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Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System (ATCRBS) Airborne Equipment

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FOREWORD

These Minimum Operational Performance Standards (MOPS) were prepared by RTCA Special Committee 209 (SC-209) and approved by the RTCA Program Management Committee (PMC) on MM DD, YYYY. This document represents the consolidated performance requirements from two sources; RTCA/DO-144, "*Minimum Operational Characteristics for Airborne ATC Transponder Systems,*" dated March 12, 1970, and Change 1 to DO-144, posted as RTCA Paper No. 232-70/EC-643, dated November 5, 1970, and the performance standards referred to in paragraph (a)(1) of Federal Aviation Administration (FAA) Technical Standard Order (TSO) -C74c, dated February 20, 1973

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- Analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity and efficiency;
- Developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of Minimum Operational Performance Standards (MOPS) for electronic systems and equipment that support aviation; and
- Assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization (ICAO) and the International Telecommunication Union (ITU) and other appropriate international organizations can be based.

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CHANGE HISTORY

Date / Version	Description
1/19/06, v0.1	Initial version of DO-144 taken from RTCA in hardcopy only and scanned into an electronic file, and OCRed to produce the first editable electronic copy. Since the original DO-144 was written in Part I, Part II, Part III nomenclature, this was changed to chapters and subsections.
8/3/06, v0.2	Used to create the initial Comparison Matrix of the Outline of DO-144 versus the proposed DO-144A.
10/11/06, v0.3	This is the first version of the draft of DO-144A that has been rearranged into the standard RTCA MOPS format. The structure of the requirements section §2.2 was modeled after that in DO-181 and the corresponding information from DO-144 was copied into the appropriate section. The test procedure section §2.4 was populated with the existing test procedures from DO-144 section §2.3, while keeping the identical outline as was set up for §2.2. Since there were no sections in the original DO-144 dealing specifically with environmental testing, then in this draft, section §2.3 was populated with standard boilerplate text from the RTCA MOPS drafting standard. Section 3.0 of a standard RTCA MOPS document deals with Installed Equipment and in this draft that section has been populated with what was in the original DO-144 for Flight Tests in §2.3.
10/31/06, v0.4	(1) During the review of TSO C74c, it was discovered that there was a "Change" document issued for DO-144, dated 11/5/70. The changes identified in that Change document are implemented into this revision. (2) It was further discovered that the current revision of the Environmental MOPS is DO-160E. Therefore, all references to DO-160 in this document were changed to reference DO-160E, and the appropriate paragraph reference numbers were double checked.
12/18/06, v0.5	ATCRBS Sub-sub team inputs to Section 2.1 and 2.2.
12/23/06, v0.5a	Added Section 2.1.10 regarding interrogator characteristics
1/6/07, v0.5b	Inputs to Section 1.0, and added an Appendix A. place holder to insert **tables from ICAO Annex 10, Volume IV, Appendix to Chapter 3**
3/12/07, v0.6	Meeting at FAA Tech Center including Pagano, Furr, Wapelhorst and Van Dongen. Relocated some sections to more closely resemble the structure of DO-181.
3/13/07, v0.7	All changes accepted and highlighting removed except for those cases where issues were to be discussed with a wider audience.
v0.8, v0.9	Rich Jennings and Tom Pagano review and edit of test procedures. John Van Dongen review and simplification of the Environmental Test Procedures of §2.3.
April 2008, v1.0	Combination of simplified §2.3 with basic document and minor formatting getting ready for more detailed review of the Working Group during April 16-17, 2008 meeting in DC.
May 2008, v2.0	Includes edits during the Working Group meeting on 17 April 2008 and minor formatting and edits in preparation for Final Review and Comment.

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1 PURPOSE AND SCOPE

1.1 Introduction

This document sets forth minimum operational performance standards for Air Traffic Control Radar Beacon System (ATCRBS) airborne equipment. Incorporated within these standards are system characteristics that will be useful to users of the system as well as designers, manufacturers and installers. These performance standards represent a consolidation of performance requirements from two sources; RTCA/DO-144, "*Minimum Operational Characteristics for Airborne ATC Transponder Systems,*" dated March 12, 1970, and Change 1 to DO-144, posted as RTCA Paper No. 232-70/EC-643, dated November 5, 1970, and the performance standards referred to in paragraph (a)(1) of Federal Aviation Administration (FAA) Technical Standard Order (TSO)-C74c, dated February 20, 1973.

Compliance with the following MOPS is required to achieve at least that minimum performance, on which control and separation of aircraft is based, and to insure against derogation of service to other users of aviation navigation and communication services. These MOPS are applicable to all users of airborne ATC transponder systems who are required by regulation to participate in the ATC system, or who voluntarily choose to do so.

Note: *The use of "**shall**" in the body of this document indicates a requirement. The use of "**should**" indicates a characteristic that is highly recommended, but is not required.*

It is recognized that any regulatory application of these standards is the responsibility of appropriate government agencies.

Because the measured values of equipment performance characteristics may be a function of the measurement method, standard test conditions and methods of test are recommended in this document.

This document considers an equipment configuration consisting of: transponder, control panel, antenna and interconnecting cables. It should not be inferred that all ATCRBS airborne equipment will necessarily include all of the foregoing components as separate units; this will depend on the design configuration chosen by the manufacturer.

If the equipment implementation includes a computer software package, the guidelines contained in the most current issue of RTCA/DO-178, Software Considerations in Airborne Systems and Equipment Certification, should be considered.

1.1.1 International Standards

The performance standards of this document also reflect current International Civil Aviation Organization (ICAO) Annex 10, Volume IV, Amendment 82, Chapter 3 requirements for airborne systems having only Mode A and Mode C capabilities.

1.1.2 Preparation of Minimum Operational Performance Standards for Airborne Systems

The Federal Aviation Administration is the responsible agency for certain aviation standards. However, FAA's regulatory effort is vastly improved by intelligent utilization of government/industry working arrangements, by which a variety and wealth of talent may be brought to bear on the development of a particular minimum requirement.

Therefore, to implement the concepts that have been outlined, RTCA established Special Committee 209 to update the Minimum Operational Performance Standards for Airborne Transponder System Elements (both ATCRBS and Mode S), together with a method of demonstration of compliance. However, as pointed out in these concepts, concise statements of system characteristics are a prerequisite to meaningful minimum operational characteristics for airborne systems. Accordingly, RTCA SC-209 was directed to consider such system characteristics that exist and to include them in its reports. If none exist, best assumptions were to be formulated by RTCA SC-209 and included in the reports.

1.2 The ATCRBS Secondary Surveillance Radar (SSR) Environment

Although the trend towards equipage of ATCRBS/Mode Select (S) capable transponders is increasing, a large number of aircraft are still equipped with ATCRBS-only capable transponders. Since Mode S transponders are required on aircraft with TCAS, Mode S transponders are installed on a large segment of the aircraft population. However, General Aviation aircraft continue to represent the largest percentage of the aircraft in the airspace and ATCRBS transponders are still the dominant equipage for these aircraft.

The primary purpose of the ATCRBS transponder is to support ATC secondary surveillance radar (SSR) requirements. The ATCRBS SSR environment consists of the airborne ATCRBS transponders, ground interrogator-receiver, processing equipment, and an antenna system. The antenna may or may not be associated with, or slaved to, a primary surveillance radar. In operation, an interrogation pulse-pair transmitted from the interrogator-transmitter unit, via an antenna assembly, triggers each airborne transponder located in the direction of the main beam, causing a multiple pulse reply group to be transmitted from each transponder. These replies are received by the ground receiver and, after processing, are displayed to the controller. Measurement of the round-trip transit time determines the range (rho) to the replying aircraft while the mean direction of the main beam of the interrogator antenna, during the reply, determines the azimuth (theta). Based on the time spacing of the interrogation pulse-pair transmitted, the airborne transponder provides a multiple-pulse reply that represents either an individualized identity code (Mode A reply) or the aircraft's current pressure altitude (Mode C reply).

The ATCRBS transponder also replies to airborne Mode A and Mode C interrogators, thereby making its presence known to aircraft that are equipped with Traffic Advisory and Collision Avoidance System (TCAS) or Airborne Collision Avoidance System (ACAS).

Additional information on ground and airborne interrogator characteristics is contained in §2.1.10.

1.3 Assumptions

This document defines the basic surveillance and link characteristics of ATCRBS transponders. Adherence to the requirements of this document will meet the needs of the airspace for surveillance of aircraft so equipped. There is no upgrade path for the ATCRBS system going forward as surveillance needs of the future may rely on different technologies.

1.4 Equipage Classes

Class A equipment is intended for installation in aircraft which operate at altitudes above 15,000 feet.

Class B equipment is intended for installation in aircraft which operate at altitudes not exceeding 15,000 feet.

1.5 Test Procedures

The specified test procedures and associated limits are intended as one means of demonstrating compliance with the minimum acceptable performance parameters. Although specific test procedures are cited, it is recognized that other methods may be preferred by the test organization. These alternate methods may be used if they provide at least equivalent information. In such cases, the procedures cited should be used as one criterion in evaluating the acceptability of the alternate procedures.

The order of tests suggests that the equipment be subjected to a succession of different tests as it moves from design and design qualification into operational use. For example, the equipment should have demonstrated compliance with the requirements of Section §2.0 as a precondition to satisfactory completion of the installed system tests of Section §3.0.

Three types of test procedures are included which should be used at different stages in the equipment approval cycle. These are discussed in the following paragraphs.

1.5.1 Environmental Tests

Environmental tests are specified in Subsection §2.3. The procedures and their associated limit requirements are intended to provide a means of determining the electrical and mechanical performance of the equipment under environmental conditions expected to be encountered in actual operations. Equipment manufacturers may use test results as design guidance in preparation of installation instructions and, in certain cases, for obtaining formal approval of equipment design and manufacture.

1.5.2 Detailed Test Procedures

Detailed test procedures are specified in Subsection §2.4. These tests are conducted at the equipment level and are intended to provide a laboratory means of demonstrating compliance with the requirements of Subsections §2.1 and §2.2. Equipment manufacturers may use test results as design guidance, for monitoring manufacturing

compliance and, in certain cases, for obtaining formal approval of equipment design and manufacture.

1.5.3 Installed System Tests

The installed system test procedures and their associated requirements are specified in Section §3.0. Although bench and environmental test procedures are not included in the installed system tests, their successful completion is a precondition to completion of the installed tests. In certain instances, however, installed system tests may be used in lieu of bench test simulation of such factors as power supply characteristics, interference from or to other equipment installed on the aircraft, etc. Installed tests are normally performed under two conditions:

a. with the aircraft on the ground and using simulated or operational system inputs, and/or

b. with the aircraft in flight using operational system signals appropriate to the equipment under test.

Test results may be used to demonstrate functional performance in the intended operational environment.

In addition, the ground test procedures may be used as an optional check of equipment performance following corrective maintenance.

1.6 Definition of Terms

ATCRBS – Air Traffic Control Radar Beacon System.

Desensitization – Temporary reduction of transponder sensitivity after receipt of a signal. This helps to reduce echo (multipath) effects.

Interrogation – A ground or airborne signal propagated toward an ATCRBS transponder to elicit a Mode A or Mode C response.

Mode A Interrogation – A signal to elicit an ATCRBS transponder reply for identity (4096 code) and surveillance.

Mode C Interrogation – A signal to elicit an ATCRBS transponder reply for automatic pressure-altitude transmission and surveillance

Multipath – The propagation phenomenon that results in signals reaching the receiving antenna by two or more paths, generally with a time or phase difference between the two.

National Airspace System (NAS) – The common system of facilities, equipment, regulations, procedures and personnel providing services and standard procedures for the safe and efficient movement of civil and military aircraft within the jurisdiction of the United States.

PAM – Pulse Amplitude Modulation. The modulation technique utilized in both the interrogation and reply signals.

Reply – A signal propagated from the transponder.

Side Lobe Suppression (SLS) Transmission – A transmission intended to prevent responses from transponders not in the main beam of the interrogating antenna.

Special Position Identification (SPI) – A special pulse used in ATCRBS located 4.35 microseconds following the last framing pulse. When used in Mode S, SPI appears as a code in the flight status (FS) field and in the surveillance status subfield (SSS).

2 ATCRBS Transponder Equipment Performance Requirements and Test Procedures

2.1 General Requirements

2.1.1 Airworthiness

In the design and manufacture of the equipment, the manufacturer **shall** provide for installation so as not to impair the airworthiness of the aircraft.

2.1.2 General Performance

The equipment **shall** perform its intended function(s), as defined by the manufacturer, and its proper use **shall not** create a hazard to other users of the National Airspace System.

2.1.3 Federal Communications Commission Rules

All equipment **shall** comply with the applicable rules of the Federal Communication Commission.

2.1.4 Fire Protection

All materials used **shall** be self-extinguishing except for small parts (such as knobs, fasteners, seals, grommets and small electrical parts) that would not contribute significantly to the propagation of a fire.

Note: *One means of showing compliance is contained in Federal Aviation Regulations (FAR), Part 25, Appendix F.*

2.1.5 Operation of Controls

The equipment **shall** be designed so that controls intended for use during flight cannot be operated in any position, combination or sequence that would result in a condition detrimental to the reliability of the equipment or operation of the aircraft.

2.1.6 Accessibility of Controls

Controls that do not require adjustment during flight **shall not** be readily accessible to flight personnel.

2.1.7 Flight Crew Control Functions

The following functions **shall** be provided.

a. Means of selecting each of the ATCRBS 4096 (Mode A) reply codes, and of indicating the code selected.

b. Means of selecting the condition in which all transponder functions, other than transmission on the reply frequency and associated self-testing, are operational (i.e., the Standby condition). Return to normal operation from this condition **shall** be possible within five seconds

c. Means of selecting ATCRBS Mode A and Mode C combined.

d. Means of initiating the IDENT (SPI) feature.

e. Means of inhibiting the transmission of the altitude information, while retaining the ATCRBS framing pulses in ATCRBS Mode C replies.

2.1.8 Optional Functions/Interfaces

With the movement toward an Automatic Dependent Surveillance – Broadcast (ADS-B) environment, there are various functions/outputs from the ATCRBS transponder that are in common with ADS-B parameter requirements. For example, the "squawk" or 4096 code, pressure altitude, and an IDENT capability are features used by both ADS-B and ATCRBS in supporting ATC surveillance needs. Equipment manufacturers should consider the development of an output interface to support these and other ADS-B broadcast requirements (e.g., Flight ID) in their future transponder designs.

2.1.9 Effects of Test

The equipment **shall** be designed so that the application of specified test procedures **shall not** be detrimental to equipment performance following the application of the tests, except as specifically allowed.

2.1.10 Interrogation Characteristics

The following subsections describe the signal in space as it can be expected to appear at the transponder's antenna. Because signals can be corrupted in transmission, tolerances for interrogator performance are more restrictive and should not be derived from this document. The modulation technique utilized in the interrogation signal is known as pulse amplitude modulation (PAM).

2.1.10.1 Interrogation Carrier Frequency

The carrier frequency of received interrogations is:

a. 1030 ±0.20 MHz from ATCRBS interrogators.

b. 1030 ±0.01 MHz from Mode S interrogators.

2.1.10.2 Measurement Convention

The following definitions are in reference to Figure 2-1.

Pulse Amplitude – the peak voltage amplitude (A) of the pulse envelope.

Pulse Rise Time – the time between 0.1A and 0.9A on the leading edge of the pulse envelope.

Pulse Decay Time – the time between 0.9A and 0.1A on the trailing edge of the pulse envelope.

Pulse Duration – the time interval between 0.5A points on leading and trailing edges of the pulse envelope.

Pulse Interval – the time interval between the 0.5A point on the leading edge of the first pulse and the 0.5A point on the leading edge of the second pulse.

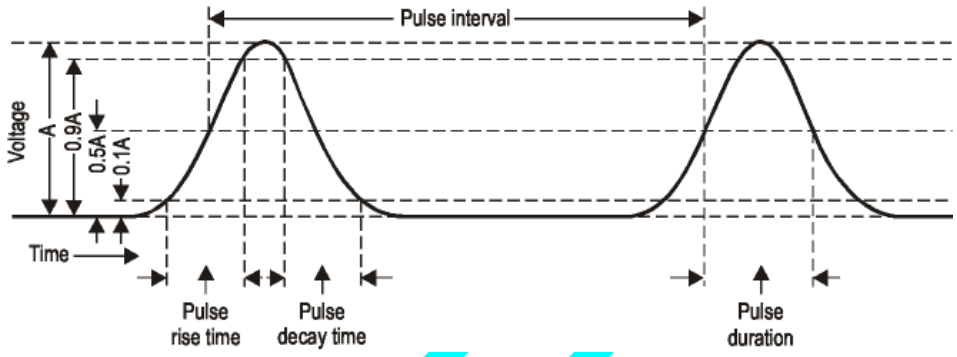

Figure 2-1: Pulse Envelope Conventions

2.1.10.3 Received PAM Signals

The following signals are valid PAM interrogations:

- ATCRBS Mode A (to elicit transponder replies for identity and surveillance)
- ATCRBS Mode C (to elicit transponder replies for automatic pressure-altitude transmission and surveillance)
- ATCRBS Mode A/C/S All-Call (to elicit replies for surveillance of Mode A/C transponders and for the acquisition of Mode S transponders)
- ATCRBS Mode A/C-Only All-Call (to elicit replies for surveillance of Mode A/C transponders. Mode S transponders do not reply)

All of these interrogations use two or more of the four pulses shown in §2.1.10.3.2. The pulses are labeled P_1, P_2, P_3 and P_4.

2.1.10.3.1 Pulse Shapes

The pulse shapes for PAM interrogations are summarized in Table 2-1 (all values are in microseconds).

Table 2-1: Pulse Shapes

Pulse Designator	Pulse Duration	Duration Tolerance	Rise Time Min/Max	Decay Time Min/Max
P_1, P_2, P_3	0.8	±0.1	0.05/0.1	0.05/0.2
P_4 (short)	0.8	±0.1	0.05/0.1	0.05/0.2
P_4 (long)	1.6	±0.1	0.05/0.1	0.05/0.2

2.1.10.3.2 Pulse Patterns

The pulse patterns of the PAM interrogations are defined in Table 2-2 (all values are in microseconds). The general format of the PAM interrogations is shown in Figure 2-2.

Table 2-2: Pulse Pattern

Interrogation Type	Spacing			
	$P_1 - P_2$	$P_1 - P_3$	$P_3 - P_4$	P_4
ATCRBS Mode A	2 ±0.15	8 ±0.2	–	None
ATCRBS Mode C	2 ±0.15	21 ±0.2	–	None
ATCRBS Mode A/Mode S All-Call	2 ±0.15	8 ±0.2	2 ±0.05	Long
ATCRBS Mode C/Mode S All-Call	2 ±0.15	21 ±0.2	2 ±0.05	Long
ATCRBS Mode A-Only All-Call	2 ±0.15	8 ±0.2	2 ±0.05	Short
ATCRBS Mode C-Only All-Call	2 ±0.15	21 ±0.2	2 ±0.05	Short

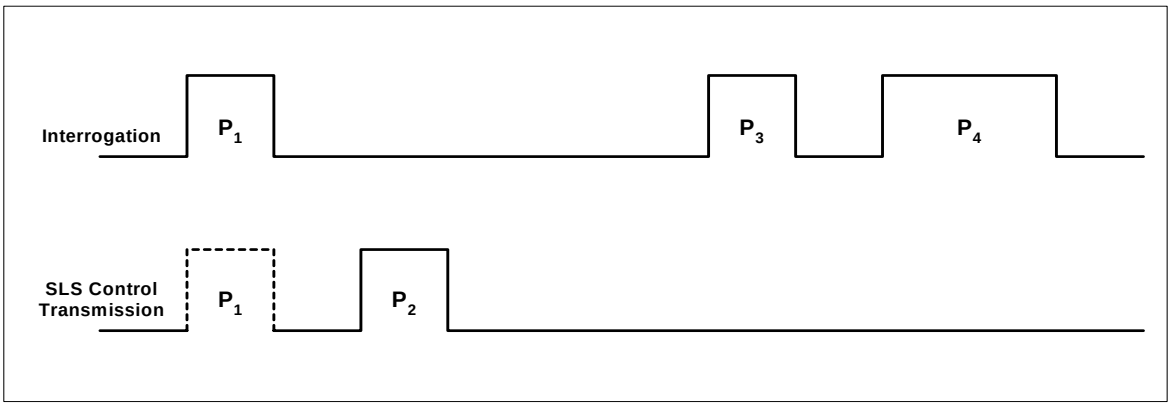

Figure 2-2: General Pulse Patterns for PAM Interrogations

2.1.10.3.3 Relative Pulse Amplitudes

P_2 amplitudes will vary from P_1.

P_3 amplitudes are P_1 ±1 dB.

2.1.10.4 Suppression

This characteristic is used to prevent replies to interrogations received via the side lobes of the interrogator antenna, and to prevent Mode A/C transponders from replying to Mode S interrogations. Suppression is in effect when the received amplitude of P_2 is equal to or in excess of the received amplitude of P_1 and spaced 2 ±0.15 microseconds (see §2.2.5.3).

2.2 Equipment Performance – Standard Conditions

2.2.1 Definition of Standard Conditions

The signal levels specified in this subsection exist at the antenna end of a transponder-to-antenna transmission line of loss equal to the maximum for which the transponder is designed.

Note: *The transponder will usually be installed with less than the designed maximum transmission line loss. Nevertheless, the standard conditions of this document are based on the maximum design value.*

2.2.2 Receiver Characteristics

2.2.2.1 Interrogation Tolerances

Paragraph §2.1.10 and its subparagraphs define tolerances allowed from the nominal interrogation values. The transponder **shall** be tolerant to all such deviations within the ranges specified in paragraph §2.1.10.

2.2.2.2 Transponder Receiver Operating Frequency and Bandwidth

a. The receiver nominal center frequency **shall** be 1030 MHz.

b. With an input signal level 3 dB above the minimum triggering level, the receiver bandwidth **shall** be such that the receiver accepts pulses as outlined in §2.1.10 with an interrogation center frequency drift of ± 0.2 MHz.

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

2.2.2.3 Receiver Sensitivity and Dynamic Range

Given an interrogation that requires a reply, the minimum triggering level (MTL) is defined as the minimum input power level that results in a 90 percent reply ratio if the interrogation signal has all nominal pulse spacings and widths and if the replies are the correct replies assigned to the interrogation format.

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

   (1) The two pulses P_1 and P_3 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 69 and 77 dB below 1 milliwatt.

   Note: *For this MTL requirement, a nominal 3 dB transmission line loss and an antenna performance equivalent to that of a simple quarter wave antenna are assumed. In the event these assumed conditions do not apply, the MTL of the installed transponder system must be comparable to that of the assumed system.*

b. The variation of the minimum triggering level between modes **shall not** exceed 1 dB for nominal pulse spacings and pulse widths.

c. The reply characteristics **shall** apply over a received signal amplitude range between minimum triggering level and -21 dBm.

d. The reply ratio **shall** not be more than 10 percent for interrogations at signal levels below -81 dBm.

e. The conditions of “a” through “d” apply when a P_4 pulse is present, either long or short, regardless of amplitude of the P_4 pulse.

2.2.3 Transmitter Characteristics

2.2.3.1 Reply Transmission Frequency

The center frequency of the reply transmission **shall** be 1090 ±3 MHz.

2.2.3.2 Transponder Power Output

2.2.3.2.1 Class A Equipment

For this class of equipment, the peak pulse power available at the antenna end of the transmission line of the transponder **shall** be at least 21 dB and not more than 27 dB above 1 watt at any reply rate up to 1,200 per second for a 15-pulse coded reply.

2.2.3.2.2 Class B Equipment

For this class of equipment, the peak pulse power-available at the antenna end of the transmission line of the transponder **shall** be at least 18.5 dB and not more than 27 dB above 1 watt at any reply rate up to 1,000 per second for a 15-pulse coded reply.

Note: *For the power output requirement specified in §2.2.3.2.1 and §2.2.3.2.2, a nominal 3 dB transmission line loss and an antenna performance equivalent to that of a simple quarter-wave antenna are assumed. In the event these assumed conditions do not apply, the peak pulse power of the installed transponder system must be comparable to that of the assumed system.*

2.2.3.3 Unwanted Output Power

When the transponder transmitter is in the inactive state, the RF output power at 1090 ±3 MHz at the terminals of the antenna **shall not** exceed -50 dBm. The inactive state is defined to include the entire period between ATCRBS transmissions less 10-microsecond transition periods, if necessary, preceding and following the extremes of the transmission.

2.2.3.4 Reply Rate Capability

a. For Class A equipment (see §1.4), the transponder **shall** be capable of at least 1,200 replies per second for a 15-pulse coded reply.

b. For Class B equipment (see §1.4), the transponder **shall** be capable of at least 1,000 replies per second for a 15-pulse coded reply.

