RTCA, Inc.
1140 Connecticut Avenue, N. W., Suite 1020
Washington, D. C. 20036-4001 U.S.A.

telephone: 202-833-9339
facsimile: 202-833-9434

ERRATA

to

RTCA/DO-209

MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR DEVICES THAT PREVENT BLOCKED CHANNELS USED IN TWO-WAY RADIO COMMUNICATIONS DUE TO SIMULTANEOUS TRANSMISSIONS

The purpose of this errata is to correct a typographical error in subparagraph 2.4.2.2, "Equipment Response and Decay Times."

Page 26, Step 2, line 2:

Change .10 percent to 10 percent.

July 1, 1992
RTCA Paper No. 508-92/TMC-41

MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR DEVICES THAT PREVENT BLOCKED CHANNELS USED IN TWO-WAY RADIO COMMUNICATIONS DUE TO SIMULTANEOUS TRANSMISSIONS

DOCUMENT NO. RTCA/DO-209
April 23, 1992
Prepared by: SC-163

RTCA

"Requirements and Technical Concepts for Aviation"

RTCA, Inc.
1140 Connecticut Avenue, Northwest, Suite 1020
Washington, D. C. 20036-4001 U.S.A.

MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR DEVICES THAT PREVENT BLOCKED CHANNELS USED IN TWO-WAY RADIO COMMUNICATIONS DUE TO SIMULTANEOUS TRANSMISSIONS

RTCA/DO-209
April 23, 1992

Prepared by:
SC-163

Copies of this document may be obtained from

RTCA, Inc.
1140 Connecticut Avenue, Northwest, Suite 1020
Washington, D. C. 20036-4001 U.S.A.

telephone: 202-833-9339
facsimile: 202-833-9434

Please contact RTCA for price and ordering information.

FOREWORD

This document was prepared by RTCA Special Committee 163 (SC-163). It was approved by the RTCA Technical Management Committee on April 23, 1992.

RTCA is an association of aeronautical organizations of the United States from both government and industry. Dedicated to the advancement of aeronautics, RTCA seeks sound technical solutions to problems involving the application of electronics and telecommunications to aeronautical operations. Its objective is the resolution of such problems by mutual agreement of its member organizations. The findings of RTCA are in the nature of recommendations to all organizations concerned. Since RTCA is not an official agency of the U. S. government, its recommendations may not be regarded as statements of official government policy unless so enunciated by the U. S. government organization or agency having statutory jurisdiction over any matters to which the recommendations relate.

Coordination of these standards was accomplished by RTCA SC-163 with the European Organisation for Civil Aviation Equipment (EUROCAE) WG-38.

This Page Intentionally Left Blank

TABLE OF CONTENTS

Page

Page

1.0 PURPOSE AND SCOPE

1.1 Introduction

This document sets forth minimum operational performance standards for systems that minimize blocked transmissions used in Air traffic Control (ATC) two-way radio voice communications due to simultaneous transmissions. Incorporated within these standards are system characteristics that should be beneficial to users of the systems as well as to designers, manufacturers and installers.

Compliance with these standards is recommended as a means of assuring that the equipment will perform its intended function(s) satisfactorily under all conditions normally encountered in routine operations. Any regulatory application of this document is the sole 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: transmitter, receiver, power supply, microphone, control panels, antenna, interconnecting cables, and related accessories. It should not be inferred that all equipment will necessarily include all of the foregoing components as separate units. This will depend on the specific design configuration chosen by the manufacturer. Additional functions and components that may refer to expanded equipment capabilities that exceed the stated minimum requirements are identified as optional features. Equipment features that are beyond the scope of this document may be developed in future RTCA activities.

If the equipment implementation includes a computer software package, the guidelines contained in RTCA/DO-178A, *Software Considerations in Airborne Systems and Equipment Certification*, shall be considered.

1.2 System Overview

The aviation communications system includes ground-based and airborne receiving and transmitting equipment which provides air-to-ground, ground-to-air, air-to-air and ground-to-ground voice and data communications. The equipment addressed in this document provides the means for reducing simultaneous transmissions that adversely affect two-way voice radio communications.

Disruption to voice communications in the ATC system presents the potential for degrading flight safety. Although these communication disruptions may occur in areas where traffic density is low, the growth of air traffic (and communications) has increased the number of disruption incidents. The FAA has concluded, as early as 1968, that the occurrence of communication disruptions presented serious problems, *e.g.*, the loss of separation standards between aircraft, near mid-air collisions, delays, and potentially disastrous disruptions of traffic flow. Various educational programs and advisory material issued by the FAA have not reduced the problem. In fact, subsequent surveys have indicated that the problem has intensified.

In 1984, the FAA was petitioned to enact rulemaking requiring two-way radio communication systems employing anti-blocking and stuck microphone protection circuitry. The FAA subsequently published the petition for rulemaking for public comment. The majority of responses to the petition for rulemaking were favorable.

Because an industry standard for such devices was not available, the FAA deferred further action on the petition for rulemaking and requested that RTCA, Incorporated, establish a Special Committee to develop appropriate guidance and equipment standards. As a result of the FAA's request, RTCA established Special Committee 163 to develop design criteria and guidance information pertaining to unintentional or simultaneous transmissions that adversely affect two-way radio communications and to develop minimum operational performance standards (MOPS) for devices that minimize unintentional and/or simultaneous voice transmissions. This MOPS only addresses simultaneous transmissions. This is defined as the occurrence of two or more operators transmitting on the same frequency at the same time.

1.3 Operational Application

This specification is applicable to ground-based, ground-mobile and airborne two-way UHF and VHF radio voice communications equipment used for control of air traffic. These standards apply to three different methods of incorporation: retrofit, modification and new designs.

1.4 Operational Goals

These devices are intended to minimize communication disruptions caused by simultaneous voice transmissions that are detrimental to the safety and efficiency of flight operations. Equipment designers, manufacturers and installers are encouraged to provide indications or annunciations to the pilot of transmitter operation, or of impending or existing actions by the equipment to inhibit transmitter operation. Refer to Appendix A for an analysis of the effectiveness of the devices intended to minimize communication disruptions caused by simultaneous voice transmission.

1.5 Assumptions

1.5.1 Simultaneous Transmissions

Simultaneous voice transmissions are generally considered detrimental to communication. Thus the initiation of a voice transmission on an occupied frequency is undesirable and should be inhibited. However, there are environments or conditions when simultaneous transmissions are normal operational occurrences, for example:

a. UNICOM

b. MULTICOM

c. Common Traffic Advisory Frequency (CTAF)

d. Flight Service Station Frequencies

e. Flight Watch Frequency

These environments exist because a single frequency is assigned to several facilities in the same geographical area.

