.3.1.3.2 Procedure

1) Connect Peak Power meter instrument to sum path connector.
2) Via the radar control position, set the following: Selected Mode: A, PRF: 100 Hz.
3) Set the power level attenuator at -2 dB (attenuation value).
4) Verify that test result is according to clause 4.2.1.3.2.
5) Repeat step 2 performing the following change: Selected Mode: C.
6) Repeat step 3 to step 4.
7) Enable "intermode interrogation" (presence of an additional P4 pulse on sum channel):
   - P4 Pulse : Short
   - Selected Mode : A
8) Repeat step 3 to step 4.
9) Enable "intermode interrogation" (presence of an additional P4 pulse on sum channel):
   - P4 Pulse : Long
   - Selected Mode : A
10) Repeat step 3 to step 4.
11) Via the radar control position, set the following:
    - Selected Mode : Mode-S Only (i.e. UF 11 format)
    - PRF : 100 Hz
12) Repeat step 3 to step 4.
13) Connect Peak Power meter instrument to OMNI path (via the Coupler and the RF Attenuator) and repeat step 2 to 12.
14) If a second channel is available, repeat the sequence 2 to 13 above and verify the expected test result for this channel.
15) Record the test results on a Test Data Record sheet.
16) Repeat step 4 to 15 setting the power level attenuator at -4 dB, -6 dB, -8 dB, -10 dB and -12 dB.

For "no power", limits described in clause 4.2.1.5.2 and procedure described in clause 5.3.1.5 shall apply.

5.3.1.4 Spectrum mask

5.3.1.4.1 Test conditions

The measurement setup shall be as in Figure B.2. An RF Spectrum Analyser shall be used.

5.3.1.4.2 Procedure

5.3.1.4.2.1 Emissions in the Out-of-Band domain

If the EUT includes two radar channels, the measurement shall be done on both channels.

The measurement procedure shall be as follows:

1) Connect the Spectrum Analyser to sum path (via the Coupler and the RF Attenuator).

2) Via the radar control position, set the following: Selected Mode: A, PRF: 100 Hz, maximum power.

3) Set the spectrum analyser according to the following parameters:

   - Central Frequency: 1 030 MHz
   - Resolution Bandwidth: 1 MHz
   - Sweep: 20 s
   - Reference Level: 5 dBm
   - Scale: 10 dB/Div.
   - Span: 250 MHz
   - Trace: Max Hold A
   - Marker reference: 1 030 MHz
   - Marker: Marker Δ

4) Verify that test results at ±20 MHz, ±30 MHz, ±40 MHz, ±50 MHz, ±60 MHz and ±125 MHz, from the measured carrier frequency are according to clause 4.2.1.4.2.

5) Record the data taking a screenshot of the RF spectrum, using the scope internal facilities.

6) Repeat above steps 3 to 5 by setting the spectrum analyser according to the following parameters:

   - Span: 30 MHz

7) Verify that test results result at ±4 MHz, ±6 MHz, ±8 MHz, and ±10 MHz from the carrier frequency are according to clause 4.2.1.4.2.

8) Record the data taking a screenshot of the RF spectrum, using the scope internal facilities.

9) Repeat above steps 3 to 8 after setting: Selected Mode: Mode-S; and by setting the spectrum analyser according to the following parameters:

   - Reference Level: 15 dBm

10) Repeat above steps 3 to 9 after setting power level to -12 dB.

11) Repeat above steps 1 to 10 for OMNI path (via the Coupler and the RF Attenuator).

12) If a second channel is available, repeat above steps 1 to 11 for this radar channel.

5.3.1.4.2.2 Emissions in the spurious domain

For the measurement of the spurious emissions level, verify, in all test cases, that the maximum value in the frequency range (up to 5^{th} harmonic) does not exceed the limits specified in clause 4.2.1.4.2.

1) Insert the stopband filter (see clause B.2).

2) Set the power attenuator to a value between 30 and 50 dB (ATT_{db}).

3) Set the following: Selected Mode: A, PRF: 100 Hz, maximum power.

4) Set the spectrum analyser according to the following parameters:

   - Central Frequency: 1 030 MHz
   - Resolution Bandwidth: 100 kHz

5) Verify that the maximum value in the 30 MHz to 905 MHz frequency range does not exceed the limits specified in clause 4.2.1.4.2.

6) Repeat step 5 after setting the power level to -12 dB, via the radar control position.

7) Change the Resolution Bandwidth of the spectrum analyser to 1 MHz.

8) Verify that the maximum value in the 1 155 MHz to 5 150 MHz frequency range does not exceed the limits specified in clause 4.2.1.4.2.

9) Repeat step 8 after setting the power level to -12 dB, via the radar control position.

10) Set the following: Selected Mode: S, PRF: 100 Hz, maximum power.

11) Repeat steps from 3 to 9.

12) Repeat steps from 1 to 11 for OMNI path, via the Coupler and the RF Attenuator.

13) If a second channel is available, repeat steps from 1 to 12 for this radar channel.

14) Record on a Test Data Record sheet the test results or measured values.

5.3.1.5 Emissions in idle mode

5.3.1.5.1 Test conditions

The measurement setup shall be as in Figure B.1. An RF Spectrum Analyser shall be used.

5.3.1.5.2 Procedure

If the EUT includes two radar channels, the measurement shall be done on both channels.

The measurement procedure shall be as follows:

1) Verify that TX radiation is disabled on both sum and OMNI channels.

2) Connect cable to sum path connector.

3) Set the spectrum analyser according to the following parameters:

   - Resolution Bandwidth: 100 kHz
   - Start Frequency: 30 MHz
   - Stop Frequency: 1 GHz

4) For the given frequency range, verify that results are according to clause 4.2.1.5.2. Record the data taking a screenshot of the RF spectrum.

5) Set the spectrum analyser according to the following parameters:

   - Resolution Bandwidth: 1 MHz
   - Start Frequency: 1 GHz
   - Stop Frequency: 6 GHz

6) For the given frequency range, verify that results are according to clause 4.2.1.5.2. Record the data taking a screenshot of the RF spectrum.

7) Connect cable to OMNI path connector.

8) Repeat above steps 3 to 6 (via the Coupler and the RF Attenuator).

9) If a second channel is available, repeat above steps 1 to 8 for this radar channel.

5.3.1.6 Transmitted Waveforms

5.3.1.6.1 Test conditions

The measurement setup shall be as in Figure B.6. An oscilloscope shall be used.

5.3.1.6.2 Procedure

If the EUT includes two radar channels, the measurement shall be done on both channels.

