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Part 2: Far Field Monitor (FFM)

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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 2 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	
Date of adoption of this EN:	26 September 2023
Date of latest announcement of this EN (doa):	31 December 2023
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	30 June 2024
Date of withdrawal of any conflicting National Standard (dow):	30 June 2025

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).

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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.

The Far Field Monitor (FFM) is a ground-installed device that is intended to monitor the uplink and/or downlink performance of a Mode S interrogator system from a site located at a suitable distance from the radar interrogator (far field).

By its fixed location, the Far Field Monitor provides a fixed geo-referenced position with respect to which the SSR interrogator can keep aligned its azimuthal reference with the geographical north.

While a Far Field Monitor has many characteristics in common with a Mode S transponder, there are a number of important differences required to allow monitoring and to ensure that FFM will not impact Air Traffic safety and have only minimal impact on Radio Frequency Interference and SSR channel Loading.

An FFM interrogated by the SSR radar in Mode A, C, S and intermode formats, replies with matching Mode A, C, S reply. The replies are evaluated by the SSR interrogator to ensure correct operation. In addition, the replies may contain data about certain interrogation parameters as seen by the monitor.

As far as Mode S is concerned, it is assumed that the FFM can process interrogations in uplink format UF11, UF4 and UF5 and can transmit the corresponding replies in downlink format DF11, DF4, DF20, DF5 and DF21.

As far as Intermode is concerned, it is assumed that the FFM having Mode-S capabilities will only reply to intermode interrogations of type Mode A only all-call and Mode C only all-call. As far as intermode interrogations of type Mode A/C/S all-call are concerned, the FFM will not reply to them. Table 1 sums up the FFM capabilities.

Table 1: FFM capabilities

Mode	Interrogation processing	Reply Transmission
Mode A	Yes	Yes
Mode C	Yes	Yes
Mode S	Yes for at least UF11, UF4 and UF5 interrogations	Yes for at least DF11, DF4, DF20, DF5 and DF21 replies
Intermode	Yes	No in case of Mode A/C/S all interrogations (long P4)

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:

Far Field Monitors (FFM) operating on the frequencies as indicated in Table 2.

Table 2: FFM operating frequencies

Mode	Operating frequencies
FFM Receive	1 030 MHz
FFM Transmit	1 090 MHz

NOTE: 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.

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) applies.

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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] 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.4] ICAO Annex 10, Volume IV: "Surveillance Radar and Collision Avoidance Systems", 5th edition, July 2014 including amendments up to amendment 91 dated 22-03-2021.

[i.5] ERC Recommendation 74-01 (2019): "Unwanted emissions in spurious domain".

[i.6] ITU-R Radio Regulations (2020).

[i.7] Eurocontrol Specification for European Mode S Station (EMS) (EUROCONTROL-SPEC-189) Ver 4.0, September 2021.

[i.8] EUROCAE ED-73F: "Minimum Operational Performance Specification for Secondary Surveillance Radar Mode S Transponders", December 2020.

[i.9] ICAO Annex 10, Volume III: "Communication Systems", 2nd Edition, 2007.

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 or OMEGA path and identified with Greek letter Ω.

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 Mode A, C and S capable device

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): system which monitors the uplink and/or downlink performance of an SSR or Mode S system from a site located at a specified distance from the radar (far field)

NOTE 1: The monitor is interrogated by the radar, and its replies can be evaluated on the radar site. In addition, the replies may contain data about certain interrogation parameters as seen by the monitor.

NOTE 2: A Mode S FFM supports Mode A, C and S.

NOTE 3: FFM is also referred to as "Remote Field Monitor" (RFM), "Position Adjustable Range Reference Orientation Transponder" (PARROT) or "Site Monitor".

FFM test equipment: equipment to simulate Mode A, C and S interrogations to enable the testing of the performance of Mode A, C and S based transponder and similar devices

FRUITs: replies received by an interrogator which are 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.4] and EUROCONTROL-SPEC-189 [i.7].

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.

lockout: status in which the FFM is prevented from replying to All-Call interrogations

NOTE: This status is triggered by the interrogator using its own IC code, via a specific "lockout" protocol. This status will last 18 seconds, unless renewed by the interrogator.

Minimum Triggering Level (MTL): minimum input power level that results in a 90 % reply ratio

mode A: type of interrogation, triggering a reply from Mode A capable devices for identity and surveillance allowing the identification of the device

NOTE 1: A Mode A interrogation is defined by the pulse separation between the two P1 and P3 pulses, and consists of P1 and P3 pulses transmitted via a high gain main beam antenna and a P2 pulse (P2 is called a sidelobe - SLS- suppression pulse) via a separate antenna pattern with a different antenna gain.

NOTE 2: A Mode A reply consists of framing pulses (F1 and F2), up to 12 pulses between F1 and F2 and an optionally manually activated and transmitted Special Identification pulse (SPI). The absence or presence of each of the 12 identification pulses between F1 and F2 determines the Mode A reply code.

mode C: interrogation elicit from Mode C capable devices replies allowing SSR interrogator automatic pressure-altitude transmission and surveillance

NOTE 1: A Mode C interrogation is defined by the pulse separation between the two P1 and P3 pulses. The Mode C interrogation is transmitted via a narrow high gain main beam antenna. A third P2 Side Lobe Suppression Pulse (SLS) is transmitted via a separate antenna pattern having a different gain.

NOTE 2: A Mode C reply consists of up to 15 pulses, two framing pulses (F1 and F2), up to 12 pulses transmitted 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 via a directional high gain antenna pattern while the P5 SLS pulse is transmitted via a separate antenna pattern having a different antenna gain (P5 is called sidelobe suppression pulse).
A Mode S reply consists of a four-pulse preamble followed by a 56 or 112 pulse reply data block using PPM.

NOTE 2: Mode S stands for "Mode Select" to allow selective addressing the unique 24 bit address allocated to a Mode S based device replying or squittering on 1 090 MHz e.g. aircraft transponder, non transponder devices or FFM. SSR Mode S address is defined in Annex 10, Volume III Part 1, chapter 9 [i.9] to be one of 16 777 214 twenty-four-bit aircraft addresses allocated by ICAO to the State of Registry or common mark registering authority and assigned as prescribed in the Appendix to the same chapter [i.9].

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.6].

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.6].

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.6].

phase overlay: technique to increase the data throughput by adding an additional phase modulation to each Mode-S Data pulse transmitted on 1 090 MHz

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): type of pulse generation, where amplitude is changed between pulses

NOTE: SLS pulses P2 and P5 are PAM pulses, the Mode-S preamble and the Mode-A and Mode-C replies are made with PAM pulses.

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 position modulation: pulse modulation of the 56 or 112 data pulses used by the Mode S reply and ADS-B formats, by either transmitting the pulse in the first or second half of a microsecond

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

reply ratio: ratio between expected replies, corresponding to a given interrogation rate, and received replies

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.6].

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

Side Lobe Suppression (SLS): technique to use specific pulses P2 in Mode A and C, P5 in Mode S, dedicated for reply suppression, which are transmitted via a separate antenna pattern with a different antenna gain

NOTE 1: The pulse amplitude of the received interrogation and SLS pulse are used to decide if SLS is activated or not.

NOTE 2: P5 is used for Mode S-only all-call interrogation (UF = 11) to prevent replies from aircraft in the side and back lobes of the antenna.

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.6].

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.6].

uplink: direction of the interrogation and data 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
ns	nano second
Pd	Probability of detection
Pd_{1090}	Probability of detection at 1 090 MHz
Pd_{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
Ω	Ohm