1.5.1.1 Normal ATC Communications

When human monitoring is used to determine channel availability, simultaneous voice transmissions are inevitable, even when proper radio communication procedures are followed by all users. This situation creates a potential to adversely affect flight safety. Furthermore, this potential is increased by frequency congestion caused by a large demand for a specific frequency, especially in areas of high traffic density.

1.5.1.2 Emergency Communications

An emergency condition may require unrestrained radio operation, therefore, provisions must be made to override transceiver-inhibiting circuits.

1.5.1.3 Offset Carrier Communications

The devices described in this document may be less effective in preventing conflict between an aircraft and an offset carrier ground station than in preventing conflict between an aircraft and a single carrier ground station. The effectiveness of the device is dependent on the design of the activity detector.

1.5.2 Activity Detector

In the context of this specification, receiver activity is defined as response to a signal strength normally associated with reception of voice transmissions from ATC or other aircraft. Any circuitry that inhibits transmissions should not be activated by reception of insufficient signal power to "lift squelch" of the associated receiver.

Activity detectors which measure AGC voltage are likely to inhibit transmission more often than necessary if set for weak signals. Those which measure noise level may fail to inhibit the transmitter when multiple carriers are present in the passband.

Operationally, and with any means of simultaneous voice transmission prevention, it is acceptable to ignore weaker received signals and to respond only to those levels of signal normally found in radio communication exchanges. In reality, any device that does this will prevent those simultaneous voice transmissions that may be disruptive and, therefore, hazardous to communication.

The time required for the detection of activity on the frequency is an important factor in determining the probability of conflict transmission prevention. The time required to detect inactivity on the frequency is important in preventing unwanted or spurious inhibition of the transmitter.

1.5.3 Transmitter Delay Time

The longer the delay time between keying the transmitter and RF output the greater the likelihood of conflicting with other transmissions. Transmitters with shorter delay times produce fewer conflicts for their operators, because they are more likely to be in the process of transmitting when other radios test for activity.

1.6 Test Procedures

The test procedures specified in this document are intended to be used as one means of demonstrating compliance with the performance requirements. Although specific test procedures are cited, it is recognized that other methods may be preferred. 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 order of test specified suggests that the equipment be subjected to a succession of tests as it moves from design and design qualification into operational use. For example, compliance with the requirements of Section 2.0 shall have been demonstrated as a precondition to satisfactory completion of the installed system tests of Section 3.0.

Three types of test procedures are specified. These include:

a. Environmental Tests

Environmental test requirements are specified in Subsection 2.3. The procedures and their associated limit requirements are intended to provide a laboratory means of determining the electrical and mechanical performance of the equipment under environmental conditions expected to be encountered in actual operations.

Unless otherwise specified, the environmental conditions and test procedures contained in RTCA/DO-160C, *Environmental Conditions and*

Test Procedures for Airborne Equipment, will be used to demonstrate equipment compliance.

b. Bench Tests

Bench test procedures are specified in Subsection 2.4. These tests provide a laboratory means of demonstrating compliance with the requirements of Subsection 2.2. Test results may be used by equipment manufacturers as design guidance for monitoring manufacturing compliance and, in certain cases, for obtaining formal approval of equipment design.

c. Installed-Equipment Tests

The installed-equipment test procedures and their associated limits are specified in Section 3.0. Although bench and environmental test procedures are not included in the installed-equipment tests, their successful completion is a precondition to completion of the installed-equipment tests. In certain instances, however, installed-equipment 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-equipment tests are normally performed under two conditions:

(1) with the aircraft on the ground and using simulated or operational system inputs, and

(2) with the aircraft in flight using operational system inputs appropriate to the equipment under test.

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

1.7 Definitions of Terms

Activity Detector Decay Time — The time required for an activity detector to detect the termination of a signal.

Activity Detector Response Time — The time required for activity detector to indicate the onset of a signal.

Common Traffic Advisory Frequency (CTAF) — A frequency assigned for the purpose of carrying out airport advisory practices while operating to or from an uncontrolled airport.

LRU — Line Replaceable Unit

MULTICOM — A mobile service, not open to public correspondence, used to provide communications essential to conduct the activity being performed by or directed from private aircraft.

Offset Carrier System — Ground radio stations that transmit two or more signals, each with a different carrier frequency, on the same channel. This system is used in Alaska and in the United Kingdom (Climax), among other locations, for en route air traffic control. By this technique, it is possible to provide coverage over large geographical areas by only one frequency assignment that may otherwise require several.

PTT — Push-To-Talk

PTT Response Time — The time for operator activation of PTT after a transmission has ended.

Queue Jumping — To deliberately make and maintain a PTT action during a period of reception that results in the associated transmitter operating at receiver activity conclusion.

Simultaneous Transmission(s) — Disruption(s) to voice communication caused by transmitters on a common frequency operating at the same time. This is commonly referred to as a stepped-on or blocked transmission.

Transmitter Rise Time — The time after operator activation of PTT for the transmitter to reach sufficient power for recognition by activity detectors in other receivers.

UNICOM — A non-government communication facility which may provide airport information at certain airports.

Unintentional Transmission(s) — Transmitter operation when such operation is not intended. This is commonly referred to as a "stuck mike" condition.

2.0 EQUIPMENT PERFORMANCE REQUIREMENTS AND TEST PROCEDURES

2.1 General Requirements

The following general requirements shall be met by all simultaneous voice transmission prevention equipment. Equipment designed to prevent conflicting simultaneous transmissions shall include the capability of automatically inhibiting transmitter operation.

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 Intended Function

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 Communications Commission.[1]

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.

---

[1] It is not intended that this requirement relating to FCC rules be interpreted as a precondition for obtaining other applicable approvals such as an FAA TSO authorization.

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 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 these tests, except as specifically allowed.

2.2 Equipment Performance — Standard Conditions

2.2.1 Automatic Inhibition of Voice Transmissions

When a selected frequency is occupied by a received signal, the equipment shall inhibit operation of the transmitter, except as provided by paragraph 2.2.3. The transmitter-inhibit-threshold shall be between 0 and 10 dB above the received signal level required to open the associated receiver squelch.

When a test signal at the level of -75 dBm (measured at the input of the associated receiver) is applied, the equipment shall have the following response and decay characteristics.

a. Response time: < 60 ms (the goal is to make this time as short as possible, and 20 ms is the recommended maximum. Refer to Appendix A).

b. Decay time: < 60 ms (for devices using random time delay only).