The measurement procedure shall be as follows:

1) Connect the oscilloscope to sum path (via the Coupler, the RF Attenuator).

2) Via the radar control position, set the following: Selected Mode: A, PRF: 100 Hz, maximum power.

3) Verify the Pulse shape and position, according to Table 5 of clause 4.2.1.6.2.

4) Repeat step 3 by setting, in sequence, via the radar control position, the following interrogation modes: Mode-C, Mode A Intermode P4 short, Mode-C Intermode P4 short, Mode-A Intermode P4 long, Mode-C Intermode P4 long, Mode-S all-call.

5) Connect the oscilloscope to OMNI path (via the Coupler, the RF Attenuator).

6) Repeat steps 2 to 4, and verify Pulse shape and position of P2 (Mode A, C and Intermode) and P5 pulse (Mode-S).

7) If a second channel is available, repeat above steps 1 to 6 for this radar channel.

5.3.2 Receiver related tests

5.3.2.0 General requirements

Before setting up the test bench, and at any time when disconnecting/reconnecting an RF cable, it has to be verified that RF radiation is disabled, for any transmitting chain.

5.3.2.1 Receiver sensitivity and flatness

5.3.2.1.1 Test conditions

The measurement setup shall be as in Figure B.3.

Signal Generator 1 of Type 2, as described in clause B.3 shall be used. If the signal generator is not able to handle low level signals, an external calibrated attenuator shall be used.

An oscilloscope shall be used to verify and measure signal level.

5.3.2.1.2 Procedure

The measurement procedure shall be as follows:

1) Via the radar control position, set the radar in Mode A/C interrogating only in Mode A with IRF = 100 Hz.

2) Set the Signal Generator 1 as follows:

   - Power = equal or less than -80 dBm

- Frequency = 1 090 MHz
- Mode A = 1240_{OCT}

and inject in the EUT the signal.

3) Set the oscilloscope as follows:
   - Trigger = auto/or externally generated at IRF (100 Hz)
4) Set the attenuation level in the RF attenuator at 0 dB.
5) By means of radar control position verify the statistics related to the number of received replies, taking into account that, with IRF = 100 Hz and antenna turning speed = 4 s, the expected number of received replies is 400. Increase the attenuation level until the effective number of detected and decoded replies is at least 90 % of injected replies.
6) Verify on the oscilloscope that the peak level of signal of the injected replies at the input of the SSR Interrogator (oscilloscope input A of Figure B.3) is in accordance to the limits defined in clause 4.2.2.1.2.
7) Take note of such level (MDL) taking into account the level of the signal from the Signal Generator set at step 2, the attenuation level set ay step 3, and the coupling factor of the RF coupler.
8) Set the Signal Generator 1 as follows:
   - Power = 1 dB higher than level set at step 2
   - Frequency = 1 089 MHz
   - Mode A = 1240_{OCT}

   and inject in the EUT the signal.
9) Repeat steps 3 to 5.
10) Set the Signal Generator 1 as follows:
    - Power = 1 dB higher than level set at step 2
    - Frequency = 1 091 MHz
    - Mode A = 1240_{OCT}

    and inject in the EUT the signal.
11) Repeat steps 3 to 5.
12) Via the radar control position, set the radar in Mode-S interrogating only in all-call with IRF = 100 Hz.
13) Set the Signal Generator 1 as follows:
    - Power = same level set at step 2
    - Frequency = 1 090 MHz
    - Mode S = $3000FF_{HEX}$

    and inject in the EUT the signal.
14) Repeat steps 3 to 5.
15) Set the Signal Generator 1 as follows:
    - Power 1 dB higher than level set at step 2
    - Frequency = 1 089 MHz
    - Mode S = $3000FF_{HEX}$

and inject in the EUT the signal.

16) Repeat steps 3 to 5.

17) Set the Signal Generator 1 as follows:

- Power = 1 dB higher than level set at step 2
- Frequency = 1 091 MHz
- Mode S = $3000FF_{HEX}$

and inject in the EUT the signal.

18) Repeat steps 3 to 5.

19) If a second channel is available, repeat for this channel the sequence 1 to 17 above for this channel.

20) Record on a Test Data Record sheet the test results or measured values.

5.3.2.2 Receiver Saturation Level and Dynamic Range

5.3.2.2.1 Test conditions

The measurement setup shall be as in Figure B.3.

Signal Generator 1 of Type 2, as described in clause B.3 shall be used. If the signal generator is not able to handle low-level signals, an external calibrated attenuator shall be used.

Three scenarios shall be arranged, simulating conventional transponders and including only Mode-A replies at 1 090 MHz, 1 089 MHz and 1 091 MHz.

An oscilloscope shall be used to verify and measure signal level.

5.3.2.2.2 Procedure

The measurement procedure shall be as follows:

1) Via the radar control position, set the radar in Mode A/C interrogating only in Mode A with IRF = 100 Hz.

2) Set the Signal Generator 1 as follows:

- Select Scenario 1 (replies at 1 090 MHz)
- Power = equal to 0 dBm
- Frequency = 1 090 MHz
- Mode A = 1240_{OCT}

and inject in the EUT the signal.

3) Set the RF attenuator to have an initial value of -20 dBm at the Σ channel input.

4) Decrease the attenuation of the RF attenuator until the output signal from the receiver as measured on the instrument (oscilloscope input B of Figure B.3), has reached its compression point, according to the definitions given in clause 4.2.2.2.1.

5) Verify that the peak level of the input signal (oscilloscope input A of Figure B.3) is in accordance to the limit defined in clause 4.2.2.2.2.

6) Calculate the Dynamic Range according to the definition in clause 4.2.2.2.1, the value measured at step 5 and the value measured and recorded at clause 5.3.2.1.2 step 6. Verify that the dynamic range is in accordance to the limit defined in clause 4.2.2.2.2.

7) Select Scenario 2 (replies at 1 089 MHz) and repeat above steps 2 to 6.

8) Select Scenario 3 (replies at 1 091 MHz) and repeat above steps 2 to 6.

9) If a second channel is available, repeat the sequence 1 to 8 above for this channel.

10) Record on a Test Data Record sheet the test results or measured values.

5.3.2.3 Receiver blocking

5.3.2.3.1 Test conditions

The measurement setup shall be as in Figure B.4. Signal Generator 2 is not used.

A Signal Generator Type 2, as defined in clause B.3, shall be used as Signal Generator 1, and a Signal Generator Type 1 shall be used as Signal Generator 3.

