

Comments supplied regarding DO-181C and ED-73B

Becker Avionics May 9, 2005

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ED-73B chapter	ED-73B requirement	DO-181C chapter	DO-181C requirement	Remarks
1.4.2.5	<p>Antenna Diversity In order to avoid the performance degradation due to the screening effects that can occur when a single antenna is mounted on the bottom of the aircraft, a second antenna is mounted on top of the aircraft. The transponder processes interrogations on both antennas and transmits the reply on the antenna which received the strongest valid interrogation. Aircraft with gross mass in excess of 5 700 kg or a maximum cruising true airspeed capability in excess of 250 kt (463 km/h) installed with Mode S equipment are required to operate with antenna diversity.</p>	2.2.12	<p>Diversity Operations Diversity Mode S transponders may be implemented for the purpose of improving air-to air surveillance and communications. Such systems shall employ two antennas, one mounted on the top and the other on the bottom of the aircraft. Appropriate switching and signal processing channels to select the best antenna on the basis of the characteristics of the received interrogation signals shall also be provided. Such diversity systems, in their installed configuration, shall not result in degraded performance relative to that which would have been produced by a single system having a bottom-mounted antenna.</p>	DO-181C no requirements for installation according to performance of aircraft
1.6.4.e	<p>Pulse Interval P1 - P2 2.00 ±0.05 µs P2 to sync phase reversal of P6 2.75 ±0.05 µs P6 to sync phase reversal of P6 1.25 ±0.05 µs <i>P5 to sync phase reversal of P6 0.4 ±0.05 µs</i> P5 may be overlaid on P6 by the interrogator as a side lobe suppression (SLS) signal in any Mode S interrogation. It will be overlaid on all Mode S-Only All-Call interrogations.</p>	2.1.11.4.4	<p>Spacings are provided below in microseconds. P1 - P2 2.00 ±0.05 P2 to sync phase reversal 2.75 ±0.05 P6 to sync phase reversal 1.25 ±0.05 P5 to sync phase reversal 0.4 ±0.1 P5 may be overlaid on P6 by the interrogator as an SLS signal in any Mode S interrogation. It will be overlaid on all Mode S-Only All-Call interrogations.</p>	<p>RHS Comment:: I do not know why RTCA DO-181C specifies P5 to Sync Phase Reversal tolerance at +/- 0.1 when ICAO Annex 10, Volume IV, section 3.1.2.1.5.2.4 clearly states "plus or minus 0.05".</p> <p>Bev report to RTCA via Tom Pagano, Gary Furr & Vince Orlando.</p>

ED-73B chapter	ED-73B requirement	DO-181C chapter	DO-181C requirement	Remarks
	-- not found --	2.1.2	The equipment shall perform its intended function as defined by the manufacturer, and its proper use shall not create a hazard to users of the National Airspace System (NAS).	General design rule
	-- not found --	2.1.3	The equipment shall comply with all applicable rules of the Federal Communications Commission.	DO-160 followed for EMC issues?
	-- not found --	2.1.9	Unless otherwise provided, the application of the specified tests shall produce no subsequently discernible condition detrimental to the continued performance of the equipment.	General design rule
3.4.1	<p>a. CLASS 1 Equipment CLASS 1 equipment shall be capable of at least 1 200 Mode A/C replies per second for a 15-pulse coded reply (including 2 framing pulses, 12 information pulses and the SPI pulse).</p> <p>b. CLASS 2 Equipment CLASS 2 equipment shall be capable of at least 1 000 Mode A/C replies per second for a 15-pulse coded reply (including 2 framing pulses, 12 information pulses and the SPI pulse).</p>	2.2.3.4.1	<p>b. If intended for installation in aircraft that operate at altitudes above 15,000 feet, the transponder shall be capable of a peak reply rate of 1,200 ATRBS 15-pulse replies for a duration of 100 milliseconds.</p> <p>c. If intended for installation in aircraft that operate at altitudes not exceeding 15,000 feet, the transponder shall be capable of a peak reply rate of 1,000 ATRBS 15-pulse replies for a duration of 100 milliseconds.</p>	<p>Presumably a bug in DO-181C, as Annex 10 also requires 1200/s max. reply rate.</p> <p>RHS Comment: Concur, as per ICAO Annex 10, Volume IV, section 3.1.1.7.9.1.</p> <p>Bev report to RTCA via Tom Pagano, Gary Furr & Vince Orlando.</p>
3.6.4	<p>a. All Mode S reply pulses shall have the following characteristics. Duration: See paragraph 3.6.2 c. Rise time: Between 0.05 and 0.1 μs. Decay time: Between 0.05 and 0.2 μs.</p>	2.2.4.2.3	<p>b. The pulse rise time shall not exceed 0.1 microsecond. c. The pulse decay time shall not exceed 0.2 microsecond.</p>	<p>RHS Comment: DO-181C does not specify the minimum rise and fall time, only the maximums. ICAO Annex 10, Volume IV, Table 3-2, and the requirements of ED-73B are consistent in regards to the minimum rise and fall times.</p> <p>Bev report to RTCA via Tom Pagano, Gary Furr & Vince Orlando.</p>