NOTE: *The specified threshold of actuation of this function is intended to provide simultaneous voice transmission protection over nearly the entire communication range in the location of the station. It is noted that due to the resulting low threshold level, non-communication-related signals in the environment may occasionally activate this function and require override of this function in order to maintain normal communications. The occasional need for override is acceptable in order to maintain simultaneous voice transmission protection over the entire communication range.*

2.2.2 Prevention of Queue Jumping

The equipment shall include a means for prevention of queue jumping. The means shall include either a or b below.

a. A PTT action made prior to the decay of a received signal shall maintain the associated transceiver in the receive mode until PTT action is reinitiated with no receiver activity present (see Figure 2-1). That is, operators initiating PTT action prior to cessation of receiver activity will continue to be inhibited from transmitting.

b. A PTT action made within 0.5 second prior to the decay of a received signal shall maintain the associated transceiver in the receive mode until the received signal is no longer detected and a random time elapses during which period no other received signal is detected. The random time delay shall be initiated when a received signal is no longer detected. The delay shall vary randomly from 0 to 200 milliseconds in approximately a rectangular distribution. Two operators initiating PTT action prior to RF

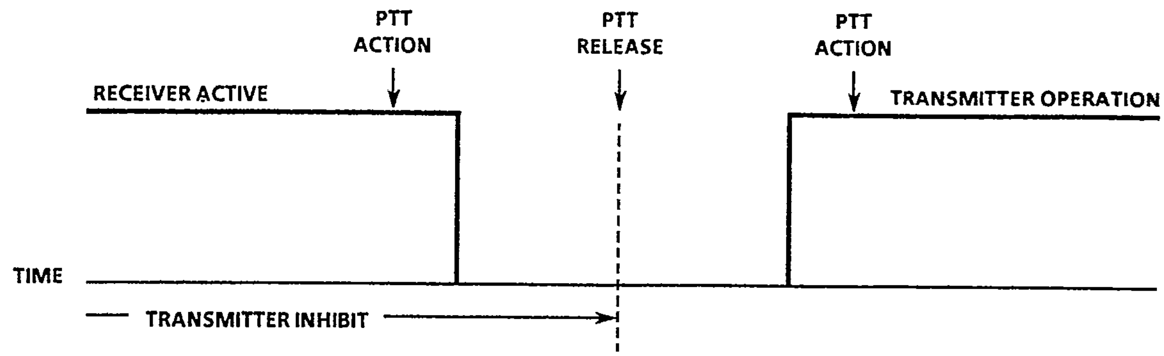


FIGURE 2-1 EXAMPLE OF QUEUE JUMPING PREVENTION WITH NO RANDOM TIME DELAY

decay will result in the probability of one operator transmitting at RF termination and the other being inhibited (see Figure 2-2).

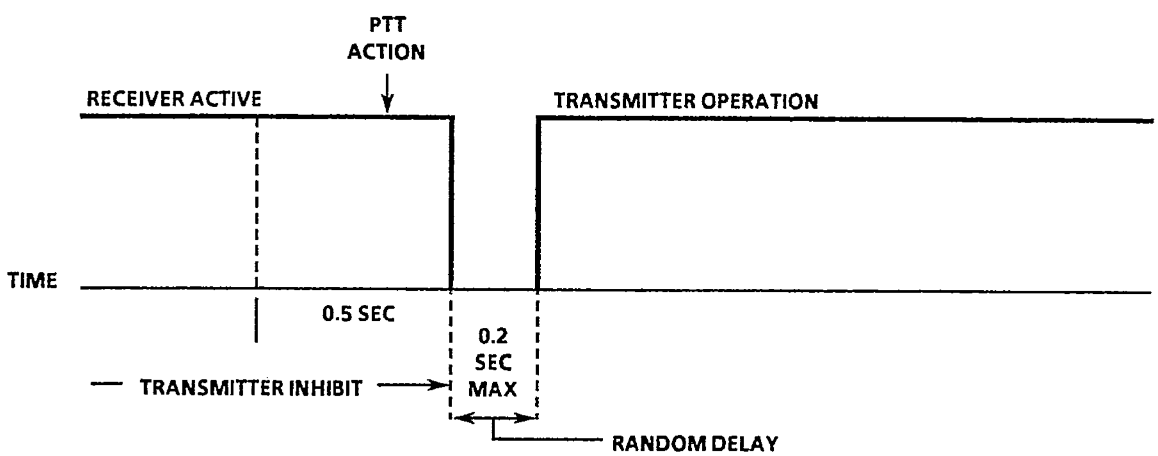


FIGURE 2-2 EXAMPLE OF QUEUE JUMPING PREVENTION WITH RANDOM TIME DELAY (ACTIVATED)

A PTT action made more than 0.5 second prior to the decay of receiver activity will cause the system to function in the same way as the basic queue jumping prevention technique described in paragraph 2.3.3 a. Refer to Figure 2-3.

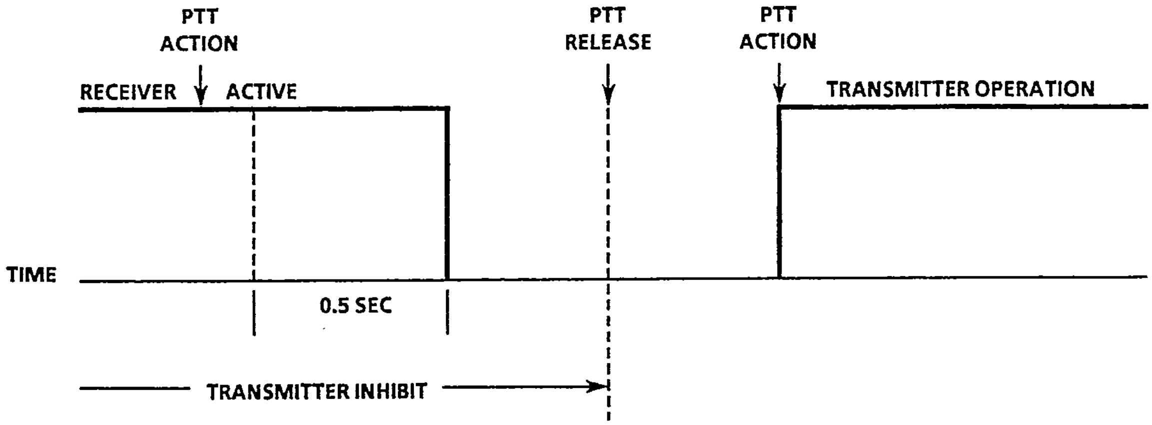


FIGURE 2-3 EXAMPLE OF QUEUE JUMPING PREVENTION WITH RANDOM TIME DELAY (NON-ACTIVATED)

2.2.3 Operator Override

A means of operator override of the transmitter inhibit function shall be provided. Such means of override shall be either: incapable of being left in the override position or be equipped to restore the inhibit function within 35 seconds of override activation.

2.2.4 Control of Associated Audio Systems

In the event that an attempted transmission is automatically inhibited, a means shall be provided to ensure continuous reception at flight crew audio stations.

This Page Intentionally Left Blank

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 for the equipment under conditions representative of those which may be encountered in actual aeronautical operations.