Signal Generator 1 is used for radar scenario generation and RF injection and Signal Generator 3 for an interfering signal generation.

A reply processing analyser/counter is also necessary to evaluate the detection performance.

The interfering signal shall consist of a sequence of pulses of 500 nsec duration, equally spaced of 2 µsec, and having leading and trailing edge of a duration of 75 nsec.

5.3.2.3.2 Procedure

The tests are performed at the maximum (saturation level), minimum (sensitivity level) and another selected value within the dynamic range (20 dB above the sensitivity level) at 10 different frequencies.

The P_d shall be calculated as the ratio between the number of times the target is detected and sent as a plot to the reply processing analyser/counter, and the number of times the target is simulated and injected by Signal Generator 1.

The measurement procedure shall be as follow:

Mode-S

1) Inject in the radar system (sum Channel) by Signal Generator 1 the RF simulated scenario, with one fixed target replying in Mode-S with amplitude P_0 = -65 dBm (20 dB above the reference minimum sensitivity of -85 dBm).

2) Evaluate the P_d of the injected scenario ($Pd_{without\ interference}$) at plot extraction level.

3) Inject in the radar system:

   - by Signal Generator 1 the same previous RF simulated scenario;

   - by Signal Generator 3 an unwanted pulse modulated signal adjusted to a frequency f1 at 1 105 MHz (15 MHz above the nominal frequency of the receiver) and an amplitude P1 = -45 dBm (20 dB above the level of the wanted signal).

4) Evaluate the P_d of the injected scenario ($Pd_{with\ interference}$) at plot extraction level.

5) Verify that the result is according to limits specified in clause 4.2.2.3.2 ($Pd_{without\ interference} - Pd_{with\ interference} \leq 5\ \%$).

6) Repeat above steps 3 to 5 varying the signal level of Signal Generator 1 to sensitivity level and injecting the unwanted modulated signal with Signal Generator 3 at a level 20 dB higher.

7) Repeat above steps 3 to 6 using the following frequencies:

   - f2 = 1 120 MHz (30 MHz above the nominal frequency of the receiver)

   - f3 = 1 140 MHz (50 MHz above the nominal frequency of the receiver)

   - f4 = 1 150 MHz (60 MHz above the nominal frequency of the receiver)

- f5 = 1 168 MHz (78 MHz above the nominal frequency of the receiver)
- f6 = 1 075 MHz (15 MHz below the nominal frequency of the receiver)
- f7 = 1 060 MHz (30 MHz below the nominal frequency of the receiver)
- f8 = 1 040 MHz (50 MHz below the nominal frequency of the receiver)
- f9 = 1 030 MHz (60 MHz below the nominal frequency of the receiver)
- f10 = 1 012 MHz (78 MHz below the nominal frequency of the receiver)

8) If a second channel is available, repeat the sequence 1 to 7 above for this channel.

9) Record on a Test Data Record sheet the test results.

Mode A/C

1) Inject in the radar system (sum Channel) by Signal Generator 1 the RF simulated scenario with one fixed target replying in Mode A/C with amplitude P_0 = -65 dBm (20 dB above the reference sensitivity measured in test in clause 5.3.2.1).

2) Evaluate the P_d of the injected scenario ($Pd_{without\ interference}$) at plot extraction level.

3) Inject in the radar system:
   - by Signal Generator 1 the previous RF simulated scenario
   - by Signal Generator 3 an unwanted modulated signal adjusted to a frequency f1 at 1 105 MHz (15 MHz above the nominal frequency of the receiver) and an amplitude P1 = -45 dBm (20 dB above the level of the wanted signal)

4) Evaluate the P_d of the injected scenario ($Pd_{with\ interference}$) at plot extraction level.

5) Verify that the result is according to limits specified in clause 4.2.2.3.2 ($Pd_{without\ interference} - Pd_{with\ interference} \leq 5\ \%$).

6) Repeat above steps 11 to 14, varying the signal level of Signal Generator 1 to sensitivity level and injecting the unwanted modulated signal with Signal Generator 3 at a level 20 dB higher.

7) Repeat above steps 11 to 15 using the following frequencies:
   - f2 = 1 120 MHz (30 MHz above the nominal frequency of the receiver)
   - f3 = 1 140 MHz (50 MHz above the nominal frequency of the receiver)
   - f4 = 1 150 MHz (60 MHz above the nominal frequency of the receiver)
   - f5 = 1 168 MHz (78 MHz above the nominal frequency of the receiver)
   - f6 = 1 075 MHz (15 MHz below the nominal frequency of the receiver)
   - f7 = 1 060 MHz (30 MHz below the nominal frequency of the receiver)
   - f8 = 1 040 MHz (50 MHz below the nominal frequency of the receiver)
   - f9 = 1 030 MHz (60 MHz below the nominal frequency of the receiver)
   - f10 = 1 012 MHz (78 MHz below the nominal frequency of the receiver)

8) If a second channel is available, repeat the sequence 1 to 16 above.

9) Record on a Test Data Record sheet the test results.

5.3.2.4 Receiver selectivity

5.3.2.4.1 Test conditions

The measurement setup shall be as in Figure B.4.

Signal Generator 1 Type 2, as defined in clause B.3 shall be used.

A reply processing analyser/counter is also necessary to evaluate the detection performance.

In order to properly set power levels, the calibrated RF attenuators of Figure B.4 shall be used.

5.3.2.4.2 Procedure

The P_d shall be calculated as the ratio between the number of times the reply is detected, decoded and sent to the reply processing analyser/counter, and the number of times the reply is generated and injected by Signal Generator 1.

The measurement procedure shall be as follows:

1) Via the radar control position, set the radar in Mode-S interrogating only in all-call with IRF = 100 Hz.
2) Set the Signal Generator as follows:
    - Power P0 = -85 dBm
    - Frequency f0 = 1 090 MHz
    - Mode S = $3000FF_{HEX}$

    and inject in the EUT (sum Channel) the relevant signals.
3) Evaluate the P_d of the injected scenario (P_d *1 090*) at reply decoding level.
4) Set the Signal Generator as follows:
    - Power P1 = -82 dBm
    - Mode S = $3000FF_{HEX}$

    and inject in the EUT (sum Channel) the relevant signals, at the following frequencies:

    1 095,5 MHz, 1 097 MHz, 1 098 MHz, 1 099 MHz, 1 084,5 MHz, 1 083 MHz, 1 082 MHz, 1 081 MHz.
5) For each of the frequencies at step 4, evaluate the P_d of the injected scenario (P_d *offset*) at reply decoding level.
6) Set the Signal Generator as follows:
    - Power P1 = -65 dBm
    - Mode S = $3000FF_{HEX}$

    and inject in the EUT (sum Channel) the relevant signals, at the following frequencies:

    1 100 MHz, 1 101 MHz, 1 102 MHz, 1 103 MHz, 1 104 MHz, 1 080 MHz, 1 079 MHz, 1 078 MHz, 1 077 MHz, 1 076 MHz.
7) For each of the frequencies at step 6, evaluate the P_d of the injected scenario (P_d *offset*) at reply decoding level.
8) Set the Signal Generator as follows:
    - Power P1 = -45 dBm
    - Mode S = $3000FF_{HEX}$

    and inject in the EUT (sum Channel) the relevant signals, at the following frequencies:

    from 1 105 MHz up to 1 114 MHz at 1 MHz step from 1 075 MHz down to 1 066 MHz at 1 MHz step.

