Repl. by - 204A

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ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: AIRBORNE ATC TRANSPONDER SYSTEM MAINTENANCE

1. PURPOSE. This circular sets forth one means, but not the only means, of demonstrating compliance with the maintenance requirements, contained in FAR 91.177 and prescribed in FAR 43, Appendix F, governing the testing of ATC transponders.

2. ACCEPTABLE MEANS OF COMPLIANCE. An acceptable means of compliance with the maintenance requirements as they apply to airborne ATC transponders is as follows:

   a. Reply radio frequency. Interrogate the transponder and verify, by use of a wavemeter having an accuracy of $\pm 0.5 MH_z$ at 1090 MH_z that the reply frequency is 1090 $\pm$ 3MH_z.

   b. Reply transmission characteristics, framing pulses. With the transponder interrogated on Mode 3/A and replying on code 0000, monitor the transmitted output with a demodulator probe and oscilloscope. Verify that the time interval between the 0.5 amplitude points on the leading edges of the two framing pulses is within 20.3 $\pm$ 0.10 microseconds. The oscilloscope time base should have a sweep speed of 5 microseconds per centimeter and an accuracy of 0.5 percent.

   c. Reply Codes

      (1) Identification. With the transponder interrogated on Mode 3/A monitor the transmitted output with a demodulator probe and oscilloscope. Verify reply coding by changing the code number and assuring the presence of all pulses listed in Table 1.

Table 1

Pulse	Position (microseconds)
F_1	0.00
C_1	1.45
A_1	2.90
C_2	4.35
A_2	5.80
C_4	7.25
A_4	8.70
B_1	11.60
D_1	13.05
B_2	14.50
D_2	15.95
B_4	17.40
D_4	18.85
F_2	20.30
SPI	24.65

(2) Pressure Altitude Transmissions

(a) For aircraft which do not have an altitude digitizer installed or not connected to the transponder, verify transmitted response to Mode C interrogations consists of framing pulses F_1 and F_2 only, by monitoring the transmitted output with a demodulator probe and an oscilloscope.

(b) For aircraft which have an altitude digitizer connected to the transponder, verify transmitted response to Mode C interrogations consists of framing pulses F_1 and F_2 only, by monitoring the transmitted output with a demodulator probe and an oscilloscope while the altitude switch is in the "off" position. Place the altitude switch in the "on" position and verify that the information pulses denote the pressure altitude (altimeter setting 29.92 in. hg.) at the time of the test. Information pulses should appear in accordance with the pulse positions listed in Tables 2 and 3.

d. Reply pulse width. With the transponder interrogated on Mode 3/A and replying on code 0000, monitor the transmitted output with a demodulator probe and oscilloscope (sweep time and accuracy same as paragraph 2.b.). Verify the duration of the F_1 and F_2 pulses between the 0.5 amplitude point on the leading and trailing edge is 0.45 ± 0.10 microseconds. Repeat the test with the transponder replying on code 7777.