ED-73B chapter	ED-73B requirement	DO-181C chapter	DO-181C requirement	Remarks
3.9.2.a	a. Mode A/C/S All-Call interrogations If the equipment receives a valid Mode A/C interrogation at any signal level from MTL+1dB to -21 dBm, followed by a pulse in the P4 position with its trailing edge between 3.3 and 4.2 μs after P3 <u>pulse width between 1.3 and 2.2 μs</u> : (1) it shall accept the interrogation as a Mode A/C/S All-Call interrogation if the received amplitude of the P4 is greater than the amplitude of P3 minus 1 dB; (2) it shall accept the interrogation as a Mode A/C interrogation if the received amplitude of a short P4 is less than the amplitude of P3 minus 6 dB.	2.2.6.1.1	If the equipment receives a valid ATCRBS interrogation at any signal level from MTL +1 dB to -21 dBm followed by a 1.6 microsecond pulse in the P4 position: a. it shall accept the interrogation as an ATCRBS/Mode S All-Call interrogation if the received amplitude of P4 is above the amplitude of P3 minus 1 dB; b. it shall accept the interrogation as an ATCRBS interrogation if the received amplitude of P4 is below the amplitude of P3 minus 6 dB.	Please see the entire following row for remarks regarding this line item.
<p><u>RHS Commentary / Remark:</u></p> <p>As per RTCA DO-181C sections 2.1.11.3.1 and 2.1.11.3.2 and ICAO Annex 10 Volume 4, Figure 3-3 and section 3.1.2.1.5.1.3: P3 pulse width = 0.8 +/- 0.1 μsec P3-P4 spacing = 2.0 +/- 0.05 μsec (spacing is from leading edge to leading edge) P4 Long width = 1.6 +/- 0.1 μsec This results in a Minimum spacing from the leading edge of P3 to the Trailing Edge of P4 as follows: $P3P4_trail_min = 2.0 - 0.05 + 1.6 - 0.1 = 3.45 \mu\text{sec}$ Likewise, the maximum spacing from the leading edge of P3 to the Trailing Edge of P4 is as follows: $P3P4_trail_max = 2.0 + 0.05 + 1.6 + 0.1 = 3.75 \mu\text{sec}$ As such, the limits of 3.3 to 4.2 μsec specified in ED-73B appear to be inconsistent with ICAO Annex 10 and RTCA DO-181C. Likewise, the limits specified in ED-73B appear to be the only place in any transponder specification where the trailing edge is being specified. This is not consistent with the decision criteria that must be applied when deciding to accept or reject the interrogations based on pulse widths and spacings. In short, this remark prefers that the wording be more in line with that provided in RTCA DO-181C.</p> <p>Please see additional discussion provided after line item 3.9.2.b, e.g., the next line item.</p> <p>In regards to Subparagraph (1) of ED-73B, section 3.9.2, it is in line with RTCA DO-181C, section 2.2.6.1.1, subparagraph a. Likewise, in regards to Subparagraph (2) of ED-73B, section 3.9.2, it is in line with RTCA DO-181C, section 2.2.6.1.1, subparagraph b.</p>				

