Department of Transportation
Federal Aviation Administration
Aircraft Certification Service
Washington, DC

TSO-C74c

Date: 2/20/73

Technical Standard Order

Subject: TSO-C74c, AIRBORNE ATC TRANSPONDER EQUIPMENT

(a) *Applicability.* This technical standard order prescribes the minimum performance standards which airborne ATC transponder equipment must meet in order to be identified with the applicable TSO marking. New models of such equipment that are to be so identified and that are manufactured on or after January 26, 1973, must meet the following performance and environmental standards:

(1) *Performance Standards.* (i) Equipment marked as Class 1A must be equipment intended for installation in aircraft that operate at altitudes above 15,000 feet and must meet the minimum performance standards of "Federal Aviation Standard, Airborne ATC Transponder Equipment," set forth at the end of this section, as applicable.

(ii) Equipment marked as class 1B must be equipemnt intended for installation in aircraft that operate at altitudes not exceeding 15,000 feet and must meet the minimum performance standards of "Federal Aviation Standard, Airborne ATC Transponder Equipment," set forth at the end of this section, as applicable.

(iii) Equipment marked as Class 2A must be equipment intended for installation in aircraft that operate at altitudes above 15,000 feet and must meet the minimum performance standards set forth in Section II of Part Two in Radio Technical Commission for Aeronautics Document No. DO-144 entitled "Minimum Operational Characteristics-Airborne ATC Transponder Systems," dated March 12, 1970, and Change No. 1 to DO-144, Paper 232-70/EC-643, dated November 5, 1970, as applicable, except as provided in subparagraph (2) of this paragraph.

(iv) Equipment marked as Class 2B must be equipment intended for installation in aircraft that operate at altitudes not exceeding 15,000 feet and must meet the minimum performance standards set forth in Section II of Part Two in Radio Technical Commission for Aeronautics Document No. DO-144 entitled "Minimum Operational Characteristics-Airborne ATC Transponder Systems," dated March 12, 1970, and Change No. 1 to DO-144, Paper 232-70/EC-643, dated November 5, 1970, as applicable, except as provided in subparagraph (2) of this paragraph.

(2) *Exceptions.* (i) In lieu of the requirements in subparagraph II A.8.c. of Part Two in RTCA Document DO-144, the reply characteristics apply over a received signal amplitude range between minimum triggering level and a level of –21 dbm.

(ii) The requirement specified in subparagraph II A.9.a. of Part Two in RTCA Document DO-144 need not be complied with.

(iii) The requirements of subparagraph II A.16.b. (2) and (3) of Part Two of

RTCA Document DO-144, in so far as, they pertain to pressure altitude information pulses, must be complied with only if complete altitude reporting capability is provided.

(iv) The requirements of subparagraph II A.16.b.(4), (5), and (6) of Part Two of RTCA Document DO-144 must be complied with only if complete altitude reporting capability is provided.

(3) *Environmental Standards*. RTCA Document No. DO-138 entitled "Environmental Conditions and Test Procedures for Airborne Electric/Electrical Equipment and Instruments," dated June 27, 1968, must be used in determining the environmental conditions over which the equipment has been designed to operate, Classes 2A and 2B equipment need only be tested for the environmental conditions of temperature and altitude, humidity, shock, vibration, and power input voltage set forth in paragraphs 4.0, 5.0, 6.0, 7.0, and 9.0 of DO-138.

(b) *Availability of documents.* RTCA Document Nos. DO-138, dated June 27, 1968, and DO-144, dated March 12, 1970, as amended by Change No. 1 (Paper 232-70/EC-643), dated November 5, 1970, are incorporated herein in accordance with 5 U.S.C. 552(a)(1) and §37.23 of the Federal Aviation Regulations and are available as indicated in §37.23. Additionally, RTCA Document Nos. DO-138 and DO-144, as amended, may be examined at any FAA regional office of the Chief of Engineering and Manufacturing Branch (or in the case of the Western Region, the Chief, Aircraft Engineering Division) and may be obtained from the RTCA Secretariat, Suite 655, 1717 H Street, N.W., Washington, D.C. 20006, at a cost for $8 per copy for Document No. DO-138 and $6 per copy for Document No. DO-144.

(c) *Marking.* In addition to the markings specified in §37.7, the equipment must meet the following requirements:

(1) The environmental categories over which it has been designed to operate as set forth in Appendix B of RTCA Document No. DO-138 must be permanently and legibly marked on the equipment. Where an environmental test procedure is not applicable and the test is not conducted, an "X" should be placed in the space assigned for that category.