9) For each of the frequencies at step 8, evaluate the P_d of the injected scenario (P_d *offset*) at reply decoding level.

10) Set the Signal Generator as follows:

- Power P1 = -25 dBm
- Mode S = $3000FF_{HEX}$

and inject in the EUT (sum Channel) the relevant signals, at the following frequencies:

from 1 115 MHz up to 1 136 MHz at 1 MHz step

from 1 065 MHz down to 1 044 MHz at 1 MHz step.

11) For each of the frequencies at step 10, evaluate the P_d of the injected scenario (P_d *offset*) at reply decoding level.

12) Verify that the test results are in accordance to the requirements specified in clause 4.2.2.4.2 (P_d *offset* $\leq$ P_d *1 090*).

13) If a second channel is available, repeat the sequence 1 to 12 above for this channel.

14) Record on a Test Data Record sheet the test results or measured values.

5.3.2.5 Inter-modulation response rejection

5.3.2.5.1 Test conditions

The measurement setup shall be as in Figure B.4.

Signal Generator 1 and 2 Type 2, and Signal Generator 3 Type 1, as defined in clause B.3, shall be used.

A reply processing analyser/counter is also necessary to evaluate the detection performance.

5.3.2.5.2 Procedure

The purpose of this test is to establish that inter-modulation caused by two unwanted Out-of-Band signals does not degrade the reception probability when their signal level is below the specified limit.

The P_d shall be calculated as the ratio between the number of times the target is detected and sent as a plot to the reply processing analyser/counter, and the number of times the target is simulated and injected by Signal Generator 1.

The measurement procedure shall be as follows:

1) Three signal generators, 1, 2 and 3, shall be connected to the receiver (sum Channel) via a combining device as follows:

- The wanted signal, provided by Signal Generator 1, shall be at the nominal frequency of the receiver and shall produce test signal emulating a valid Mode-S reply, at amplitude and frequencies as specified by test steps.
- The first unwanted signal, provided by Signal Generator 3, shall be unmodulated and adjusted to a frequency f1 at 20 MHz above the nominal frequency of the receiver.
- The second unwanted signal, provided by Signal Generator 2, shall be modulated, with a test signal having the following characteristics:
    - PRF = 450 Hz, Waveform = valid Mode-S reply, Amplitude as specified, and adjusted to a frequency f2 at 40 MHz above the nominal frequency of the receiver.

2) Initially, Signal Generators 2 and 3 (unwanted signals) shall be switched off (maintaining the output impedance).

- The level of the wanted signal from generator 1 shall be adjusted to the level, which is -65 dBm, i.e. 20 dB above the reference minimum sensitivity of -85 dBm

3) Record the P_d of the wanted signal.

4) Signal generators 2 and 3 shall then be switched on; and set to a level 40 dB above the reference sensitivity as referenced to the input of the receiver under test.

5) Record the P_d of the wanted signal.

6) Verify that the P_d from step 5 is degraded by no more than the limit specified in clause 4.2.2.5.2.

7) The measurement shall be repeated with the unwanted signal generator 3 at the frequency 20 MHz below that of the wanted signal and the frequency of the unwanted signal generator 2 at the frequency 40 MHz below that of the wanted signal.

8) Repeat the test steps 1 to 7 with at least the 4 frequencies below fulfilling fc = 2 × f1 - f2 (with an offset of f1 and f2 in the range of +20 MHz to +78 MHz and -20 MHz to -78 MHz):

   - f1 = 1 051, f2 = 1 012 (f2 = 1 090 MHz - 78 MHz)

   - f1 = 1 060, f2 = 1 030 (f2 = 1 090 MHz - 60 MHz)

   - f1 = 1 108, f2 = 1 126 (f2 = 1 090 MHz + 36 MHz)

   - f1 = 1 129, f2 = 1 168 (f2 = 1 090 MHz + 78 MHz)

   The frequency f2 = 1 030 MHz is included since it corresponds to another interrogator.

   Since there are potential DME interferences at 1 MHz steps from 962 MHz to 1 213 MHz, any frequency in that range is valid for testing.

9) If a second channel is available, repeat the sequence 1 to 8 above for this channel.

5.3.2.6 Receiver co-channel rejection

5.3.2.6.1 Test conditions

The measurement setup shall be as in Figure B.4.

Two Signal Generators Type 2, as defined in clause B.3 shall be used: Signal Generator 1 for radar scenario generation and RF injection and Signal Generator 2 for an interfering signal generation.

A reply processing analyser/counter is also necessary to evaluate the detection performance.

5.3.2.6.2 Procedure

The P_d shall be calculated as the ratio between the number of times the target is detected and sent as a plot to the reply processing analyser/counter, and the number of times the target is simulated and injected by Signal Generator 1.

The measurement procedure shall be as follows:

1) Set the Signal Generator 1 as follows:

   - Power level = -65 dBm (i.e. 20 dB above the reference minimum sensitivity of -85 dBm

   - Frequency = 1 090 MHz

   - Mode S = $3000FF_{HEX}$

   and inject the signal.

2) Evaluate the P_d of the injected scenario ($Pd_{without\ interference}$) at plot extraction level.

3) Inject in the radar system the previous signals by Signal Generator 1 and an RF simulated scenario by Signal Generator 2, composed by 11 000 FRUITs per second (all-call replies only).

4) Evaluate the P_d of the injected scenario ($Pd_{with\ interference}$) at plot extraction level.

5) Verify that the test results are in accordance to limits specified in clause 4.2.2.5.2 ($Pd_{without\ interference} - Pd_{with\ interference} \leq 5\ \%$).