ED-73B chapter	ED-73B requirement	DO-181C chapter	DO-181C requirement	Remarks
3.9.2.b	<p>If the equipment receives a valid Mode A/C interrogation at any signal level from MTL+1dB to -21 dBm, followed by any pulse in the P4 position with a pulse width less than 1.2 μs its trailing edge less than 3.3 μs after P3,</p> <p>(1) it shall accept the interrogation as a Mode A/C interrogation if the received amplitude of P4 is less than the amplitude of P3 minus 6 dB;</p> <p>(2) it shall not accept the interrogation if the received amplitude of any P4 is greater than P3 minus 1 dB.</p>	2.2.6.1.2	<p>If the equipment receives a valid ATRBS interrogation at any signal level from MTL +1 dB to -21 dBm followed by a 0.8 microsecond pulse in the P4 position:</p> <p>a. it shall accept the interrogation as an ATRBS interrogation if the received amplitude of P4 is below the amplitude of P3 minus 6 dB;</p> <p>b. it shall not accept the interrogation if the received amplitude of P4 is above P3 minus 1 dB.</p>	<p>Please see the entire following row for remarks regarding this line item.</p>

ED-73B chapter	ED-73B requirement	DO-181C chapter	DO-181C requirement	Remarks
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RHS Commentary / Remark:

Prior to addressing the issue with 3.9.2.b, please review the following as provided in ED-73B and DO-181C

ED-73B Provides:

3.9.3 Pulse Position Tolerances

- a. Mode A/C Interrogations - Acceptance
The equipment shall accept the pulse position of Mode A/C interrogations as valid if the spacing between P1 and P3 is within $\pm 0.2 \mu\text{s}$ of the nominal spacing.
- b. Mode A/C/S All-Call Interrogations - Acceptance
The transponder shall accept the pulse positions of Mode A/C/S All-Call interrogations as valid if the spacing between P1 and P3 is within $\pm 0.2 \mu\text{s}$ of the nominal spacing and if the spacing between P3 and P4 is within $\pm 0.05 \mu\text{s}$ of nominal.
- c. Mode A/C, Mode A/C/S All-Call and Mode A/C-Only All-Call Interrogations - Non-Acceptance (P1 - P3)
The transponder shall not accept the pulse position of Mode A/C, Mode A/C/S All-Call and Mode A/C-Only All-Call interrogations as valid if the spacing between P1 and P3 differs from the nominal spacing by $1.0 \mu\text{s}$ or more.
- d. Mode A/C/S All-Call interrogations - Non-Acceptance (P4)
The transponder shall not accept an interrogation as a Mode A/C/S All-Call if the leading edge of P4 is not detected within the interval from $1.7 \mu\text{s}$ to $2.3 \mu\text{s}$ following the leading edge of P3.

DO-181C Provides:

2.2.6.2 Pulse Position Tolerances

- a. The equipment shall accept the pulse position of Mode A/C interrogations as valid if the spacing between P1 and P3 is within $\pm 0.2 \mu\text{s}$ of the nominal spacing.
The transponder shall accept the pulse positions of Mode A/C/S All-Call interrogations as valid if the spacing between P1 (**Note that there is a typographical error in DO-181C which has F1 as opposed to P1**) and P3 is within $\pm 0.2 \mu\text{s}$ of the nominal spacing and if the spacing between P3 and P4 is within $\pm 0.05 \mu\text{s}$ of nominal.
- b. Mode A/C, Mode A/C/S All-Call and Mode A/C-Only All-Call Interrogations - Non-Acceptance (P1 - P3)
The transponder shall not accept the pulse position of Mode A/C, Mode A/C/S All-Call and Mode A/C-Only All-Call interrogations as valid if the spacing between P1 and P3 differs from the nominal spacing by $1.0 \mu\text{s}$ or more.
- c. Mode A/C/S All-Call interrogations - Non-Acceptance (P4)
The transponder shall not accept an interrogation as a Mode A/C/S All-Call if the leading edge of P4 is not detected within the interval from $1.7 \mu\text{s}$ to $2.3 \mu\text{s}$ following the leading edge of P3.