(2) The class which the equipment meets must be permanently and legibly marked on the equipment. Equipment which meets the requirements of more than one class need only be marked with the class which contains the more severe requirements. When listed in order of severity of requirements, highest first, the classes are: 1A, 1B, 2A, and 2B.

(3) Each separate component of equipment (antenna, receiver-transmitter, etc.) must be permanently and legibly marked with at least the name of the manufacturer, the TSO number, and the environmental categories over which it is designed to operate.

(d) *Data requirements.* (1) In accordance with §37.5, the manufacturer must furnish to the Chief, Engineering and Manufacturing Branch, Flight Standards Division (or in case of the Western Region, the Chief, Aircraft Engineering Division), Federal Aviation Administration, in the region in which the manufacturer is located, one copy of the following technical data:

(i) Manufacturer's operating instructions and equipment limitations.

(ii) Installation procedures with applicable schematic diagrams, wiring diagrams, and specifications. Indicate any limitations, restrictions, or other conditions pertinent to the installation.

(iii) Manufacturer's test report(s).

(iv) Equipment data sheets specifying, within the prescribed range of environmental conditions, the actual performance of equipment of that type with respect to each performance factor prescribed in the applicable standard. Performance data for abnormal environmental conditions may also be included.

(2) One copy of the technical data specified in subdivisions (i), (ii), and (iv) of sub paragraph (d)(1) must be furnished with each article.

(e) *Previously approved equipment.* Airborne ATC Transponder Equipment approved prior to the effective date of this section may continue to be manufactured under the provisions of its original approval.

FEDERAL AVIATION ADMINISTRATION STANDARD
Airborne ATC Transponder Equipment

1.0 General Standards.

1.1 *Operation of Controls.* The design of the equipment must be such that the controls intended for use during flight cannot be operated in any possible position combination, or sequence that would result in a condition detrimental to the continued performance of the equipment. Controls that are not normally adjusted in flight must not be readily accessible in flight.

1.2 *Operating Controls.* In addition to such other operating controls as are necessary, controls must be provided to accomplish the following functions:

a. Selection of reply codes.
b. Selection of "standby" condition.
c. Selection of Modes 3/A and C combined.
d. Activation of identification feature.
e. Removal of all information pulses on the Mode C reply.

1.3 *Effects of Test.* Unless otherwise stated, the design of the equipment must be such that the application of the specified tests procedures no discernible condition that would be detrimental to the continued performance of equipment manufactured in accordance with such design.

2.0 Minimum Performance Standards Under Standard Conditions.

The test conditions and definitions of terms applicable to a determination of the performance of airborne ATC transponder equipment are set forth in Appendix A.

2.1 *Receiver Operating Frequency and Bandwidth.*

a. The receiver nominal center frequency must be 1030 MHz.

b. With an input signal level 3 db above the minimum triggering level, the receiver bandwidth must be such that the receiver accepts pulses as outlined in Appendix A with a interrogation center frequency drift of ±0.2 MHz.

c. The skirt bandwidth must be such that the sensitivity of the receiver is at least 60 db down at ±25 MHz and beyond.

2.2 *receiver Sensitivity and Dynamic Range.*

a. The minimum triggering level (MTL) of the transponder must be such that replies are generated to 90 percent of the interrogation signals when—

1. The two pulses P_1 and P_2 constituting an interrogation are of equal amplitude and P_2 is not detected; and
2. The amplitude of these signals received at the antenna end of the transmission line of the transponder is nominally 71 db below 1 milliwatt with limits between 09 and 77 db below 1 milliwatt.

b. With the transponder adjusted to comply with paragraph a, the random triggering rate (squitter) must not be greater than five reply pulse groups or suppressions per second averaged over a period of at least 30 seconds.

c. The variation of the minimum triggering level between modes must not exceed 1db for nominal pulse spacings and pulse widths.

d. The reply characteristics apply over a received signal amplitude range between minimum triggering level and 50db above that level.

e. The standards of this section assume a transmission line loss of 3db and an antenna performance equivalent to that of a simple quarter wave antenna. In the event that these assumed conditions do not apply, the equipment must be adjusted as necessary to provide a sensitivity equivalent to that specified.

2.3 *Spurious Responses.* All spurious responses, including response to image frequencies, must be such that the response to such signals is at least 60db down from the normal sensitivity of the receiver.

2.4 *Interrogation.* The equipment must accept and reply to interrogations on at least Modes 3/A and C.

Note.—Interrogation Modes B and D as defined in Figure 1 have been agreed upon internationally and their use may be specified for certain flight operations. These modes may be provided as optional features on transponder equipment.

2.5 *Side-lobe Suppression.* The equipment must provide side-lobe suppression.