Some of the environmental tests contained in this subsection do not have to 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 under any of these additional environmental conditions, then the appropriate "When Required" tests shall be performed.

Unless otherwise specified, the test procedures applicable to a determination of equipment performance under environmental test conditions are contained in RTCA/DO-160C, *Environmental Conditions and Test Procedures for Airborne Equipment*.

Some of the performance requirements in Subsection 2.2 are not required to be tested to all of the conditions contained in RTCA/DO-160C. 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 Subsection 2.2 will not be measurably degraded by exposure to these conditions.

2.3.1 Temperature and Altitude Tests

RTCA/DO-160C contains several temperature and altitude test procedures, which are specified according to equipment category. These categories are included in Subsection 4.3 of RTCA/DO-160C. The following subparagraphs contain the applicable test conditions specified in Section 4.0 of RTCA/DO-160C.

2.3.1.1 Operating Low Temperature Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraph 4.5.1, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.1.2 Short-Time Operating High Temperature Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraph 4.5.2, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.1.3 Operating High Temperature

The equipment shall be subjected to the test conditions specified in RTCA/DO-160C, paragraph 4.5.3, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

This test is intended for equipment whose continued operation in the event of loss of cooling is essential to the safe flight of the aircraft. Additionally, ensure that all mechanical devices operate satisfactorily.

2.3.1.4 In-Flight Loss of Cooling

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraph 4.5.4, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

This test is intended for equipment whose continued operation in the event of loss of cooling is essential to the safe flight of the aircraft. Additionally, ensure that all mechanical devices operate satisfactorily.

2.3.1.5 Altitude Tests

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraph 4.6.1, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.1.6 Decompression Test (When Required)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraph 4.6.2, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.1.7 Overpressure Test (When Required)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraph 4.6.3, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.2 Temperature Variation Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 5.0, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.3 Humidity Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 6.0, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.4 Shock Tests

2.3.4.1 Operational Shocks

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Subsection 7.2, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.4.2 Crash Safety Shocks

The application of the crash safety shock tests may result in damage to the equipment under test; therefore, this test may be conducted after the other tests have been completed. In this case, paragraph 2.1.7, "Effects of Test," does not apply.

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Subsection 7.3, and shall meet the requirements specified therein.

2.3.5 Vibration Tests

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 8.0, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.6 Explosion Test (When Required)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 9.0. During this test the equipment shall not cause detonation of the explosive mixture within the test chamber.

2.3.7 Waterproofness Test (RTCA/DO-160C, Section 10.0) (When Required)

2.3.7.1 Drip Proof Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraph 10.3.1, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.7.2 Spray Proof Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraph 10.3.2, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

NOTE: *This test shall be conducted with the spray directed perpendicular to the equipment.*

2.3.7.3 Continuous Stream Proof Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraph 10.3.3, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

NOTE: *This test shall be conducted with the stream directed perpendicular to the equipment.*

2.3.8 Fluids Susceptibility Tests (When Required)

The following subparagraphs contain the applicable test conditions specified in Section 11.0 of RTCA/DO-160C.

2.3.8.1 Spray Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraph 11.4.1, and the following requirements of this standard shall apply:

a. At the end of the 24-hour operational period, the equipment shall function.

b. Following the two-hour operational period at ambient temperature, after the 160-hour exposure period at elevated temperature, the following requirements of this standard shall be met:

(1) Paragraph 2.2.1 — Automatic Inhibition of Transmissions
(2) Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.8.2 Immersion Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraph 11.4.2, and the following requirements of this standard shall apply:

a. At the end of the 24-hour immersion period, the equipment shall function.

b. Following the two-hour operational period at ambient temperature, after the 160-hour exposure period at elevated temperature, the following requirements of this standard shall be met:

(1) Paragraph 2.2.1 — Automatic Inhibition of Transmissions
(2) Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.9 Sand and Dust Test (When Required)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 12.0, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.10 Fungus Resistance Test (When Required)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 13.0, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.11 Salt Spray Test (When Required)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 14.0, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily. Inspect for corrosion.

2.3.12 Magnetic Effect Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 15.0, and the equipment shall meet the requirements of the appropriate instrument or equipment class specified therein.

2.3.13 Power Input Tests

2.3.13.1 Normal Operating Conditions

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraphs 16.5.1 and 16.5.2, as appropriate, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

Any timers in the equipment may be reset by the momentary power interruptions of durations less than those defined in subparagraphs 16.5.1.4 and 16.5.2.3 of RTCA/DO-160C. The equipment is not required to operate during these power interrupts but must automatically recover to normal operation after them.

2.3.13.2 Abnormal Operating Conditions

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraphs 16.5.3 and 16.5.4, as appropriate, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

For equipment operating on dc power, the gradual reduction to zero of the primary power voltage(s) shall produce no detrimental effects (see paragraph 2.1.7). This shall be included but not limited to inadvertent keying of the associated communication equipment.

In respect to RTCA/DO-160C, subparagraphs 16.5.1.4 and 16.5.2.3 (Power Interruptions), the test may be carried out following the power interruptions.

2.3.14 Voltage Spike Conducted Test

The following subparagraphs contain the applicable test conditions specified in Section 17.0 of RTCA/DO-160C.

2.3.14.1 Category 'A' Requirements (If Applicable)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Subsection 17.3, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

2.3.14.2 Category 'B' Requirements (If Applicable)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, paragraphs 17.4.1, "Intermittent Transients," and 17.4.2 "Repetitive Transients," and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

2.3.15 Audio Frequency Conducted Susceptibility Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 18.0, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

2.3.16 Induced Signal Susceptibility Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 19.0, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

2.3.17 Radio Frequency Susceptibility Test (Radiated and Conducted)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 20.0, and the following requirements of this standard shall be met:

a. Paragraph 2.2.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.2.2 — Prevention of Queue Jumping

NOTE: *The radiated and conducted RF test signal should exclude the frequency to which the receiver is tuned and all frequencies within the receiver's resonant passband.*

2.3.18 Emission of Radio Frequency Energy Test

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 21.0.

2.3.19 Lightning Induced Transient Susceptibility Test (When Required)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 22.0, and the following requirements of this standard shall be met:

a. Paragraph 2.3.1 — Automatic Inhibition of Transmissions
b. Paragraph 2.3.2 — Prevention of Queue Jumping

Ensure that all mechanical devices operate satisfactorily.

2.3.20 Lightning Direct Effects Test (If Applicable)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 23.0.

2.3.21 Icing Test (When Required)

The equipment shall be subjected to the test conditions as specified in RTCA/DO-160C, Section 24.0.

This Page Intentionally Left Blank

2.4 Equipment Test Procedures

2.4.1 Definitions of Terms and Conditions of Test

The following are definitions of terms and conditions under which the following tests 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 two percent. 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 two percent.