Now, back to ED-73B 3.9.2.b. Once again, the trailing edge of P4 being specified at $3.3 \mu\text{sec}$ presents a problem. The only way one can get this is the minimum spacing of $1.7 \mu\text{sec}$ specified in 3.9.3.d and adding the nominal P4 pulse width of $1.6 \mu\text{sec}$. In reality, this could be $1.7 \mu\text{sec}$ from the minimum spacing and then $1.5 \mu\text{sec}$ from the minimum acceptable pulse width of a long P4, thereby resulting in $3.2 \mu\text{sec}$ as opposed to the 3.3 specified.

ED-73B chapter	ED-73B requirement	DO-181C chapter	DO-181C requirement	Remarks
3.11	If a reply rate limiting device is provided for Mode S replies, it shall permit at least the reply rates specified in paragraph 3.4 and shall not prevent acquisition squitter transmission as per 3.20.2.6 and extended squitter as per 3.21.2.6 nor the transmission of a DF=16 (3.21.1.4).	2.2.7.3.2	If a reply rate limiting device is provided for Mode S replies, it shall permit at least the reply rates required in subparagraph 2.2.3.4.2. A limiting device may be used to protect the transponder from accidental over-interrogation.	Please see the entire following row for remarks regarding this line item.
RHS Commentary / Remark: Essentially, ED-73B and DO-181C (as far as 2.2.3.4.2.a and b) are the same with the exception that ED-73B addresses the squitter transmissions. DO-181C probably does not address the squitter transmissions since squitter (other than event driven squitter) transmissions are not included in the count that would be used to establish Mode-S limiting. It is interesting to note that ICAO Annex 10, Volume 4 section 3.1.2.10.3.6 does not address the squitter issue either.				
3.12.4	a. A Standard Interfering Pulse is defined as a 0.8 \pm 0.1 μ s pulse with a carrier frequency of 1 030 \pm 0.2 MHz, that is incoherent with the Mode S signal of the test and that overlaps the P6 of the Mode S interrogation anywhere after the sync phase reversal.	2.2.8.2	A standard interfering pulse is defined as a 0.8 microsecond pulse with a carrier frequency of 1030 \pm 0.2 MHz that is incoherent with the Mode S signal of the test and that overlaps the P6 of the Mode S interrogation anywhere after the sync phase reversal.	Please see the entire following row for remarks regarding this line item.
RHS Commentary / Remark: The only difference between ED-73B and DO-181C is that ED-73B provides a tolerance of +/- 0.1 μ sec for the interference pulse. I do not know where that came from as ICAO Annex 10, Volume IV does not seem to address the tolerance. However, it should be of minor consequence since the worse case situation is when the interference pulse covers three consecutive phase reversals. But, consider that three consecutive phase reversals represents 0.75 μ sec, that says that you do not want to reduce the interference pulse level down to 0.7 μ sec which would be allowed by ED-73B. Therefore, I recommend that the tolerance be removed from ED-73B and the pulse width be left at 0.8 μ sec as per DO-181C.				
3.12.2	If a transponder recognises two valid pulse patterns simultaneously, it shall a. enter the Mode A/C suppression state if one of the received pulse patterns is a P1-P2 suppression pair; b. and if one of the received pulse patterns is not a P1-P2 suppression pair, then generate a valid Mode C altitude reply if either of the two received pulse patterns is a Mode C interrogation.	2.2.8.5	If a transponder receives two valid ATRBS pulse patterns simultaneously, it shall: a. Enter the ATRBS suppression state if one of the received pulse patterns is a P1-P2 suppression pair. b. Generate a valid Mode C reply if the two received pulse patterns are Mode A and Mode C interrogations.	RHS Commentary / Remark: The Requirements are essentially the same, just the wording is a little different, but that should not be an adverse impact.
		2.2.10.3	The Mode S transponder shall declare a transponder failure in the event that its own Mode S address is all zeros or all ones.	