2.6 *Decoding Performance.*

a. Conditions Under Which Transponder Must Reply. When selected to reply to a particular interrogation mode, and with a signal amplitude range from the minimum triggering level to 50 db above that level, the transponder must reply to at least 90 percent of the

interrogations when all of the following conditions are met:

(1) Either the received amplitude of P_1 is in excess of a level of 9db above the received amplitude of P_2, or no pulse is received 2 ±0.7 microsecond following P_1.

(2) The received amplitude of P_2 is in excess of a level 1 db below the received amplitude of P_1 but no greater than 3db above the received amplitude of P_1.

(3) The received amplitude of a proper interrogation is more than 10 db above the received amplitude of random pulses where the latter are not reorganized by the transponder as P_1, P_2, or P_3.

b. Conditions Under Which Transponder Must Not Reply. Over the signal amplitude from the minimum triggering level to 50db above this level, the transponder must not reply to more than 10 percent of the interrogations under either or the following conditions:

(1) The interval between interrogation pulse P_1 and P_3 differ from the specified spacing for the particular mode setting by more than ±1.0 microsecond.

(2) The interrogations consists of single pulses. However, this does not apply to those combinations of single pulses that occur at the selected interrogation spacing or to single pulses that have amplitude variations approximating a normal interrogation condition.

c. *Side-lobe Suppression.* The transponder must be suppressed for a period of 35 ±10 microseconds following receipt of a pulse pair of proper spacing and suppression action must be capable of being reinitiated for the full duration within 2 microseconds after the end of any suppression period. The transponder must be suppressed with a 99 percent efficiency over a received signal amplitude range between 3 db above minimum triggering level and 50 db above that level and upon receipt of properly spaced interrogations when the received amplitude of P_2 is equal to or in excess of the received amplitude of P_1 and spaced 2.0 ±0.15 microsecond from P_3.

2.7 *Transponder Discrimination and Desensitization.*

a. Pulse Width Discrimination. Received signals of amplitude between minimum triggering level and at least 6 db above this level, and of a duration less than 0.3 microsecond, must not cause the transponder to initiate more than 10 percent reply or suppression action. With the exception of pulses having amplitude variations approximating a normal interrogation or suppression pulse pair condition, any pulse of a duration more than 1.5 microseconds must not cause the transponder to initiate reply or suppression action over the signal amplitude range from the minimum triggering level to 50 db above that level.

b. Echo Suppression and Recovery.

(1) *Echo suppression desensitization.* Upon receipt of any pulse more than 0.7 microsecond in duration (desensitization pulse), the receiver must be desensitized by an amount that is within at least 9 db of the amplitude of the desensitizing pulse but must at no time exceed the amplitude of the desensitizing pulse except for overshoot during the first microsecond following the desensitizing pulse.

(2) *Recovery.* Following desensitization, the receiver must recover sensitivity (within 3 db of minimum triggering level) within 15 microseconds after reception of a desensitizing pulse having a signal strength up to 50 db above minimum triggering level. Recovery must be nominally linear at an average rate not exceeding 3.5 db per microsecond.

(3) *Narrow pulses.* Single pulses of duration less than 0.7 microsecond must not cause desensitization of duration or amount greater than that permitted in subparagraphs (1) or (2).

c. *Dead Time.*

(1) After reception of a proper interrogation, the transponder must reply to no other interrogation for the duration of the reply pulse train. This dead time must end no later than 125 microseconds after the transmission of the last reply pulse of the group.

(2) The dead time of the transponder created by means other than normal interrogations shall not exceed a period of more than 2,500 microseconds duration at a maximum duty cycle of 4.5 percent.

d. *Reply Rate Control.* A sensitivity reduction type reply rate control must be provided. The rate of this control must permit adjustment of the reply rate to any value between 500 replies per second and the maximum rate of which the transponder is capable, or 2,000 replies per second, whichever is the lesser, without regard to the number of pulses in each reply. Sensitivity reduction in excess of 3 db must not take effect until 90 percent of the selected reply rate is exceeded. The sensitivity must be reduced by at least 30 db when the rate exceeds the selected value by 50 percent. The reply rate limit must be set at 1,200 replies per second of which the transponder is capable.

2.8 *Transponder Reply Rate Capability.*

a. For equipment intended for installation in aircraft that operate at altitudes above 15,000 feet, the reply rate capability must be at least 1,200 reply groups per second for a 15-pulse coded reply.

b. For equipment intended for installation in aircraft that operate at altitudes not exceeding 15,000 feet, the reply rate capability must be at least 1,000 reply groups per second for a 15 pulse coded reply.