6) If a second channel is available, repeat the sequence 1 to 5 above for this channel.

7) Record on a Test Data Record sheet the test results.

5.3.2.7 Receiver Noise Figure

5.3.2.7.1 Test conditions

The measurement setup shall be as in Figure B.5.

A Noise Figure Meter, employing a calibrated noise source, shall be used.

5.3.2.7.2 Procedure

The measurement procedure shall be as follows:

1) Connect the calibrated noise generator to the RX sum (∑) channel input and the Noise Figure meter output.

2) Connect the Noise Figure meter to the RX sum (∑) channel output.

3) Measure the Noise Figure of the RX sum (∑) channel.

4) Verify that the result is according to the limits specified in clause 4.2.2.7.2.

5) Repeat above steps 1 to 4 for:

    a) RX Δ channel

    b) RX Ω channel

6) If a second channel is available, repeat the sequence 1 to 5 above.

Annex A (informative): Relationship between the present document and the essential requirements of Directive 2014/53/EU

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.2] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.1].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in Table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive, and associated EFTA regulations.

Table A.1: Relationship between the present document and the essential requirements of Directive 2014/53/EU

Harmonised Standard ETSI EN 303 363-1					
Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive	Clause(s) of the present document	U/C	Condition
1	Maximum frequency deviation	3.2	4.2.1.1	U	
2	Transmitter power	3.2	4.2.1.2	U	
3	Transmitter power control	3.2	4.2.1.3	U	
4	Spectrum mask	3.2	4.2.1.4	U	
5	Emissions in idle mode	3.2	4.2.1.5	U	
6	Transmitted waveforms	3.2	4.2.1.6	U	
7	Receiver sensitivity and flatness	3.2	4.2.2.1	U	
8	Receiver Saturation Level and Dynamic Range	3.2	4.2.2.2	U	
9	Receiver blocking	3.2	4.2.2.3	U	
10	Receiver selectivity	3.2	4.2.2.4	U	
11	Inter-modulation response rejection	3.2	4.2.2.5	U	
12	Receiver co-channel rejection	3.2	4.2.2.6	U	
13	Receiver Noise Figure	3.2	4.2.2.7	U	

Key to columns:

Requirement:

No A unique identifier for one row of the table which may be used to identify a requirement.

Description A textual reference to the requirement.

Essential requirements of Directive
Identification of article(s) defining the requirement in the Directive.

Clause(s) of the present document
Identification of clause(s) defining the requirement in the present document unless another document is referenced explicitly.

Requirement Conditionality:

U/C Indicates whether the requirement is unconditionally applicable (U) or is conditional upon the manufacturer's claimed functionality of the equipment (C).

Condition Explains the conditions when the requirement is or is not applicable for a requirement which is classified "conditional".

Presumption of conformity stays valid only as long as a reference to the present document is maintained in the list published in the Official Journal of the European Union. Users of the present document should consult frequently the latest list published in the Official Journal of the European Union.

Other Union legislation may be applicable to the product(s) falling within the scope of the present document.

Annex B (normative): Measurement setups

B.1 Setup 1

Figure B.1 shows the measurement setup to be used, when verifying the following parameters of the EUT transmitter:

1) maximum frequency deviation (clause 5.3.1.1)
2) transmitted power (clause 5.3.1.2)
3) transmission power control (clause 5.3.1.3)
4) emissions in idle mode (clause 5.3.1.5)

Control Position (EUT Adapter) is necessary to input commands/settings to the EUT in order to select the required operational parameters to execute the foreseen test measurements.

According to the scheme in Figure B.1, two dummy loads (50 Ω, 4 kW peak power) are required to match the output port in absence of the real antenna RF path.

When not part of the specific manufacturer design and so already included in the TX chains, an external Directional coupler is needed to connect the test instruments at the RF port under measurement without modifying the output impedance and taking the required part of signal necessary for the measurement.

In a similar way, two variable RF attenuators are required, in order to get signals in the measurable scale at the input of the test instruments, and to avoid any possible damages to instruments caused by high power signals.

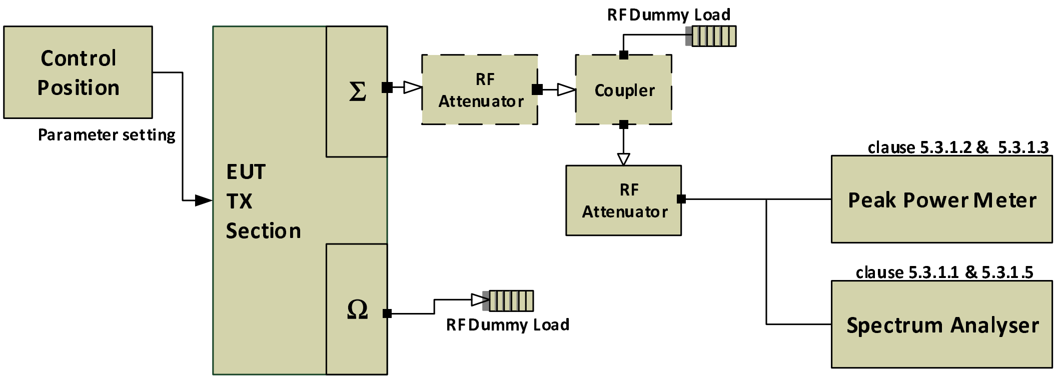

Figure B.1: Setup for the measurement of the operating frequency, transmitter power, transmission power control and emissions in idle mode (for sum Channel measurements)

With reference to the above Figure B.1, tests for Ω channel shall be executed with the same scheme, after having connected the Dummy Load to Σ channel.

All measurements for the emissions in idle mode shall be made with a reference bandwidth as shown in Table B.1.

Table B.1: Reference Bandwidths

Frequency Range	RBW
30 MHz ≤ f < f_{m1}	100 kHz
f_{m2} < f ≤ 5 150 MHz	1 MHz

NOTE 1: f is the measurement frequency.
NOTE 2: f_{m1} is the lower edge of the Out-of-Band Domain and equals f_c - 125 MHz.
NOTE 3: f_{m2} is the upper edge of the Out-of-Band Domain and equals f_c + 125 MHz.
NOTE 4: The Out-of-Band Domain is defined in clause 4.2.1.4 (Spectrum mask).
NOTE 5: 5 150 MHz corresponds to the 5^{th} harmonic of the Interrogator transmitting at 1 030 MHz.
NOTE 6: Reference bandwidths are defined in ERC/Recommendation 74-01 [i.7].