ED-73B chapter	ED-73B requirement	DO-181C chapter	DO-181C requirement	Remarks
3.15.1	<p><u>(Editorial note – Insert new note as follows:)</u></p> <p><i><u>Note: This document does not establish the design parameters of the mutual suppression system. However, it is recommended that all sources of mutual suppression pulses be dc coupled while sinks are ac coupled. This standardization will prevent source or sink failures from disabling all users of the mutual suppression pulses.</u></i></p>	2.2.11	<p><i>Note: This document does not establish the design parameters of the mutual suppression system. However, it is recommended that all sources of mutual suppression pulses be dc coupled while sinks are ac coupled. This standardization will prevent source or sink failures from disabling all users of the mutual suppression pulses.</i></p>	<p>AC coupling used for both input and output?</p> <p><u>RHS Commentary / Remark:</u> The actual design of the suppression network is discussed in ARINC-718-4, ARINC-718A, and ARINC-735A. Transmitters usually are wired-OR to the suppression network and are therefore DC Coupled. Receivers are then AC coupled to the network. Therefore, the note provided in DO-181C appears to be appropriate.</p>

ED-73B chapter	ED-73B requirement	DO-181C chapter	DO-181C requirement	Remarks
3.17.1 a	<p>a. Fixed Direct Data Fixed direct data characterise the aircraft and include:</p> <ul style="list-style-type: none"> (1) Mode S Discrete Address, (2) Maximum Airspeed (aircraft's maximum normal operating airspeed), (3) Aircraft Identification Data. <p>NOTE: <i>If the tail number or registration of the aircraft is used to identify the aircraft for ATC purposes, it constitutes "fixed" data.</i></p>	2.2.13.1.1	<p>Fixed direct data characterize the aircraft.</p> <p>a. Mode S Discrete Address (1) Protection of Mode S address bits – During the power-on initialization process, the transponder shall read in and store its 24-bit discrete address. Thereafter, the address used by the transponder shall not change from the value stored at power-up. The transponder should continue to monitor the 24-bit discrete address after the initial read and store at power-up. If a change in the 24-bit discrete address is detected after the initial read and store, the transponder shall continue to use only the 24-bit discrete address stored at power-up and shall generate a diagnostic error message in order to alert maintenance personnel to the occurrence of intermittent discrete address bit input data. [...]</p> <p>b. Maximum Airspeed In response to certain surveillance interrogations, the transponder shall place an encoded indication of the aircraft's maximum normal operating airspeed into bits 14-17 of the RI field. Coding is described in subparagraph 2.2.14.4.25.</p> <p>c. Aircraft Identification Data If the tail number or registration number of the aircraft is used to identify the aircraft for ATC purposes, it constitutes "fixed" data. If the aircraft uses a flight number in lieu of a registration number, then the data are no longer "fixed," but classified as "variable" (subparagraph 2.2.13.1.2). If not equipped with the aircraft identification data capability, the transponder shall insert ZEROs into the appropriate field.</p>	DO-181C: monitors AA for changes. Additionally also monitors AM and AIM and AT.
3.17.1		2.2.13.1.2	[too long to insert here]	
3.17.3 (1)	<p>Information Content The interface shall transfer the entire content of both short and long received uplink transmissions, with the possible exception of the last 24 bits (address/parity bits). This permits the receiving devices to properly identify the data field contents. The additional transfer of the address/parity bits will permit parity determination at an I/O device.</p>	2.2.13.3.1 a	<p>Information Content – The interface shall transfer the entire content of both short and long accepted uplink interrogations (with the possible exception of the AP Field) except for interrogations UF=0, 11,16 and a UF=24 interrogation containing a request for a downlink ELM transfer (RC=3). This permits the receiving devices to properly identify the data field contents and permits possible additional parity determination at the I/O device.</p>	DO-181C. It only sends UF=4, 5, 20, 21 interrogations to the data link. UF=0 is not transferred.