2.9 *Transponder Reply Code Capability.* Transponders must provide the following code capability:

a. Framing pulses (see par. 2.13a.).

b. Information pulses in all combinations of the A, B, C, and D subscript groups, to create 4096 codes (see par. 2.13b.).

c. Special position identification pulse (SPI) (see par.2.13c.).

2.10 *Reply Transmission Frequency.* The center frequency of the reply transmission must be 1090 ±3 MHz.

2.11 *Transmitter Power Output.*

a. For equipment intended for installation in aircraft which operate at altitudes above 15,000 feet, the peak pulse power available at the antenna end of the transmission line of the transponder must be at least 21 db and not more than 27db above 1 watt at any reply rate up to 1,200 per second for a 15-pulse coded reply.

b. For equipment intended for installation in aircraft which operate at altitudes not exceeding 15,000 feet, the peak pulse power available at the antenna end of the transmission line of the transponder must be at least 18.5db and not more than 27db above 1 watt at any reply rate up to 1,200 per second for a 15-pulse coded reply.

c. The standards of this section assume a transmission line loss of 3db and an antenna performance equivalent to that of a simple quarter wave antenna. In the event that these assumed conditions do not apply, the equipment must be adjusted as necessary to provide a transmitter power output equivalent to that specified.

2.12. *Reply Delay and Jitter.*

a. The time delay between the arrival, at the transponder input, of the leading edge of P_3, and the transmission of the leading edge of the first pulse of the reply must be 3 ±0.5 microseconds.

d. The jitter of the reply pulse code group with respect to P_3 must not exceed ±0.1 microsecond for receiver input levels between 3 and 50db above the minimum triggering level.

c. Delay variations between modes on which the transponder is capable of replying must not exceed 0.2 microseconds.

2.13 *Reply Transmission Pulse Characteristics.*

a. Framing Pulses. The reply function must employ a signal comprising two framing pulses spaced 20.3 microseconds measured leading-edge to leading-edge at half-voltage points, as the most elementary code.

b. Information Pulses. Information pulses spaced at intervals of 1.45 microseconds measured leading-edge to leading-edge at the half-voltage points with the first pulse positioned 1.45 microseconds after the first framing pulse must be provided. The designation of these pulses and their position with respect to the first framing pulse is as follows:

PULSE	POSITION (Microseconds)
C_1	1.45
A_1	2.90
C_2	4.35
PULSE	POSITION (Microseconds)
A_2	5.80
C_4	7.25
A_4	8.70
X^*	10.15
B_1	11.60
D_1	13.05
B_2	14.50
D_2	15.95
B_4	17.40
D_4	18.85

* The X pulse is referenced here for possible future use.

NOTE.—Details and nomenclature of the transponder reply pulse codes are set forth in Appendix A.

c. Special Position Identification Pulse (SPI). In addition to the information pulses provided, a special position identification pulse, which may be used with any of the other information pulses upon request, must be provided at a spacing 4.35 microseconds following the last framing pulse. When replying to any mode of interrogation to which the transponder is capable, except Mode C, the selection of the SPI pulse must be initiated by an IDENT switch, the SPI pulse must be transmitted for a period between 15 and 30 seconds and must be repeatable at any time.

d. Reply Pulse Shape. All reply pulses and SPI pulses must be 0.45 ±0.10 microsecond in duration and have rise times of from 0.05 to 0.1 microsecond and decay times of from 0.05 to 0.2 microsecond. The

pulse amplitude variation of one pulse with respect to any other pulse in a reply train must not exceed 1 db. The rise and decay time may be less providing the sideband radiation is no greater than that which would be produced theoretically by a trapezoidal wave having the stated rise and decay time.

e. Reply Pulse Spacing Tolerances. The pulse spacing tolerances for each pulse (including the last framing pulse) with respect to the first framing pulse of the reply group must be ±0.10 microsecond. The pulse spacing tolerance of the special position identification pulse with respect to the last framing pulse of the reply group must be ±0.10 microsecond. The pulse spacing tolerance of any pulse in the reply group with respect to any other pulse (except the first framing pulse) must be no more than ±0.15 microsecond.

2.14 *Pressure-Altitude Transmission.* The equipment must have the capability for automatic pressure-altitude transmission in 100-foot increments on Mode C when operated in conjunction with a pressure-altitude encoder (digitizer). The equipment must be capable of automatic reply to Mode C interrogations with combinations of information pulses coded in binary form in 100-foot increments necessary for the equipment to operate up to design maximum altitude. The transponder must be provided with a means to remove the information pulses from the Mode C reply when requested by Air Traffic Control. The transponder must continue transmitting the framing pulses on Mode C when the information pulses have been removed or are not provided. Automatic pressure altitude transmission codes pulse position assignment are set forth in figure 2.