2.2.3.5 Sensitivity Reduction Reply Rate Control

A sensitivity-reduction reply rate limit **shall** be incorporated in the transponder for ATCRBS replies. The limit **shall** be capable of being adjusted between 500 continuous ATCRBS Mode A and Mode C replies per second and the maximum continuous rate of which the transponder is capable, or 2000 replies per second, whichever is less, without regard to the number of pulses in each reply.

Note: *The reply rate limit control should be set at 1,200 replies per second, or the maximum value below 1,200 replies per second of which the transponder is capable. (See §2.2.3.4).*

2.2.4 Reply Pulse Characteristics (Signals in Space)

The following subsections describe the reply pulse characteristics. The general format of the reply pulse is shown in Figure 2-3.

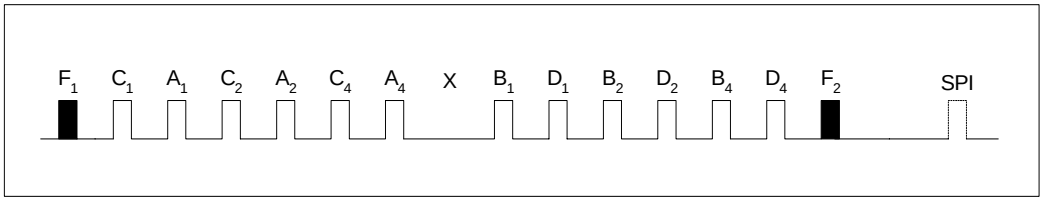

Figure 2-3 ATCRBS Reply Pulse Pattern

2.2.4.1 Framing Pulses

The reply function **shall** employ a signal comprising two framing pulses spaced 20.3 microseconds, as the most elementary code.

2.2.4.2 Information Pulses

Information pulses **shall** be spaced in increments of 1.45 microseconds from the first framing pulse. The designation and position of these information pulses **shall** be as shown in Table 2-3.

Table 2-3: Information Pulses

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
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
F_2	20.30

2.2.4.3 Special Position Identification (SPI) Pulses

In addition to the information pulses provided, a Special Position Identification (SPI) Pulse, which may be transmitted with the information pulses, **shall** occur at a pulse interval of 4.35 microseconds following the last framing pulse.

The SPI pulse **shall** be initiated by an IDENT switch (see §2.1.7.d). Upon activation of the IDENT switch, the SPI pulse **shall** be transmitted for a period of between 15 and 30 seconds and must be capable of being reinitiated at any time. The SPI pulse **shall not** be included when transmitting Mode C replies.

2.2.4.4 Reply Pulse Shape

All reply pulses **shall** have a pulse duration of 0.45 ±0.10 microsecond, a pulse rise time between 0.05 and 0.1 microsecond, and a pulse decay time between 0.05 and 0.2 microsecond. The pulse amplitude variation of one pulse with respect to any other pulse in a reply group **shall not** exceed 1 dB. (See §2.1.10.2)

Note: *The intent of the lower limit of rise and decay times (0.05 microseconds) is to reduce sideband radiation. Equipment will meet this requirement if the sideband radiation is no greater than that which theoretically would be produced by a trapezoidal wave having 0.05 microsecond rise and decay times and a 0.35 microsecond pulse duration.*

2.2.4.5 Reply Pulse Spacing Tolerances

The pulse interval tolerance for each pulse (including the last framing pulse) with respect to the first framing pulse of the reply group **shall** be ±0.10 microsecond. The pulse interval tolerance of the Special Position Identification Pulse with respect to the last framing pulse of the reply group **shall** be ±0.10 microseconds. The pulse interval tolerance of any pulse in the reply group with respect to any other pulse (except the first framing pulse) **shall** not exceed ±0.15 microseconds.

2.2.4.6 Reply Delay and Jitter

The time delay between the arrival at the transponder of the leading edge of P_3, and the transmission of the leading edge of the first pulse of the reply **shall** be 3 ±0.5 microseconds. The total jitter of the reply pulse code group with respect to P_3 **shall not** exceed ±0.1 microseconds. Delay variations between modes on which the transponder is capable of replying **shall not** exceed 0.2 microseconds. These requirements apply for receiver input levels between 3 and 50 dB above minimum triggering level.

2.2.5 Decoding Performance

Unless otherwise specified, the following pulse decoder characteristics **shall** apply over the RF input signal level range from MTL +3 dB to MTL +50 dB and interrogation signal characteristics per §2.1.10.3.

2.2.5.1 Pulse Level Tolerances

When selected to reply to a particular interrogation mode (See §2.1.10.3.2), the transponder **shall** reply (not less than 90 percent efficiency) under each of the following conditions:

a. The received amplitude of P_3 is in excess of a level 1 dB below the received amplitude of P_1 but no greater than 3 dB above the received amplitude of P_1.

b. The received amplitude of a proper interrogation is more than 10 dB above the received amplitude of random pulses where the latter are not recognized by the transponder as P_1, P_2, or P_3.

c. The conditions of "a" and "b," apply when a P_4 pulse is present, either long or short, regardless of amplitude of the P_4 pulse.

2.2.5.2 Pulse Position Tolerances

The transponder **shall** accept interrogations as valid if the spacing between P_1 and P_3 is within plus or minus 0.20 microseconds of the nominal spacing.

The transponder **shall not** reply to more than 10 percent of the interrogations under each of the following conditions:

a. To interrogations when the interval between pulses P_1 and P_3 differs from that defined in §2.1.10.3.2 for the mode selected in the transponder by more than ±1 microsecond.

b. Upon receipt of any single pulse which has no amplitude variations approximating a normal interrogation condition.

2.2.5.3 Suppression

Upon receipt of an interrogation complying with the interrogation modes defined in §2.1.10.3, selected manually or automatically, the transponder **shall** be suppressed (not less than 99 percent efficiency) when the received amplitude of P_2 is equal to or in excess of the received amplitude of P_1 and spaced 2 ±0.15 microseconds.

Notes:

1. *It is not the intent of this paragraph to require the detection of P_3 as a prerequisite for initiation of suppression action.*

2. *After reception of a valid P_3 pulse the transponder should not initiate suppression based on the reception of a P_4 pulse.*

a. The transponder suppression **shall** be for a period of 35 ±10 microseconds.

b. The suppression **shall** be capable of being reinitiated for the full duration within two microseconds after the end of any suppression period.

c. The transponder **shall not** initiate suppression if the level of P_1 exceeds the level of P_2 by 9 dB or more.

d. The transponder **shall not** initiate suppression if no pulse is received at the position 2.0 ±0.7 microseconds following P_1.

e. The transponder **shall not** initiate suppression if the duration of P_2 is less than 0.3 microseconds.

2.2.5.4 Pulse Duration Discrimination

a. For all signal levels from MTL to -45 dBm, the transponder **shall** reply to no more than 10 percent of ATCRBS, ATCRBS-Only All-Call or ATCRBS/Mode S All-Call interrogations if the duration of either the P1 or the P3 pulse is less than 0.3 microseconds. .

b. With the exception of single pulses with amplitude variations approximating an interrogation, any single pulse of duration more than 1.5 microseconds **shall not** cause the transponder to initiate reply or suppression action over the signal amplitude range of minimum triggering level to 50 dB above minimum triggering level.

2.2.5.5 Compatibility with TCAS ATCRBS Surveillance

With P_1 at MTL and S_1 at MTL -6 dB, the transponder **shall** reply to ATCRBS interrogations at least 90 % of the time.

With P_1 at MTL and S_1 at MTL -3 dB, the transponder **shall** reply to ATCRBS interrogations at least 70 % of the time.

With P_1 at MTL and S_1 at MTL, the transponder **shall** reply to no more than 10% of ATCRBS interrogations.

Note: *S_1 is equal to P_1 in duration with the leading edge of S_1 being 2.0 microseconds ahead of the leading edge of P_1. Amplitude of S_1 is varied relative to P_1 as indicated above.*

2.2.6 Desensitization and Recovery Characteristics

2.2.6.1 Dead Time

After reception of a valid interrogation, the transponder **shall not** reply to any other interrogation at least for the duration of the reply pulse train. This dead time **shall** end no later than 125 microseconds after the transmission of the last reply pulse of the group.

2.2.6.2 Echo Suppression and Recovery

The transponder **shall** contain an echo suppression facility designed to permit normal operation in the presence of echoes of signals-in-space. The provision of this facility **shall** be compatible with the requirements for suppression of side lobes given in §2.2.5.3.

2.2.6.2.1 Desensitization

Upon receipt of any pulse more than 0.7 microseconds in duration, the receiver **shall** be desensitized by an amount that is within at least 9 dB of the amplitude of the desensitizing pulse, but **shall** at no time exceed the amplitude of the desensitizing pulse, with the exception of possible overshoot during the first microsecond following the desensitizing pulse. Single pulses of duration less than 0.7 microseconds are not required to cause the specified desensitization, and **shall not** cause desensitization of duration greater than that permitted herein or by §2.2.6.2.2.

2.2.6.2.2 Recovery

Following desensitization, the receiver **shall** recover sensitivity (within 3 dB of MTL) within 15 microseconds after reception of a desensitizing pulse having a signal strength up to 50 dB above MTL. Recovery **shall** be nominally linear at an average rate not exceeding 4.0 dB per microsecond.

2.2.7 Undesired Replies

2.2.7.1 Random Triggering and Suppression Rate

In the absence of valid interrogation signals, the random triggering rate (squitter) of the transponder **shall not** exceed 30 replies and/or suppressions per second as integrated over an interval equivalent to at least 300 random triggers, or 30 seconds, whichever is less.

***Note**: When demonstrating compliance to these requirements, the equipment manufacturer should consider possible interference (triggering) caused by equipment typically found in the aircraft of intended installation (e.g., VHF communication, DME, Radio Altimeter, etc.), operating at their maximum interference levels.*

2.2.7.2 Random Triggering in the Presence of CW

The total random triggering on all Mode A and/or Mode C replies **shall not** exceed 10 replies or suppressions per second, averaged over a period of 30 seconds, when operated in the presence of non-coherent CW interference at a frequency of 1030 ±0.2 MHz and a signal level of –60 dBm, or less.

2.2.8 Transponder Self Test and Monitor

2.2.8.1 Manual Self-Test

a. When a manual self-test device is provided, it **shall** be limited to intermittent use by a spring-loaded return-to-off switch, or equivalent.

b. The test interrogation rate **shall not** exceed 450 per second.

c. The lowest RF level at the input to the antenna required to accomplish the test **shall** be used. The maximum RF level at the input to the antenna **shall not** exceed 40 dB below 1 milliwatt.

2.2.8.2 Automatic Self-Test

a. When an automatic self-test device is provided, it **shall** be limited to use only in the absence of a valid interrogation. (A minimum period of 15 seconds will be sufficient to establish the absence of ground interrogations).

b. The maximum test time for the automatic self-test **shall not** exceed 0.1 second in any given l5-second interval.

c. The test interrogation rate **shall not** exceed 450 per second.

d. The lowest RF level at the input to the antenna required to accomplish the test **shall** be used. The maximum RF level at the input to the antenna **shall not** exceed 40 dB below 1 milliwatt.

2.2.9 Response to Mutual Suppression Pulses

The equipment **shall** accept and respond to suppression pulses from other electronic equipment in the aircraft (to disable it while the other equipment is transmitting), the equipment **shall** regain normal sensitivity within 3 dB, not later than 15 microseconds after the end of the applied suppression pulse.

2.2.10 Data Handling and Interfaces

2.2.10.1 Code Nomenclature

The code designations **shall** consist of four digits, each of which lies between 0 and 7 inclusive, and is determined by the sum of the pulse subscripts given in Table 2-3, employed as shown in Table 2-4:

Table 2-4: Code Nomenclature

Digit	Pulse Group
First (most significant)	A
Second	B
Third	C
Fourth	D

Examples:

Code 3615 would consist of information pulses A_1, A_2 (1 + 2 = 3), B_2, B_4 (2 + 4 = 6), C_1 (1 = 1), D_1, D_4 (1 + 4 = 5).

Code 3600 would consist of information pulses A_1, A_2, B_2 and B_4

Code 2057 would consist of information pulses A_2, C_1, C_4, D_1, D_2 and D_4

Code 0301 would consist of information pulses B_1, B_2 and D_1

2.2.10.2 Identification

The 4096 codes specified in §2.2.10.1 **shall** be manually selectable for reply to interrogations on Mode A.

2.2.10.3 Pressure Altitude Transmissions

a. Independently of the other modes and codes manually selected, the transponder **shall** automatically reply to Mode C interrogations.

b. The reply to Mode C interrogations **shall** consist of the two framing pulses together with the information pulses specified in §2.2.4.2.

c. The transponders **shall** be provided with means to remove the information pulses, but to retain the framing pulses when the provision of subparagraph ”f” below is not complied with, in reply to Mode C interrogation.

Note: *The information pulses should be capable of being removed either in response to a failure detection system or manually at the request of the controlling agency.*

d. The information pulses **shall** be automatically selected by an analog-to-digital converter connected to a pressure-altitude data source in the aircraft referenced to the standard pressure setting of 29.92 inches of mercury.

e. Pressure altitude **shall** be reported in 100-foot increments by selection of pulses as shown in the tables in Appendix A. If the transponder is capable of accepting altitude sources with better than 100-foot resolution, the pressure altitude-information **shall** be reported in the closest 100-foot increment as specified in Appendix A.

f. The digitizer code selected **shall** correspond to within ±125 feet, on a 95 percent probability basis with the pressure altitude information (referenced to the standard pressure setting of 29.92 inches of mercury) used on board the aircraft to adhere to the assigned flight profile.

2.2.11 Antenna

2.2.11.1 Frequency

The antenna **shall** be designed to receive and transmit vertically polarized signals in the frequency range of 1030 to 1090 MHz.

2.2.11.2 Impedance and VSWR

The VSWR produced by the antenna when terminated in a 50-ohm transmission line **shall** not exceed 1.5:1 over the 1030 to 1090 MHz frequency band.

2.2.11.3 Polarization

The antenna **shall** be vertically polarized.

2.2.11.4 Radiation Pattern

The transponder antenna system when installed on an aircraft **shall** have a radiation pattern that is essentially omni-directional in the horizontal plane and should have a vertical beam-width sufficient to provide system operation during normal maneuvers of the aircraft.

2.2.12 Power Interruption

The transponder equipment **shall** regain operational capability to within its operational limits within two seconds after the restoration of power following a momentary power interruption.

Note: *The transponder equipment is not required to continue operation during momentary power interruptions.*

2.2.13 Diversity

Diversity transponders may be implemented for the purpose of improving surveillance performance. 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.

2.2.13.1 Diversity Antenna Selection and Selection Threshold

a. Diversity Antenna Selection

Antenna selection **shall** be automatic. The transponder **shall** select one of the two antennas on the basis of the relative strengths of the detected interrogation signals, provided that both channels simultaneously receive a valid identical interrogation or pulse pair. Antenna selection and switching may occur after the receipt of the P_3 pulse of a P_1 - P_3 pulse pair, indicating an ATCRBS or ATCRBS/Mode S All-Call interrogation.

The selected antenna **shall** be used, if necessary, to transmit a reply.

b. Selection Threshold

The transponder **shall** nominally select the antenna connected to the RF port having the stronger signal. To allow for unbalance in the characteristics of the two channels, a transition zone ±3 dB wide is permitted, in which either antenna may be selected.

2.2.13.2 Received Signal Delay Tolerance

If an interrogation is received at either antenna 0.125 microsecond or less in advance of reception at the other antenna, the interrogations **shall** be considered simultaneous and the reply antenna selection criteria **shall** be applied. If an interrogation is received at

either antenna 0.375 microsecond or more in advance of reception at the other antenna, the antenna selected for the reply **shall** be the one which received the earlier interrogation. If the relative time of receipt is between 0.125 and 0.375 microsecond, the transponder **shall** select the reply antenna based on either the simultaneous interrogation criteria or the earlier time of arrival.

2.2.13.3 Diversity Transmission Channel Isolation

The peak RF power transmitted from the selected antenna **shall** exceed the power transmitted from the non-selected antenna by at least 20 dB.

2.2.13.4 Reply Delay of Diversity Transponders

The total difference in mean reply delay between the two antenna channels (including the transponder-to-antenna cables) **shall** not exceed 0.08 microsecond for interrogations of equal amplitude. This requirement is applicable to interrogation signal strengths between MTL +3 dB and MTL +50 dB.

Note: *This requirement limits apparent jitter caused by diversity operation and by cable delay differences. The jitter requirements on each individual channel remain as specified for non-diversity transponders. Control of apparent jitter caused by antenna location is specified in §3.1.6.*

2.3 Equipment Performance – Environmental Conditions

The environmental tests and performance requirements described in this subsection provide a laboratory means of determining the overall performance characteristics of the equipment under conditions representative of those that may be encountered in actual aeronautical operations.

Some of the environmental tests contained in this subsection need not be performed unless the manufacturer wishes to qualify the equipment for that particular environmental condition. These tests are identified by the phrase "When Required." If the manufacturer wishes to qualify the equipment to these additional environmental conditions, then these "when required" tests **shall** be performed.

The test procedures applicable to a determination of equipment performance under environmental test conditions are contained in RTCA Document DO 160E, Environmental Conditions and Test Procedures for Airborne Equipment.

Some of the performance requirements in §2.1 and §2.2 are not tested by the test procedures herein. Moreover, not all tests are required to be done at each of the environmental conditions in RTCA/DO-160E. Judgment and experience have indicated that these particular performance parameters are not susceptible to certain environmental conditions and that the level of performance specified in §2.1 and §2.2 will not be measurably degraded by exposure to these environmental conditions.

Additional tests may have to be performed in order to determine performance of particular design requirements that are not specified in this document. It is the responsibility of the manufacturer to determine appropriate tests for these functions.

Specific transponder performance tests have been included in this section for use in conjunction with the environmental procedures of DO-160E. These tests have been judiciously chosen as a subset of the transponder performance tests of §2.4. Normally, a MOPS document does not provide specific equipment performance tests to be used in conjunction with the environmental procedures of DO-160E. However, there is a sufficiently large number of transponder performance tests in §2.4 that it would be impractical to repeat all of those tests in conjunction with all of the appropriate environmental procedures.

2.3.1 Environmental Test Conditions

Table 2-5 lists all of the environmental conditions and test procedures (hereafter referred to as environmental procedures) that are documented in DO-160E. Table 2-6 lists the subset of transponder performance tests from section §2.4 that are intended to be run subject to the various environmental procedures of DO-160E. In order to simplify the process of relating the environmental procedures to the transponder performance tests, Table 2-5 divides the environmental procedures into groups. All of the procedures in a given group are carried out in conjunction with the same set of transponder performance tests. Using this approach, the environmental procedures fall into six groups. The environmental procedures that apply to all of the sets of transponder performance tests fall into group 1. Group 2 procedures apply to 8 of the sets of transponder performance tests. Groups 3, 4, and 5 apply to 4, 3 and 3 of the sets of transponder performance tests,

respectively. (Group 6, which applies to none of the transponder performance tests, includes only environmental procedures that are intended to determine the effect of the transponder on rack mounting hardware, compass needles, explosive gasses, and other RF hardware.)

Table 2-6 indicates which of the groups of environmental procedures is related to each set of transponder performance tests. Each transponder performance test **shall** be validated under all of the environmental procedures in the groups required for that test as indicated in Table 2-6.

Table 2-5: Environmental Test Groups

	ENVIRONMENTAL CONDITION	DO-160E Paragraph	GROUPS	REMARKS
4a	Temperature	§4.5	1	
4b	Altitude	§4.6.1	4	
4c	Decompression & Overpressure	§4.6.2 - §4.6.3	4	When required
5	Temperature Variation	§5.0	3	
6	Humidity	§6.0	2	
7a	Operational Shock	§7.2	2	When required
7b	Crash Safety	§7.3	6	See Note
8	Vibration	§8.0	3 & 1	3 during: 1 after
9	Explosion	§9.0	6	See Note
10	Waterproofness	§10.0	2	When required
11	Fluids Susceptibility	§11.0	2	When required
12	Sand and Dust	§12.0	2	When required
13	Fungus Resistance	§13.0	2	When required
14	Salt Spray	§14.0	2	When required
15	Magnetic Effect	§15.0	6	See Note
16	Power Input Momentary Interruptions All Others	§16.0	5 3 & 2	3 during: 2 after
17	Voltage Spike	§17.0	2	
18	Audio Freq. Conducted Susceptibility	§18.0	1	
19	Induced Signal Susceptibility	§19.0	1	
20	RF Susceptibility	§20.0	1	
21	Emission of RF Energy	§21.1	6	See Note
22	Lightning Induced Transient Susceptibility	§22.0	none	Procedure not yet defined

Note: *Tests in Group 6 determine the effects of the transponder on other equipment (mounts, compass needles, explosive gasses, and other RF equipment) and therefore do not involve the transponder performance requirements of this document.*

Table 2-6: Performance Test Requirements During Environmental Tests

Test Procedure Paragraph	DESCRIPTION	REQUIRED ENVIRONMENT TEST GROUPS (See Table 2-5)					
		1	2	3	4	5	6
§2.4.2.2 (1)	Transponder Receiver Operating Frequency	X	X	X			
§2.4.2.3 (1), (5)	Receiver Sensitivity and Dynamic Range	X	X	X			
§2.4.3.1	Reply Transmission Frequency	X	X	X	X		
§2.4.3.2	Transponder Power Output	X	X		X		
§2.4.3.4	Reply Rate Capability	X					
§2.4.4.1	Framing Pulses	X					
§2.4.4.2	Information Pulses	X					
§2.4.4.4	Reply Pulse Shape	X					
§2.4.4.6 (1)	Reply Delay and Jitter	X					
§2.4.5.2 (1)	Pulse Position Tolerance	X	X				
§2.4.5.3 (1), (2), (5)	Side Lobe Suppression	X	X				
§2.4.5.4 (1)	Pulse Duration Discrimination	X	X				
§2.4.6.1	Dead Time	X					
§2.4.6.2.1	Desensitization	X					
§2.4.6.2.2	Recovery Note: It is sufficient for environmental tests to just verify that sensitivity has recovered to within 3 dB of MTL after 15 microseconds. It is not necessary to measure the gradual recovery rate.	X					
§2.4.7.1	Random Triggering	X		X		X	
§2.4.8.1 (1)	Manual Self Test	X	X	X	X	X	
§2.4.10.2	Identification	X	X				
§2.4.10.3	Pressure Altitude	X	X				
§2.4.12	Power Interruption	X	X			X	
§2.4.13	Diversity	X	X				

Note: *It is sufficient to test with standard Mode A and Mode C as required for the environmental tests. It is not necessary to include interrogation types that include a P_4 pulse as may be required for some detailed test procedures.*

2.4 Equipment Test Procedures

Compliance with the Minimum Operational Performance Standards contained in Section §2.2 may be demonstrated by a combination of bench tests of the individual system components (or certification thereof by either the manufacturer or the installer) and flight tests of the entire installed system. A suggested procedure which will minimize the need for extensive evaluation in the field is as follows in the paragraphs below.

2.4.1 Definitions of Terms and Conditions of Test (§2.2.1)

The following are definitions of terms and the conditions under which the tests described in this subsection should be conducted.

a. Power Input Voltage – Unless otherwise specified, all tests **shall** be conducted with the power input voltage adjusted to design voltage, plus or minus 2%. The input voltage **shall** be measured at the input terminals of the equipment under test.

b. Power Input Frequency

   1) In the case of equipment designed for operation from an AC source of essentially constant frequency (e.g., 400 Hz), the input frequency **shall** be adjusted to design frequency, plus or minus 2%.

   2) In the case of equipment designed for operation form an AC source of variable frequency (e.g., 300 to 1,000 Hz), unless otherwise specified, tests **shall** be conducted with the input frequency adjusted to within 5% of a selected frequency and within the range for which the equipment is designed.

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

d. Test Equipment – All equipment used in the performance of the tests should be identified by make, model and serial number where appropriate, and its latest calibration date. When appropriate, all test equipment calibration standards should be traceable to national and/or international standards.

e. Test Instrument Precautions – Adequate precautions **shall** be taken during the test to prevent the introduction of errors resulting from the connection of voltmeters, oscilloscopes and other test instruments across the input and output impedances of the equipment under test.

f. Ambient Conditions – Unless otherwise specified, all tests **shall** be made within the following ambient conditions:

   1) Temperature: +15 to +35 degrees C (+59 to +95 degrees F).

   2) Relative Humidity: Not greater than 85%.

   3) Ambient Pressure: 84 to 1-7 kPa (equivalent to +5,000 to –1,500 ft) (+1,525 to –460m).

g. Connected Loads – Unless otherwise specified, all tests **shall** be performed with the equipment connected to loads having the impedance values for which it is designed.

h. Standard Interrogation Test Signals

The nominal interrogation characteristics **shall** be as specified in subparagraph §2.1.10.3.

The signal measurement convention **shall** be as specified in paragraph §2.1.10.2.