ED-73B chapter	ED-73B requirement	DO-181C chapter	DO-181C requirement	Remarks
	-- not found --	2.2.13.3.1 f	Transponder Capability – The transponder datalink communication capacity information shall be made available to the ADLP. This information includes the ELM capacity of the transponder and the ability of the transponder to support the enhanced datalink transponder capability.	
3.17.3	(4) Storage Design - Buffer Function The internal data storage system shall provide storage for all information bits required within standard down link messages. Storage registers shall be provided for each of the 255 possible Comm-B messages associated with Ground-Initiated protocols. An addressable FIFO type storage facility shall be provided to maintain at least two Comm-B messages associated with Air-Initiated protocols. The design of the storage system shall ensure, by double buffering or other means, that storage register content is not in a state of transition during the insertion of the content in a down link reply.\	2.2.13.3.2	d. Storage Design – Buffer Function – The design shall ensure that register content shall not be in a state of transition during the insertion of the content in a downlink reply.	
3.20.2.2	b. All-Call Address - If the address extracted from the received interrogation consists of 24 ONEs and UF=11, the transmission is a Mode S-Only All-Call and the received interrogation shall be accepted according to i below unless the lockout protocol is in effect or the "on the ground" report (VS or FS field) indicates the ground condition.	2.2.16.2.2	b. All-Call Address – If the address extracted from the received interrogation consists of 24 ONEs and UF=11, the transmission is a Mode S-Only All-Call and the received interrogation shall be accepted according to i below unless the lockout protocol is in effect.	ED-73B (does not reply on the ground)
3.20.2.2	c. Mode A/C/Mode S All-Call - A Mode A/C/Mode S All-Call interrogation (1.6 microseconds P4) shall be accepted unless the TD timer is running or side lobe suppression is in effect or the "on the ground" report (VS or FS field) indicates the ground condition.	2.2.16.2.2	c. ATCRBS/Mode S All-Call – An ATCRBS/Mode S All-Call interrogation (1.6 microseconds P4) shall be accepted unless the TD timer is running or side lobe suppression is in effect.	ED-73B (does not reply on the ground)

ED-73B chapter	ED-73B requirement	DO-181C chapter	DO-181C requirement	Remarks
3.20.2.2	g. All-Call Lockout Conditions - On receipt of a Mode S-Only All-Call (UF=11) containing II corresponding to the designator of a running TL timer, the interrogation shall not be accepted unless the contained PR code is 8 through 12 and the "on the ground" report (VS or FS field) does not indicate the ground condition. Upon receipt of a Mode S-Only All-Call (UF=11) containing II=0, the interrogation shall be accepted if the TD timer is not running or if the received PR code is 8 through 12 and the "on the ground" report (VS or FS field) does not indicate the ground condition.	2.2.16.2.2	g. All-Call Lockout Conditions – On receipt of a Mode S-Only All-Call (UF=11) containing II corresponding to the designator of a running TL timer, the interrogation shall not be accepted unless the contained PR code is 8 through 12. Upon receipt of a Mode S-Only All-Call (UF=11) containing II=0, the interrogation shall be accepted if the TD timer is not running or if the received PR code is 8 through 12.	ED-73B (does not reply on the ground)
3.20.2.2	l. Broadcast address - If the address extracted from the received interrogation consists of 24 ONES and UF = 20 or 21, then the received interrogation shall be accepted as a broadcast interrogation.	2.2.16.2.2	-- not found --	ED-73B (accepts broadcast UF=20, 21)
3.21.2.6	Review of standards not finished	2.2.16.2.6.2	Review of standards not finished yet	
3.20.2.7	[requires SPI retrigerability]	2.2.16.2.7	[requires ground status validation] [requires SPI retrrigerability]	No validation of ground status. No retrrigerability of SPI pulse.