2.15 *Self Test and Monitor.* If a self test feature or monitor is provided, the devices that radiate test interrogation signals, or prevent transponder reply to proper interrogation during the test period, must be limited to intermittent use which is no longer than that required to determine the transponder status. The test interrogation rate must not exceed 450 per second and the interrogation signal level at the antenna end of the transmission line must not exceed a level of –40 dbm.

2.16 *Antenna.* The equipment antenna radiation pattern must be predominantly vertically polarized and be essentially omnidirectional in the horizontal plane with a nominal vertical beamwidth of at least ±30 degrees from the horizontal plane. The voltage standing wave ratio (VSWR) produced on the antenna transmission line by the antenna must not exceed 1.5:1 when operating on the radio frequencies of 1030 and 1090 MHz.

2.17 *Interference Suppression Pulse Response.* If the equipment is designed to accept and respond to suppression pulses from other electronic equipment in the aircraft (to disable it while the other equipment is transmitting), the equipment must regain normal sensitivity, within 3 db, not later than 15 microseconds after the end of the applied suppression pulse.

2.18 *Emission of Spurious Radiofrequency Energy.* The levels of conducted and radiated spurious radiofrequency energy emitted by the equipment must not exceed those levels specified in Appendix A of RTCA Document No. DO-138 entitled "Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments," dated June 27, 1968.

3.0 Minimum Performance Standards Under Environmental Conditions.

Unless otherwise specified, the test procedures applicable to a determination of the performance of airborne ATC transponder equipment under environmental conditions are set forth in RTCA Document No. DO-138 entitled "Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments," dated June 27, 1968.

3.1 *Temperature-Altitude.*

a. *Low Temperature.*

(1) When the equipment is subjected to this test, the standards of the following paragraphs must be met: 2.1a; 2.2, except that at temperatures below –15ºC., the sensitivity must not be less than –69 dbm and the variation of sensitivity of the receiver between any mode on which it is capable of operating must be less than 2 db; 2.6a(1); 2.6b(1); 2.6c; 2.7b; 2.7c; 2.10; 2.11; 2.12, except that at temperatures below –15ºC., the delay variation between modes on which the transponder is capable of replying must be less than 0.4 microsecond; 2.13c; 2.13d; and 2.13e.

(2) Following the low temperature test, the requirements of paragraph 2.16 must be met.

b. *High Temperature.*

(1) When the equipment is subjected to the high short-time operating temperature test, the equipment must operate electrically and mechanically.

(2) When the equipment is subjected to the high operating temperature test, the standards of the following paragraphs must be met: 2.1a; 2.2. except that at temperatures above +40ºC., the sensitivity must not be less than –60 dbm and the variation of sensitivity of the receiver between any mode on which it is capable of operating must be less than 2 db; 2.6a(1); 2.6b(1); 2.6c; 2.7b; 2.7c; 2.10; 2.11; 2.12, except that at temperatures above +40ºC., the delay variation between modes on

which the transponder is capable of replying must be less than 0.4 microsecond; 2.13c; 2.13d; and 2.13e.

(3) Following the high temperature test, the requirements of paragraph 2.16 must be met.

c. *Altitude.*

(1) When the equipment is subjected to this test, the standards of the following paragraphs must be met: 2.1d and b; 2.10; 2.11; and 2.13a.

(2) Following the altitude test, the requirements of paragraph 2.16 must be met.

d. *Decompression (when required).* When the equipment is subjected to this test, the standards of paragraphs 2.1a and b; 2.10; 2.11; and 2.13a must be met.

e. *Overpressure (when required).* When the equipment is subject to this test, the standards of paragraphs 2.1a and b; 2.10; 2.11; and 2.13a must be met.

3.2 *Humidity.* After being subjected to this test, the equipment must meet the following:

a. Within 15 minutes from the time primary power is applied, the receiver sensitivity must be within 3db of that specified in paragraph 2.2, transmitter power output must be within 3 db of that specified in paragraph 2.11, and the requirements of 2.1a; 2.1b; and 2.10 must be met.

b. Within 4 hours from the time primary power is applied, the standards of paragraphs 2.1a and b; 2.2; 2.10; 2.11; and 2.16 must be met.

3.3 *Shock.*

a. Following the application of the 6G shocks, the standards of the following paragraphs must be met: 2.1a; 2.2; 2.6a(1); 2.6c; 2.7b; 2.7c; 2.10; 2.11; 2.12; 2.13c; 2.13d; 2.13e; and 2.16.

b. Following the application of the 15G shocks, the equipment must have remained in its mounting and no parts of the equipment or its mounting become detached and free of the shock test equipment. The application of the 15G shock test may result in damage to the equipment. Therefore, this test may be conducted after the other tests are completed.