TABLE 2 ALTITUDE INFORMATION PULSE POSITIONS

RANGE			PULSE POSITIONS (*0 or 1 in a pulse position denotes absence or presence of a pulse, respectively*)										
INCREMENTS (*Feet*)			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
-1 000	to	-950	0	0	0	0	0	0	0	0	0	1	0
-950	to	-850	0	0	0	0	0	0	0	0	1	1	0
-850	to	-750	0	0	0	0	0	0	0	0	1	0	0
-750	to	-650	0	0	0	0	0	0	0	1	1	0	0
-650	to	-550	0	0	0	0	0	0	0	1	1	1	0
-550	to	-450	0	0	0	0	0	0	0	1	0	1	0
-450	to	-350	0	0	0	0	0	0	0	1	0	1	1
-350	to	-250	0	0	0	0	0	0	0	1	0	0	1
-250	to	-150	0	0	0	0	0	0	1	1	0	0	1
-150	to	-50	0	0	0	0	0	0	1	1	0	1	1
-50	to	50	0	0	0	0	0	0	1	1	0	1	0
50	to	150	0	0	0	0	0	0	1	1	1	1	0
150	to	250	0	0	0	0	0	0	1	1	1	0	0
250	to	350	0	0	0	0	0	0	1	0	1	0	0
350	to	450	0	0	0	0	0	0	1	0	1	1	0
450	to	550	0	0	0	0	0	0	1	0	0	1	0
550	to	650	0	0	0	0	0	0	1	0	0	1	1
650	to	750	0	0	0	0	0	0	1	0	0	0	1
750	to	850	0	0	0	0	0	1	1	0	0	0	1
850	to	950	0	0	0	0	0	1	1	0	0	1	1
950	to	1 050	0	0	0	0	0	1	1	0	0	1	0
1 050	to	1 150	0	0	0	0	0	1	1	0	1	1	0
1 150	to	1 250	0	0	0	0	0	1	1	0	1	0	0
1 250	to	1 350	0	0	0	0	0	1	1	1	1	0	0
1 350	to	1 450	0	0	0	0	0	1	1	1	1	1	0
1 450	to	1 550	0	0	0	0	0	1	1	1	0	1	0
1 550	to	1 650	0	0	0	0	0	1	1	1	0	1	1
1 650	to	1 750	0	0	0	0	0	1	1	1	0	0	1
1 750	to	1 850	0	0	0	0	0	1	0	1	0	0	1
1 850	to	1 950	0	0	0	0	0	1	0	1	0	1	1
1 950	to	2 050	0	0	0	0	0	1	0	1	0	1	0
2 050	to	2 150	0	0	0	0	0	1	0	1	1	1	0
2 150	to	2 250	0	0	0	0	0	1	0	1	1	0	0
2 250	to	2 350	0	0	0	0	0	1	0	0	1	0	0
2 350	to	2 450	0	0	0	0	0	1	0	0	1	1	0
2 450	to	2 550	0	0	0	0	0	1	0	0	0	1	0
2 550	to	2 650	0	0	0	0	0	1	0	0	0	1	1
2 650	to	2 750	0	0	0	0	0	1	0	0	0	0	1
2 750	to	2 850	0	0	0	0	1	1	0	0	0	0	1
2 850	to	2 950	0	0	0	0	1	1	0	0	0	1	1
2 950	to	3 050	0	0	0	0	1	1	0	0	0	1	0
3 050	to	3 150	0	0	0	0	1	1	0	0	1	1	0
3 150	to	3 250	0	0	0	0	1	1	0	0	1	0	0
3 250	to	3 350	0	0	0	0	1	1	0	1	1	0	0
3 350	to	3 450	0	0	0	0	1	1	0	1	1	1	0
3 450	to	3 550	0	0	0	0	1	1	0	1	0	1	0
3 550	to	3 650	0	0	0	0	1	1	0	1	0	1	1
3 650	to	3 750	0	0	0	0	1	1	0	1	0	0	1
3 750	to	3 850	0	0	0	0	1	1	1	1	0	0	1
3 850	to	3 950	0	0	0	0	1	1	1	1	0	1	1
3 950	to	4 050	0	0	0	0	1	1	1	1	0	1	0
4 050	to	4 150	0	0	0	0	1	1	1	1	1	1	0
4 150	to	4 250	0	0	0	0	1	1	1	1	1	0	0
4 250	to	4 350	0	0	0	0	1	1	1	0	1	0	0
4 350	to	4 450	0	0	0	0	1	1	1	0	1	1	0
4 450	to	4 550	0	0	0	0	1	1	1	0	0	1	0
4 550	to	4 650	0	0	0	0	1	1	1	0	0	1	1
4 650	to	4 750	0	0	0	0	1	1	1	0	0	0	1