B.2 Setup 2

Figure B.2 shows the measurement setup to be used, when verifying the following parameters of the EUT transmitter:

1) spectrum mask (clause 5.3.1.4).

As per previous test bench arrangement, the used instrument has to be connected to the EUT using an RF attenuator.

When not part of the specific manufacturer design and so already included in the TX chains, an external Directional coupler is needed to connect the test instruments at the RF port under measurement without modifying the output impedance and taking the required part of signal necessary for the measurement.

The measurement requires the insertion of a stopband filter, when analysing parts of the spectrum (2nd up to 5th harmonics) in the spurious domain.

The essential minimum characteristics of the stopband filter are the following:

Parameters	Min.	Max.	Units
Pass Frequency (Low)	DC	0,9	GHz
Pass Frequency (High)	1,1	6	GHz
Reject Bandwidth		200 (@ -3 dB)	MHz
Insertion Loss		2,0	dB
Ripple in Pass Band		1,0	dB
Rejection	50 dB @ 1 GHz		dB
Power Rating (Average)	30		W
Impedance	50		Ohms

The chosen value of the attenuation shall depend on the characteristics of the filter and the Spectrum Analyser, in order to get signals in the measurable scale at the input of the test instrument, and to avoid any possible damages to the test bench devices. The RF Dummy Load shall be adequate to support maximum power with a duty cycle of 6 %.

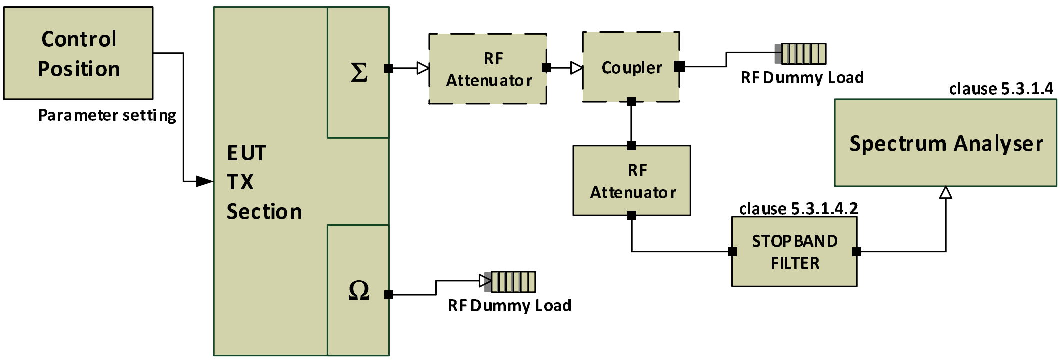

Figure B.2: Setup for the measurement of the spectrum mask (for sum Channel measurements)

With reference to the above Figure B.2, the test for Ω channel shall be executed with the same scheme, after having connected the Dummy Load to Σ channel.

All measurements shall be made with a reference bandwidth of 1 MHz.

B.3 Setup 3

Figure B.3 shows the measurement setup to be used, when verifying the following parameters of the EUT receiver:

1) sensitivity and flatness (clause 5.3.2.1)

2) saturation level and dynamic range (clause 5.3.2.2)

Figure B.4 shows the measurement setup to be used, when verifying the following parameters of the EUT receiver:

1) blocking (clause 5.3.2.3)

2) selectivity (clause 5.3.2.4)

3) inter-modulation response rejection (clause 5.3.2.5)

4) receiver co-channel rejection (clause 5.3.2.6)

In the schematic, the RF splitter and the RF combiner are separated, but a single hybrid device is equivalent, this configuration allowing the simultaneous injection of replies in the receiver channels of the EUT. This is needed to enable proper reply reception and decoding from injected signals coming from the Signal Generators.

In Figure B.3 the coupler has the purpose to pick the generated signal to have it displayed on the oscilloscope.

In Figure B.4 the isolators and the couplers are included to prevent damage to instruments in case of high VSWR due to chain mismatching.

Variable RF attenuators capable at least of 1 dB steps are required, in order have the possibility to set accurately relative levels of overlapping signals coming from the different sources.

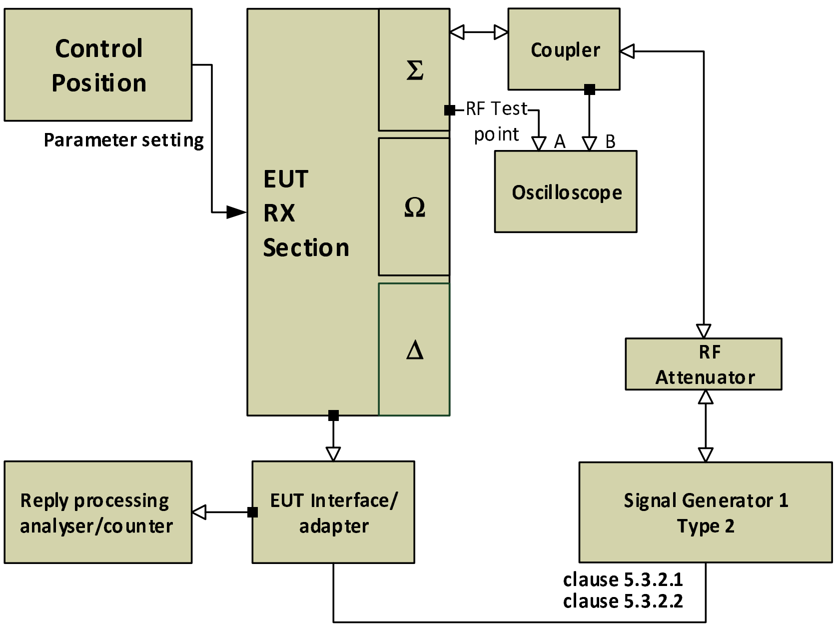

Figure B.3: Setup for the measurement of the receiver parameters (sensitivity, saturation level)