3.4 *Vibration.*

a. When the equipment is subjected to this test, the standards of the following paragraphs must be met: 2.1a; 2.2; 2.6a(1); 2.6b(1); 2.6c; 2.7b; 2.7c; 2.10; 2.11; 2.13c; 2.13d; and 2.13e.

b. Following the vibration test, the requirements of paragraph 2.16 must be met.

3.5 *Temperature Variation.*

a. When the equipment is subjected to this test, the standards of the following paragraphs must be met: 2.1a; 2.2, except that at temperatures below –15° C. and above +40° C., the sensitivity must be not less than –69 dbm and the variation of sensitivity of the receiver between any mode on which it is capable of operating must be less than 2 db; 2.6a(1); 2.6b(1); 2.6c; 2.7b; 2.7c; 2.10; 2.11; 2.12, except that at temperatures below –15° C. and above +40° C., the delay variation between modes on which the transponder is capable of replying must be less than 0.4 microsecond; 2.13c; 2.13d; and 2.13e.

b. Following the temperature variation test, the requirement of paragraph 2.16 must be met.

3.6 *Power Input Variation.* When the equipment is subjected to this test, the standards of the following paragraphs must be met: 2.1a; 2.2; 2.6a(1); 2.6b(1); 2.6c; 2.7b; 2.7c; 2.10; 2.11; 2.12; 2.13c; 2.13d; and 2.13e.

3.7 *Low Voltage.*

a. When the primary power voltage(s) of d.c. operated equipment is 80 percent and when that of a.c. operated equipment is 87½ percent of design voltage(s), the equipment must operate electrically and mechanically.

b. D.C. operated equipment must beet the standards of paragraphs 2.1a and b; 2.2; 2.10; and 2.11 within two (2) minutes upon returning the primary power voltage(s) to design voltage, after the gradual reduction of the primary voltage(s) from 80 percent to 50 percent of design voltage(s).

c. The gradual reduction of the primary power voltage(s) of d.c. operated equipment from 50 percent to 0 percent of design voltage(s) must produce no evidence of the presence of fire or smoke. Paragraph 1.2 does not apply.

3.8 *Conducted Voltage Transient.* When the equipment is subjected to this test, the standards of paragraphs 2.1a and b; 2.2; 2.10; and 2.11 must be met.

3.9 *Conducted Audiofrequency Susceptibility.* When the equipment is subjected to this test, the standards of paragraphs 2.1a and b; 2.2; 2.10; and 2.11 must be met.

3.10 *Audiofrequency Magnetic Field Susceptibility.* When the equipment is subjected to this test, the standards of paragraphs 2.1a and b; 2.2; 2.10; and 2.11 must be met.

3.11 *Radiofrequency Susceptibility (radiated and conducted).* When the equipment is subjected to this test, the standards of paragraphs 2.1a and b; 2.2b; 2.10; and 2.11 must be met.

3.12 *Explosion (when required).* When the equipment is subjected to this test, the equipment must cause no detonation of the explosive mixture within the test chamber.

3.13 *Waterproofness (drip proof) Test (when required).* After subjection to this test, the standards of paragraphs 2.1; 2.2; 2.10; 2.11; and 2.13a must be met.

3.14 *Hydraulic Fluid Test (when required).* After subjection to this test, the standards of paragraphs 2.1; 2.2; 2.10; 2.11; and 2.13a must be met.

3.15 *Sand and Dust Test (when required).* After subjection to this test, the standards of paragraphs 2.1; 2.2; 2.10; 2.11; and 2.13a must be met.

3.16 *Fungus Resistance Test (when required).* After subjection to this test, the standards of paragraphs 2.1; 2.2; 2.10; 2.11; and 2.13a must be met.

3.17 *Salt Spray Test (when required).* After subjection to this test, the standards of paragraphs 2.1; 2.2; 2.10; 2.11; and 2.13a must be met.