General Characteristics

1) Radio Frequency: The carrier frequency of the signal generator for ATCRBS and ATCRBS/Mode S All-Call interrogation **shall** be 1030 ±0.1 MHz.

2) CW Output: The CW output between pulses **shall** be at least 50 dB below the peak level of the pulse.

3) Pulse Rise and Fall Time: Rise and fall times **shall** be as specified in §2.1.10.3.

Note: Unless otherwise indicated, interval measurements are measured between half voltage points of the respective pulses as detected by a linear detector.

4) Pulse Top Ripple: The instantaneous amplitude of the pulses **shall** not fall more than l dB below the maximum value between the 90 percent voltage amplitude point on the leading and trailing edge of the pulse.

5) Signal Level: Unless otherwise noted in the measurement procedure, the signal level **shall** be -60 ±3 dBm.

6) Interrogation Repetition Rate: Unless otherwise noted in the measurement procedure, interrogation rates **shall** be 450 ±25 Hz.

2.4.2 Verification of Receiver Characteristics (§2.2.2)

2.4.2.1 Verification of Interrogation Tolerances (§2.2.2.1)

Purpose/Introduction:

Paragraph §2.1.10 and its subparagraphs define a number of deviations allowed in the interrogation values. The transponder **shall** be tolerant to all such deviations within the ranges specified in §2.1.10.

Measurement Procedures:

The transponder's acceptance of the tolerances specified in §2.1.10 is tested in various test procedures throughout §2.4.

2.4.2.2 Verification of Transponder Receiver Operating Frequency and Bandwidth (§2.2.2.2)

Purpose/Introduction:

a. The receiver nominal center frequency **shall** be 1030 MHz.

b. With an input signal level 3 dB above the minimum triggering level, the receiver bandwidth **shall** be such that the receiver accepts pulses as outlined in §2.1.10 with an interrogation center frequency drift of ± 0.2 MHz.

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

Measurement Procedures:

(1) Interrogate the transponder at 500 interrogations per second with a Mode A interrogation signal. Vary the RF signal frequency over the range 1029.8 to 1030.2 MHz Determine the variation in RF signal level required to produce 90 percent transponder reply efficiency. Also determine the required maximum RF signal level.

(2) Interrogate the transponder at 500 interrogations per second with a Mode A interrogation signal. Determine the interrogation signal level (MTL) which results in a transponder reply rate of 450. Set the interrogation frequency to 1055 and 1005 MHz and verify that the transponder sensitivity is at least 60 dB below the MTL level measured at nominal frequency in both cases.

2.4.2.3 Verification of Receiver Sensitivity and Dynamic Range (§2.2.2.3)

Purpose/Introduction:

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

(1) The two pulses P_1 and P_3 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 69 and 77 dB below 1 milliwatt.

Note: *For this MTL requirement, a nominal 3 dB transmission line loss and an antenna performance equivalent to that of a simple quarter wave antenna are assumed. In the event these assumed conditions do not apply, the MTL of the installed transponder system must be comparable to that of the assumed system.*

b. The variation of the minimum triggering level between modes **shall not** exceed 1 dB for nominal pulse spacings and pulse widths.

c. The reply characteristics **shall** apply over a received signal amplitude range between minimum triggering level and 50 dB above minimum triggering level.

d. The reply ratio **shall** not be more than 10 percent for interrogations at signal levels below -81 dBm.

e. The conditions of "a" through "d" apply when a P_4 pulse is present, either long or short, regardless of amplitude of the P_4 pulse.

Measurement Procedures:

(1) Interrogate the transponder with a standard Mode A interrogation at a repetition rate of 500 interrogations per second. Adjust P_1 and P_3 equal in amplitude (no P_2 pulse) and apply a signal level known to be below minimum triggering level. Increase the signal generator output level until the transponder reply rate is 450 replies per second. This is the transponder minimum triggering level (MTL). The installed system MTL (including transmission line loss) should be between 69 and 77 dB below 1 milliwatt.

EXAMPLE:		
	Transponder MTL	-74 dBm
	Transmission Line Loss	3 dB
	System MTL	-71 dBm

(2) Repeat step (1) above using a standard Mode C interrogation. The variation in MTL between steps (1) and (2) should not exceed 1 dB.

(3) Repeat steps (1) and (2) above and include both a narrow and wide P_4 pulse at the nominal position, equal in amplitude to P_1 and P_3.

(4) Interrogate the transponder with a standard Mode A interrogation at a repetition rate of 500 interrogations per second. Adjust the RF signal level between MTL +3 dB and -21 dBm in 5 dB increments and determine the reply ratio. Repeat with both a narrow and wide P_4 pulse at the nominal position, equal in amplitude to P_1 and P_3.

(5) Repeat step (4) with a Mode C interrogation.

(6) Interrogate the transponder with a standard Mode A interrogation at an RF level of -81 dBm. Determine reply ratio and verify that the reply ratio is 10 percent or less.

2.4.3 Verification of Transmitter Characteristics (§2.2.3)

2.4.3.1 Verification of Reply Transmission Frequency (§2.2.3.1)

Purpose/Introduction:

The center frequency of the reply transmission **shall** be 1090 ±3 MHz.

Measurement Procedures:

Set transponder Mode A code to 7777. Interrogate the transponder with a Mode A interrogation and verify that the reply frequency is 1090 ±3 MHz.

2.4.3.2 Verification of Transponder Power Output (§2.2.3.2)

2.4.3.2.1 Verification of Transponder Power Output for Class A Equipment

Purpose/Introduction:

For this class of equipment, the peak pulse power available at the antenna end of the transmission line of the transponder **shall** be at least 21 dB and not more than 27 dB above 1 watt at any reply rate up to 1,200 per second for a 15-pulse coded reply.

Measurement Procedures:

Transponder power output may be determined with a dummy load and power meter which are suitable for use at 1090 MHz.

Set the transponder for a 15-pulse reply (code = 7777 + SPI). Interrogate the transponder with a standard Mode A interrogation and measure the single pulse having the least RF power output. While varying the interrogation rate from 100 interrogations per second to the maximum interrogation rate specified for the transponder, determine that the power output meets the requirements of §2.2.3.2.1.

2.4.3.2.2 Verification of Transponder Power Output for Class B Equipment

Purpose/Introduction:

For this class of equipment, the peak pulse power-available at the antenna end of the transmission line of the transponder **shall** be at least 18.5 dB and not more than 27 dB above 1 watt at any reply rate up to 1,000 per second for a 15-pulse coded reply.

Measurement Procedures:

Transponder power output may be determined with a dummy load and power meter which are suitable for use at 1090 MHz.

Set the transponder for a 15-pulse reply (code = 7777 + SPI). Interrogate the transponder with a standard Mode A interrogation and measure the single pulse having the least RF power output. While varying the interrogation rate from 100 interrogations per second to the maximum interrogation rate specified for the transponder, determine that the power output meets the requirements of §2.2.3.2.2.

2.4.3.3 Verification of Unwanted Output Power (§Error! Reference source not found.)

Purpose/Introduction:

When the transponder transmitter is in the inactive state, the RF output power at 1090 ±3 MHz at the terminals of the antenna **shall not** exceed -50 dBm. The inactive state is defined to include the entire period between ATCRBS and/or Mode S transmissions less

10-microsecond transition periods, if necessary, preceding and following the extremes of the transmission.

Measurement Procedures:

With no interrogations, measure the RF output power and verify that it does not exceed -50 dBm.

2.4.3.4 Verification of Reply Rate Capability (§2.2.3.4)

Purpose/Introduction:

a. For Class A equipment (see §1.4), the transponder **shall** be capable of at least 1,200 replies per second for a 15-pulse coded reply.

b. For Class B equipment (see §1.4), the transponder **shall** be capable of at least 1,000 replies per second for a 15-pulse coded reply.

Measurement Procedures:

Set the transponder for a 15-pulse ATCRBS reply. For Class A equipment, interrogate the transponder with a Mode A signal at a constant rate of 1,200 interrogations per second. For Class B equipment, interrogate the transponder with a Mode A signal at a constant rate of 1,000 interrogations per second. Verify that the reply efficiency is not less than 90%.

2.4.3.5 Verification of Sensitivity Reduction Reply Rate Control (§2.2.3.5)

Purpose/Introduction:

A sensitivity-reduction reply rate limit **shall** be incorporated in the transponder for ATCRBS replies. The limit **shall** be capable of being adjusted between 500 continuous ATCRBS Mode A and Mode C replies per second and the maximum continuous rate of which the transponder is capable, or 2000 replies per second, whichever is less, without regard to the number of pulses in each reply.

Measurement Procedure:

Set the transponder's Mode C code to 0000 and its Mode A code to any value other than 0000. Interrogate the transponder with the sum of:

a) a Mode C interrogation 20 dB above MTL at a continuous rate equal to the reply rate limit determined in Step 1, and

b.) a second unsynchronized Mode A interrogation 3 dB above MTL at a continuous rate equal to 50% of the reply rate limit determined in Step 1.

Verify that the transponder replies to at least 90% of the interrogations at the signal level 20 dB above MTL and that it does not reply to more than 10% of the interrogations at the signal level 3 dB above MTL.

2.4.4 Verification of Reply Pulse Characteristics (Signals in Space) (§2.2.4)

The reply transmission characteristics can be determined with a demodulating probe and a wide band oscilloscope comparing the reply pulse group waveform against an accurate timing waveform such as from a crystal oscillator.

2.4.4.1 Verification of Framing Pulses (§2.2.4.1)

Purpose/Introduction:

The reply function **shall** employ a signal comprising two framing pulses spaced 20.3 microseconds, as the most elementary code.

Measurement Procedures:

With the transponder interrogated on Mode A and replying on Code 0000, the time interval between the 0.5 amplitude points on the leading edges of the two framing pulses should be within 20.3 ±0.10 microseconds.

2.4.4.2 Verification of Information Pulses (§2.2.4.2)

Purpose/Introduction:

Information pulses **shall** be spaced in increments of 1.45 microseconds from the first framing pulse. The designation and position of these information pulses **shall** be as shown in Table 2-3.

Measurement Procedures:

With the transponder replying on Code 7777, the time interval between the 0.5 amplitude points on the leading edge of each pulse, including the last framing pulse, with respect to the first framing pulse should be equal to that listed in §2.2.4.2 with a tolerance of ±0.1 microsecond. Also, the time interval from any pulse, in the reply group, with respect to any other pulse, except the first framing pulse, should not exceed ±0.15 microsecond.

2.4.4.3 Verification of Special Position Identification (SPI) Pulse (§2.2.4.3)

Purpose/Introduction:

In addition to the information pulses provided, a Special Position Identification (SPI) Pulse, which may be transmitted with the information pulses, **shall** occur at a pulse interval of 4.35 microseconds following the last framing pulse.

The SPI pulse **shall** be initiated by an IDENT switch (see §2.1.7.d). Upon activation of the IDENT switch, the SPI pulse **shall** be transmitted for a period of between 15 and 30 seconds and must be capable of being reinitiated at any time. The SPI pulse **shall not** be included when transmitting Mode C replies.

Measurement Procedures:

(1) With the transponder replying with the SPI pulse, the time interval between the 0.5 amplitude points on the leading edge of the second framing pulse and the SPI pulse should be 4.35 ±0.10 microseconds.

(2) Interrogate the transponder with a Mode A interrogation signal. With the transponder operating, manually initiate the SPI pulse and verify that the transmission time of the SPI pulse is between 15 and 30 seconds, and that it can be re-initiated immediately.

(3) While interrogating the transponder with a Mode C interrogation, manually activate the SPI pulse and verify that there is no SPI pulse in the reply.

2.4.4.4 Verification of Reply Pulse Shape (§2.2.4.4)

Purpose/Introduction:

All reply pulses **shall** have pulse duration of 0.45 ±0.10 microseconds, a pulse rise time between 0.05 and 0.1 microseconds, and a pulse decay time between 0.05 and 0.2 microseconds. The pulse amplitude variation of one pulse with respect to any other pulse in a reply group **shall not** exceed 1 dB.

Measurement Procedures:

With the transponder replying with Code 7777 and the SPI pulse activated, verify the following reply pulse characteristics:

The duration of each reply pulse, as measured between the 0.5 amplitude points on the leading and trailing edge, should be between 0.35 and 0.55 microseconds.

The rise time of each reply pulse, as measured between the 0.1 amplitude and 0.9 amplitude points on the leading edge should be between 0.05 and 0.10 microseconds.

The decay time of each reply pulse, as measured between the 0.9 amplitude and 0.1 amplitude points on the trailing edge should be between 0.05 and 0.20 microseconds.

The amplitude variation of anyone pulse as measured with respect to any other pulse in a reply group should not exceed 1 dB.

Note: *The fundamental requirements of sideband radiation can be met either as described above or by determining that the actual sideband radiation is no greater than that which theoretically would be produced by a trapezoidal wave having 0.05 microsecond rise and decay times and a 0.35 microsecond pulse duration.*

2.4.4.5 Verification of Reply Pulse Interval Tolerances (§2.2.4.5)

Purpose/Introduction:

The pulse interval tolerance for each pulse (including the last framing pulse) with respect to the first framing pulse of the reply group **shall** be ±0.10 microseconds. The pulse interval tolerance of the Special Position Identification Pulse with respect to the last framing pulse of the reply group **shall** be ±0.10 microseconds. The pulse interval tolerance of any pulse in the reply group with respect to any other pulse (except the first framing pulse) **shall not** exceed ±0.15 microseconds.

Measurement Procedures:

These requirements are tested in test procedures §2.4.4.1, §2.4.4.2 and §2.4.4.3.

2.4.4.6 Verification of Reply Delay and Jitter (§2.2.4.6)

Purpose/Introduction:

The time delay between the arrival at the transponder of the leading edge of P_3, and the transmission of the leading edge of the first pulse of the reply **shall** be 3 ±0.5 microseconds. The total jitter of the reply pulse code group with respect to P_3 **shall not** exceed ±0.1 microsecond. Delay variations between modes on which the transponder is capable of replying **shall not** exceed 0.2 microseconds. These requirements apply for receiver input levels between 3 and 50 dB above minimum triggering level.

Measurement Procedures:

(1) Interrogate the transponder with a Mode A signal. Measure the time interval between the 50% voltage point of the leading edge of P_3 and the 50% voltage point of the leading edge of the first framing pulse at the antenna terminal. Vary the interrogation RF level from 3 to 50 dB above MTL. Verify that the delay is within the limits of 3 ±0.5 microseconds. Verify that the jitter from the leading edge of P_3 to the leading edge of the first framing pulse does not exceed ±0.1 microsecond.

(2) Repeat step (1) using a Mode A-Only All-Call interrogation.

(3) Repeat steps (1) and (2) for Mode C interrogation types. Verify that the delay variation between all modes does not exceed 0.2 microseconds.

2.4.5 Verification of Decoding Performance (§2.2.5)

2.4.5.1 Verification of Pulse Level Tolerances (§2.2.5.1)

Purpose/Introduction:

When selected to reply to a particular interrogation mode (See §2.1.10.3.2), the transponder **shall** reply (not less than 90 percent efficiency) under each of the following conditions:

a. The received amplitude of P_3 is in excess of a level 1 dB below the received amplitude of P_1 but no greater than 3 dB above the received amplitude of P_1.

b. The received amplitude of a proper interrogation is more than 10 dB above the received amplitude of random pulses where the latter are not recognized by the transponder as P_1, P_2, or P_3.

c. The conditions of "a" and "b" apply when a P_4 pulse is present, either long or short, regardless of amplitude of the P_4 pulse.

Measurement Procedures:

Interrogate the transponder with a Mode A signal at a repetition rate of 500 interrogations per second and with a level 3 dB above the receiver minimum triggering level.

(1) Using the nominal pulse interval between P_1 and P_3 for Mode A, vary the amplitude of P_3 between 1 dB below and 3 dB above the amplitude of P_1. Note the lowest reply rate obtained. Repeat this step for Mode C.

(2) Repeat step (1) for P_1 amplitudes of 10, 25, and 50 dB above the minimum triggering level.

(3) Combine the interrogation signal with a non-synchronous 0.8 microsecond pulses at 5000 Hz and at an RF level 10 db below that of P1 and P3 and repeat step (1) above.

The reply rates obtained in each case above should be at least 450 replies per second.

2.4.5.2 Verification of Pulse Position Tolerance (§2.2.5.2)

Purpose/Introduction:

The transponder **shall** accept interrogations as valid if the spacing between P_1 and P_3 is within ±0.2 microsecond of the nominal spacing.

The transponder **shall not** reply to more than 10 percent of the interrogations under each of the following conditions:

a. To interrogations when the interval between pulses P_1 and P_3 differs from that defined in §2.1.10.3.2 for the mode selected in the transponder by more than ±1 microsecond.

b. receipt of any single pulse which has no amplitude variations approximating a normal interrogation condition.

Measurement Procedures:

(1) Interrogate the transponder with interrogation pulse signals for Mode A and C, at a repetition rate of 500 interrogations per second and with a signal level 3 dB above the receiver minimum triggering level. In the absence of P_2 pulses, slowly adjust the interval between P_1 and P_3 from 7.8 microseconds to 8.2 microseconds and from 20.8 microseconds to 21.2 microseconds, respectively, and note the reply rate in each case.

(2) Adjust the interval between P_1 and P_3 to 7.0, 9.0, 20.0 and 22.0 microseconds, respectively. Note the reply rate in each case. The reply rate should be no more than 50 replies per second.

(3) Repeat steps (1) and (2) for amplitudes of 10, 25, and 50 dB above the minimum triggering level.

Note: *The requirement in §2.2.5.2.b is tested in test procedure §2.4.5.4, Step (3).*

2.4.5.3 Verification of Suppression (§2.2.5.3)

Purpose/Introduction:

Upon receipt of an interrogation complying with the interrogation modes defined in §2.1.10.3 selected manually or automatically, the transponder **shall** be suppressed (not less than 99% efficiency) when the received amplitude of P_2 is equal to or in excess of the received amplitude of P_1 and spaced 2 ±0.15 microseconds.

Notes:

1. *It is not the intent of this paragraph to require the detection of P_3 as a prerequisite for initiation of suppression action.*

2. *After reception of a valid P_3 pulse the transponder should not initiate suppression based on the reception of a P_4 pulse.*

a. The transponder suppression **shall** be for a period of 35 ±10 microseconds.

b. The suppression **shall** be capable of being reinitiated for the full duration within two microseconds after the end of any suppression period.

c. The transponder **shall not** initiate suppression if the level of P_1 exceeds the level of P_2 by 9 dB or more.

d. The transponder **shall not** initiate suppression if no pulse is received at the position 2.0 ±0.7 microseconds following P_1.

e. The transponder **shall not** initiate suppression if the duration of P_2 is less than 0.3 microseconds.

Measurement Procedures:

Interrogate the transponder with Mode A interrogation at a repetition rate of 500 interrogations per second and at a signal level of 3 dB above receiver MTL.

(1) Adjust P_2 equal in amplitude to P_1 while varying spacing from 1.85 to 2.15 microseconds and note the reply rate. Repeat with P_2 adjusted to 10 dB greater than P_1 and note the reply rate. Both rates should be no greater than 5 replies per second.

(2) Increase the signal level of P_1 and P_3 20 dB, with P_3 equal in amplitude to P_1 and with P_2 set to an amplitude 9 dB below that of P_1 and P_3. Vary the interval of P_2 from 1.85 to 2.15 microseconds with respect to P_1 and verify 90% or more reply rate.

(3) With the signal level of P_1 and P_3 set as in step (2), set the level of P_2 equal in amplitude to P_1 and P_3. Set the spacing of P_2 at 1.3 and 2.7 microseconds respectively with respect to P_1 and verify 90% or more reply rate.

(4) With the signal level of P_1, P_2 and P_3 as in step (3), set the width of the P_2 pulse to 0.3 microseconds. With the P_2 pulse in the nominal position, and verify 90% or more reply rate.

(5) Disable P_3 and readjust P_2 equal in amplitude to P_1 and at nominal spacing. Using a second signal source (set to at least 3 dB above the receiver MTL) with the interrogation rate synchronized with the first but delayed more than 50 microseconds, interrogate the transponder on Mode A. Gradually shorten the delay until no replies are received from the second interrogation source. Verify that the interval between P_2 of the first signal source and P_1 of the second signal source is between 25 and 45 microseconds.

(6) Increase the delay time of the second interrogation source by 2 microseconds from that at which no replies were received in step (1) above. There should be at least 450 replies per second from the second interrogation source. Insert a P_2 into the second interrogation source equal in amplitude to P_1. Verify that the reply rate from the second interrogation source does not exceed 5 replies per second.

2.4.5.4 Verification of Pulse Duration Discrimination (§2.2.5.4)

Purpose/Introduction:

a. For all signal levels from MTL to -45 dBm, the transponder **shall** reply to no more than 10 percent of ATCRBS, ATCRBS-Only All-Call or ATCRBS/Mode S All-Call interrogations if the duration of either the P1 or the P3 pulse is less than 0.3 microseconds. .

b. With the exception of single pulses with amplitude variations approximating an interrogation, any single pulse of duration more than 1.5 microseconds **shall not** cause the transponder to initiate reply or suppression action over the signal amplitude range of minimum triggering level to 50 dB above minimum triggering level.

Measurement Procedures:

(1) Interrogate the transponder with Mode A interrogations at a repetition rate of 500 interrogations per second. Adjust P_1 and P_3 (no P_2 pulse) to a width of 0.3 microseconds and set the RF level to minimum triggering level. The reply efficiency should not exceed 10%. Repeat for signal levels between MTL and -45 dBm in 5 dB steps.

(2) Interrogate the transponder with a single input pulse at 1030 MHz. Vary the pulse width of the interrogation signal from 1.5 to 22 microseconds at input signal levels of 3, 10, 25, and 50 dB above MTL. At each input signal, verify that the transponder does not reply to, and/or is not suppressed by, the interrogation signal.

Note: *Pulse duration discrimination for the P_2 pulse is tested in §2.4.5.3 (4).*

2.4.5.5 Verification of Compatibility with TCAS ATCRBS Surveillance (§2.2.5.5)

Purpose/Introduction:

With P_1 at MTL and S_1 at MTL -6 dB, the transponder **shall** reply to ATCRBS interrogations at least 90 % of the time.

With P_1 at MTL and S_1 at MTL -3 dB, the transponder **shall** reply to ATCRBS interrogations at least 70 % of the time.

With P_1 at MTL and S_1 at MTL, the transponder **shall** reply to no more than 10% of ATCRBS interrogations.

Measurement Procedures:

a. Interrogate the transponder with a Mode A interrogation, having P_1 at MTL. Inject an S_1 pulse ahead of a P_1 pulse at MTL -6 dB. Verify at least 90% reply rate efficiency.

b. Continue the interrogation as in part "a" above. Set the level of S_1 to MTL -3 dB and verify at least 70% reply rate efficiency.

c. Continue the interrogation as in part "a" above. Set the level of S_1 to MTL and verify reply rate efficiency of not more than 10%.

2.4.6 Verification of Desensitization and Recovery Characteristics (§2.2.6)

2.4.6.1 Verification of Dead Time (§2.2.6.1)

Purpose/Introduction:

After reception of a valid interrogation, the transponder **shall not** reply to any other interrogation at least for the duration of the reply pulse train. This dead time **shall** end no later than 125 microseconds after the transmission of the last reply pulse of the group.

Measurement Procedures:

In the absence of P_2 pulses, interrogate the transponder on Mode A at a repetition rate of 500 interrogations per second and at a signal level at least 3 dB above the receiver minimum triggering level. Using a second signal source (set to a comparable output level) with the interrogation rate synchronized with the first but delayed more than 150 microseconds, interrogate the transponder on Mode C. Gradually shorten the delay until the replies to the Mode C interrogations disappear. Note the interval between the last pulse of the Mode A reply and the first framing pulse of the Mode C reply. The interval should be between 0 and 125 microseconds.

2.4.6.2 Verification of Echo Suppression and Recovery (§2.2.6.2)

2.4.6.2.1 Verification of Desensitization (§2.2.6.2.1)

Purpose/Introduction:

Upon receipt of any pulse more than 0.7 microseconds in duration, the receiver **shall** be desensitized by an amount that is within at least 9 dB of the amplitude of the desensitizing pulse, but **shall** at no time exceed the amplitude of the desensitizing pulse, with the exception of possible overshoot during the first microsecond following the desensitizing pulse. Single pulses of duration less than 0.7 microseconds are not required to cause the specified desensitization, and **shall not** cause desensitization of duration greater than that permitted herein or by §2.2.6.2.2.

Measurement Procedures:

Interrogate the transponder with Mode A interrogation pulse signals at a repetition rate of 500 interrogations per second. Precede P_1 by 2.8 microseconds with a single 0.8 microsecond wide pulse at a signal level of 50 dB above the receiver minimum triggering level. Adjust P_1 and P_3 equal in amplitude and increase the output to a level causing a reply rate of 450 replies per second. This level should be between 34 and 43 dB above the receiver minimum triggering level.