   (2) In the case of equipment designed for operation from an ac source of variable frequency (*e.g.*, 300 to 1000 Hz), unless otherwise specified, the test shall be conducted with the input frequency adjusted to within five percent 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 — Due precautions shall be taken during the tests 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°C to +35°C
   (+59°F to +95°F)

   (2) Relative Humidity: Not greater than 85%

(3) Ambient Pressure: 84 to 107 kPA (equivalent to: +5000 to -1500 feet) (+1525 to -460 meters)

When tests are conducted at ambient conditions that differ from the above values, allowances shall be made and differences recorded.

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. RF Signal Source Output — The RF generator signal source output impedance shall comprise a resistance within 10 percent and a reactance of not more than 10 percent of the characteristic impedance of the transmission line for which the receiver is designed.

2.4.2 Detailed Test Procedures

2.4.2.1 Automatic Inhibition of Simultaneous Transmissions (Paragraph 2.2.1)

Equipment Required

Wattmeter (Bird Electronics Model 611 or equivalent)
Signal Generator (Hewlett Packard 8640B or equivalent)
6 dB Pad
20 dB Pad
-20 dB Directional Coupler (Narda 3039-20 or equivalent)

Measurement Procedure

Step 1 – Connect the equipment as shown in Figure 2-4. Apply an on-channel RF signal modulated less than or equal to 10 percent at 1000 Hz, at a level below the receiver squelch threshold.

Step 2 – Increase the RF signal level until the receiver squelch opens.

Step 3 – Increase the RF signal level 10 dB.

Step 4 – Key the associated transmitter. Verify that no transmitter RF output is present when the associated transmitter is keyed.

Step 5 – Reduce the RF signal level until the associated receiver's squelch closes.

Step 6 – Key the associated transmitter; verify that normal transmitter RF output is present.

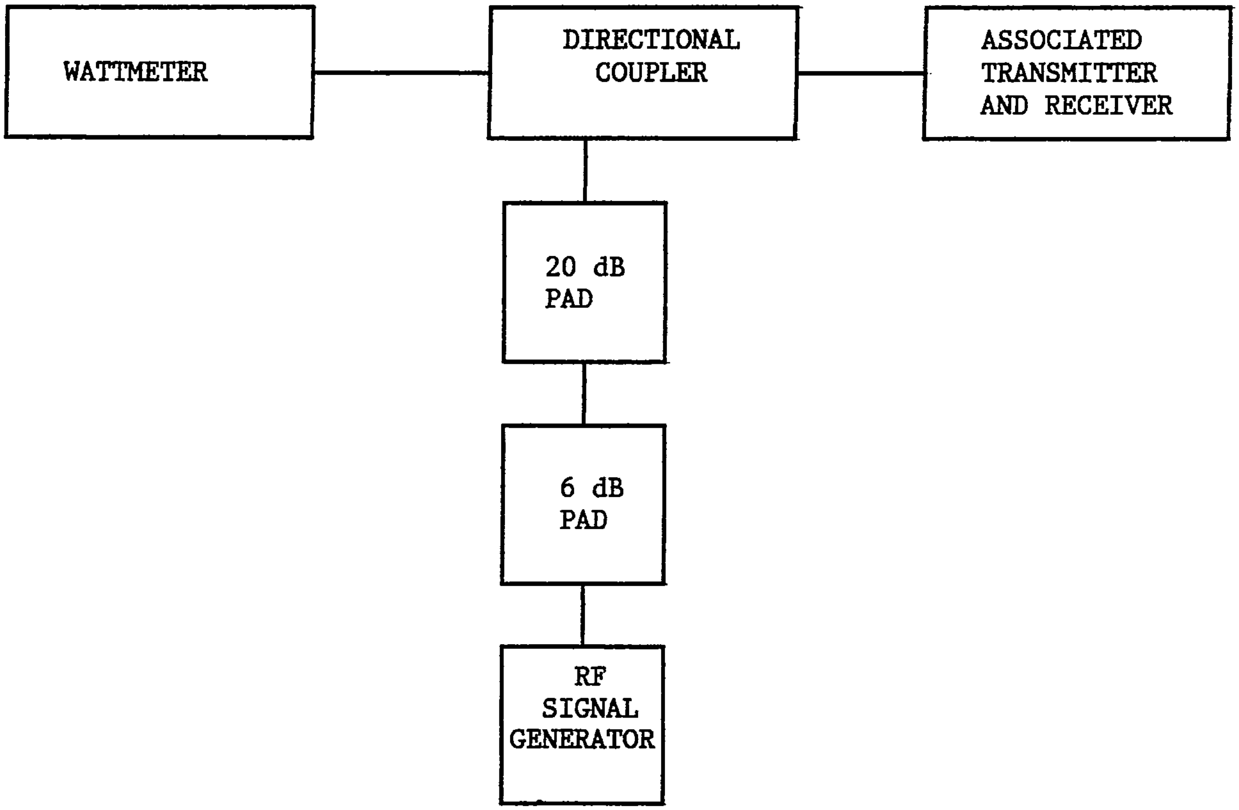


FIGURE 2-4 TEST EQUIPMENT CONNECTION – PREVENTION OF SIMULTANEOUS TRANSMISSION

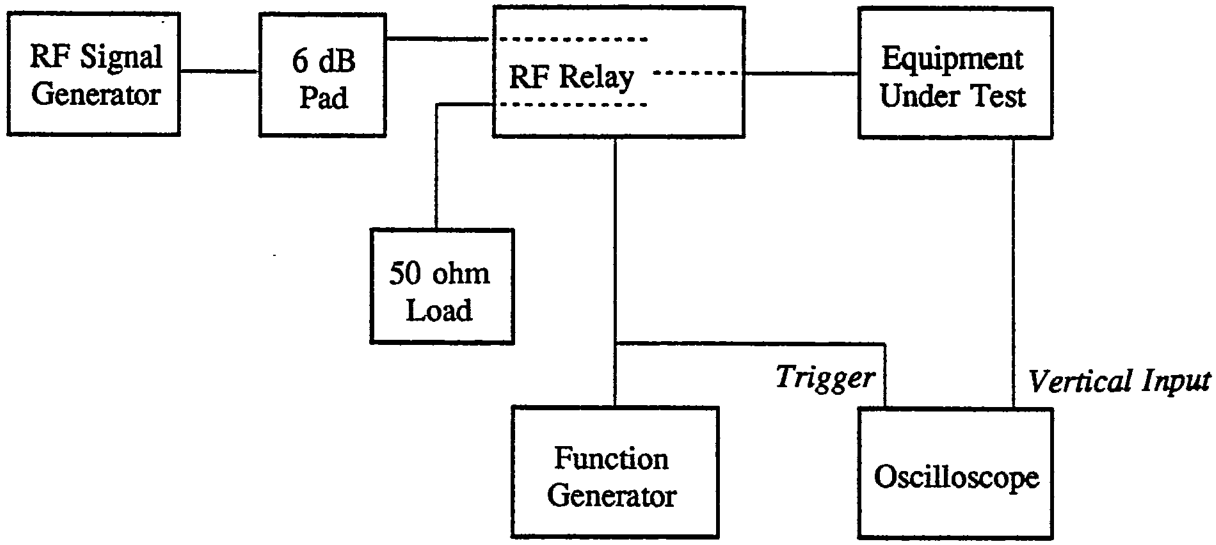
2.4.2.2 Equipment Response and Decay Times (Paragraph 2.2.1)

Equipment Required

RF Signal Generator
6 dB Pad
Oscilloscope
RF Relay
50 Ohm Load
Function Generator

Measurement Procedure

Step 1 – Connect the equipment as shown in Figure 2-5. Adjust the function generator so that the RF relay is activated in the position that connects the RF signal generator to the receiver RF input.