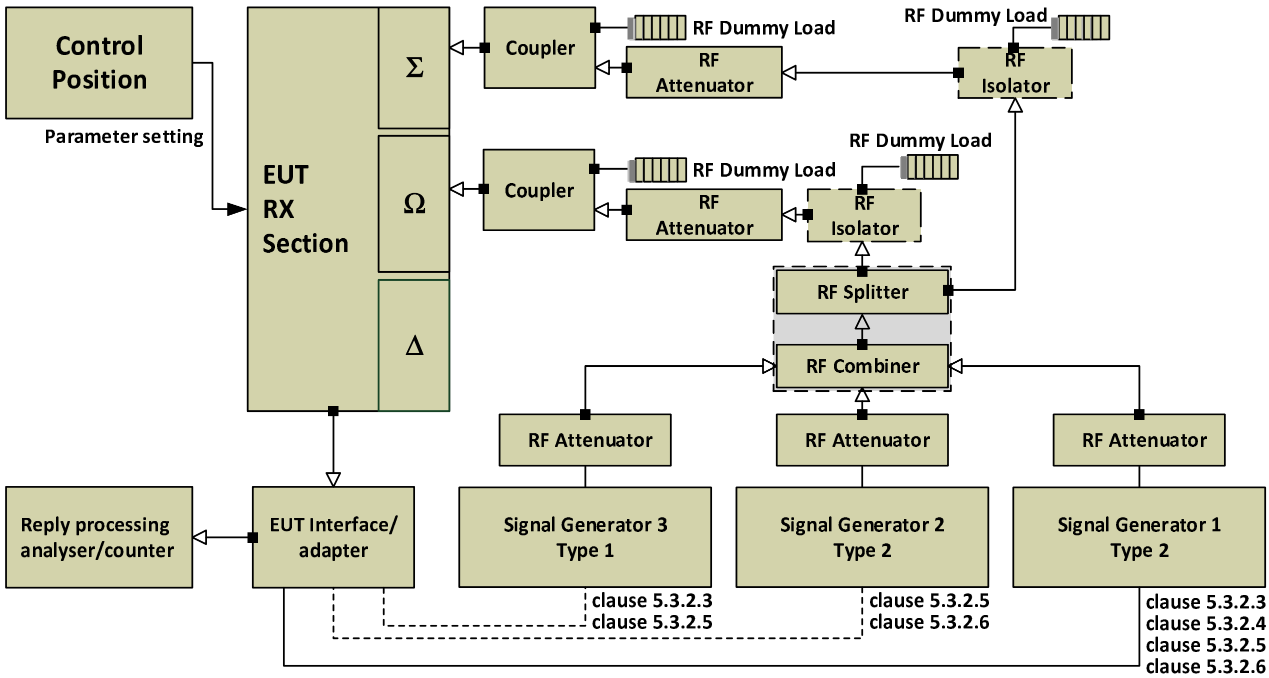

Figure B.4: Setup for the measurement of the receiver parameters (blocking, selectivity, inter-modulation response rejection and co-channel immunity)

The testing of an SSR Interrogator, for its receiving part, requires evaluating the percentage of detected replies, and an SSR Interrogator will validate replies only synchronous with its interrogations. Non-synchronous signals are discarded (and are designated as FRUITs - False Replies Unsynchronized In Time).

In the test description, this type of Signal Generator (i.e. able to generate signals similar to those coming from a real RF environment, operating triggered by the radar synchronism) has been referred to as Type 2 Signal Generator.

Type 2 Signal Generators shall have the following functions:

- Reply to SSR interrogations like an airborne transponder, implementing specific Mode A/C/S values
- Reply to SSR Interrogators implementing complex RF environment to emulate air traffic scenarios and operating with the same azimuth encoder simulated data of the SSR receiver.
- Generate waveforms similar to true replies, but altered to emulate disturbing signals, and injected in a synchronous or asynchronous way with respect to simulated scan time.

Such features are not all needed in each test case, but the execution of testing as described in the present document needs that each feature is used in at least one test case.

Type 1 Signal Generators are RF signal (CW and pulsed) generators.

B.4 Setup 4

Figure B.5 shows the measurement setup to be used when verifying the following parameters:

1) Noise Figure (clause 5.3.2.7)

The setup consists, as basic instruments, of a Calibrated Noise Source and a Noise Figure Meter.

The Noise source is sequentially connected at the input of the Receiver Channel under measurement, the Noise Figure meter at the output of the same Channel, providing a reference signal at the input of the Noise Source.

The output can be available as direct output or via directional coupler, or as test points.

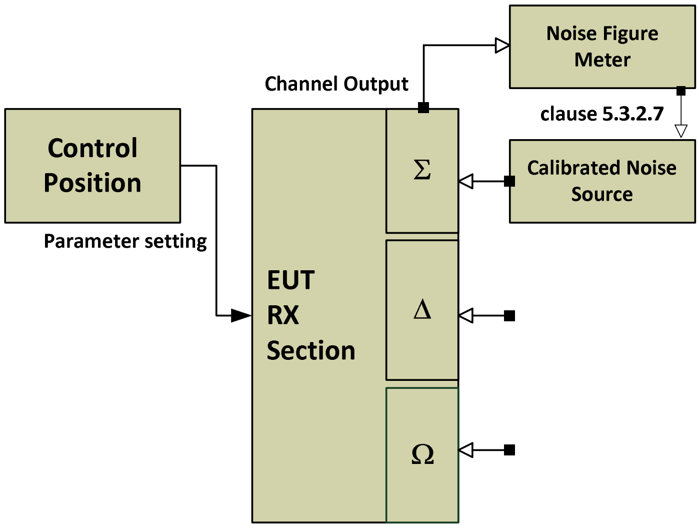

Figure B.5: Setup for the measurement of the Noise Figure (setup for Σ channel)

Testing of Δ and Ω channels is executed with the same arrangement.

B.5 Setup 5

Figure B.6 and Figure B.7 show the measurement setup to be used, when verifying the following parameters of the EUT transmitter:

1) Transmitted Waveforms (clause 5.3.1.6)

A dedicated interface is necessary to input commands/settings to the EUT, in order to select required operational parameters to execute the foreseen test measurements.

According to the scheme in Figure B.6 and Figure B.7, dummy loads are required to match the output port in absence of the real antenna RF path. The Phase shifter is needed for check of P6 pulse and synch phase reversal.

When not part of the specific manufacturer design, and so already included in the TX chains, a Directional coupler is needed to connect the test instruments at the RF port under measurement without modifying the output impedance and taking the required part of signal necessary for the measurement.

RF detectors are needed to transform the RF signal to baseband signal, in order to be analysed by the oscilloscope, when this feature is not available in the oscilloscope itself.

If the oscilloscope does not have internal facilities to sum up the signals at digital level, a mixer and one detector only (if this feature is not available in the oscilloscope) shall be used as shown in Figure B.7.

If the oscilloscope does have internal facilities to sum up the signals at digital level, a mixer is not needed and 2 detectors (if this feature is not available in the oscilloscope) shall be used as shown in Figure B.6

RF attenuators (fixed or variable) are required. The chosen value of the attenuation shall depend on the presence and characteristics of the couplers, the detectors and the oscilloscope, in order to get signals in the measurable scale at the input of the test instrument, to calibrate the bench in order to have the same overall attenuation on signals from Sum and Omni channels, and to avoid any possible damages to the test bench devices.