APPENDIX A

1.0 Test Conditions.

The following definitions of terms and conditions of test are applicable to the ATC transponder equipment.

a. Power Input Voltage-Direct Current. Unless otherwise specified, when the equipment is designed for operation from a direct current power source, all measurements must be conducted with the power input voltage adjusted to 13.75 volts, ±2 percent for 12-14 volt equipment, or 27.5 volts, ±2 percent for 24-28 volt equipment. The input voltage must be measured at the equipment power input terminals.

b. Power Input Voltage-Alternating Current. Unless otherwise specified, when the equipment is designed for operation from an alternating current power source, all tests must be conducted with the power input voltage adjusted to design voltage ±2 percent. In the case of equipment designed for operation from a power source of essentially constant frequency (e.g., 400 Hz, the input frequency must be adjusted to design ±2 percent. In the case of equipment designed for operation from a power source of variable frequency (e.g., 350 to 1000 Hz, tests must be conducted with the input frequency adjusted to within 5 percent of a selected frequency within the range from which the equipment is designed.

c. Adjustment of Equipment. The circuits of equipment under test must be properly aligned and otherwise adjusted in accordance with the manufacturer's recommended practices prior to the application of the specified tests.

d. Tests Instrument Precautions. Due precautions must be taken during the conduct of the tests to prevent the introduction of errors resulting from the improper connection of headphones, voltmeters, oscilloscopes, and other test instruments across the input and output impedances of the equipment under test.

e. Ambient Conditions. Unless otherwise specified, all tests must be conducted under conditions of ambient room temperature, pressure and humidity. However, the room temperature must not be lower than 10º C.

f. Warm-up Period. Unless otherwise specified, all tests must be conducted after a warm-up period of not less than fifteen (15) minutes.

g. Connected Load. Unless otherwise specified, all tests must be performed with the equipment connected to loads having the impedance value for which it is designed.

h. Interrogation Test Signal. The characteristics of the interrogation test signal are:

Radio frequency: The frequency of the signal generator oscillator must be 1030 MHz±0.01 percent.

CW output: CW output between pulses must be at least 60 db below the peak level of the pulses.

Interrogation: The interrogation must consist of two transmitted pulses designated P_1 and P_3. When providing side-lobe suppression, the basic interrogation is supplemented by pulse P_2 transmitted after P_1. The amplitude of P_3 must not be more than 1 db below the radiated amplitude of P_1.

Pulse coding: The interval, measured leading-edge to leading-edge at half voltage points, between P_1 and P_3, is as follows:

Mode 3/A	8 ±0.2 microseconds.
Mode B	17 ±0.2 microseconds
Mode C	21 ±0.2 microseconds
Mode D	25 ±0.2 microseconds

The interval between P_1 and P_2 when P_2 is used, must be 2.0 ±0.15 microseconds.

Pulse shape: The pulse envelope as detected by a linear detector must have a shape falling within the following limits:

(1) *Pulse rise time:* The time required for the leading edge of pulses P_1, P_2, and P_3 to rise form 10 to 90 per-

cent of its maximum voltage amplitude must be between 0.05 and 0.1 microsecond.

(2) *Pulse fall time:* The time required for the leading edge of pulses P_1, P_2, and P_3 to fall from 10 to 90 percent of its maximum voltage amplitude must be between 0.05 and 0.2 microsecond.

(3) *Pulse duration:* The duration of pulses P_1, P_2, and P_3 must be 0.8 ±0.1 microsecond measured at the half voltage points.

i. Code Nomenclature. The code designations consist of four digits each of which lies between 0 and 7, inclusive, and consist of the sum of the numerical subscripts of the pulse employed as follows:

Digit	*Pulse group*
First	A
Second	B
Third	C
Fourth	D

Examples:

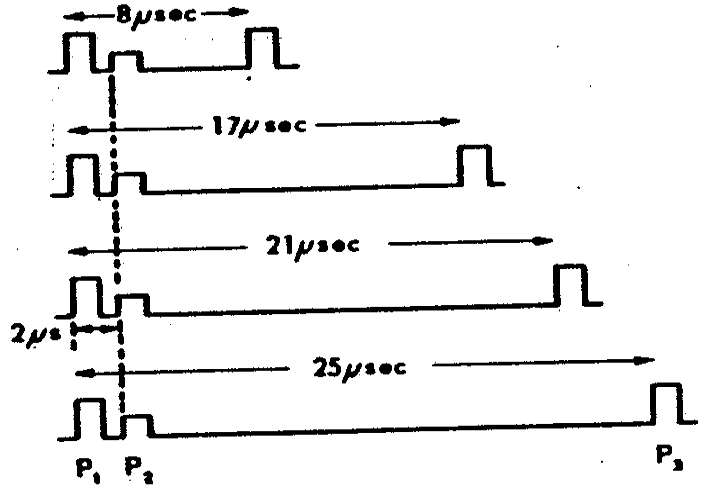
1. Code 3600 consists of information pulses A_2, A_2, B_2, B_4.

2. Code 2057 consists of A_2, C_1, C_4, D_1, D_2, D_4.

j. Minimum Triggering Level (MTL). Means the lowest level of signal to which the transponder will reply to 90 percent of the received interrogations.