<u>FIGURE 2-5</u> TEST CONFIGURATION – EQUIPMENT RESPONSE AND DECAY TIMES

<u>Step 2</u> – Apply an on-channel RF signal, modulated less than or equal to .10 percent at 1000 Hz, at a level of -75 dBm.

<u>Step 3</u> – Adjust the function generator to slowly pulse on and off the RF input to the equipment under test (approximately 0.5-second rate). Trigger the oscilloscope at the -75 dBm level, and measure the time from the application of the -75 dBm level to when the associated transmitter is inhibited.

<u>NOTE</u>: The response time of the RF relay should be determined and subtracted from the measurement.

<u>Step 4</u> – Repeat <u>Step 3</u>, but measure the time from the cessation of RF input at -75 dBm to when the associated transmitter becomes uninhibited.

2.4.2.3 <u>Prevention of Queue Jumping (Paragraph 2.2.2)</u>

<u>NOTE</u>: The manufacturer shall determine which of two procedures, A or B, are applicable to the equipment to be tested.

<u>Equipment Required</u>

Wattmeter (Bird Electronics Model 611 or equivalent)
Signal Generator (Hewlett Packard 8640B or equivalent)
6 dB Pad
20 dB Pad

-20 dB Directional Coupler (Narda 3039-20 or equivalent)
Oscilloscope (Tektronix Model 453 or equivalent)

Measurement Procedure A

Step 1 – Connect the equipment as shown in Figure 2-4. Apply an on-channel RF signal modulated less than or equal to 10 percent at 1000 Hz, at a level below the receiver squelch threshold.

Step 2 – Increase the RF signal level until the receiver squelch opens.

Step 3 – Increase the RF signal level 10 dB.

Step 4 – Key the associated transmitter and then reduce the RF signal generator output to zero. Verify that no transmitter RF output results.

Step 5 – Momentarily cycle the key line from transmit mode to receive mode and back. Verify that normal transmitter RF output results.

Measurement Procedure B

Step 1 – Connect the equipment as shown in Figure 2-4. Apply an on-channel RF signal modulated less than or equal to 10 percent at 1000 Hz, at a level below the receiver squelch threshold.

Step 2 – Increase the RF signal level until the receiver squelch opens.

Step 3 – Increase the RF signal level 10 dB and record level.

Step 4 – Key the associated transmitter and reduce the RF signal generator output to zero in not less than 0.5 second after application of the key input. Verify that no transmitter RF output results.

Step 5 – Momentarily cycle the key line from transmit mode to receive mode and back. Verify that normal transmitter RF output results.

Step 6 – Unkey transmitter and reapply the RF signal generator input to associated receiver at the level obtained in Step 3.

Step 7 – Key the associated transmitter and then reduce the RF signal generator output to zero in not more than 0.5 second after application of the key input. Measure the time, t, between cessation of RF signal generator output and achievement of 90 percent of normal transmitter RF output power.

Step 8 – Repeat Step 6 and Step 7 as necessary to verify a near-rectangular distribution of the random time delay between 0 ms and 200 ms.

2.4.2.4 Operator Override (Paragraph 2.2.3)

Equipment Required

Wattmeter (Bird Electronics Model 611 or equivalent)
Signal Generator (Hewlett Packard 8640B or equivalent)
6 dB Pad
20 dB Pad
-20 dB Directional Coupler (Narda 3039-20 or equivalent)

Measurement Procedure

Step 1 – Connect the equipment as shown in Figure 2-4. Apply an on-channel RF signal modulated less than or equal to 10 percent at 1000 Hz, at a level below the receiver squelch threshold.

Step 2 – Increase the RF signal level until the receiver squelch opens.

Step 3 – Increase the RF signal level 10 dB.

Step 4 – Activate the operator override function and verify that keying the transmitter results in RF output.

Step 5 – Unkey the transmitter, and with override function deactivated, rekey the transmitter and verify that there is no RF output. If the equipment includes an override timing feature, rekey the transmitter after the specified period and verify that there is no RF output.

3.0 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 2.0, which were verified through bench and environmental tests. 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 into consideration these situations.

3.1 Equipment Installation

The equipment shall be installed in accordance with the manufacturer's installation instructions.

3.1.1 Accessibility

Controls and monitors, if provided for in-flight operation, shall be readily accessible from the pilot's normal seated position. The appropriate operator/crew member(s) shall have an unobstructed view of displayed data when in the normal seated position.

3.1.2 Aircraft Environment

Equipment shall be compatible with the environmental conditions present in the specific location in the aircraft where the equipment is installed.

3.1.3 Display Visibility (If Applicable)

Display intensity shall be suitable for data interpretation under all cockpit ambient light conditions ranging from total darkness to reflected sunlight.

3.1.4 Dynamic Response

Operation of the equipment shall not be adversely affected by aircraft maneuvering or changes in attitude encountered in normal flight operations.

3.1.5 Failure Protection

Any probable failure of the equipment shall not degrade the normal operation of equipment or systems connected to it. Likewise, the failure of interfaced equipment or systems shall not degrade normal operation of this equipment.

3.1.6 Interference Effects

The equipment shall not be the source of harmful conducted or radiated interference nor be adversely affected by conducted or radiated interference from other equipment or systems installed in the aircraft.

NOTE: *Electromagnetic compatibility problems noted after installation of this equipment may result from such factors as the design characteristics of previously installed systems or equipment and the physical installation itself. It is not intended that the equipment manufacturer design for all installation environments. The installing facility will be responsible for resolving any incompatibility between this equipment and previously installed equipment in the aircraft. The various factors contributing to the incompatibility shall be considered.*

3.1.7 Inadvertent Turnoff

Appropriate protection shall be provided to avert the inadvertent turnoff of the equipment.