2.4.6.2.2 Verification of Recovery (§2.2.6.2.2)

Purpose/Introduction:

Following desensitization, the receiver **shall** recover sensitivity (within 3 dB of MTL) within 15 microseconds after reception of a desensitizing pulse having a signal strength up to 50 dB above MTL. Recovery **shall** be nominally linear at an average rate not exceeding 4.0 dB per microsecond.

Measurement Procedures:

Note the signal levels required to just maintain 450 replies per second as the interval between the 0.8 microsecond pulse and P_1 is gradually increased. Also note that the average rate does not exceed 4.0 dB per microsecond as the signal level and interval is changed to just maintain the 450 pulses per second reply rate. At an interval of 15 microseconds, verify that the sensitivity returns to at least MTL +3 dB.

Note: *An interval corresponding to a normal Mode A interrogation and a side lobe interrogation is excluded.*

2.4.7 Verification of Undesired Replies (§2.2.7)

2.4.7.1 Verification of Random Triggering and Suppression Rate (§2.2.7.1)

Purpose/Introduction:

In the absence of valid interrogation signals, the random triggering rate (squitter) of the transponder **shall not** exceed 30 replies and/or suppressions per second as integrated over an interval equivalent to at least 300 random triggers, or 30 seconds, whichever is less.

Measurement Procedures:

Non-Interference Environment

Set up test equipment to count reply transmissions from the transponder. While not interrogating the transponder, count the number of replies for a minimum of one minute.

2.4.7.2 Verification of Random Triggering in the Presence of CW (§2.2.7.2)

Purpose/Introduction:

The total random triggering on all Mode A and/or Mode C replies **shall not** exceed 10 replies or suppressions per second, averaged over a period of 30 seconds, when operated in the presence of non-coherent CW interference at a frequency of 1030 ±0.2 MHz and a signal level of –60 dBm, or less.

Measurement Procedure:

Random Trigger Rate

Repeat the procedure provided in §2.4.7.1 while injecting non-coherent CW interference at a frequency of 1030 ±0.2 MHz at a signal level of -60 dBm.

Count the number of replies for a minimum of one minute and verify that the reply rate does not exceed the specified limits.

2.4.8 Verification of Transponder Self-Test and Monitor (§2.2.8)

2.4.8.1 Verification of Manual Self-Test (§2.2.8.1)

Purpose/Introduction:

a. When a manual self-test device is provided, it **shall** be limited to intermittent use by a spring loaded return-to-off switch, or equivalent.

b. The test interrogation rate **shall** not exceed 450 per second.

c. The lowest RF level at the input to the antenna required to accomplish the test **shall** be used. The maximum RF level at the input to the antenna **shall not** exceed 40 dB below 1 milliwatt.

Measurement Procedures:

(l) Self-Test Interrogation/Reply Rate

With equipment connected to the transponder for the purpose of detecting and counting reply rate, activate the self-test function (if provided) of the transponder under test and determine the reply rate to the self-test interrogation.

(2) Self-Test Interrogation Level

With equipment connected to the transponder for the purpose of measuring transmit power, activate the self-test function (if provided) of the transponder under test and determine that the transmit power is within the required limits.

2.4.8.2 Verification of Automatic Self-Test (§2.2.8.2)

Purpose/Introduction:

a. When an automatic self-test device is provided, it **shall** be limited to use only in the absence of a valid interrogation. (A minimum period of 15 seconds will be sufficient to establish the absence of ground interrogations).

b. The maximum test time for the automatic self-test **shall** not exceed 0.1 second in any given 15-second interval.

c. The test interrogation rate **shall** not exceed 450 per second.

d. The lowest RF level at the input to the antenna required to accomplish the test **shall** be used. The maximum RF level at the input to the antenna **shall not** exceed 40 dB below 1 milliwatt.

Measurement Procedures:

(1) Interrogate the transponder at a nominal interrogation rate of 100 interrogations per second. Stop the interrogations and, using a timing device (such as an oscilloscope) and a suitable RF detector at the transponder output, verify that no test transmissions occur for a period of 15 seconds after the interrogations cease.

(2) With no external interrogations, observe the output of the RF detector and verify that the automatic self-test transmissions do not occur for more than 0.1 second in any given 15 second interval.

(3) The test interrogation rate may be measured on the bench using a suitable detector and counter. The interrogation rate averaged over a five second interval should not exceed 450 interrogations per second.

(4) The test signal level may be measured at the antenna end of the transmission line in the actual aircraft, or on the bench using a length of transmission line equal to that in the airplane. One way to measure the level is to adjust a second test transponder to just trigger at the prescribed radiation limit. Connect this test transponder to the transmission line and determine if it is triggered when the self-testing device of the first transponder is operated.

Note: *Due to the close proximity of the units and because of the high signal level, the transmitter of the first transponder should be disabled. A calibrated attenuator should be placed in the transmission line between the transponders to prevent receiver damage.*

2.4.9 Verification of Response to Mutual Suppression Pulses (§2.2.9)

Purpose/Introduction:

The equipment **shall** accept and respond to suppression pulses from other electronic equipment in the aircraft (to disable it while the other equipment is transmitting), the equipment **shall** regain normal sensitivity within 3 dB, not later than 15 microseconds after the end of the applied suppression pulse.

Measurement Procedures:

Interrogate the transponder with a Mode A interrogation at an RF level of 3 dB above minimum triggering level. Inject a suppression pulse into the transponder with a pulse width of 35 microseconds. Position the leading edge of the suppression pulse at the 50% amplitude point so that it precedes the leading edge of P_1 by 2.0 microseconds. Verify that no reply is generated by the transponder.

Delay the interrogation so the leading edge of P_1 occurs 15 microseconds after the end of the suppression pulse. Verify that the transponder replies to the interrogation.

2.4.10 Verification of Data Handling and Interfaces (§2.2.10)

2.4.10.1 Verification of Code Nomenclature (§2.2.10.1)

Purpose/Introduction:

The code designations **shall** consist of four digits, each of which lies between 0 and 7 inclusive, and is determined by the sum of the pulse subscripts given in Table 2-3, employed as shown in Table 2-4.

Measurement Procedures:

These requirements are tested in the test procedure in §2.4.10.2.

2.4.10.2 Verification of Identification (§2.2.10.2)

Purpose/Introduction:

The 4096 codes specified in §2.1.10.1 **shall** be manually selectable for reply to interrogations on Mode A.

Measurement Procedures:

Interrogate the transponder with a standard ATCRBS Mode A interrogation. Set identification codes which should result in the setting of each of the identification reply bits one at a time. Verify proper positioning of these bits in the reply.

2.4.10.3 Verification of Pressure Altitude Transmissions (§2.2.10.3)

Purpose/Introduction:

a. Independently of the other modes and codes manually selected, the transponder **shall** automatically reply to Mode C interrogations.

b. The reply to Mode C interrogations **shall** consist of the two framing pulses together with the information pulses specified in §2.2.4.2.

c. The transponders **shall** be provided with means to remove the information pulses, but to retain the framing pulses when the provision of subparagraph "f" below is not complied with, in reply to Mode C interrogation.

Note: *The information pulses should be capable of being removed either in response to a failure detection system or manually at the request of the controlling agency.*

d. The information pulses **shall** be automatically selected by an analog-to-digital converter connected to a pressure-altitude data source in the aircraft referenced to the standard pressure setting of 29.92 inches of mercury.

e. Pressure altitude **shall** be reported in 100-foot increments by selection of pulses as shown in Appendix A. If the transponder is capable of accepting altitude sources with 25-foot or better resolution, the pressure altitude-information **shall** be reported in the closest 100-foot increment as specified in Appendix A.

f. The digitizer code selected **shall** correspond to within ±125 feet, on a 95 percent probability basis with the pressure altitude information (referenced to the standard pressure setting of 29.92 inches of mercury) used on board the aircraft to adhere to the assigned flight profile.

Measurement Procedures:

(a) Transponder response to Mode C interrogations may be monitored with a demodulator probe and an oscilloscope. A Mode C reply without the digitizer connected to the transponder should consist of the two framing pulses F1 and F2.

(b) The altitude reporting switch in the "off" position should prevent the transmission of digitizer information pulses but not the transmission of the framing pulses.

(c) If a digitizer is connected to the transponder, the information pulses will appear in accordance with the pattern represented in Appendix A.

2.4.11 Verification of Antennas (§2.2.11)

No test procedures are provided herein to verify the requirements of §2.2.11. Appropriate test procedures are the responsibility of the manufacturer.

2.4.12 Verification of Power Interruption (§2.2.12)

Purpose/Introduction:

The transponder equipment **shall** regain operational capability to within its operational limits within two seconds after the restoration of power following a momentary power interruption.

Note: *The transponder equipment is not required to continue operation during momentary power interruptions.*

Measurement Procedures:

Apply a momentary power interruption to the transponder. Interrogate the transponder with a standard Mode A interrogation at a power level equal to 3 dB above the minimum triggering level. Verify that the transponder is able to reply with at least 90% reply efficiency two seconds after power is restored.

2.4.13 Verification of Diversity (§2.2.13)

Purpose/Introduction:

Diversity transponders may be implemented for the purpose of improving surveillance performance. 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.

Diversity Antenna Selection and Selection Threshold

a. Diversity Antenna Selection

Antenna selection **shall** be automatic. The transponder **shall** select one of the two antennas on the basis of the relative strengths of the detected interrogation signals, provided that both channels simultaneously receive a valid identical interrogation or pulse pair. Antenna selection and switching may occur after the receipt of the P_3 pulse of a P_1 - P_3 pulse pair, indicating an ATCRBS or ATCRBS/Mode S All-Call interrogation.

The selected antenna **shall** be used, if necessary, to transmit a reply.

b. Selection Threshold

The transponder **shall** nominally select the antenna connected to the RF port having the stronger signal. To allow for unbalance in the characteristics of the two channels, a transition zone ±3 dB wide is permitted, in which either antenna may be selected.

Received Signal Delay Tolerance

If an interrogation is received at either antenna 0.125 microsecond or less in advance of reception at the other antenna, the interrogations **shall** be considered simultaneous and the reply antenna selection criteria **shall** be applied. If an interrogation is received at either antenna 0.375 microsecond or more in advance of reception at the other antenna, the antenna selected for the reply **shall** be the one which received the earlier interrogation. If the relative time of receipt is between 0.125 and 0.375 microsecond, the transponder **shall** select the reply antenna based on either the simultaneous interrogation criteria or the earlier time of arrival.

Diversity Transmission Channel Isolation

The peak RF power transmitted from the selected antenna **shall** exceed the power transmitted from the non-selected antenna by at least 20 dB.

Reply Delay of Diversity Transponders

The total difference in mean reply delay between the two antenna channels (including the transponder-to-antenna cables) **shall** not exceed 0.08 microsecond for interrogations of equal amplitude. This requirement is applicable to interrogation signal strengths between MTL +3 dB and MTL +50 dB.

Note: *This requirement limits apparent jitter caused by diversity operation and by cable delay differences. The jitter requirements on each individual channel remain as specified for non-diversity transponders. Control of apparent jitter caused by antenna location is specified in §3.1.6.*

Equipment Required:

Two means of generating identical ATCRBS interrogations that can be delayed from each other from 125 to 375 nanoseconds. These two generators must also have independent control of power level.

Means of determining the antenna terminal that generates the reply.

Means of determining the reply power level on both antennas simultaneously.

Means of determining reply delay for each channel and between channels.

Measurement Procedures:

Note: *Because the specifications for diversity operations are symmetrical in all respects, channels are arbitrarily designated A and B.*

(1) Single Channel Test (See §2.2.13.3 and §2.2.13.4)

When measuring channel A and B parameters take care that any cables used for measurements are of equal length and equal loss. Interrogate channel A only, while monitoring channel A and B. At signal level MTL +3 dB use the following types of interrogations and record the listed observations:

ATCRBS Mode A.
ATCRBS Mode C.

For signal levels of -50 dBm and -21 dBm use an ATCRBS Mode C and record the listed observations.

Observe: Correct reply ratio.
Correct reply channel.
Power level of replies from channel A (§2.2.13.3).
Power level of replies from channel B (§2.2.13.3).

Record: Reply delay for each interrogation signal type and for the signal levels as specified.

Repeat the above test reversing channels.
Compare records of reply delays for conformance with §2.2.13.4.

(2) Selection Test (See §2.2.13.1)

Synchronize the interrogations to channels A and B so that they are 0.125 +0.00/-0.04 microseconds apart where channel A is first.

Use an ATCRBS Mode C at a power level on channel A of MTL and a power level on channel B of MTL +3 dB.

Observe that 90 percent of the replies are on channel B.

Use an ATCRBS Mode C at a power level on channel A of MTL +3 dB and a power level on channel B of MTL.

Observe that 90 percent of the replies are on channel A.

Synchronize the interrogations to channels A and B so that they are 0.125 +0.00/-0.04 microseconds apart where channel B is first.

Use an ATCRBS Mode C at a power level on channel A of MTL and a power level on channel B of MTL +3 dB.

Observe that 90 percent of the replies are on channel B.

Use an ATCRBS Mode C at a power level on channel A of MTL +3 dB and a power level on channel B of MTL.

Observe that 90 percent of the replies are on channel A.

(3) Delay-Selection Test (See §2.2.13.2)

Synchronize the interrogations to channels A and B so that they are 0.375 +.040/-0.00 microseconds apart where channel A is first.

Use an ATCRBS Mode C at a power level on channel A of MTL +3 and a power level on channel B of -50 dBm.

Observe that 90 percent of the replies are on channel A.

Synchronize the interrogations to channels A and B so that they are 0.375 +0.040/-0.00 microseconds apart where channel B is first.

Use an ATCRBS Mode C at a power level on channel A of -50 dBm and a power level on channel B of MTL +3.

Observe that 90 percent of the replies are on channel B.

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3 INSTALLED EQUIPMENT PERFORMANCE

This section states the minimum acceptable level of performance for the equipment when installed in the aircraft. For the most part, installed performance requirements are the same as those contained in Section 2, which were verified through bench and environmental test. However, certain requirements may be affected by the physical installation (e.g., antenna patterns, receiver sensitivity, etc.) and can only be verified after installation. The installed performance limits stated below take in consideration these situations.

3.1 Equipment Installation

The airborne ATC transponder system should have been installed in the aircraft by the use of acceptable workmanship and engineering practices in an airworthy manner, and in accordance with the equipment manufacturer's recommendations as set forth in his equipment installation manual or other appropriate publication. To assure that the airborne ATC transponder system has been properly and safely installed in the aircraft, make a thorough visual inspection thereof and conduct a gross over-all operational/functional check of the system on the ground prior to flight.

3.1.1 Equipment Accessibility

Equipment controls and display(s) installed for in-flight operation **shall** be readily accessible from the normal seated position. The appropriate operator/crew members(s) **shall** have an unobstructed view of the display(s) when in the normal sitting position.

3.1.2 Inadvertent Turn Off

Appropriate controls **shall** be provided with adequate protection against inadvertent turn off.

3.1.3 Displays

All installed system displays **shall** be readily visible and readable from the crew member's normal position in all ambient lighting conditions for which system use is required.

Note: *Visors, glareshields or filters may be an acceptable means of obtaining daylight visibility.*

3.1.4 Aircraft Power Source

The voltage and voltage tolerance characteristics of the equipment **shall** be compatible with the aircraft power source of appropriate category as specified in RTCA/DO-160E.

3.1.5 Transmission Line(s)

The transmission line(s) connecting antenna(s) and transponder(s) **shall** have impedance, power handling and loss characteristics in accordance with the equipment manufacturer's specifications.

3.1.6 Antenna Location

a. Single Antenna

The antenna **shall** be installed on the bottom of the aircraft as close to the longitudinal axis of the aircraft as possible.

b. Diversity Transponder Installation

The top and bottom antennas **shall** be mounted as near as possible to the center line of the fuselage. Antennas **shall** be located so as to minimize obstruction to their fields in the horizontal plane.

Recommendation: *The horizontal distance between the top and bottom antennas should not be greater than 7.6 meters.*

Note: *This recommendation is intended to support the operation of any diversity transponder (including cables) with any diversity antenna installation and still satisfy the requirement of §3.1.6 c.*

c. Reply Delay of Diversity Transponders.

The total two-way transmission difference in mean reply delay between the two antenna channels (including the differential delay caused by transponder-to-antenna cables and the horizontal distance along the aircraft centerline between the two antennas) **shall** not exceed 0.130 microseconds for interrogations of equal amplitude. This requirement **shall** hold for interrogation signal strengths between MTL +3 dB and -21 dBm. The jitter requirements on each individual channel **shall** remain as specified for non-diversity transponders (see §2.2.4.6).

Note: *This requirement limits the total apparent jitter caused by antenna switching and by cable and antenna location delay differences.*

3.1.7 Mutual Suppression

If other equipment is installed in the aircraft operating at or near 1030 and 1090 MHz, such as DME, the need for mutual suppression **shall** be determined. When mutual suppression is used, the requirements of §2.2.9 **shall** be met.

3.2 Conditions of Test

The conditions of test stated in the following subparagraphs are applicable to the equipment tests specified in Subsection §3.3. Ground tests may be used for all tests specified.

3.2.1 Power Input

Tests may be conducted using either the aircraft's electrical power distribution system or an appropriate external power supply.

3.2.2 Interference Effects

With the equipment energized from the aircraft's electrical power generating system, individually operate each of the other electrically operated aircraft equipment and systems to determine that no significant conducted or radiated interference exists. Evaluate all reasonable combinations of control settings and operating modes. Operate communication and navigation equipment on at least the low, high and one mid-band frequencies. If appropriate, repeat tests using emergency power source(s).

3.2.3 Environment

During the tests, the equipment **shall not** be subjected to environmental conditions that exceed those in RTCA/DO-160E as specified by the equipment manufacturer.

3.2.4 Adjustment of Equipment

Circuits of the equipment under test **shall** be properly aligned and otherwise adjusted in accordance with the manufacturer's recommended practices prior to application of the specified tests.

3.2.5 Warm-up Period

Unless otherwise specified, all tests **shall** be conducted after a warm-up period of not more than 15 minutes.

Comment: Is the above reasonable? Shouldn't this be not "less" than 15 minutes? This would mean that after each test, the unit needs to be turned off and returned to cold start conditions before proceeding with the next test.

3.2.6 Radiation Pattern

The antenna **shall** have a radiation pattern that is essentially omni-directional in the horizontal plane and have sufficient vertical beamwidth to assure proper equipment operation during normal aircraft maneuvers.

3.3 Test Procedures for Installed Equipment Performance

The test procedures set forth below are considered satisfactory in determining required installed equipment performance. Testing requirements are stated, in a manner that will make maximum use of bench test data while limiting flight tests to those requirements which cannot be tested conveniently by other means. Although suggested test procedures are cited, it is recognized that other methods may be preferred by the installing activity. These alternate procedures may be used if the installing activity can show that they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures.

Installed equipment performance tests confirm surveillance functions.

Current U.S. operating regulations require tests similar to those described herein be performed bi-annually to ensure against deterioration of performance. Since equipment installation requires initial performance of these tests, they are included herein.

3.3.1 Conformity Inspection

Visually inspect the installed equipment to determine the use of acceptable workmanship and engineering practices. Verify that all mechanical and electrical connections have been made properly and that the equipment has been installed and located in accordance with the manufacturer's recommendations.

3.3.2 Bench Tests

The equipment **shall** have been tested and certified by the equipment manufacturer to demonstrate compliance with the minimum requirements stated in §2.4.

The transponder tests required below may be conducted using portable test equipment.

3.3.3 Reply Frequency

Interrogate the installed transponder and verify that the reply frequency of the system is 1090 ±3.

3.3.4 Framing Pulse Spacing

Verify that the time interval between the leading edges of the two framing pulses is 20.3 ±0.10 microseconds.

3.3.5 Reply Codes

a. Verify that all Mode A reply pulses listed below in Table 3-1 are present.

Table 3-1: Mode A Reply Pulses

Pulse	Position (microseconds)	4096 code for this pulse only
F1	0.00	
C1	1.45	0010
A1	2.90	1000
C2	4.35	0020
A2	5.80	2000
C4	7.25	0040
A4	8.70	4000
B1	11.60	0100
D1	13.05	0001
B2	14.50	0200
D2	15.95	0002
B4	17.40	0400
D4	18.85	0004
F2	20.30	
SPI	24.65	

b. Interrogate the transponder a sufficient number of times to verify that the correct 4096 code is transmitted. Use more than one 4096 code.

3.3.6 Pressure Altitude Transmissions

a. Verify that the transponder response to Mode C interrogations consists only of framing pulses F1 and F2. If complete altitude reporting capability is provided, the altitude digitizer may not be connected to the transponder at the time of the test.

b. Verify that the transponder response to Mode C interrogations consists of only framing pulses F1 and F2 with the altitude switch in the "OFF" position.

3.3.7 Altitude Reporting Test

a. A sufficient number of test points **shall** be checked to ensure that the altitude reporting equipment and transponder perform their intended function through their entire range while ascending or descending. Tests of each altitude code segment of the encoder (2300, 2500, 3800, 4300, 4800, 6800, 14,800 and 30,800 if available) are sufficient to ensure proper operation of each altitude code segment of the encoder.

b. Verify that the correspondence value of the altimeter system is 125 feet or less.

3.3.8 Reply Pulse Width

Verify that the duration of the F1 and F2 pulses between the 0.5 amplitude points on the leading and trailing edge is 0.45, ±0.10 microsecond with the transponder replying on Mode A, code 0001, and code 7477.

3.3.9 Receiver Sensitivity

a. Verify that for ATCRBS interrogations the receiver sensitivity of the system at the antenna end of the transmission line is is nominally 71 dB below 1 milliwatt with limits between 69 and 77 dB below 1 milliwatt.

b. The minimum triggering level (MTL) of the transponder **shall** be such that replies are generated to 90 percent of the interrogation signals when:

(1) The two pulses P_1 and P_3 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 69 and 77 dB below 1 milliwatt.

Note: *For this MTL requirement, a nominal 3 dB transmission line loss and an antenna performance equivalent to that of a simple quarter wave antenna are assumed. In the event these assumed conditions do not apply, the MTL of the installed transponder system must be comparable to that of the assumed system.*

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

d. The reply characteristics **shall** apply over a received signal amplitude range between minimum triggering level and 50 dB above minimum triggering level.

e. The suppression characteristics **shall** apply over a received, .signal amplitude range between 3 dB above minimum triggering level and 50 dB above minimum triggering level.

3.3.10 Transmitter Power Output

a. Verify that transponders operating at altitudes above 15,000 feet have a peak pulse power at the antenna end of the transmission line of at least +21 dBW and not more than +27 dBW.

b. Verify that transponders intended for operation at altitudes not above 15,000 feet have a peak pulse power at the antenna end of the transmission line of at least +18.5 dBW and not more than +27 dBW.

3.3.11 Diversity Antenna Installations

Verify that the antennas on the aircraft are no more than 7.6 meter (25 feet) apart in the horizontal plane. The cables **shall** be essentially of equal electrical length.

3.4 Flight Test Procedures

The following test procedures provide one means of determining installed equipment performance. Although specific test procedures are cited, it is recognized that other methods may be preferred by the installing activity. These alternate procedures may be used if they provide at least equivalent information. In such cases, the procedures cited herein should be used as one criterion in evaluating the acceptability of the alternate procedures. The equipment **shall** be tested to determine compliance with the minimum requirements stated in §2.2. In order to meet this requirement, test results supplied by the equipment manufacturer or other proof of conformity may be accepted in lieu of bench tests performed by the installing activity.

This guidance material offers examples of flight test procedures for demonstration of selected performance functions. Flight demonstration of installed performance may be required by the aircraft operator or by airworthiness inspection agencies.

A schedule must be arranged with the area air traffic control facility so that a controller is available to observe the transponder reply and communicate with the test aircraft to confirm performance of the transponder.

Select a test area such that line-of-sight signal propagation is assured. Test maneuvers may include standard rate turns through 360 degrees, climbs and descents so that ATC can confirm valid return through normal flight attitudes. Verification of Ident codes selected and reported altitude response to Mode C should be checked.

3.4.1 Ground Pre-Flight Tests

The following transponder characteristic should be determined and the performance level noted:

(1) Random triggering of the transponder should not exceed 30 replies per second as integrated over an interval equivalent to at least 300 random triggers, or 30 seconds, whichever is less. This should be determined with all possible interfering equipments operating in their normal manner on operational channels of maximum interference, but with the absence of bona fide transponder interrogations. This test can be performed by using an RF detector sufficiently coupled to the antenna to count the rate of non-interrogated replies.