ATCRBS INTERROGATION MODES

MODE	APPLICATION	CHARACTERISTIC
3/A	COMMON (ATC)	
B	CIVIL (ATC) (NOT REQUIRED FOR U.S. OPERATION)	
C	CIVIL (ALTITUDE)	
D	CIVIL (UNASSIGNED)	



TRANSPONDER REPLY CODES

SPACING (μs) LEADING EDGE TO LEADING EDGE	0	1.45	2.9	4.35	5.8	7.25	8.7	10.15	11.6	13.05	14.5	15.95	17.4	18.85	20.3		24.65
NOMENCLATURE OF PULSES	F_1	C_1	A_1	C_2	A_2	C_4	A_4	X	B_1	D_1	B_2	D_2	B_4	D_4	F_2		SPI

Figure 1.—ATCRBS, Interrogation modes and reply codes.

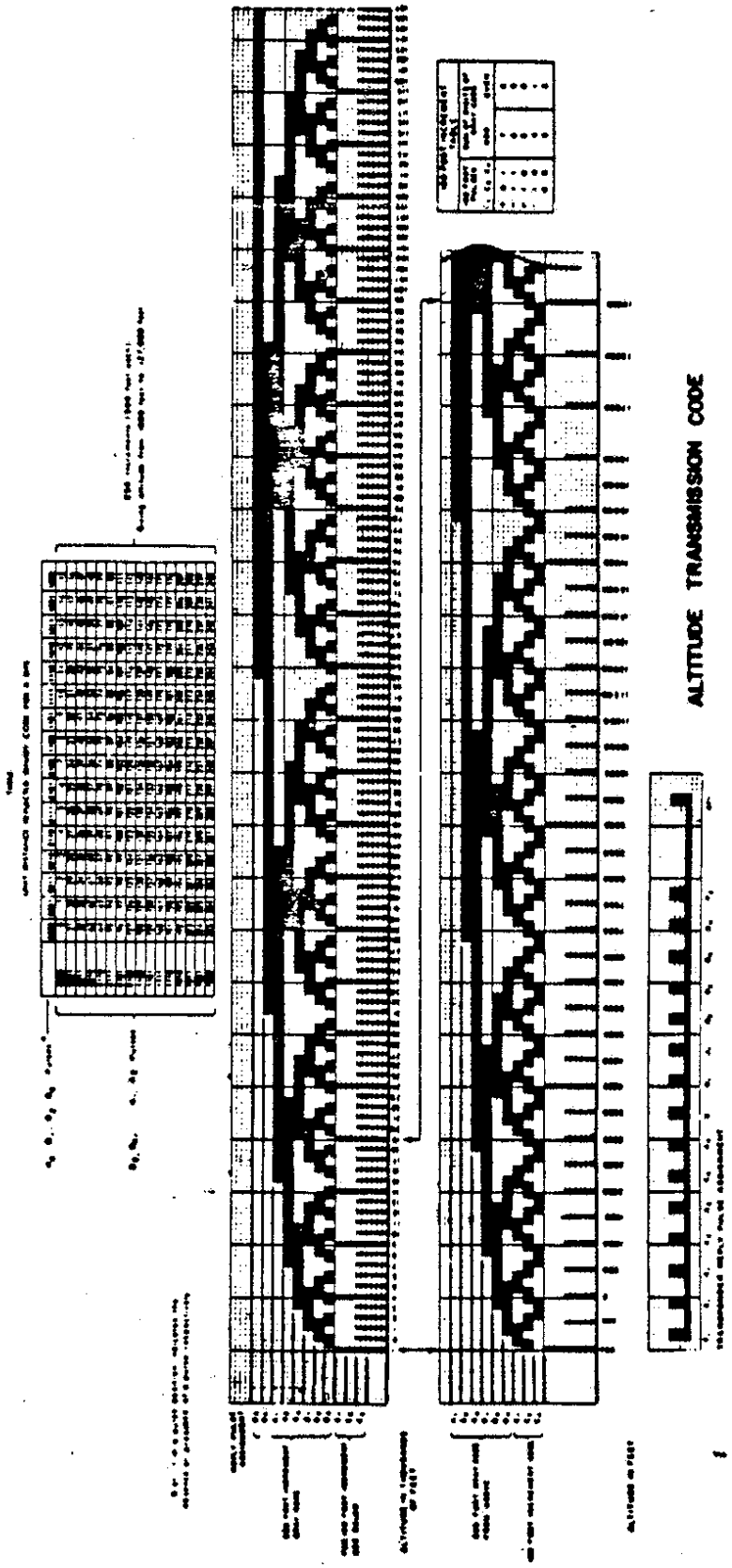


FIGURE 2—Altitude transmission code.