3.1.8 Aircraft Power Source

The voltage and voltage tolerance characteristics of the equipment shall be compatible with the aircraft power source.

3.2 Installed Equipment Performance Requirements

The installed equipment shall meet the requirements of Subsections 2.1 and 2.2.

3.3 Conditions of Test

The following paragraphs define conditions under which tests, specified in Subsection 3.4, shall be conducted.

3.3.1 Power Input

Unless otherwise specified, tests shall be conducted with the equipment powered by the aircraft's electrical power generating system.

3.3.2 Associated Equipment or Systems

Unless otherwise specified, all aircraft electrically operated equipment and systems shall be turned on before conducting interference tests.

3.3.3 Environment

During test, the equipment shall not be subjected to environmental conditions that exceed those specified by the equipment manufacturer.

3.3.4 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.

3.3.5 Warm-Up Period

Unless otherwise specified, tests shall be conducted after a warm-up (stabilization) period of not more than that recommended by the manufacturer.

3.4 Test Procedures for Installed Equipment Performance

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 demonstrate compliance with the minimum requirements stated in Subsections 2.2 and 2.3. 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.

3.4.1 Ground Test Procedures

3.4.1.1 Conformity Inspection

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

3.4.1.2 Equipment Function

Vary all controls of the equipment through their full range to determine that the equipment is operating according to the manufacturer's instructions and that each control performs its intended function.

3.4.1.3 Interference Effects

With the equipment energized, individually operate each of the other electrically operated aircraft equipment and systems to determine that significant conducted or radiated interference does not exist. Evaluate all reasonable combinations of control settings and operating modes. Operate communication and navigation equipment on the low, high and at least one but preferably four mid-band frequencies. Make note of systems or modes of operation that should also be evaluated during flight. If appropriate, repeat tests using emergency power with the aircraft's batteries alone and the inverters operating.

3.4.1.4 Power Supply Fluctuations

Under normal aircraft conditions, cycle the aircraft engine(s) through all normal power settings, and verify proper operation of the equipment as specified by the equipment manufacturer.

3.4.1.5 Equipment Accessibility

Determine that all equipment controls and displayed data are readily accessible and easily interpreted.

3.4.1.6 Functional Tests

a. With aircraft transceiver on and tuned to an appropriate test frequency with no incoming receiver signal, transmit in a normal manner. Verify transmission.

b. When frequency is occupied with an incoming signal, attempt transmission and verify that transmission is inhibited and that incoming signal reception is maintained at all cockpit audio stations, including cockpit speakers if usable with system installed.

c. When frequency is occupied with an incoming signal, activate the override function and transmit. Verify transmission.

d. After the override function should have lapsed or terminated, and while the frequency is occupied with an incoming signal, attempt transmission and verify transmission is inhibited.

MEMBERSHIP

Special Committee 163

MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR DEVICES THAT PREVENT BLOCKED CHANNELS USED IN TWO-WAY RADIO COMMUNICATIONS DUE TO SIMULTANEOUS TRANSMISSIONS

Chariman

J. J. Raia	Honeywell, Inc., CFSG

Secretary

J. R. Lohr	RTCA, Inc.

Members

V. J. Adam	International Air Transport Association
P. J. Akers	Federal Aviation Administration
A. Arndt	ABD
W. L Aronow	American Airlines, Inc.
P. H. Arnstein	United States Coast Guard
W. J. Baker	Air Line Pilots Association
B. F. Barron	Federal Aviation Administration
H. W. Beningfield	Honeywell, Inc.
C. A. Bennett	Teledyne Controls
K. J. Blake-Roberts	Civil Aviation Authority (U.K.)
R. L. Bowers	Air Transport Association of America
V. S. G. Brennan	British Embassy
R. H. Campbell	Bang-Campbell Associates
W. F. Chapman	Federal Aviation Administration
R. J. Chimera	United Air Lines, Inc.
G. M. Chittum	Federal Aviation Administration
N. M. Corrigan	Pipercross Communications
W. B. Cotton	United Air Lines, Inc.
W. Crawford	Global-Wulfsberg Systems
T. R. Degner	American Airlines, Inc.
F. E. Etherton	Federal Aviation Administration
A. J. G. Evans	Civil Aviation Authority (U.K.)
D. Farncombe	Civil Aviation Authority (U.K.)
N. A. Ferrett	Civil Aviation Authority (U.K.)
D. W. Flygstad	Telex Communications, Inc.
G. B. Foster	BFGoodrich FlightSystems, Inc.
B. M. Funk	Aircraft Owners and Pilots Association
M. L. Garelick	Federal Aviation Administration
E. R. Godberson	International Civil Aviation Authority
D. H. Gorman	Civil Aviation Authority (U.K.)

T. Graff	United Air Lines, Inc.
G. N. Gromov	All-Union Scientific Research Institution of Radio Equipment
K. Hanneman	Allied-Signal, Bendix/King
B. L. Hassell	AT&T Bell Laboratories
L. Heckler	NARCO Avionics, Inc.
R. C. Henderson	General Aviation Electronics
T. H. Hitt	Teledyne Controls
T. C. A. Hoole	Boeing Commercial Airplane Company
M. R. Hope	American Airlines, Inc.
J. Howell, III	Honeywell, Inc.
W. Hunter	Bendix Avionics, Allied-Signal Aerospace Division
J. Ihasz	Litton Industries
L. L. James	Trans World Airlines, Inc.
V. P. Jikharev	All-Union Scientific Research Institute of Radio Equipment
K. H. King	ARINC/SITA Joint Satellite Venture
J. R. Knight	Civil Aviation Authority (U.K.)
F. Koepke	Air Line Pilots Association
T. J. Kreamer	Air Line Pilots Association
P. Kreider	Kreider Associates, Inc.
C. L. Lane	Consultant
D. A. Martinec	Aeronautical Radio, Inc.
R. Matthews	Federal Aviation Administration
B. May	American Airlines, Inc.
J. D. McDonnell	Douglas Aircraft Company
M. O'Rourke	National Transportation Safety Board
M. Parkes	Civil Aviation Authority (U.K.)
P. Payne	E-Systems
T. L. Pearsall	Aircraft Electronics Association
B. Perret	EUROCAE
L. Poradowski	Roanwell Corporation
R. Powell	NARCO Avionics, Inc.
G. F. Quinby	G. F. Quinby Associates
N. Rasch	National Aeronautics and Space Administration
I. R. Reese	Boeing Commercial Airplane Company
A. Reiner	Pan American World Airways, Inc.
D. L. Riechel	Boeing Commercial Airplane Company
W. Rountree	Teledyne Controls
W. M. Russell, III	Air Transport Association of America
M. P. Russo	Aeronautical Radio, Inc.
P. Rutkowski	Roanwell Corporation
J. Rutty	ABD
M. W. Shuey	Aircraft Owners and Pilots Association
M. R. Snow	Boeing Commercial Airplane Company
D. N. Smedsrud	Telex Communications, Inc.
R. B. Steinacker	Trans World Airlines, Inc.
R. L. Striegel	Air Line Pilots Association