(2) Receiver/Transmitter system characteristics should be assured by determining the attenuation constant of the installed coaxial transmission line and the characteristics of the antenna. Measure the length of transmission line and refer to suitable handbooks regarding the type of coaxial cable or the transponder

manufacturer's equipment manual to determine the amount, of attenuation in decibels. Inspect the antenna system and carefully observe that the antenna is installed in accordance with the manufacturer's recommendations, and that there are no protrusions from the aircraft which will affect the efficiency of the antenna. The following examples are given to empirically determine the system compliance:

EXAMPLE #1:

Effective radiated power =ERP

$ERP = P_T - L + G_A$

Where: P_T = Power in dBW at the antenna terminal of the transponder. (Refer to §2.3.2.1.14)
L = Transmission Line Loss
G_A = Antenna gain above isotropic

Assume the following:

a) The measured transmitter power at the transponder antenna terminal is 100 watts (+20 dBW). The measured receiver sensitivity is -71 dBm.

b) 10 feet of RG-8/U = 0.9 dB.

c) Antenna gain is unity with respect to isotropic which results in 0 dB.

Then:

Transmitted ERP = 20 – 0.9 + 0
= 19.1 dBW

Effective Receiver Sensitivity = -71 + 0.9 – 0
= -70.1 dBm

This example would allow the system to operate in aircraft for altitudes not exceeding 15,000 feet.

EXAMPLE #2:

Assume the following:

a) The measured transmitter power at the trans- ponder terminal is 29 dBW.

b) 33 feet of RG-8/U = 3 dB

c) Antenna gain is unity with respect to isotropic which results in 0 dB.

Then:

Transmitter ERP = 29 – 3 + 0
= 26 dBW

Effective Receiver Sensitivity = -74 + 3 – 0
= -71 dBm

This example would allow the system to operate in aircraft intended to operate at all altitudes.

(3) Automatic altitude reporting performance should be checked as follows with aircraft on the ground:

(a) Set the altimeter normally used to maintain flight altitude to 29.92 inches of mercury (1013.2 millibars).

(b) Select 10 or more evenly-spaced altitude test points between zero (sea level) and the maximum operating altitude of the aircraft. Test each of these test points for increasing altitude and for decreasing altitude.

(c) Apply pressure to the static system. If separate static systems serve altimeter and digitizer, apply identical pressures simultaneously to each. Approach each test point slowly, decreasing pressure for increasing altitude, and vice versa, until a transition to the test point value occurs in the digital output. Record the pilot's altimeter reading at the instant of transition in the digitizer.

(d) The installation is acceptable if the altimeter normally used to maintain flight altitude corresponds with the output of the digitizer within 125 feet at each test point and within ±62 feet at not less than 70 percent of the test points.

(4) The performance characteristics of any equipment(s) functioning external to the transponder system **shall** be evaluated to determine that the algebraic cumulative effective dead time does not exceed the specified limits.

3.4.2 Operational Flight Tests

(1) Perform the flight test using an ATC facility and procedures. The flight should be conducted from the airport to approximately 25 miles from the ground facility. Put the aircraft through those maneuvers normally associated with take-off, climb, holding procedures, descent and final approach. Determine in the course of these maneuvers that the transponder performs its intended function and is suitable for use in the ATC system.

(2) If the system includes altitude reporting and while performing (1) above, request ATC to monitor the altitude being reported by the transponder and compare with the altimeter being used to maintain flight altitude.

(3) Request ATC to verify proper performance while operating on several different codes. Do not use codes 7700 or 7600, unless requested by ATC.

Note: *It should be recognized that some aircraft attitudes with respect to the ground station will cause momentary loss of contact.*

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4 EQUIPMENT OPERATIONAL PERFORMANCE CHARACTERISTICS

4.1 Required Operational Performance Requirements

To ensure the operator that operations can be conducted safely and reliably in the expected operational environment, there are specific minimum acceptable performance requirements that **shall** be met. The following paragraphs identify these requirements.

4.1.1 Power Inputs

Prior to flight, verify that the equipment is receiving primary input power necessary for proper conditions.

4.1.2 Equipment Operating Modes

The equipment **shall** operate in each of its operating modes.

4.1.3 Continue with Other Operational Requirements as Necessary

4.2 Test Procedures for Operational Performance Requirements

Operation equipment tests may be conducted as part of normal pre-flight tests. For those tests that can only be run in flight, procedures should be developed to perform these tests as early during the flight as possible to verify that the equipment is performing its intended function(s).

4.2.1 Power Input

With the aircraft's electrical power generating system operating, energize the equipment and verify that electrical power is available to the equipment.

4.2.2 Equipment Operating Modes

Verify that the equipment performs its intended function(s) for each of the operating modes available to the operator.

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Membership

RTCA Special Committee 209

Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System (ATCRBS) Airborne Equipment

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Steve Yeager	Raytheon Electronic Combat Systems

Appendix A

SSR automatic pressure altitude transmission code (pulse position assignment)

The following Table is reproduced from ICAO Annex 10, Volume IV, Appendix to Chapter 3.

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

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
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
4 750	to	4 850	0	0	0	0	1	0	1	0	0	0	1
4 850	to	4 950	0	0	0	0	1	0	1	0	0	1	1
4 950	to	5 050	0	0	0	0	1	0	1	0	0	1	0
5 050	to	5 150	0	0	0	0	1	0	1	0	1	1	0
5 150	to	5 250	0	0	0	0	1	0	1	0	1	0	0
5 250	to	5 350	0	0	0	0	1	0	1	1	1	0	0
5 350	to	5 450	0	0	0	0	1	0	1	1	1	1	0
5 450	to	5 550	0	0	0	0	1	0	1	1	0	1	0
5 550	to	5 650	0	0	0	0	1	0	1	1	0	1	1
5 650	to	5 750	0	0	0	0	1	0	1	1	0	0	1
5 750	to	5 850	0	0	0	0	1	0	0	1	0	0	1
5 850	to	5 950	0	0	0	0	1	0	0	1	0	1	1
5 950	to	6 050	0	0	0	0	1	0	0	1	0	1	0
6 050	to	6 150	0	0	0	0	1	0	0	1	1	1	0
6 150	to	6 250	0	0	0	0	1	0	0	1	1	0	0
6 250	to	6 350	0	0	0	0	1	0	0	0	1	0	0
6 350	to	6 450	0	0	0	0	1	0	0	0	1	1	0
6 450	to	6 550	0	0	0	0	1	0	0	0	0	1	0
6 550	to	6 650	0	0	0	0	1	0	0	0	0	1	1
6 650	to	6 750	0	0	0	0	1	0	0	0	0	0	1
6 750	to	6 850	0	0	0	1	1	0	0	0	0	0	1
6 850	to	6 950	0	0	0	1	1	0	0	0	0	1	1
6 950	to	7 050	0	0	0	1	1	0	0	0	0	1	0
7 050	to	7 150	0	0	0	1	1	0	0	0	1	1	0
7 150	to	7 250	0	0	0	1	1	0	0	0	1	0	0
7 250	to	7 350	0	0	0	1	1	0	0	1	1	0	0
7 350	to	7 450	0	0	0	1	1	0	0	1	1	1	0
7 450	to	7 550	0	0	0	1	1	0	0	1	0	1	0
7 550	to	7 650	0	0	0	1	1	0	0	1	0	1	1
7 650	to	7 750	0	0	0	1	1	0	0	1	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
7 750	to	7 850	0	0	0	1	1	0	1	1	0	0	1
7 850	to	7 950	0	0	0	1	1	0	1	1	0	1	1
7 950	to	8 050	0	0	0	1	1	0	1	1	0	1	0
8 050	to	8 150	0	0	0	1	1	0	1	1	1	1	0
8 150	to	8 250	0	0	0	1	1	0	1	1	1	0	0
8 250	to	8 350	0	0	0	1	1	0	1	0	1	0	0
8 350	to	8 450	0	0	0	1	1	0	1	0	1	1	0
8 450	to	8 550	0	0	0	1	1	0	1	0	0	1	0
8 550	to	8 650	0	0	0	1	1	0	1	0	0	1	1
8 650	to	8 750	0	0	0	1	1	0	1	0	0	0	1
8 750	to	8 850	0	0	0	1	1	1	1	0	0	0	1
8 850	to	8 950	0	0	0	1	1	1	1	0	0	1	1
8 950	to	9 050	0	0	0	1	1	1	1	0	0	1	0
9 050	to	9 150	0	0	0	1	1	1	1	0	1	1	0
9 150	to	9 250	0	0	0	1	1	1	1	0	1	0	0
9 250	to	9 350	0	0	0	1	1	1	1	1	1	0	0
9 350	to	9 450	0	0	0	1	1	1	1	1	1	1	0
9 450	to	9 550	0	0	0	1	1	1	1	1	0	1	0
9 550	to	9 650	0	0	0	1	1	1	1	1	0	1	1
9 650	to	9 750	0	0	0	1	1	1	1	1	0	0	1
9 750	to	9 850	0	0	0	1	1	1	0	1	0	0	1
9 850	to	9 950	0	0	0	1	1	1	0	1	0	1	1
9 950	to	10 050	0	0	0	1	1	1	0	1	0	1	0
10 050	to	10 150	0	0	0	1	1	1	0	1	1	1	0
10 150	to	10 250	0	0	0	1	1	1	0	1	1	0	0
10 250	to	10 350	0	0	0	1	1	1	0	0	1	0	0
10 350	to	10 450	0	0	0	1	1	1	0	0	1	1	0
10 450	to	10 550	0	0	0	1	1	1	0	0	0	1	0
10 550	to	10 650	0	0	0	1	1	1	0	0	0	1	1
10 650	to	10 750	0	0	0	1	1	1	0	0	0	0	1
10 750	to	10 850	0	0	0	1	0	1	0	0	0	0	1
10 850	to	10 950	0	0	0	1	0	1	0	0	0	1	1
10 950	to	11 050	0	0	0	1	0	1	0	0	0	1	0
11 050	to	11 150	0	0	0	1	0	1	0	0	1	1	0
11 150	to	11 250	0	0	0	1	0	1	0	0	1	0	0
11 250	to	11 350	0	0	0	1	0	1	0	1	1	0	0
11 350	to	11 450	0	0	0	1	0	1	0	1	1	1	0
11 450	to	11 550	0	0	0	1	0	1	0	1	0	1	0
11 550	to	11 650	0	0	0	1	0	1	0	1	0	1	1
11 650	to	11 750	0	0	0	1	0	1	0	1	0	0	1
11 750	to	11 850	0	0	0	1	0	1	1	1	0	0	1
11 850	to	11 950	0	0	0	1	0	1	1	1	0	1	1
11 950	to	12 050	0	0	0	1	0	1	1	1	0	1	0
12 050	to	12 150	0	0	0	1	0	1	1	1	1	1	0
12 150	to	12 250	0	0	0	1	0	1	1	1	1	0	0
12 250	to	12 350	0	0	0	1	0	1	1	0	1	0	0
12 350	to	12 450	0	0	0	1	0	1	1	0	1	1	0
12 450	to	12 550	0	0	0	1	0	1	1	0	0	1	0
12 550	to	12 650	0	0	0	1	0	1	1	0	0	1	1
12 650	to	12 750	0	0	0	1	0	1	1	0	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
12 750	to	12 850	0	0	0	1	0	0	1	0	0	0	1
12 850	to	12 950	0	0	0	1	0	0	1	0	0	1	1
12 950	to	13 050	0	0	0	1	0	0	1	0	0	1	0
13 050	to	13 150	0	0	0	1	0	0	1	0	1	1	0
13 150	to	13 250	0	0	0	1	0	0	1	0	1	0	0
13 250	to	13 350	0	0	0	1	0	0	1	1	1	0	0
13 350	to	13 450	0	0	0	1	0	0	1	1	1	1	0
13 450	to	13 550	0	0	0	1	0	0	1	1	0	1	0
13 550	to	13 650	0	0	0	1	0	0	1	1	0	1	1
13 650	to	13 750	0	0	0	1	0	0	1	1	0	0	1
13 750	to	13 850	0	0	0	1	0	0	0	1	0	0	1
13 850	to	13 950	0	0	0	1	0	0	0	1	0	1	1
13 950	to	14 050	0	0	0	1	0	0	0	1	0	1	0
14 050	to	14 150	0	0	0	1	0	0	0	1	1	1	0
14 150	to	14 250	0	0	0	1	0	0	0	1	1	0	0
14 250	to	14 350	0	0	0	1	0	0	0	0	1	0	0
14 350	to	14 450	0	0	0	1	0	0	0	0	1	1	0
14 450	to	14 550	0	0	0	1	0	0	0	0	0	1	0
14 550	to	14 650	0	0	0	1	0	0	0	0	0	1	1
14 650	to	14 750	0	0	0	1	0	0	0	0	0	0	1
14 750	to	14 850	0	0	1	1	0	0	0	0	0	0	1
14 850	to	14 950	0	0	1	1	0	0	0	0	0	1	1
14 950	to	15 050	0	0	1	1	0	0	0	0	0	1	0
15 050	to	15 150	0	0	1	1	0	0	0	0	1	1	0
15 150	to	15 250	0	0	1	1	0	0	0	0	1	0	0
15 250	to	15 350	0	0	1	1	0	0	0	1	1	0	0
15 350	to	15 450	0	0	1	1	0	0	0	1	1	1	0
15 450	to	15 550	0	0	1	1	0	0	0	1	0	1	0
15 550	to	15 650	0	0	1	1	0	0	0	1	0	1	1
15 650	to	15 750	0	0	1	1	0	0	0	1	0	0	1
15 750	to	15 850	0	0	1	1	0	0	1	1	0	0	1
15 850	to	15 950	0	0	1	1	0	0	1	1	0	1	1
15 950	to	16 050	0	0	1	1	0	0	1	1	0	1	0
16 050	to	16 150	0	0	1	1	0	0	1	1	1	1	0
16 150	to	16 250	0	0	1	1	0	0	1	1	1	0	0
16 250	to	16 350	0	0	1	1	0	0	1	0	1	0	0
16 350	to	16 450	0	0	1	1	0	0	1	0	1	1	0
16 450	to	16 550	0	0	1	1	0	0	1	0	0	1	0
16 550	to	16 650	0	0	1	1	0	0	1	0	0	1	1
16 650	to	16 750	0	0	1	1	0	0	1	0	0	0	1
16 750	to	16 850	0	0	1	1	0	1	1	0	0	0	1
16 850	to	16 950	0	0	1	1	0	1	1	0	0	1	1
16 950	to	17 050	0	0	1	1	0	1	1	0	0	1	0
17 050	to	17 150	0	0	1	1	0	1	1	0	1	1	0
17 150	to	17 250	0	0	1	1	0	1	1	0	1	0	0
17 250	to	17 350	0	0	1	1	0	1	1	1	1	0	0
17 350	to	17 450	0	0	1	1	0	1	1	1	1	1	0
17 450	to	17 550	0	0	1	1	0	1	1	1	0	1	0
17 550	to	17 650	0	0	1	1	0	1	1	1	0	1	1
17 650	to	17 750	0	0	1	1	0	1	1	1	0	0	1

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
17 750	to	17 850	0	0	1	1	0	1	0	1	0	0	1
17 850	to	17 950	0	0	1	1	0	1	0	1	0	1	1
17 950	to	18 050	0	0	1	1	0	1	0	1	0	1	0
18 050	to	18 150	0	0	1	1	0	1	0	1	1	1	0
18 150	to	18 250	0	0	1	1	0	1	0	1	1	0	0
18 250	to	18 350	0	0	1	1	0	1	0	0	1	0	0
18 350	to	18 450	0	0	1	1	0	1	0	0	1	1	0
18 450	to	18 550	0	0	1	1	0	1	0	0	0	1	0
18 550	to	18 650	0	0	1	1	0	1	0	0	0	1	1
18 650	to	18 750	0	0	1	1	0	1	0	0	0	0	1
18 750	to	18 850	0	0	1	1	1	1	0	0	0	0	1
18 850	to	18 950	0	0	1	1	1	1	0	0	0	1	1
18 950	to	19 050	0	0	1	1	1	1	0	0	0	1	0
19 050	to	19 150	0	0	1	1	1	1	0	0	1	1	0
19 150	to	19 250	0	0	1	1	1	1	0	0	1	0	0
19 250	to	19 350	0	0	1	1	1	1	0	1	1	0	0
19 350	to	19 450	0	0	1	1	1	1	0	1	1	1	0
19 450	to	19 550	0	0	1	1	1	1	0	1	0	1	0
19 550	to	19 650	0	0	1	1	1	1	0	1	0	1	1
19 650	to	19 750	0	0	1	1	1	1	0	1	0	0	1
19 750	to	19 850	0	0	1	1	1	1	1	1	0	0	1
19 850	to	19 950	0	0	1	1	1	1	1	1	0	1	1
19 950	to	20 050	0	0	1	1	1	1	1	1	0	1	0
20 050	to	20 150	0	0	1	1	1	1	1	1	1	1	0
20 150	to	20 250	0	0	1	1	1	1	1	1	1	0	0
20 250	to	20 350	0	0	1	1	1	1	1	0	1	0	0
20 350	to	20 450	0	0	1	1	1	1	1	0	1	1	0
20 450	to	20 550	0	0	1	1	1	1	1	0	0	1	0
20 550	to	20 650	0	0	1	1	1	1	1	0	0	1	1
20 650	to	20 750	0	0	1	1	1	1	1	0	0	0	1
20 750	to	20 850	0	0	1	1	1	0	1	0	0	0	1
20 850	to	20 950	0	0	1	1	1	0	1	0	0	1	1
20 950	to	21 050	0	0	1	1	1	0	1	0	0	1	0
21 050	to	21 150	0	0	1	1	1	0	1	0	1	1	0
21 150	to	21 250	0	0	1	1	1	0	1	0	1	0	0
21 250	to	21 350	0	0	1	1	1	0	1	1	1	0	0
21 350	to	21 450	0	0	1	1	1	0	1	1	1	1	0
21 450	to	21 550	0	0	1	1	1	0	1	1	0	1	0
21 550	to	21 650	0	0	1	1	1	0	1	1	0	1	1
21 650	to	21 750	0	0	1	1	1	0	1	1	0	0	1
21 750	to	21 850	0	0	1	1	1	0	0	1	0	0	1
21 850	to	21 950	0	0	1	1	1	0	0	1	0	1	1
21 950	to	22 050	0	0	1	1	1	0	0	1	0	1	0
22 050	to	22 150	0	0	1	1	1	0	0	1	1	1	0
22 150	to	22 250	0	0	1	1	1	0	0	1	1	0	0
22 250	to	22 350	0	0	1	1	1	0	0	0	1	0	0
22 350	to	22 450	0	0	1	1	1	0	0	0	1	1	0
22 450	to	22 550	0	0	1	1	1	0	0	0	0	1	0
22 550	to	22 650	0	0	1	1	1	0	0	0	0	1	1
22 650	to	22 750	0	0	1	1	1	0	0	0	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
22 750	to	22 850	0	0	1	0	1	0	0	0	0	0	1
22 850	to	22 950	0	0	1	0	1	0	0	0	0	1	1
22 950	to	23 050	0	0	1	0	1	0	0	0	0	1	0
23 050	to	23 150	0	0	1	0	1	0	0	0	1	1	0
23 150	to	23 250	0	0	1	0	1	0	0	0	1	0	0
23 250	to	23 350	0	0	1	0	1	0	0	1	1	0	0
23 350	to	23 450	0	0	1	0	1	0	0	1	1	1	0
23 450	to	23 550	0	0	1	0	1	0	0	1	0	1	0
23 550	to	23 650	0	0	1	0	1	0	0	1	0	1	1
23 650	to	23 750	0	0	1	0	1	0	0	1	0	0	1
23 750	to	23 850	0	0	1	0	1	0	1	1	0	0	1
23 850	to	23 950	0	0	1	0	1	0	1	1	0	1	1
23 950	to	24 050	0	0	1	0	1	0	1	1	0	1	0
24 050	to	24 150	0	0	1	0	1	0	1	1	1	1	0
24 150	to	24 250	0	0	1	0	1	0	1	1	1	0	0
24 250	to	24 350	0	0	1	0	1	0	1	0	1	0	0
24 350	to	24 450	0	0	1	0	1	0	1	0	1	1	0
24 450	to	24 550	0	0	1	0	1	0	1	0	0	1	0
24 550	to	24 650	0	0	1	0	1	0	1	0	0	1	1
24 650	to	24 750	0	0	1	0	1	0	1	0	0	0	1
24 750	to	24 850	0	0	1	0	1	1	1	0	0	0	1
24 850	to	24 950	0	0	1	0	1	1	1	0	0	1	1
24 950	to	25 050	0	0	1	0	1	1	1	0	0	1	0
25 050	to	25 150	0	0	1	0	1	1	1	0	1	1	0
25 150	to	25 250	0	0	1	0	1	1	1	0	1	0	0
25 250	to	25 350	0	0	1	0	1	1	1	1	1	0	0
25 350	to	25 450	0	0	1	0	1	1	1	1	1	1	0
25 450	to	25 550	0	0	1	0	1	1	1	1	0	1	0
25 550	to	25 650	0	0	1	0	1	1	1	1	0	1	1
25 650	to	25 750	0	0	1	0	1	1	1	1	0	0	1
25 750	to	25 850	0	0	1	0	1	1	0	1	0	0	1
25 850	to	25 950	0	0	1	0	1	1	0	1	0	1	1
25 950	to	26 050	0	0	1	0	1	1	0	1	0	1	0
26 050	to	26 150	0	0	1	0	1	1	0	1	1	1	0
26 150	to	26 250	0	0	1	0	1	1	0	1	1	0	0
26 250	to	26 350	0	0	1	0	1	1	0	0	1	0	0
26 350	to	26 450	0	0	1	0	1	1	0	0	1	1	0
26 450	to	26 550	0	0	1	0	1	1	0	0	0	1	0
26 550	to	26 650	0	0	1	0	1	1	0	0	0	1	1
26 650	to	26 750	0	0	1	0	1	1	0	0	0	0	1
26 750	to	26 850	0	0	1	0	0	1	0	0	0	0	1
26 850	to	26 950	0	0	1	0	0	1	0	0	0	1	1
26 950	to	27 050	0	0	1	0	0	1	0	0	0	1	0
27 050	to	27 150	0	0	1	0	0	1	0	0	1	1	0
27 150	to	27 250	0	0	1	0	0	1	0	0	1	0	0
27 250	to	27 350	0	0	1	0	0	1	0	1	1	0	0
27 350	to	27 450	0	0	1	0	0	1	0	1	1	1	0
27 450	to	27 550	0	0	1	0	0	1	0	1	0	1	0
27 550	to	27 650	0	0	1	0	0	1	0	1	0	1	1
27 650	to	27 750	0	0	1	0	0	1	0	1	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
27 750	to	27 850	0	0	1	0	0	1	1	1	0	0	1
27 850	to	27 950	0	0	1	0	0	1	1	1	0	1	1
27 950	to	28 050	0	0	1	0	0	1	1	1	0	1	0
28 050	to	28 150	0	0	1	0	0	1	1	1	1	1	0
28 150	to	28 250	0	0	1	0	0	1	1	1	1	0	0
28 250	to	28 350	0	0	1	0	0	1	1	0	1	0	0
28 350	to	28 450	0	0	1	0	0	1	1	0	1	1	0
28 450	to	28 550	0	0	1	0	0	1	1	0	0	1	0
28 550	to	28 650	0	0	1	0	0	1	1	0	0	1	1
28 650	to	28 750	0	0	1	0	0	1	1	0	0	0	1
28 750	to	28 850	0	0	1	0	0	0	1	0	0	0	1
28 850	to	28 950	0	0	1	0	0	0	1	0	0	1	1
28 950	to	29 050	0	0	1	0	0	0	1	0	0	1	0
29 050	to	29 150	0	0	1	0	0	0	1	0	1	1	0
29 150	to	29 250	0	0	1	0	0	0	1	0	1	0	0
29 250	to	29 350	0	0	1	0	0	0	1	1	1	0	0
29 350	to	29 450	0	0	1	0	0	0	1	1	1	1	0
29 450	to	29 550	0	0	1	0	0	0	1	1	0	1	0
29 550	to	29 650	0	0	1	0	0	0	1	1	0	1	1
29 650	to	29 750	0	0	1	0	0	0	1	1	0	0	1
29 750	to	29 850	0	0	1	0	0	0	0	1	0	0	1
29 850	to	29 950	0	0	1	0	0	0	0	1	0	1	1
29 950	to	30 050	0	0	1	0	0	0	0	1	0	1	0
30 050	to	30 150	0	0	1	0	0	0	0	1	1	1	0
30 150	to	30 250	0	0	1	0	0	0	0	1	1	0	0
30 250	to	30 350	0	0	1	0	0	0	0	0	1	0	0
30 350	to	30 450	0	0	1	0	0	0	0	0	1	1	0
30 450	to	30 550	0	0	1	0	0	0	0	0	0	1	0
30 550	to	30 650	0	0	1	0	0	0	0	0	0	1	1
30 650	to	30 750	0	0	1	0	0	0	0	0	0	0	1
30 750	to	30 850	0	1	1	0	0	0	0	0	0	0	1
30 850	to	30 950	0	1	1	0	0	0	0	0	0	1	1
30 950	to	31 050	0	1	1	0	0	0	0	0	0	1	0
31 050	to	31 150	0	1	1	0	0	0	0	0	1	1	0
31 150	to	31 250	0	1	1	0	0	0	0	0	1	0	0
31 250	to	31 350	0	1	1	0	0	0	0	1	1	0	0
31 350	to	31 450	0	1	1	0	0	0	0	1	1	1	0
31 450	to	31 550	0	1	1	0	0	0	0	1	0	1	0
31 550	to	31 650	0	1	1	0	0	0	0	1	0	1	1
31 650	to	31 750	0	1	1	0	0	0	0	1	0	0	1
31 750	to	31 850	0	1	1	0	0	0	1	1	0	0	1
31 850	to	31 950	0	1	1	0	0	0	1	1	0	1	1
31 950	to	32 050	0	1	1	0	0	0	1	1	0	1	0
32 050	to	32 150	0	1	1	0	0	0	1	1	1	1	0
32 150	to	32 250	0	1	1	0	0	0	1	1	1	0	0
32 250	to	32 350	0	1	1	0	0	0	1	0	1	0	0
32 350	to	32 450	0	1	1	0	0	0	1	0	1	1	0
32 450	to	32 550	0	1	1	0	0	0	1	0	0	1	0
32 550	to	32 650	0	1	1	0	0	0	1	0	0	1	1
32 650	to	32 750	0	1	1	0	0	0	1	0	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
32 750	to	32 850	0	1	1	0	0	1	1	0	0	0	1
32 850	to	32 950	0	1	1	0	0	1	1	0	0	1	1
32 950	to	33 050	0	1	1	0	0	1	1	0	0	1	0
33 050	to	33 150	0	1	1	0	0	1	1	0	1	1	0
33 150	to	33 250	0	1	1	0	0	1	1	0	1	0	0
33 250	to	33 350	0	1	1	0	0	1	1	1	1	0	0
33 350	to	33 450	0	1	1	0	0	1	1	1	1	1	0
33 450	to	33 550	0	1	1	0	0	1	1	1	0	1	0
33 550	to	33 650	0	1	1	0	0	1	1	1	0	1	1
33 650	to	33 750	0	1	1	0	0	1	1	1	0	0	1
33 750	to	33 850	0	1	1	0	0	1	0	1	0	0	1
33 850	to	33 950	0	1	1	0	0	1	0	1	0	1	1
33 950	to	34 050	0	1	1	0	0	1	0	1	0	1	0
34 050	to	34 150	0	1	1	0	0	1	0	1	1	1	0
34 150	to	34 250	0	1	1	0	0	1	0	1	1	0	0
34 250	to	34 350	0	1	1	0	0	1	0	0	1	0	0
34 350	to	34 450	0	1	1	0	0	1	0	0	1	1	0
34 450	to	34 550	0	1	1	0	0	1	0	0	0	1	0
34 550	to	34 650	0	1	1	0	0	1	0	0	0	1	1
34 650	to	34 750	0	1	1	0	0	1	0	0	0	0	1
34 750	to	34 850	0	1	1	0	1	1	0	0	0	0	1
34 850	to	34 950	0	1	1	0	1	1	0	0	0	1	1
34 950	to	35 050	0	1	1	0	1	1	0	0	0	1	0
35 050	to	35 150	0	1	1	0	1	1	0	0	1	1	0
35 150	to	35 250	0	1	1	0	1	1	0	0	1	0	0
35 250	to	35 350	0	1	1	0	1	1	0	1	1	0	0
35 350	to	35 450	0	1	1	0	1	1	0	1	1	1	0
35 450	to	35 550	0	1	1	0	1	1	0	1	0	1	0
35 550	to	35 650	0	1	1	0	1	1	0	1	0	1	1
35 650	to	35 750	0	1	1	0	1	1	0	1	0	0	1
35 750	to	35 850	0	1	1	0	1	1	1	1	0	0	1
35 850	to	35 950	0	1	1	0	1	1	1	1	0	1	1
35 950	to	36 050	0	1	1	0	1	1	1	1	0	1	0
36 050	to	36 150	0	1	1	0	1	1	1	1	1	1	0
36 150	to	36 250	0	1	1	0	1	1	1	1	1	0	0
36 250	to	36 350	0	1	1	0	1	1	1	0	1	0	0
36 350	to	36 450	0	1	1	0	1	1	1	0	1	1	0
36 450	to	36 550	0	1	1	0	1	1	1	0	0	1	0
36 550	to	36 650	0	1	1	0	1	1	1	0	0	1	1
36 650	to	36 750	0	1	1	0	1	1	1	0	0	0	1
36 750	to	36 850	0	1	1	0	1	0	1	0	0	0	1
36 850	to	36 950	0	1	1	0	1	0	1	0	0	1	1
36 950	to	37 050	0	1	1	0	1	0	1	0	0	1	0
37 050	to	37 150	0	1	1	0	1	0	1	0	1	1	0
37 150	to	37 250	0	1	1	0	1	0	1	0	1	0	0
37 250	to	37 350	0	1	1	0	1	0	1	1	1	0	0
37 350	to	37 450	0	1	1	0	1	0	1	1	1	1	0
37 450	to	37 550	0	1	1	0	1	0	1	1	0	1	0
37 550	to	37 650	0	1	1	0	1	0	1	1	0	1	1
37 650	to	37 750	0	1	1	0	1	0	1	1	0	0	1