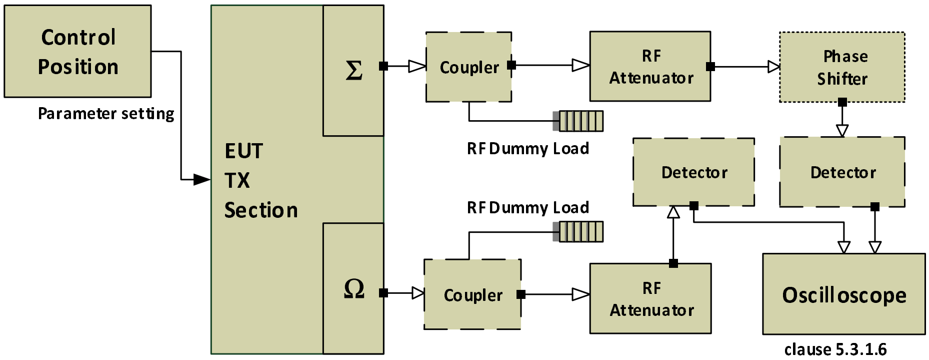

Figure B.6: Setup 1 for the measurement of the transmitted waveform

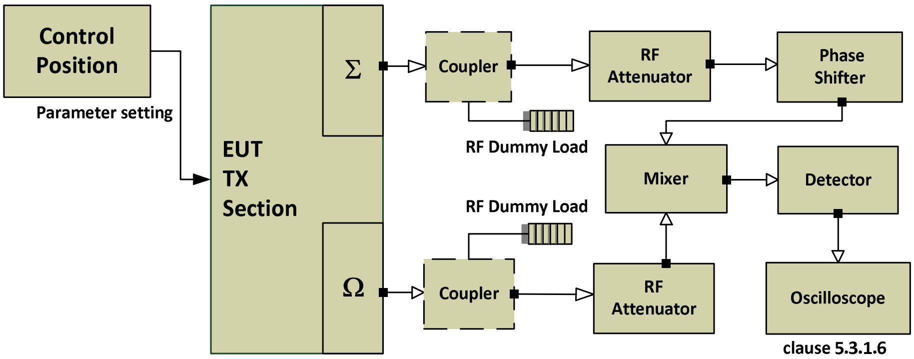

Figure B.7: Setup 2 for the measurement of the transmitted waveform

Annex C (informative): Checklist

This annex provides a traceability of the technical parameters for article 3.2 of Directive 2014/53/EU [i.1] defined in ETSI EG 203 336 [i.4] with the technical requirements for conformance defined in clause 4 of the present document.

If a technical parameter for article 3.2 of Directive 2014/53/EU [i.1] defined in ETSI EG 203 336 [i.4] has not been included in the present document, an explanation is provided.

An explanation is also provided whenever a technical parameter defined in ETSI EG 203 336 [i.4] is covered by an alternative technical requirement.

Table C.1: Checklist

Technical Parameters defined in ETSI EG 203 336 [i.4]	Clauses of the present document	Comments
Transmitter Parameters		
Transmit power (and possible accuracy)	4.2.1.2, 4.2.1.3	
Spectrum mask	4.2.1.4	
Transmitter Frequency stability	4.2.1.1	
Transmitter Intermodulation attenuation	NA	ETSI EG 203 336 [i.4] considers this parameter as applicable for base stations with shared sites and dense usage scenarios. Since appropriate means (e.g. circulators) to separate the TX and RX signals are used, an interfering signal entering the transmitter via its antenna. cannot cause any intermodulation. Radars do not transmit continuously (the mode S pulse duration is less than 31 µs – worst case) and since the high gain antenna rotates once every 4 to 12 seconds, the probability of an external signal entering the antenna during the transmission is very low.
Unwanted emissions (OoB and spurious domains)	4.2.1.4, 4.2.1.5	
Transmitter Time domain characteristics (e.g. the duty cycle, turn-on and turn-off, frequency hopping cycle, dynamic changes of modulation scheme and others)	4.2.1.6	
Transmitter Transients	4.2.1.4	This requirement is covered by the spectrum mask.
Receiver Parameters		
Receiver sensitivity	4.2.2.1	
Receiver co-channel rejection	4.2.2.6	
Adjacent band/channel Selectivity	4.2.2.4	
Spurious response Rejection	4.2.2.4	It is covered by the Selectivity.
Receiver blocking	4.2.2.3	
Receiver radio-frequency intermodulation	4.2.2.5	
Receiver dynamic range	4.2.2.2	
Reciprocal mixing	4.2.2.4 4.2.2.3 4.2.2.5	Reciprocal mixing is covered by the Selectivity and the receiver blocking. Moreover TX and RX frequencies are fixed and so image frequencies are evaluated as part of the intermodulation rejection.
Desensitization	4.2.2.3	It is covered by the receiver blocking.
Receiver unwanted emissions in the spurious domain	4.2.1.5	It is included in the transmitted signals verification in idle state.

Annex D (informative): Maximum Measurement Uncertainty

The measurements described in the present document are based on the following assumptions:

- the measured value related to the corresponding limit is used to decide whether an equipment meets the requirements of the present document;
- the value of the measurement uncertainty for the measurement of each parameter is included in the test report.

Table D.1 shows the recommended values for the maximum measurement uncertainty figures.

Table D.1: Maximum measurement uncertainty

Parameter	Uncertainty
Environment measurements	
Temperature	1 °C
Relative humidity	5 %
Mains Supply Voltage	±2 %
Transmitter measurements	
Frequency	±1 ppm
Transmitter power	±1,5 dB
Transmitter power control	±1 dB
Out-of-Band emissions	±4 dB
Spurious emissions	±4 dB
Receiver measurements	
Noise Figure	±1 dB
Receiver Selectivity	±1 dB
Receiver Sensitivity and flatness	±1 dB
Receiver Saturation Level and Dynamic range	±1 dB
Receiver blocking	±1 dB
Inter-modulation response rejection	±1 dB
Receiver co-channel rejection	±1 dB

History

Document history				
V1.0.1	December 2020	EN Approval Procedure	AP 20210315:	2020-12-15 to 2021-03-15
V1.0.4	December 2021	Vote	V 20220213:	2021-12-15 to 2022-02-14
V1.1.1	February 2022	Publication		