TABLE 3 ALTITUDE INFORMATION PULSE POSITIONS

RANGE			PULSE POSITIONS (*0 or 1 in a pulse position denotes absence or presence of a pulse, respectively*)										
INCREMENTS (*Feet*)			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
4750	to	4850	0	0	0	0	1	0	1	0	0	0	1
4850	to	4950	0	0	0	0	1	0	1	0	0	1	1
4950	to	5050	0	0	0	0	1	0	1	0	0	1	0
5050	to	5150	0	0	0	0	1	0	1	0	1	1	0
5150	to	5250	0	0	0	0	1	0	1	0	1	0	0
5250	to	5350	0	0	0	0	1	0	1	1	1	0	0
5350	to	5450	0	0	0	0	1	0	1	1	1	1	0
5450	to	5550	0	0	0	0	1	0	1	1	0	1	0
5550	to	5650	0	0	0	0	1	0	1	1	0	1	1
5650	to	5750	0	0	0	0	1	0	1	1	0	0	1
5750	to	5850	0	0	0	0	1	0	0	1	0	0	1
5850	to	5950	0	0	0	0	1	0	0	1	0	1	1
5950	to	6050	0	0	0	0	1	0	0	1	0	1	0
6050	to	6150	0	0	0	0	1	0	0	1	1	1	0
6150	to	6250	0	0	0	0	1	0	0	1	1	0	0
6250	to	6350	0	0	0	0	1	0	0	0	1	0	0
6350	to	6450	0	0	0	0	1	0	0	0	1	1	0
6450	to	6550	0	0	0	0	1	0	0	0	0	1	0
6550	to	6650	0	0	0	0	1	0	0	0	0	1	1
6650	to	6750	0	0	0	0	1	0	0	0	0	0	1
6750	to	6850	0	0	0	1	1	0	0	0	0	0	1
6850	to	6950	0	0	0	1	1	0	0	0	0	1	1
6950	to	7050	0	0	0	1	1	0	0	0	0	1	0
7050	to	7150	0	0	0	1	1	0	0	0	1	1	0
7150	to	7250	0	0	0	1	1	0	0	0	1	0	0
7250	to	7350	0	0	0	1	1	0	0	1	1	0	0
7350	to	7450	0	0	0	1	1	0	0	1	1	1	0
7450	to	7550	0	0	0	1	1	0	0	1	0	1	0
7550	to	7650	0	0	0	1	1	0	0	1	0	1	1
7650	to	7750	0	0	0	1	1	0	0	1	0	0	1
7750	to	7850	0	0	0	1	1	0	1	1	0	0	1
7850	to	7950	0	0	0	1	1	0	1	1	0	1	1
7950	to	8050	0	0	0	1	1	0	1	1	0	1	0
8050	to	8150	0	0	0	1	1	0	1	1	1	1	0
8150	to	8250	0	0	0	1	1	0	1	1	1	0	0
8250	to	8350	0	0	0	1	1	0	1	0	1	0	0
8350	to	8450	0	0	0	1	1	0	1	0	1	1	0
8450	to	8550	0	0	0	1	1	0	1	0	0	1	0
8550	to	8650	0	0	0	1	1	0	1	0	0	1	1
8650	to	8750	0	0	0	1	1	0	1	0	0	0	1
8750	to	8850	0	0	0	1	1	1	1	0	0	0	1
8850	to	8950	0	0	0	1	1	1	1	0	0	1	1
8950	to	9050	0	0	0	1	1	1	1	0	0	1	0
9050	to	9150	0	0	0	1	1	1	1	0	1	1	0
9150	to	9250	0	0	0	1	1	1	1	0	1	0	0
9250	to	9350	0	0	0	1	1	1	1	1	1	0	0
9350	to	9450	0	0	0	1	1	1	1	1	1	1	0
9450	to	9550	0	0	0	1	1	1	1	1	0	1	0
9550	to	9650	0	0	0	1	1	1	1	1	0	1	1
9650	to	9750	0	0	0	1	1	1	1	1	0	0	1
9750	to	9850	0	0	0	1	1	1	0	1	0	0	1
9850	to	9950	0	0	0	1	1	1	0	1	0	1	1
9950	to	10050	0	0	0	1	1	1	0	1	0	1	0
10050	to	10150	0	0	0	1	1	1	0	1	1	1	0
10150	to	10250	0	0	0	1	1	1	0	1	1	0	0
10250	to	10350	0	0	0	1	1	1	0	0	1	0	0
10350	to	10450	0	0	0	1	1	1	0	0	1	1	0
10450	to	10550	0	0	0	1	1	1	0	0	0	1	0
10550	to	10650	0	0	0	1	1	1	0	0	0	1	1
10650	to	10750	0	0	0	1	1	1	0	0	0	0	1
10750	to	10850	0	0	0	1	0	1	0	0	0	0	1
10850	to	10950	0	0	0	1	0	1	0	0	0	1	1
10950	to	11050	0	0	0	1	0	1	0	0	0	1	0
11050	to	11150	0	0	0	1	0	1	0	0	1	1	0
11150	to	11250	0	0	0	1	0	1	0	0	1	0	0

e. Suppression. Interrogate the transponder with a Mode 3/A interrogation signal at a repetition rate of 500 interrogations per second and at a signal level 3db above receiver minimum trigger level. Adjust P_2 pulse equal in amplitude to P_1 pulse and verify that reply rate is no greater than 5 replies per second. Adjust P_2 pulse amplitude 9db less than P_1 pulse and verify that the reply rate is at least 450 replies per second.

f. Receiver Sensitivity. With the test set connected to the antenna end of the transmission line, interrogate the transponder with a Mode 3/A interrogation signal at a repetition rate of 500 interrogations per second. Adjust P_1 and P_3 equal in amplitude and apply a signal level known to be below receiver minimum trigger level. Increase the signal level until the transponder reply rate is 450 replies per second. This is the receiver minimum trigger level (MTL). Verify the MTL is between 69 and 77 db below 1 milliwatt. Test equipment attenuator accuracy should be within $\pm$ 2db. As an alternative the test set may be connected to the antenna terminal of the transponder and the reading corrected for transmission line loss. Repeat the test using a Mode C interrogation signal and verify that the MTL is within 1db of the reading obtained on Mode 3/A.

g. Transponder Power Output. Transponder power output may be determined with a dummy load and power meter which are suitable for use at 1090 MH_z. The power meter accuracy should be within $\pm$ 2 db. Connect the dummy load and power meter to the antenna end of the transmission line, interrogate the transponder with a Mode 3/A interrogation signal and verify that the peak pulse power is at least:

(1) +21 dbW (125W) and not more than +27 dbW (500W) for transponders intended for installation in aircraft which operate at altitudes above 15,000 feet.

(2) +18.5 dbW (70W) and not more than +27 dbW (500W) for transponders intended for installation in aircraft which operate at altitudes not exceeding 15,000 feet.

In each of the above cases antenna gain must be added to the power meter reading. As an alternative, the dummy load and power meter may be connected to the antenna terminal of the transponder and the power meter reading corrected for transmission line loss and antenna gain.

3. PORTABLE LINE TEST EQUIPMENT. Portable line test equipment may be substituted for any of the test equipment specified in paragraph 2, provided its accuracy is equivalent.

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