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
37 750	to	37 850	0	1	1	0	1	0	0	1	0	0	1
37 850	to	37 950	0	1	1	0	1	0	0	1	0	1	1
37 950	to	38 050	0	1	1	0	1	0	0	1	0	1	0
38 050	to	38 150	0	1	1	0	1	0	0	1	1	1	0
38 150	to	38 250	0	1	1	0	1	0	0	1	1	0	0
38 250	to	38 350	0	1	1	0	1	0	0	0	1	0	0
38 350	to	38 450	0	1	1	0	1	0	0	0	1	1	0
38 450	to	38 550	0	1	1	0	1	0	0	0	0	1	0
38 550	to	38 650	0	1	1	0	1	0	0	0	0	1	1
38 650	to	38 750	0	1	1	0	1	0	0	0	0	0	1
38 750	to	38 850	0	1	1	1	1	0	0	0	0	0	1
38 850	to	38 950	0	1	1	1	1	0	0	0	0	1	1
38 950	to	39 050	0	1	1	1	1	0	0	0	0	1	0
39 050	to	39 150	0	1	1	1	1	0	0	0	1	1	0
39 150	to	39 250	0	1	1	1	1	0	0	0	1	0	0
39 250	to	39 350	0	1	1	1	1	0	0	1	1	0	0
39 350	to	39 450	0	1	1	1	1	0	0	1	1	1	0
39 450	to	39 550	0	1	1	1	1	0	0	1	0	1	0
39 550	to	39 650	0	1	1	1	1	0	0	1	0	1	1
39 650	to	39 750	0	1	1	1	1	0	0	1	0	0	1
39 750	to	39 850	0	1	1	1	1	0	1	1	0	0	1
39 850	to	39 950	0	1	1	1	1	0	1	1	0	1	1
39 950	to	40 050	0	1	1	1	1	0	1	1	0	1	0
40 050	to	40 150	0	1	1	1	1	0	1	1	1	1	0
40 150	to	40 250	0	1	1	1	1	0	1	1	1	0	0
40 250	to	40 350	0	1	1	1	1	0	1	0	1	0	0
40 350	to	40 450	0	1	1	1	1	0	1	0	1	1	0
40 450	to	40 550	0	1	1	1	1	0	1	0	0	1	0
40 550	to	40 650	0	1	1	1	1	0	1	0	0	1	1
40 650	to	40 750	0	1	1	1	1	0	1	0	0	0	1
40 750	to	40 850	0	1	1	1	1	1	1	0	0	0	1
40 850	to	40 950	0	1	1	1	1	1	1	0	0	1	1
40 950	to	41 050	0	1	1	1	1	1	1	0	0	1	0
41 050	to	41 150	0	1	1	1	1	1	1	0	1	1	0
41 150	to	41 250	0	1	1	1	1	1	1	0	1	0	0
41 250	to	41 350	0	1	1	1	1	1	1	1	1	0	0
41 350	to	41 450	0	1	1	1	1	1	1	1	1	1	0
41 450	to	41 550	0	1	1	1	1	1	1	1	0	1	0
41 550	to	41 650	0	1	1	1	1	1	1	1	0	1	1
41 650	to	41 750	0	1	1	1	1	1	1	1	0	0	1
41 750	to	41 850	0	1	1	1	1	1	0	1	0	0	1
41 850	to	41 950	0	1	1	1	1	1	0	1	0	1	1
41 950	to	42 050	0	1	1	1	1	1	0	1	0	1	0
42 050	to	42 150	0	1	1	1	1	1	0	1	1	1	0
42 150	to	42 250	0	1	1	1	1	1	0	1	1	0	0
42 250	to	42 350	0	1	1	1	1	1	0	0	1	0	0
42 350	to	42 450	0	1	1	1	1	1	0	0	1	1	0
42 450	to	42 550	0	1	1	1	1	1	0	0	0	1	0
42 550	to	42 650	0	1	1	1	1	1	0	0	0	1	1
42 650	to	42 750	0	1	1	1	1	1	0	0	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
42 750	to	42 850	0	1	1	1	0	1	0	0	0	0	1
42 850	to	42 950	0	1	1	1	0	1	0	0	0	1	1
42 950	to	43 050	0	1	1	1	0	1	0	0	0	1	0
43 050	to	43 150	0	1	1	1	0	1	0	0	1	1	0
43 150	to	43 250	0	1	1	1	0	1	0	0	1	0	0
43 250	to	43 350	0	1	1	1	0	1	0	1	1	0	0
43 350	to	43 450	0	1	1	1	0	1	0	1	1	1	0
43 450	to	43 550	0	1	1	1	0	1	0	1	0	1	0
43 550	to	43 650	0	1	1	1	0	1	0	1	0	1	1
43 650	to	43 750	0	1	1	1	0	1	0	1	0	0	1
43 750	to	43 850	0	1	1	1	0	1	1	1	0	0	1
43 850	to	43 950	0	1	1	1	0	1	1	1	0	1	1
43 950	to	44 050	0	1	1	1	0	1	1	1	0	1	0
44 050	to	44 150	0	1	1	1	0	1	1	1	1	1	0
44 150	to	44 250	0	1	1	1	0	1	1	1	1	0	0
44 250	to	44 350	0	1	1	1	0	1	1	0	1	0	0
44 350	to	44 450	0	1	1	1	0	1	1	0	1	1	0
44 450	to	44 550	0	1	1	1	0	1	1	0	0	1	0
44 550	to	44 650	0	1	1	1	0	1	1	0	0	1	1
44 650	to	44 750	0	1	1	1	0	1	1	0	0	0	1
44 750	to	44 850	0	1	1	1	0	0	1	0	0	0	1
44 850	to	44 950	0	1	1	1	0	0	1	0	0	1	1
44 950	to	45 050	0	1	1	1	0	0	1	0	0	1	0
45 050	to	45 150	0	1	1	1	0	0	1	0	1	1	0
45 150	to	45 250	0	1	1	1	0	0	1	0	1	0	0
45 250	to	45 350	0	1	1	1	0	0	1	1	1	0	0
45 350	to	45 450	0	1	1	1	0	0	1	1	1	1	0
45 450	to	45 550	0	1	1	1	0	0	1	1	0	1	0
45 550	to	45 650	0	1	1	1	0	0	1	1	0	1	1
45 650	to	45 750	0	1	1	1	0	0	1	1	0	0	1
45 750	to	45 850	0	1	1	1	0	0	0	1	0	0	1
45 850	to	45 950	0	1	1	1	0	0	0	1	0	1	1
45 950	to	46 050	0	1	1	1	0	0	0	1	0	1	0
46 050	to	46 150	0	1	1	1	0	0	0	1	1	1	0
46 150	to	46 250	0	1	1	1	0	0	0	1	1	0	0
46 250	to	46 350	0	1	1	1	0	0	0	0	1	0	0
46 350	to	46 450	0	1	1	1	0	0	0	0	1	1	0
46 450	to	46 550	0	1	1	1	0	0	0	0	0	1	0
46 550	to	46 650	0	1	1	1	0	0	0	0	0	1	1
46 650	to	46 750	0	1	1	1	0	0	0	0	0	0	1
46 750	to	46 850	0	1	0	1	0	0	0	0	0	0	1
46 850	to	46 950	0	1	0	1	0	0	0	0	0	1	1
46 950	to	47 050	0	1	0	1	0	0	0	0	0	1	0
47 050	to	47 150	0	1	0	1	0	0	0	0	1	1	0
47 150	to	47 250	0	1	0	1	0	0	0	0	1	0	0
47 250	to	47 350	0	1	0	1	0	0	0	1	1	0	0
47 350	to	47 450	0	1	0	1	0	0	0	1	1	1	0
47 450	to	47 550	0	1	0	1	0	0	0	1	0	1	0
47 550	to	47 650	0	1	0	1	0	0	0	1	0	1	1
47 650	to	47 750	0	1	0	1	0	0	0	1	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
47 750	to	47 850	0	1	0	1	0	0	1	1	0	0	1
47 850	to	47 950	0	1	0	1	0	0	1	1	0	1	1
47 950	to	48 050	0	1	0	1	0	0	1	1	0	1	0
48 050	to	48 150	0	1	0	1	0	0	1	1	1	1	0
48 150	to	48 250	0	1	0	1	0	0	1	1	1	0	0
48 250	to	48 350	0	1	0	1	0	0	1	0	1	0	0
48 350	to	48 450	0	1	0	1	0	0	1	0	1	1	0
48 450	to	48 550	0	1	0	1	0	0	1	0	0	1	0
48 550	to	48 650	0	1	0	1	0	0	1	0	0	1	1
48 650	to	48 750	0	1	0	1	0	0	1	0	0	0	1
48 750	to	48 850	0	1	0	1	0	1	1	0	0	0	1
48 850	to	48 950	0	1	0	1	0	1	1	0	0	1	1
48 950	to	49 050	0	1	0	1	0	1	1	0	0	1	0
49 050	to	49 150	0	1	0	1	0	1	1	0	1	1	0
49 150	to	49 250	0	1	0	1	0	1	1	0	1	0	0
49 250	to	49 350	0	1	0	1	0	1	1	1	1	0	0
49 350	to	49 450	0	1	0	1	0	1	1	1	1	1	0
49 450	to	49 550	0	1	0	1	0	1	1	1	0	1	0
49 550	to	49 650	0	1	0	1	0	1	1	1	0	1	1
49 650	to	49 750	0	1	0	1	0	1	1	1	0	0	1
49 750	to	49 850	0	1	0	1	0	1	0	1	0	0	1
49 850	to	49 950	0	1	0	1	0	1	0	1	0	1	1
49 950	to	50 050	0	1	0	1	0	1	0	1	0	1	0
50 050	to	50 150	0	1	0	1	0	1	0	1	1	1	0
50 150	to	50 250	0	1	0	1	0	1	0	1	1	0	0
50 250	to	50 350	0	1	0	1	0	1	0	0	1	0	0
50 350	to	50 450	0	1	0	1	0	1	0	0	1	1	0
50 450	to	50 550	0	1	0	1	0	1	0	0	0	1	0
50 550	to	50 650	0	1	0	1	0	1	0	0	0	1	1
50 650	to	50 750	0	1	0	1	0	1	0	0	0	0	1
50 750	to	50 850	0	1	0	1	1	1	0	0	0	0	1
50 850	to	50 950	0	1	0	1	1	1	0	0	0	1	1
50 950	to	51 050	0	1	0	1	1	1	0	0	0	1	0
51 050	to	51 150	0	1	0	1	1	1	0	0	1	1	0
51 150	to	51 250	0	1	0	1	1	1	0	0	1	0	0
51 250	to	51 350	0	1	0	1	1	1	0	1	1	0	0
51 350	to	51 450	0	1	0	1	1	1	0	1	1	1	0
51 450	to	51 550	0	1	0	1	1	1	0	1	0	1	0
51 550	to	51 650	0	1	0	1	1	1	0	1	0	1	1
51 650	to	51 750	0	1	0	1	1	1	0	1	0	0	1
51 750	to	51 850	0	1	0	1	1	1	1	1	0	0	1
51 850	to	51 950	0	1	0	1	1	1	1	1	0	1	1
51 950	to	52 050	0	1	0	1	1	1	1	1	0	1	0
52 050	to	52 150	0	1	0	1	1	1	1	1	1	1	0
52 150	to	52 250	0	1	0	1	1	1	1	1	1	0	0
52 250	to	52 350	0	1	0	1	1	1	1	0	1	0	0
52 350	to	52 450	0	1	0	1	1	1	1	0	1	1	0
52 450	to	52 550	0	1	0	1	1	1	1	0	0	1	0
52 550	to	52 650	0	1	0	1	1	1	1	0	0	1	1
52 650	to	52 750	0	1	0	1	1	1	1	0	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
52 750	to	52 850	0	1	0	1	1	0	1	0	0	0	1
52 850	to	52 950	0	1	0	1	1	0	1	0	0	1	1
52 950	to	53 050	0	1	0	1	1	0	1	0	0	1	0
53 050	to	53 150	0	1	0	1	1	0	1	0	1	1	0
53 150	to	53 250	0	1	0	1	1	0	1	0	1	0	0
53 250	to	53 350	0	1	0	1	1	0	1	1	1	0	0
53 350	to	53 450	0	1	0	1	1	0	1	1	1	1	0
53 450	to	53 550	0	1	0	1	1	0	1	1	0	1	0
53 550	to	53 650	0	1	0	1	1	0	1	1	0	1	1
53 650	to	53 750	0	1	0	1	1	0	1	1	0	0	1
53 750	to	53 850	0	1	0	1	1	0	0	1	0	0	1
53 850	to	53 950	0	1	0	1	1	0	0	1	0	1	1
53 950	to	54 050	0	1	0	1	1	0	0	1	0	1	0
54 050	to	54 150	0	1	0	1	1	0	0	1	1	1	0
54 150	to	54 250	0	1	0	1	1	0	0	1	1	0	0
54 250	to	54 350	0	1	0	1	1	0	0	0	1	0	0
54 350	to	54 450	0	1	0	1	1	0	0	0	1	1	0
54 450	to	54 550	0	1	0	1	1	0	0	0	0	1	0
54 550	to	54 650	0	1	0	1	1	0	0	0	0	1	1
54 650	to	54 750	0	1	0	1	1	0	0	0	0	0	1
54 750	to	54 850	0	1	0	0	1	0	0	0	0	0	1
54 850	to	54 950	0	1	0	0	1	0	0	0	0	1	1
54 950	to	55 050	0	1	0	0	1	0	0	0	0	1	0
55 050	to	55 150	0	1	0	0	1	0	0	0	1	1	0
55 150	to	55 250	0	1	0	0	1	0	0	0	1	0	0
55 250	to	55 350	0	1	0	0	1	0	0	1	1	0	0
55 350	to	55 450	0	1	0	0	1	0	0	1	1	1	0
55 450	to	55 550	0	1	0	0	1	0	0	1	0	1	0
55 550	to	55 650	0	1	0	0	1	0	0	1	0	1	1
55 650	to	55 750	0	1	0	0	1	0	0	1	0	0	1
55 750	to	55 850	0	1	0	0	1	0	1	1	0	0	1
55 850	to	55 950	0	1	0	0	1	0	1	1	0	1	1
55 950	to	56 050	0	1	0	0	1	0	1	1	0	1	0
56 050	to	56 150	0	1	0	0	1	0	1	1	1	1	0
56 150	to	56 250	0	1	0	0	1	0	1	1	1	0	0
56 250	to	56 350	0	1	0	0	1	0	1	0	1	0	0
56 350	to	56 450	0	1	0	0	1	0	1	0	1	1	0
56 450	to	56 550	0	1	0	0	1	0	1	0	0	1	0
56 550	to	56 650	0	1	0	0	1	0	1	0	0	1	1
56 650	to	56 750	0	1	0	0	1	0	1	0	0	0	1
56 750	to	56 850	0	1	0	0	1	1	1	0	0	0	1
56 850	to	56 950	0	1	0	0	1	1	1	0	0	1	1
56 950	to	57 050	0	1	0	0	1	1	1	0	0	1	0
57 050	to	57 150	0	1	0	0	1	1	1	0	1	1	0
57 150	to	57 250	0	1	0	0	1	1	1	0	1	0	0
57 250	to	57 350	0	1	0	0	1	1	1	1	1	0	0
57 350	to	57 450	0	1	0	0	1	1	1	1	1	1	0
57 450	to	57 550	0	1	0	0	1	1	1	1	0	1	0
57 550	to	57 650	0	1	0	0	1	1	1	1	0	1	1
57 650	to	57 750	0	1	0	0	1	1	1	1	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
57 750	to	57 850	0	1	0	0	1	1	0	1	0	0	1
57 850	to	57 950	0	1	0	0	1	1	0	1	0	1	1
57 950	to	58 050	0	1	0	0	1	1	0	1	0	1	0
58 050	to	58 150	0	1	0	0	1	1	0	1	1	1	0
58 150	to	58 250	0	1	0	0	1	1	0	1	1	0	0
58 250	to	58 350	0	1	0	0	1	1	0	0	1	0	0
58 350	to	58 450	0	1	0	0	1	1	0	0	1	1	0
58 450	to	58 550	0	1	0	0	1	1	0	0	0	1	0
58 550	to	58 650	0	1	0	0	1	1	0	0	0	1	1
58 650	to	58 750	0	1	0	0	1	1	0	0	0	0	1
58 750	to	58 850	0	1	0	0	0	1	0	0	0	0	1
58 850	to	58 950	0	1	0	0	0	1	0	0	0	1	1
58 950	to	59 050	0	1	0	0	0	1	0	0	0	1	0
59 050	to	59 150	0	1	0	0	0	1	0	0	1	1	0
59 150	to	59 250	0	1	0	0	0	1	0	0	1	0	0
59 250	to	59 350	0	1	0	0	0	1	0	1	1	0	0
59 350	to	59 450	0	1	0	0	0	1	0	1	1	1	0
59 450	to	59 550	0	1	0	0	0	1	0	1	0	1	0
59 550	to	59 650	0	1	0	0	0	1	0	1	0	1	1
59 650	to	59 750	0	1	0	0	0	1	0	1	0	0	1
59 750	to	59 850	0	1	0	0	0	1	1	1	0	0	1
59 850	to	59 950	0	1	0	0	0	1	1	1	0	1	1
59 950	to	60 050	0	1	0	0	0	1	1	1	0	1	0
60 050	to	60 150	0	1	0	0	0	1	1	1	1	1	0
60 150	to	60 250	0	1	0	0	0	1	1	1	1	0	0
60 250	to	60 350	0	1	0	0	0	1	1	0	1	0	0
60 350	to	60 450	0	1	0	0	0	1	1	0	1	1	0
60 450	to	60 550	0	1	0	0	0	1	1	0	0	1	0
60 550	to	60 650	0	1	0	0	0	1	1	0	0	1	1
60 650	to	60 750	0	1	0	0	0	1	1	0	0	0	1
60 750	to	60 850	0	1	0	0	0	0	1	0	0	0	1
60 850	to	60 950	0	1	0	0	0	0	1	0	0	1	1
60 950	to	61 050	0	1	0	0	0	0	1	0	0	1	0
61 050	to	61 150	0	1	0	0	0	0	1	0	1	1	0
61 150	to	61 250	0	1	0	0	0	0	1	0	1	0	0
61 250	to	61 350	0	1	0	0	0	0	1	1	1	0	0
61 350	to	61 450	0	1	0	0	0	0	1	1	1	1	0
61 450	to	61 550	0	1	0	0	0	0	1	1	0	1	0
61 550	to	61 650	0	1	0	0	0	0	1	1	0	1	1
61 650	to	61 750	0	1	0	0	0	0	1	1	0	0	1
61 750	to	61 850	0	1	0	0	0	0	0	1	0	0	1
61 850	to	61 950	0	1	0	0	0	0	0	1	0	1	1
61 950	to	62 050	0	1	0	0	0	0	0	1	0	1	0
62 050	to	62 150	0	1	0	0	0	0	0	1	1	1	0
62 150	to	62 250	0	1	0	0	0	0	0	1	1	0	0
62 250	to	62 350	0	1	0	0	0	0	0	0	1	0	0
62 350	to	62 450	0	1	0	0	0	0	0	0	1	1	0
62 450	to	62 550	0	1	0	0	0	0	0	0	0	1	0
62 550	to	62 650	0	1	0	0	0	0	0	0	0	1	1
62 650	to	62 750	0	1	0	0	0	0	0	0	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
62 750	to	62 850	1	1	0	0	0	0	0	0	0	0	1
62 850	to	62 950	1	1	0	0	0	0	0	0	0	1	1
62 950	to	63 050	1	1	0	0	0	0	0	0	0	1	0
63 050	to	63 150	1	1	0	0	0	0	0	0	1	1	0
63 150	to	63 250	1	1	0	0	0	0	0	0	1	0	0
63 250	to	63 350	1	1	0	0	0	0	0	1	1	0	0
63 350	to	63 450	1	1	0	0	0	0	0	1	1	1	0
63 450	to	63 550	1	1	0	0	0	0	0	1	0	1	0
63 550	to	63 650	1	1	0	0	0	0	0	1	0	1	1
63 650	to	63 750	1	1	0	0	0	0	0	1	0	0	1
63 750	to	63 850	1	1	0	0	0	0	1	1	0	0	1
63 850	to	63 950	1	1	0	0	0	0	1	1	0	1	1
63 950	to	64 050	1	1	0	0	0	0	1	1	0	1	0
64 050	to	64 150	1	1	0	0	0	0	1	1	1	1	0
64 150	to	64 250	1	1	0	0	0	0	1	1	1	0	0
64 250	to	64 350	1	1	0	0	0	0	1	0	1	0	0
64 350	to	64 450	1	1	0	0	0	0	1	0	1	1	0
64 450	to	64 550	1	1	0	0	0	0	1	0	0	1	0
64 550	to	64 650	1	1	0	0	0	0	1	0	0	1	1
64 650	to	64 750	1	1	0	0	0	0	1	0	0	0	1
64 750	to	64 850	1	1	0	0	0	1	1	0	0	0	1
64 850	to	64 950	1	1	0	0	0	1	1	0	0	1	1
64 950	to	65 050	1	1	0	0	0	1	1	0	0	1	0
65 050	to	65 150	1	1	0	0	0	1	1	0	1	1	0
65 150	to	65 250	1	1	0	0	0	1	1	0	1	0	0
65 250	to	65 350	1	1	0	0	0	1	1	1	1	0	0
65 350	to	65 450	1	1	0	0	0	1	1	1	1	1	0
65 450	to	65 550	1	1	0	0	0	1	1	1	0	1	0
65 550	to	65 650	1	1	0	0	0	1	1	1	0	1	1
65 650	to	65 750	1	1	0	0	0	1	1	1	0	0	1
65 750	to	65 850	1	1	0	0	0	1	0	1	0	0	1
65 850	to	65 950	1	1	0	0	0	1	0	1	0	1	1
65 950	to	66 050	1	1	0	0	0	1	0	1	0	1	0
66 050	to	66 150	1	1	0	0	0	1	0	1	1	1	0
66 150	to	66 250	1	1	0	0	0	1	0	1	1	0	0
66 250	to	66 350	1	1	0	0	0	1	0	0	1	0	0
66 350	to	66 450	1	1	0	0	0	1	0	0	1	1	0
66 450	to	66 550	1	1	0	0	0	1	0	0	0	1	0
66 550	to	66 650	1	1	0	0	0	1	0	0	0	1	1
66 650	to	66 750	1	1	0	0	0	1	0	0	0	0	1
66 750	to	66 850	1	1	0	0	1	1	0	0	0	0	1
66 850	to	66 950	1	1	0	0	1	1	0	0	0	1	1
66 950	to	67 050	1	1	0	0	1	1	0	0	0	1	0
67 050	to	67 150	1	1	0	0	1	1	0	0	1	1	0
67 150	to	67 250	1	1	0	0	1	1	0	0	1	0	0
67 250	to	67 350	1	1	0	0	1	1	0	1	1	0	0
67 350	to	67 450	1	1	0	0	1	1	0	1	1	1	0
67 450	to	67 550	1	1	0	0	1	1	0	1	0	1	0
67 550	to	67 650	1	1	0	0	1	1	0	1	0	1	1
67 650	to	67 750	1	1	0	0	1	1	0	1	0	0	1

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
67 750	to	67 850	1	1	0	0	1	1	1	1	0	0	1
67 850	to	67 950	1	1	0	0	1	1	1	1	0	1	1
67 950	to	68 050	1	1	0	0	1	1	1	1	0	1	0
68 050	to	68 150	1	1	0	0	1	1	1	1	1	1	0
68 150	to	68 250	1	1	0	0	1	1	1	1	1	0	0
68 250	to	68 350	1	1	0	0	1	1	1	0	1	0	0
68 350	to	68 450	1	1	0	0	1	1	1	0	1	1	0
68 450	to	68 550	1	1	0	0	1	1	1	0	0	1	0
68 550	to	68 650	1	1	0	0	1	1	1	0	0	1	1
68 650	to	68 750	1	1	0	0	1	1	1	0	0	0	1
68 750	to	68 850	1	1	0	0	1	0	1	0	0	0	1
68 850	to	68 950	1	1	0	0	1	0	1	0	0	1	1
68 950	to	69 050	1	1	0	0	1	0	1	0	0	1	0
69 050	to	69 150	1	1	0	0	1	0	1	0	1	1	0
69 150	to	69 250	1	1	0	0	1	0	1	0	1	0	0
69 250	to	69 350	1	1	0	0	1	0	1	1	1	0	0
69 350	to	69 450	1	1	0	0	1	0	1	1	1	1	0
69 450	to	69 550	1	1	0	0	1	0	1	1	0	1	0
69 550	to	69 650	1	1	0	0	1	0	1	1	0	1	1
69 650	to	69 750	1	1	0	0	1	0	1	1	0	0	1
69 750	to	69 850	1	1	0	0	1	0	0	1	0	0	1
69 850	to	69 950	1	1	0	0	1	0	0	1	0	1	1
69 950	to	70 050	1	1	0	0	1	0	0	1	0	1	0
70 050	to	70 150	1	1	0	0	1	0	0	1	1	1	0
70 150	to	70 250	1	1	0	0	1	0	0	1	1	0	0
70 250	to	70 350	1	1	0	0	1	0	0	0	1	0	0
70 350	to	70 450	1	1	0	0	1	0	0	0	1	1	0
70 450	to	70 550	1	1	0	0	1	0	0	0	0	1	0
70 550	to	70 650	1	1	0	0	1	0	0	0	0	1	1
70 650	to	70 750	1	1	0	0	1	0	0	0	0	0	1
70 750	to	70 850	1	1	0	1	1	0	0	0	0	0	1
70 850	to	70 950	1	1	0	1	1	0	0	0	0	1	1
70 950	to	71 050	1	1	0	1	1	0	0	0	0	1	0
71 050	to	71 150	1	1	0	1	1	0	0	0	1	1	0
71 150	to	71 250	1	1	0	1	1	0	0	0	1	0	0
71 250	to	71 350	1	1	0	1	1	0	0	1	1	0	0
71 350	to	71 450	1	1	0	1	1	0	0	1	1	1	0
71 450	to	71 550	1	1	0	1	1	0	0	1	0	1	0
71 550	to	71 650	1	1	0	1	1	0	0	1	0	1	1
71 650	to	71 750	1	1	0	1	1	0	0	1	0	0	1
71 750	to	71 850	1	1	0	1	1	0	1	1	0	0	1
71 850	to	71 950	1	1	0	1	1	0	1	1	0	1	1
71 950	to	72 050	1	1	0	1	1	0	1	1	0	1	0
72 050	to	72 150	1	1	0	1	1	0	1	1	1	1	0
72 150	to	72 250	1	1	0	1	1	0	1	1	1	0	0
72 250	to	72 350	1	1	0	1	1	0	1	0	1	0	0
72 350	to	72 450	1	1	0	1	1	0	1	0	1	1	0
72 450	to	72 550	1	1	0	1	1	0	1	0	0	1	0
72 550	to	72 650	1	1	0	1	1	0	1	0	0	1	1
72 650	to	72 750	1	1	0	1	1	0	1	0	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
72 750	to	72 850	1	1	0	1	1	1	1	0	0	0	1
72 850	to	72 950	1	1	0	1	1	1	1	0	0	1	1
72 950	to	73 050	1	1	0	1	1	1	1	0	0	1	0
73 050	to	73 150	1	1	0	1	1	1	1	0	1	1	0
73 150	to	73 250	1	1	0	1	1	1	1	0	1	0	0
73 250	to	73 350	1	1	0	1	1	1	1	1	1	0	0
73 350	to	73 450	1	1	0	1	1	1	1	1	1	1	0
73 450	to	73 550	1	1	0	1	1	1	1	1	0	1	0
73 550	to	73 650	1	1	0	1	1	1	1	1	0	1	1
73 650	to	73 750	1	1	0	1	1	1	1	1	0	0	1
73 750	to	73 850	1	1	0	1	1	1	0	1	0	0	1
73 850	to	73 950	1	1	0	1	1	1	0	1	0	1	1
73 950	to	74 050	1	1	0	1	1	1	0	1	0	1	0
74 050	to	74 150	1	1	0	1	1	1	0	1	1	1	0
74 150	to	74 250	1	1	0	1	1	1	0	1	1	0	0
74 250	to	74 350	1	1	0	1	1	1	0	0	1	0	0
74 350	to	74 450	1	1	0	1	1	1	0	0	1	1	0
74 450	to	74 550	1	1	0	1	1	1	0	0	0	1	0
74 550	to	74 650	1	1	0	1	1	1	0	0	0	1	1
74 650	to	74 750	1	1	0	1	1	1	0	0	0	0	1
74 750	to	74 850	1	1	0	1	0	1	0	0	0	0	1
74 850	to	74 950	1	1	0	1	0	1	0	0	0	1	1
74 950	to	75 050	1	1	0	1	0	1	0	0	0	1	0
75 050	to	75 150	1	1	0	1	0	1	0	0	1	1	0
75 150	to	75 250	1	1	0	1	0	1	0	0	1	0	0
75 250	to	75 350	1	1	0	1	0	1	0	1	1	0	0
75 350	to	75 450	1	1	0	1	0	1	0	1	1	1	0
75 450	to	75 550	1	1	0	1	0	1	0	1	0	1	0
75 550	to	75 650	1	1	0	1	0	1	0	1	0	1	1
75 650	to	75 750	1	1	0	1	0	1	0	1	0	0	1
75 750	to	75 850	1	1	0	1	0	1	1	1	0	0	1
75 850	to	75 950	1	1	0	1	0	1	1	1	0	1	1
75 950	to	76 050	1	1	0	1	0	1	1	1	0	1	0
76 050	to	76 150	1	1	0	1	0	1	1	1	1	1	0
76 150	to	76 250	1	1	0	1	0	1	1	1	1	0	0
76 250	to	76 350	1	1	0	1	0	1	1	0	1	0	0
76 350	to	76 450	1	1	0	1	0	1	1	0	1	1	0
76 450	to	76 550	1	1	0	1	0	1	1	0	0	1	0
76 550	to	76 650	1	1	0	1	0	1	1	0	0	1	1
76 650	to	76 750	1	1	0	1	0	1	1	0	0	0	1
76 750	to	76 850	1	1	0	1	0	0	1	0	0	0	1
76 850	to	76 950	1	1	0	1	0	0	1	0	0	1	1
76 950	to	77 050	1	1	0	1	0	0	1	0	0	1	0
77 050	to	77 150	1	1	0	1	0	0	1	0	1	1	0
77 150	to	77 250	1	1	0	1	0	0	1	0	1	0	0
77 250	to	77 350	1	1	0	1	0	0	1	1	1	0	0
77 350	to	77 450	1	1	0	1	0	0	1	1	1	1	0
77 450	to	77 550	1	1	0	1	0	0	1	1	0	1	0
77 550	to	77 650	1	1	0	1	0	0	1	1	0	1	1
77 650	to	77 750	1	1	0	1	0	0	1	1	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
77 750	to	77 850	1	1	0	1	0	0	0	1	0	0	1
77 850	to	77 950	1	1	0	1	0	0	0	1	0	1	1
77 950	to	78 050	1	1	0	1	0	0	0	1	0	1	0
78 050	to	78 150	1	1	0	1	0	0	0	1	1	1	0
78 150	to	78 250	1	1	0	1	0	0	0	1	1	0	0
78 250	to	78 350	1	1	0	1	0	0	0	0	1	0	0
78 350	to	78 450	1	1	0	1	0	0	0	0	1	1	0
78 450	to	78 550	1	1	0	1	0	0	0	0	0	1	0
78 550	to	78 650	1	1	0	1	0	0	0	0	0	1	1
78 650	to	78 750	1	1	0	1	0	0	0	0	0	0	1
78 750	to	78 850	1	1	1	1	0	0	0	0	0	0	1
78 850	to	78 950	1	1	1	1	0	0	0	0	0	1	1
78 950	to	79 050	1	1	1	1	0	0	0	0	0	1	0
79 050	to	79 150	1	1	1	1	0	0	0	0	1	1	0
79 150	to	79 250	1	1	1	1	0	0	0	0	1	0	0
79 250	to	79 350	1	1	1	1	0	0	0	1	1	0	0
79 350	to	79 450	1	1	1	1	0	0	0	1	1	1	0
79 450	to	79 550	1	1	1	1	0	0	0	1	0	1	0
79 550	to	79 650	1	1	1	1	0	0	0	1	0	1	1
79 650	to	79 750	1	1	1	1	0	0	0	1	0	0	1
79 750	to	79 850	1	1	1	1	0	0	1	1	0	0	1
79 850	to	79 950	1	1	1	1	0	0	1	1	0	1	1
79 950	to	80 050	1	1	1	1	0	0	1	1	0	1	0
80 050	to	80 150	1	1	1	1	0	0	1	1	1	1	0
80 150	to	80 250	1	1	1	1	0	0	1	1	1	0	0
80 250	to	80 350	1	1	1	1	0	0	1	0	1	0	0
80 350	to	80 450	1	1	1	1	0	0	1	0	1	1	0
80 450	to	80 550	1	1	1	1	0	0	1	0	0	1	0
80 550	to	80 650	1	1	1	1	0	0	1	0	0	1	1
80 650	to	80 750	1	1	1	1	0	0	1	0	0	0	1
80 750	to	80 850	1	1	1	1	0	1	1	0	0	0	1
80 850	to	80 950	1	1	1	1	0	1	1	0	0	1	1
80 950	to	81 050	1	1	1	1	0	1	1	0	0	1	0
81 050	to	81 150	1	1	1	1	0	1	1	0	1	1	0
81 150	to	81 250	1	1	1	1	0	1	1	0	1	0	0
81 250	to	81 350	1	1	1	1	0	1	1	1	1	0	0
81 350	to	81 450	1	1	1	1	0	1	1	1	1	1	0
81 450	to	81 550	1	1	1	1	0	1	1	1	0	1	0
81 550	to	81 650	1	1	1	1	0	1	1	1	0	1	1
81 650	to	81 750	1	1	1	1	0	1	1	1	0	0	1
81 750	to	81 850	1	1	1	1	0	1	0	1	0	0	1
81 850	to	81 950	1	1	1	1	0	1	0	1	0	1	1
81 950	to	82 050	1	1	1	1	0	1	0	1	0	1	0
82 050	to	82 150	1	1	1	1	0	1	0	1	1	1	0
82 150	to	82 250	1	1	1	1	0	1	0	1	1	0	0
82 250	to	82 350	1	1	1	1	0	1	0	0	1	0	0
82 350	to	82 450	1	1	1	1	0	1	0	0	1	1	0
82 450	to	82 550	1	1	1	1	0	1	0	0	0	1	0
82 550	to	82 650	1	1	1	1	0	1	0	0	0	1	1
82 650	to	82 750	1	1	1	1	0	1	0	0	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
82 750	to	82 850	1	1	1	1	1	1	0	0	0	0	1
82 850	to	82 950	1	1	1	1	1	1	0	0	0	1	1
82 950	to	83 050	1	1	1	1	1	1	0	0	0	1	0
83 050	to	83 150	1	1	1	1	1	1	0	0	1	1	0
83 150	to	83 250	1	1	1	1	1	1	0	0	1	0	0
83 250	to	83 350	1	1	1	1	1	1	0	1	1	0	0
83 350	to	83 450	1	1	1	1	1	1	0	1	1	1	0
83 450	to	83 550	1	1	1	1	1	1	0	1	0	1	0
83 550	to	83 650	1	1	1	1	1	1	0	1	0	1	1
83 650	to	83 750	1	1	1	1	1	1	0	1	0	0	1
83 750	to	83 850	1	1	1	1	1	1	1	1	0	0	1
83 850	to	83 950	1	1	1	1	1	1	1	1	0	1	1
83 950	to	84 050	1	1	1	1	1	1	1	1	0	1	0
84 050	to	84 150	1	1	1	1	1	1	1	1	1	1	0
84 150	to	84 250	1	1	1	1	1	1	1	1	1	0	0
84 250	to	84 350	1	1	1	1	1	1	1	0	1	0	0
84 350	to	84 450	1	1	1	1	1	1	1	0	1	1	0
84 450	to	84 550	1	1	1	1	1	1	1	0	0	1	0
84 550	to	84 650	1	1	1	1	1	1	1	0	0	1	1
84 650	to	84 750	1	1	1	1	1	1	1	0	0	0	1
84 750	to	84 850	1	1	1	1	1	0	1	0	0	0	1
84 850	to	84 950	1	1	1	1	1	0	1	0	0	1	1
84 950	to	85 050	1	1	1	1	1	0	1	0	0	1	0
85 050	to	85 150	1	1	1	1	1	0	1	0	1	1	0
85 150	to	85 250	1	1	1	1	1	0	1	0	1	0	0
85 250	to	85 350	1	1	1	1	1	0	1	1	1	0	0
85 350	to	85 450	1	1	1	1	1	0	1	1	1	1	0
85 450	to	85 550	1	1	1	1	1	0	1	1	0	1	0
85 550	to	85 650	1	1	1	1	1	0	1	1	0	1	1
85 650	to	85 750	1	1	1	1	1	0	1	1	0	0	1
85 750	to	85 850	1	1	1	1	1	0	0	1	0	0	1
85 850	to	85 950	1	1	1	1	1	0	0	1	0	1	1
85 950	to	86 050	1	1	1	1	1	0	0	1	0	1	0
86 050	to	86 150	1	1	1	1	1	0	0	1	1	1	0
86 150	to	86 250	1	1	1	1	1	0	0	1	1	0	0
86 250	to	86 350	1	1	1	1	1	0	0	0	1	0	0
86 350	to	86 450	1	1	1	1	1	0	0	0	1	1	0
86 450	to	86 550	1	1	1	1	1	0	0	0	0	1	0
86 550	to	86 650	1	1	1	1	1	0	0	0	0	1	1
86 650	to	86 750	1	1	1	1	1	0	0	0	0	0	1
86 750	to	86 850	1	1	1	0	1	0	0	0	0	0	1
86 850	to	86 950	1	1	1	0	1	0	0	0	0	1	1
86 950	to	87 050	1	1	1	0	1	0	0	0	0	1	0
87 050	to	87 150	1	1	1	0	1	0	0	0	1	1	0
87 150	to	87 250	1	1	1	0	1	0	0	0	1	0	0
87 250	to	87 350	1	1	1	0	1	0	0	1	1	0	0
87 350	to	87 450	1	1	1	0	1	0	0	1	1	1	0
87 450	to	87 550	1	1	1	0	1	0	0	1	0	1	0
87 550	to	87 650	1	1	1	0	1	0	0	1	0	1	1
87 650	to	87 750	1	1	1	0	1	0	0	1	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
87 750	to	87 850	1	1	1	0	1	0	1	1	0	0	1
87 850	to	87 950	1	1	1	0	1	0	1	1	0	1	1
87 950	to	88 050	1	1	1	0	1	0	1	1	0	1	0
88 050	to	88 150	1	1	1	0	1	0	1	1	1	1	0
88 150	to	88 250	1	1	1	0	1	0	1	1	1	0	0
88 250	to	88 350	1	1	1	0	1	0	1	0	1	0	0
88 350	to	88 450	1	1	1	0	1	0	1	0	1	1	0
88 450	to	88 550	1	1	1	0	1	0	1	0	0	1	0
88 550	to	88 650	1	1	1	0	1	0	1	0	0	1	1
88 650	to	88 750	1	1	1	0	1	0	1	0	0	0	1
88 750	to	88 850	1	1	1	0	1	1	1	0	0	0	1
88 850	to	88 950	1	1	1	0	1	1	1	0	0	1	1
88 950	to	89 050	1	1	1	0	1	1	1	0	0	1	0
89 050	to	89 150	1	1	1	0	1	1	1	0	1	1	0
89 150	to	89 250	1	1	1	0	1	1	1	0	1	0	0
89 250	to	89 350	1	1	1	0	1	1	1	1	1	0	0
89 350	to	89 450	1	1	1	0	1	1	1	1	1	1	0
89 450	to	89 550	1	1	1	0	1	1	1	1	0	1	0
89 550	to	89 650	1	1	1	0	1	1	1	1	0	1	1
89 650	to	89 750	1	1	1	0	1	1	1	1	0	0	1
89 750	to	89 850	1	1	1	0	1	1	0	1	0	0	1
89 850	to	89 950	1	1	1	0	1	1	0	1	0	1	1
89 950	to	90 050	1	1	1	0	1	1	0	1	0	1	0
90 050	to	90 150	1	1	1	0	1	1	0	1	1	1	0
90 150	to	90 250	1	1	1	0	1	1	0	1	1	0	0
90 250	to	90 350	1	1	1	0	1	1	0	0	1	0	0
90 350	to	90 450	1	1	1	0	1	1	0	0	1	1	0
90 450	to	90 550	1	1	1	0	1	1	0	0	0	1	0
90 550	to	90 650	1	1	1	0	1	1	0	0	0	1	1
90 650	to	90 750	1	1	1	0	1	1	0	0	0	0	1
90 750	to	90 850	1	1	1	0	0	1	0	0	0	0	1
90 850	to	90 950	1	1	1	0	0	1	0	0	0	1	1
90 950	to	91 050	1	1	1	0	0	1	0	0	0	1	0
91 050	to	91 150	1	1	1	0	0	1	0	0	1	1	0
91 150	to	91 250	1	1	1	0	0	1	0	0	1	0	0
91 250	to	91 350	1	1	1	0	0	1	0	1	1	0	0
91 350	to	91 450	1	1	1	0	0	1	0	1	1	1	0
91 450	to	91 550	1	1	1	0	0	1	0	1	0	1	0
91 550	to	91 650	1	1	1	0	0	1	0	1	0	1	1
91 650	to	91 750	1	1	1	0	0	1	0	1	0	0	1
91 750	to	91 850	1	1	1	0	0	1	1	1	0	0	1
91 850	to	91 950	1	1	1	0	0	1	1	1	0	1	1
91 950	to	92 050	1	1	1	0	0	1	1	1	0	1	0
92 050	to	92 150	1	1	1	0	0	1	1	1	1	1	0
92 150	to	92 250	1	1	1	0	0	1	1	1	1	0	0
92 250	to	92 350	1	1	1	0	0	1	1	0	1	0	0
92 350	to	92 450	1	1	1	0	0	1	1	0	1	1	0
92 450	to	92 550	1	1	1	0	0	1	1	0	0	1	0
92 550	to	92 650	1	1	1	0	0	1	1	0	0	1	1
92 650	to	92 750	1	1	1	0	0	1	1	0	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
92 750	to	92 850	1	1	1	0	0	0	1	0	0	0	1
92 850	to	92 950	1	1	1	0	0	0	1	0	0	1	1
92 950	to	93 050	1	1	1	0	0	0	1	0	0	1	0
93 050	to	93 150	1	1	1	0	0	0	1	0	1	1	0
93 150	to	93 250	1	1	1	0	0	0	1	0	1	0	0
93 250	to	93 350	1	1	1	0	0	0	1	1	1	0	0
93 350	to	93 450	1	1	1	0	0	0	1	1	1	1	0
93 450	to	93 550	1	1	1	0	0	0	1	1	0	1	0
93 550	to	93 650	1	1	1	0	0	0	1	1	0	1	1
93 650	to	93 750	1	1	1	0	0	0	1	1	0	0	1
93 750	to	93 850	1	1	1	0	0	0	0	1	0	0	1
93 850	to	93 950	1	1	1	0	0	0	0	1	0	1	1
93 950	to	94 050	1	1	1	0	0	0	0	1	0	1	0
94 050	to	94 150	1	1	1	0	0	0	0	1	1	1	0
94 150	to	94 250	1	1	1	0	0	0	0	1	1	0	0
94 250	to	94 350	1	1	1	0	0	0	0	0	1	0	0
94 350	to	94 450	1	1	1	0	0	0	0	0	1	1	0
94 450	to	94 550	1	1	1	0	0	0	0	0	0	1	0
94 550	to	94 650	1	1	1	0	0	0	0	0	0	1	1
94 650	to	94 750	1	1	1	0	0	0	0	0	0	0	1
94 750	to	94 850	1	0	1	0	0	0	0	0	0	0	1
94 850	to	94 950	1	0	1	0	0	0	0	0	0	1	1
94 950	to	95 050	1	0	1	0	0	0	0	0	0	1	0
95 050	to	95 150	1	0	1	0	0	0	0	0	1	1	0
95 150	to	95 250	1	0	1	0	0	0	0	0	1	0	0
95 250	to	95 350	1	0	1	0	0	0	0	1	1	0	0
95 350	to	95 450	1	0	1	0	0	0	0	1	1	1	0
95 450	to	95 550	1	0	1	0	0	0	0	1	0	1	0
95 550	to	95 650	1	0	1	0	0	0	0	1	0	1	1
95 650	to	95 750	1	0	1	0	0	0	0	1	0	0	1
95 750	to	95 850	1	0	1	0	0	0	1	1	0	0	1
95 850	to	95 950	1	0	1	0	0	0	1	1	0	1	1
95 950	to	96 050	1	0	1	0	0	0	1	1	0	1	0
96 050	to	96 150	1	0	1	0	0	0	1	1	1	1	0
96 150	to	96 250	1	0	1	0	0	0	1	1	1	0	0
96 250	to	96 350	1	0	1	0	0	0	1	0	1	0	0
96 350	to	96 450	1	0	1	0	0	0	1	0	1	1	0
96 450	to	96 550	1	0	1	0	0	0	1	0	0	1	0
96 550	to	96 650	1	0	1	0	0	0	1	0	0	1	1
96 650	to	96 750	1	0	1	0	0	0	1	0	0	0	1
96 750	to	96 850	1	0	1	0	0	1	1	0	0	0	1
96 850	to	96 950	1	0	1	0	0	1	1	0	0	1	1
96 950	to	97 050	1	0	1	0	0	1	1	0	0	1	0
97 050	to	97 150	1	0	1	0	0	1	1	0	1	1	0
97 150	to	97 250	1	0	1	0	0	1	1	0	1	0	0
97 250	to	97 350	1	0	1	0	0	1	1	1	1	0	0
97 350	to	97 450	1	0	1	0	0	1	1	1	1	1	0
97 450	to	97 550	1	0	1	0	0	1	1	1	0	1	0
97 550	to	97 650	1	0	1	0	0	1	1	1	0	1	1
97 650	to	97 750	1	0	1	0	0	1	1	1	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
97 750	to	97 850	1	0	1	0	0	1	0	1	0	0	1
97 850	to	97 950	1	0	1	0	0	1	0	1	0	1	1
97 950	to	98 050	1	0	1	0	0	1	0	1	0	1	0
98 050	to	98 150	1	0	1	0	0	1	0	1	1	1	0
98 150	to	98 250	1	0	1	0	0	1	0	1	1	0	0
98 250	to	98 350	1	0	1	0	0	1	0	0	1	0	0
98 350	to	98 450	1	0	1	0	0	1	0	0	1	1	0
98 450	to	98 550	1	0	1	0	0	1	0	0	0	1	0
98 550	to	98 650	1	0	1	0	0	1	0	0	0	1	1
98 650	to	98 750	1	0	1	0	0	1	0	0	0	0	1
98 750	to	98 850	1	0	1	0	1	1	0	0	0	0	1
98 850	to	98 950	1	0	1	0	1	1	0	0	0	1	1
98 950	to	99 050	1	0	1	0	1	1	0	0	0	1	0
99 050	to	99 150	1	0	1	0	1	1	0	0	1	1	0
99 150	to	99 250	1	0	1	0	1	1	0	0	1	0	0
99 250	to	99 350	1	0	1	0	1	1	0	1	1	0	0
99 350	to	99 450	1	0	1	0	1	1	0	1	1	1	0
99 450	to	99 550	1	0	1	0	1	1	0	1	0	1	0
99 550	to	99 650	1	0	1	0	1	1	0	1	0	1	1
99 650	to	99 750	1	0	1	0	1	1	0	1	0	0	1
99 750	to	99 850	1	0	1	0	1	1	1	1	0	0	1
99 850	to	99 950	1	0	1	0	1	1	1	1	0	1	1
99 950	to	100 050	1	0	1	0	1	1	1	1	0	1	0
100 050	to	100 150	1	0	1	0	1	1	1	1	1	1	0
100 150	to	100 250	1	0	1	0	1	1	1	1	1	0	0
100 250	to	100 350	1	0	1	0	1	1	1	0	1	0	0
100 350	to	100 450	1	0	1	0	1	1	1	0	1	1	0
100 450	to	100 550	1	0	1	0	1	1	1	0	0	1	0
100 550	to	100 650	1	0	1	0	1	1	1	0	0	1	1
100 650	to	100 750	1	0	1	0	1	1	1	0	0	0	1
100 750	to	100 850	1	0	1	0	1	0	1	0	0	0	1
100 850	to	100 950	1	0	1	0	1	0	1	0	0	1	1
100 950	to	101 050	1	0	1	0	1	0	1	0	0	1	0
101 050	to	101 150	1	0	1	0	1	0	1	0	1	1	0
101 150	to	101 250	1	0	1	0	1	0	1	0	1	0	0
101 250	to	101 350	1	0	1	0	1	0	1	1	1	0	0
101 350	to	101 450	1	0	1	0	1	0	1	1	1	1	0
101 450	to	101 550	1	0	1	0	1	0	1	1	0	1	0
101 550	to	101 650	1	0	1	0	1	0	1	1	0	1	1
101 650	to	101 750	1	0	1	0	1	0	1	1	0	0	1
101 750	to	101 850	1	0	1	0	1	0	0	1	0	0	1
101 850	to	101 950	1	0	1	0	1	0	0	1	0	1	1
101 950	to	102 050	1	0	1	0	1	0	0	1	0	1	0
102 050	to	102 150	1	0	1	0	1	0	0	1	1	1	0
102 150	to	102 250	1	0	1	0	1	0	0	1	1	0	0
102 250	to	102 350	1	0	1	0	1	0	0	0	1	0	0
102 350	to	102 450	1	0	1	0	1	0	0	0	1	1	0
102 450	to	102 550	1	0	1	0	1	0	0	0	0	1	0
102 550	to	102 650	1	0	1	0	1	0	0	0	0	1	1
102 650	to	102 750	1	0	1	0	1	0	0	0	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
102 750	to	102 850	1	0	1	1	1	0	0	0	0	0	1
102 850	to	102 950	1	0	1	1	1	0	0	0	0	1	1
102 950	to	103 050	1	0	1	1	1	0	0	0	0	1	0
103 050	to	103 150	1	0	1	1	1	0	0	0	1	1	0
103 150	to	103 250	1	0	1	1	1	0	0	0	1	0	0
103 250	to	103 350	1	0	1	1	1	0	0	1	1	0	0
103 350	to	103 450	1	0	1	1	1	0	0	1	1	1	0
103 450	to	103 550	1	0	1	1	1	0	0	1	0	1	0
103 550	to	103 650	1	0	1	1	1	0	0	1	0	1	1
103 650	to	103 750	1	0	1	1	1	0	0	1	0	0	1
103 750	to	103 850	1	0	1	1	1	0	1	1	0	0	1
103 850	to	103 950	1	0	1	1	1	0	1	1	0	1	1
103 950	to	104 050	1	0	1	1	1	0	1	1	0	1	0
104 050	to	104 150	1	0	1	1	1	0	1	1	1	1	0
104 150	to	104 250	1	0	1	1	1	0	1	1	1	0	0
104 250	to	104 350	1	0	1	1	1	0	1	0	1	0	0
104 350	to	104 450	1	0	1	1	1	0	1	0	1	1	0
104 450	to	104 550	1	0	1	1	1	0	1	0	0	1	0
104 550	to	104 650	1	0	1	1	1	0	1	0	0	1	1
104 650	to	104 750	1	0	1	1	1	0	1	0	0	0	1
104 750	to	104 850	1	0	1	1	1	1	1	0	0	0	1
104 850	to	104 950	1	0	1	1	1	1	1	0	0	1	1
104 950	to	105 050	1	0	1	1	1	1	1	0	0	1	0
105 050	to	105 150	1	0	1	1	1	1	1	0	1	1	0
105 150	to	105 250	1	0	1	1	1	1	1	0	1	0	0
105 250	to	105 350	1	0	1	1	1	1	1	1	1	0	0
105 350	to	105 450	1	0	1	1	1	1	1	1	1	1	0
105 450	to	105 550	1	0	1	1	1	1	1	1	0	1	0
105 550	to	105 650	1	0	1	1	1	1	1	1	0	1	1
105 650	to	105 750	1	0	1	1	1	1	1	1	0	0	1
105 750	to	105 850	1	0	1	1	1	1	0	1	0	0	1
105 850	to	105 950	1	0	1	1	1	1	0	1	0	1	1
105 950	to	106 050	1	0	1	1	1	1	0	1	0	1	0
106 050	to	106 150	1	0	1	1	1	1	0	1	1	1	0
106 150	to	106 250	1	0	1	1	1	1	0	1	1	0	0
106 250	to	106 350	1	0	1	1	1	1	0	0	1	0	0
106 350	to	106 450	1	0	1	1	1	1	0	0	1	1	0
106 450	to	106 550	1	0	1	1	1	1	0	0	0	1	0
106 550	to	106 650	1	0	1	1	1	1	0	0	0	1	1
106 650	to	106 750	1	0	1	1	1	1	0	0	0	0	1
106 750	to	106 850	1	0	1	1	0	1	0	0	0	0	1
106 850	to	106 950	1	0	1	1	0	1	0	0	0	1	1
106 950	to	107 050	1	0	1	1	0	1	0	0	0	1	0
107 050	to	107 150	1	0	1	1	0	1	0	0	1	1	0
107 150	to	107 250	1	0	1	1	0	1	0	0	1	0	0
107 250	to	107 350	1	0	1	1	0	1	0	1	1	0	0
107 350	to	107 450	1	0	1	1	0	1	0	1	1	1	0
107 450	to	107 550	1	0	1	1	0	1	0	1	0	1	0
107 550	to	107 650	1	0	1	1	0	1	0	1	0	1	1
107 650	to	107 750	1	0	1	1	0	1	0	1	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
107 750	to	107 850	1	0	1	1	0	1	1	1	0	0	1
107 850	to	107 950	1	0	1	1	0	1	1	1	0	1	1
107 950	to	108 050	1	0	1	1	0	1	1	1	0	1	0
108 050	to	108 150	1	0	1	1	0	1	1	1	1	1	0
108 150	to	108 250	1	0	1	1	0	1	1	1	1	0	0
108 250	to	108 350	1	0	1	1	0	1	1	0	1	0	0
108 350	to	108 450	1	0	1	1	0	1	1	0	1	1	0
108 450	to	108 550	1	0	1	1	0	1	1	0	0	1	0
108 550	to	108 650	1	0	1	1	0	1	1	0	0	1	1
108 650	to	108 750	1	0	1	1	0	1	1	0	0	0	1
108 750	to	108 850	1	0	1	1	0	0	1	0	0	0	1
108 850	to	108 950	1	0	1	1	0	0	1	0	0	1	1
108 950	to	109 050	1	0	1	1	0	0	1	0	0	1	0
109 050	to	109 150	1	0	1	1	0	0	1	0	1	1	0
109 150	to	109 250	1	0	1	1	0	0	1	0	1	0	0
109 250	to	109 350	1	0	1	1	0	0	1	1	1	0	0
109 350	to	109 450	1	0	1	1	0	0	1	1	1	1	0
109 450	to	109 550	1	0	1	1	0	0	1	1	0	1	0
109 550	to	109 650	1	0	1	1	0	0	1	1	0	1	1
109 650	to	109 750	1	0	1	1	0	0	1	1	0	0	1
109 750	to	109 850	1	0	1	1	0	0	0	1	0	0	1
109 850	to	109 950	1	0	1	1	0	0	0	1	0	1	1
109 950	to	110 050	1	0	1	1	0	0	0	1	0	1	0
110 050	to	110 150	1	0	1	1	0	0	0	1	1	1	0
110 150	to	110 250	1	0	1	1	0	0	0	1	1	0	0
110 250	to	110 350	1	0	1	1	0	0	0	0	1	0	0
110 350	to	110 450	1	0	1	1	0	0	0	0	1	1	0
110 450	to	110 550	1	0	1	1	0	0	0	0	0	1	0
110 550	to	110 650	1	0	1	1	0	0	0	0	0	1	1
110 650	to	110 750	1	0	1	1	0	0	0	0	0	0	1
110 750	to	110 850	1	0	0	1	0	0	0	0	0	0	1
110 850	to	110 950	1	0	0	1	0	0	0	0	0	1	1
110 950	to	111 050	1	0	0	1	0	0	0	0	0	1	0
111 050	to	111 150	1	0	0	1	0	0	0	0	1	1	0
111 150	to	111 250	1	0	0	1	0	0	0	0	1	0	0
111 250	to	111 350	1	0	0	1	0	0	0	1	1	0	0
111 350	to	111 450	1	0	0	1	0	0	0	1	1	1	0
111 450	to	111 550	1	0	0	1	0	0	0	1	0	1	0
111 550	to	111 650	1	0	0	1	0	0	0	1	0	1	1
111 650	to	111 750	1	0	0	1	0	0	0	1	0	0	1
111 750	to	111 850	1	0	0	1	0	0	1	1	0	0	1
111 850	to	111 950	1	0	0	1	0	0	1	1	0	1	1
111 950	to	112 050	1	0	0	1	0	0	1	1	0	1	0
112 050	to	112 150	1	0	0	1	0	0	1	1	1	1	0
112 150	to	112 250	1	0	0	1	0	0	1	1	1	0	0
112 250	to	112 350	1	0	0	1	0	0	1	0	1	0	0
112 350	to	112 450	1	0	0	1	0	0	1	0	1	1	0
112 450	to	112 550	1	0	0	1	0	0	1	0	0	1	0
112 550	to	112 650	1	0	0	1	0	0	1	0	0	1	1
112 650	to	112 750	1	0	0	1	0	0	1	0	0	0	1

RANGE Increments (Feet)	PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
	D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
112 750 to 112 850	1	0	0	1	0	1	1	0	0	0	1
112 850 to 112 950	1	0	0	1	0	1	1	0	0	1	1
112 950 to 113 050	1	0	0	1	0	1	1	0	0	1	0
113 050 to 113 150	1	0	0	1	0	1	1	0	1	1	0
113 150 to 113 250	1	0	0	1	0	1	1	0	1	0	0
113 250 to 113 350	1	0	0	1	0	1	1	1	1	0	0
113 350 to 113 450	1	0	0	1	0	1	1	1	1	1	0
113 450 to 113 550	1	0	0	1	0	1	1	1	0	1	0
113 550 to 113 650	1	0	0	1	0	1	1	1	0	1	1
113 650 to 113 750	1	0	0	1	0	1	1	1	0	0	1
113 750 to 113 850	1	0	0	1	0	1	0	1	0	0	1
113 850 to 113 950	1	0	0	1	0	1	0	1	0	1	1
113 950 to 114 050	1	0	0	1	0	1	0	1	0	1	0
114 050 to 114 150	1	0	0	1	0	1	0	1	1	1	0
114 150 to 114 250	1	0	0	1	0	1	0	1	1	0	0
114 250 to 114 350	1	0	0	1	0	1	0	0	1	0	0
114 350 to 114 450	1	0	0	1	0	1	0	0	1	1	0
114 450 to 114 550	1	0	0	1	0	1	0	0	0	1	0
114 550 to 114 650	1	0	0	1	0	1	0	0	0	1	1
114 650 to 114 750	1	0	0	1	0	1	0	0	0	0	1
114 750 to 114 850	1	0	0	1	1	1	0	0	0	0	1
114 850 to 114 950	1	0	0	1	1	1	0	0	0	1	1
114 950 to 115 050	1	0	0	1	1	1	0	0	0	1	0
115 050 to 115 150	1	0	0	1	1	1	0	0	1	1	0
115 150 to 115 250	1	0	0	1	1	1	0	0	1	0	0
115 250 to 115 350	1	0	0	1	1	1	0	1	1	0	0
115 350 to 115 450	1	0	0	1	1	1	0	1	1	1	0
115 450 to 115 550	1	0	0	1	1	1	0	1	0	1	0
115 550 to 115 650	1	0	0	1	1	1	0	1	0	1	1
115 650 to 115 750	1	0	0	1	1	1	0	1	0	0	1
115 750 to 115 850	1	0	0	1	1	1	1	1	0	0	1
115 850 to 115 950	1	0	0	1	1	1	1	1	0	1	1
115 950 to 116 050	1	0	0	1	1	1	1	1	0	1	0
116 050 to 116 150	1	0	0	1	1	1	1	1	1	1	0
116 150 to 116 250	1	0	0	1	1	1	1	1	1	0	0
116 250 to 116 350	1	0	0	1	1	1	1	0	1	0	0
116 350 to 116 450	1	0	0	1	1	1	1	0	1	1	0
116 450 to 116 550	1	0	0	1	1	1	1	0	0	1	0
116 550 to 116 650	1	0	0	1	1	1	1	0	0	1	1
116 650 to 116 750	1	0	0	1	1	1	1	0	0	0	1
116 750 to 116 850	1	0	0	1	1	0	1	0	0	0	1
116 850 to 116 950	1	0	0	1	1	0	1	0	0	1	1
116 950 to 117 050	1	0	0	1	1	0	1	0	0	1	0
117 050 to 117 150	1	0	0	1	1	0	1	0	1	1	0
117 150 to 117 250	1	0	0	1	1	0	1	0	1	0	0
117 250 to 117 350	1	0	0	1	1	0	1	1	1	0	0
117 350 to 117 450	1	0	0	1	1	0	1	1	1	1	0
117 450 to 117 550	1	0	0	1	1	0	1	1	0	1	0
117 550 to 117 650	1	0	0	1	1	0	1	1	0	1	1
117 650 to 117 750	1	0	0	1	1	0	1	1	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
117 750	to	117 850	1	0	0	1	1	0	0	1	0	0	1
117 850	to	117 950	1	0	0	1	1	0	0	1	0	1	1
117 950	to	118 050	1	0	0	1	1	0	0	1	0	1	0
118 050	to	118 150	1	0	0	1	1	0	0	1	1	1	0
118 150	to	118 250	1	0	0	1	1	0	0	1	1	0	0
118 250	to	118 350	1	0	0	1	1	0	0	0	1	0	0
118 350	to	118 450	1	0	0	1	1	0	0	0	1	1	0
118 450	to	118 550	1	0	0	1	1	0	0	0	0	1	0
118 550	to	118 650	1	0	0	1	1	0	0	0	0	1	1
118 650	to	118 750	1	0	0	1	1	0	0	0	0	0	1
118 750	to	118 850	1	0	0	0	1	0	0	0	0	0	1
118 850	to	118 950	1	0	0	0	1	0	0	0	0	1	1
118 950	to	119 050	1	0	0	0	1	0	0	0	0	1	0
119 050	to	119 150	1	0	0	0	1	0	0	0	1	1	0
119 150	to	119 250	1	0	0	0	1	0	0	0	1	0	0
119 250	to	119 350	1	0	0	0	1	0	0	1	1	0	0
119 350	to	119 450	1	0	0	0	1	0	0	1	1	1	0
119 450	to	119 550	1	0	0	0	1	0	0	1	0	1	0
119 550	to	119 650	1	0	0	0	1	0	0	1	0	1	1
119 650	to	119 750	1	0	0	0	1	0	0	1	0	0	1
119 750	to	119 850	1	0	0	0	1	0	1	1	0	0	1
119 850	to	119 950	1	0	0	0	1	0	1	1	0	1	1
119 950	to	120 050	1	0	0	0	1	0	1	1	0	1	0
120 050	to	120 150	1	0	0	0	1	0	1	1	1	1	0
120 150	to	120 250	1	0	0	0	1	0	1	1	1	0	0
120 250	to	120 350	1	0	0	0	1	0	1	0	1	0	0
120 350	to	120 450	1	0	0	0	1	0	1	0	1	1	0
120 450	to	120 550	1	0	0	0	1	0	1	0	0	1	0
120 550	to	120 650	1	0	0	0	1	0	1	0	0	1	1
120 650	to	120 750	1	0	0	0	1	0	1	0	0	0	1
120 750	to	120 850	1	0	0	0	1	1	1	0	0	0	1
120 850	to	120 950	1	0	0	0	1	1	1	0	0	1	1
120 950	to	121 050	1	0	0	0	1	1	1	0	0	1	0
121 050	to	121 150	1	0	0	0	1	1	1	0	1	1	0
121 150	to	121 250	1	0	0	0	1	1	1	0	1	0	0
121 250	to	121 350	1	0	0	0	1	1	1	1	1	0	0
121 350	to	121 450	1	0	0	0	1	1	1	1	1	1	0
121 450	to	121 550	1	0	0	0	1	1	1	1	0	1	0
121 550	to	121 650	1	0	0	0	1	1	1	1	0	1	1
121 650	to	121 750	1	0	0	0	1	1	1	1	0	0	1
121 750	to	121 850	1	0	0	0	1	1	0	1	0	0	1
121 850	to	121 950	1	0	0	0	1	1	0	1	0	1	1
121 950	to	122 050	1	0	0	0	1	1	0	1	0	1	0
122 050	to	122 150	1	0	0	0	1	1	0	1	1	1	0
122 150	to	122 250	1	0	0	0	1	1	0	1	1	0	0
122 250	to	122 350	1	0	0	0	1	1	0	0	1	0	0
122 350	to	122 450	1	0	0	0	1	1	0	0	1	1	0
122 450	to	122 550	1	0	0	0	1	1	0	0	0	1	0
122 550	to	122 650	1	0	0	0	1	1	0	0	0	1	1
122 650	to	122 750	1	0	0	0	1	1	0	0	0	0	1

RANGE Increments (Feet)			PULSE POSITIONS (0 or 1 in a pulse position denotes absence or presence of a pulse, respectively)										
			D_2	D_4	A_1	A_2	A_4	B_1	B_2	B_4	C_1	C_2	C_4
122 750	to	122 850	1	0	0	0	0	1	0	0	0	0	1
122 850	to	122 950	1	0	0	0	0	1	0	0	0	1	1
122 950	to	123 050	1	0	0	0	0	1	0	0	0	1	0
123 050	to	123 150	1	0	0	0	0	1	0	0	1	1	0
123 150	to	123 250	1	0	0	0	0	1	0	0	1	0	0
123 250	to	123 350	1	0	0	0	0	1	0	1	1	0	0
123 350	to	123 450	1	0	0	0	0	1	0	1	1	1	0
123 450	to	123 550	1	0	0	0	0	1	0	1	0	1	0
123 550	to	123 650	1	0	0	0	0	1	0	1	0	1	1
123 650	to	123 750	1	0	0	0	0	1	0	1	0	0	1
123 750	to	123 850	1	0	0	0	0	1	1	1	0	0	1
123 850	to	123 950	1	0	0	0	0	1	1	1	0	1	1
123 950	to	124 050	1	0	0	0	0	1	1	1	0	1	0
124 050	to	124 150	1	0	0	0	0	1	1	1	1	1	0
124 150	to	124 250	1	0	0	0	0	1	1	1	1	0	0
124 250	to	124 350	1	0	0	0	0	1	1	0	1	0	0
124 350	to	124 450	1	0	0	0	0	1	1	0	1	1	0
124 450	to	124 550	1	0	0	0	0	1	1	0	0	1	0
124 550	to	124 650	1	0	0	0	0	1	1	0	0	1	1
124 650	to	124 750	1	0	0	0	0	1	1	0	0	0	1
124 750	to	124 850	1	0	0	0	0	0	1	0	0	0	1
124 850	to	124 950	1	0	0	0	0	0	1	0	0	1	1
124 950	to	125 050	1	0	0	0	0	0	1	0	0	1	0
125 050	to	125 150	1	0	0	0	0	0	1	0	1	1	0
125 150	to	125 250	1	0	0	0	0	0	1	0	1	0	0
125 250	to	125 350	1	0	0	0	0	0	1	1	1	0	0
125 350	to	125 450	1	0	0	0	0	0	1	1	1	1	0
125 450	to	125 550	1	0	0	0	0	0	1	1	0	1	0
125 550	to	125 650	1	0	0	0	0	0	1	1	0	1	1
125 650	to	125 750	1	0	0	0	0	0	1	1	0	0	1
125 750	to	125 850	1	0	0	0	0	0	0	1	0	0	1
125 850	to	125 950	1	0	0	0	0	0	0	1	0	1	1
125 950	to	126 050	1	0	0	0	0	0	0	1	0	1	0
126 050	to	126 150	1	0	0	0	0	0	0	1	1	1	0
126 150	to	126 250	1	0	0	0	0	0	0	1	1	0	0
126 250	to	126 350	1	0	0	0	0	0	0	0	1	0	0
126 350	to	126 450	1	0	0	0	0	0	0	0	1	1	0
126 450	to	126 550	1	0	0	0	0	0	0	0	0	1	0
126 550	to	126 650	1	0	0	0	0	0	0	0	0	1	1
126 650	to	126 750	1	0	0	0	0	0	0	0	0	0	1