F. Studenberg	Collins Avionics, Rockwell International
D. J. Tangney	United Air Lines, Inc.
T. S. Teetor	DCA, Inc.
J. C. Thornton	Collins Avionics, Rockwell International
A. Tone, Jr.	Teledyne Controls
Y. Toshitsuna	Electronic Industries Association of Japan
C. Tromborg	Telex Communications, Inc.
K. van den Boogaard	International Air Transport Association
K. Van der Putten	AVTECH
B. Walters	Telex Communications, Inc.
J. P. Washburn	Collins Avionics, Rockwell International
R. J. Wentworth	National Transportation Safety Board
F. C. White	Consultant

APPENDIX A

SIMULTANEOUS VOICE TRANSMISSIONS

1.0 INTRODUCTION

Many aspects of the problem of simultaneous voice transmissions were considered in developing the minimum operational performance standards.

It was recognized that there are basically two different types of simultaneous voice transmissions:

Type A: This type occurs when an operator activates a transmitter on a frequency that already has activity. One example is when an operator misinterprets a momentary voice pause by a controller as the end of a transmission.

The devices specified in this document are expected to provide nearly complete protection from Type A simultaneous voice transmissions.

Type B: This type occurs when two or more operators activate their transmitters at essentially the same time, on what they perceive to be a clear frequency; for example, in a busy terminal area when a transmission has ended, and two operators begin transmitting at almost the same time.

This Page Intentionally Left Blank

2.0 ANALYSIS OF EFFECTIVENESS OF DEVICES TO PREVENT TYPE B SIMULTANEOUS VOICE TRANSMISSIONS

This analysis assumes that all users of a given frequency are equipped with a device as described in this document.

2.1 Types of Delays

There are four time delays that determine the operational effectiveness of devices to prevent Type B simultaneous voice transmissions: PTT response time, transmitter rise time, activity detector response time and activity detector decay time. The time for RF propagation is negligible compared to the other delays and is ignored.

2.2 Time Delay Effects

Time delays affect the operation of a device to prevent Type B simultaneous voice transmissions (where no signal is present at the beginning of the sequence) in the following manner:

Until transmitter #1 has caused operation of the activity detector of transceiver #2, a PTT action by operator #2 will result in a conflict.

2.3 Determination of Time Delays

2.3.1 PTT Response Time

A test was conducted to determine nominal values for PTT response time.

A subject, wearing headphones, adjusted the level of a continuous 1000 Hz tone to a comfortable level. The subject was instructed to press the PTT switch on a standard aircraft-type hand microphone as soon as the 1000 Hz tone was removed. The tone was on for random periods of 10 to 20 seconds. The time from tone removal until activation of the PTT by the subject was measured by means of a digital storage oscilloscope triggered by the tone removal. Five different subjects were tested, with each subject performing the test 10 times.

The fastest response time was 200 milliseconds with the slowest 420 milliseconds. Each subject had responses in that range with no subject consistently fast or slow. Based on these tests, it was concluded that the time difference between activation of two PTT circuits by two operators, concentrating on activating the PTT following cessation of an on-going transmission, would range from near zero to 220 milliseconds.

<u>NOTE:</u> *In other tests using pilots in a simulated flight environment and with random transmission background traffic, approximately 50 percent of the measured PTT response times fall between 340 ms and 740 ms, <u>i.e.,</u> a PTT response time spread of about 400 ms. In this 400-ms time span, the data more closely approximates a uniform distribution.*

2.3.2 <u>Transmitter Rise Time</u>

SC-163 surveyed RTCA members who manufacture avionics equipment for data on transmitter rise time. This data was requested for transmitters considered representative of those currently in use by the aviation community. Responses were received from 10 manufacturers covering 13 different models. The transmitter rise times ranged from 2 to 70 milliseconds.

It was noted that there are no transmitter rise time limits specified in RTCA or EUROCAE VHF transceiver MOPS.

2.3.3 <u>Activity Detector Response Time</u>

The operation of an activity detector was viewed as very similar to voice squelch circuits in use in most aircraft receivers. In order to determine a minimum and maximum response time that would be practical and yet still provide immunity from false operation, the committee surveyed RTCA members who manufacture avionics equipment. This survey was for data on squelch attack and decay times, at 10 microvolt and 1000 microvolt levels for receivers considered representative of those currently in use by the aviation community. The attack times ranged from 2 to 75 milliseconds. Shorter activity detector response times will improve the effectiveness; however, too short a response time may produce unreliable operation.

2.3.4 <u>Activity Detector Decay Time</u>

The survey described in paragraph 2.3.3 above indicated values from 4 to 108 milliseconds for squelch decay times.

Activity detector decay time has the following effects on simultaneous voice transmission prevention:

<u>Type A conflicts</u> — Activity detector decay time is not a factor in Type A conflicts.

<u>Type B conflicts</u> — Activity detector decay time is not a factor in effectiveness as long as the decay time is less than the PTT response time. If the decay time is longer than the PTT response time, it becomes a modified Type B conflict (with a random clock).

Type B conflicts (with a random clock) — The decay time determines when the random clock timer begins and influences conflict prevention effectiveness. Excessive decay times can result in first-syllable clipping due to delays in transmitter activation after a PTT action.

This Page Intentionally Left Blank

2.4 Analysis of Effectiveness for Type A and B Simultaneous Voice Transmissions Using Surveyed Transceiver Data

2.4.1 Type A

The devices specified in this document are expected to provide nearly complete protection from Type A simultaneous voice transmissions.

2.4.2 Type B

The committee performed a computer simulation of Type B simultaneous voice transmissions. The simulation was based on the situation described in Subsection 2.2. The following uniformly distributed time values were used and it was assumed that two operators decided to transmit at the same instant.

1. PTT response time — 0 to 220 milliseconds.

2. Transmitter rise time — 2 to 70 milliseconds.

3. Activity detector response time — 2 to 60 milliseconds.

4. Activity detector decay time — not applicable.

Based on 1000 trials, 485 conflicts were prevented, for an effectiveness of 49 percent.

2.4.3 Type B (with a random clock)

The committee performed a computer simulation of Type B (with a random clock) simultaneous voice transmissions. The simulation was based on the situation described in Subsection 2.2 for a random clock delay system. The following randomly distributed time values were used:

1. PTT response time — Key activated before transmission ended.

2. Random clock delay — 0 to 200 milliseconds.

3. Transmitter rise time — 2 to 70 milliseconds.

4. Activity detector response time — 2 to 60 milliseconds.

5. Activity detector decay time — 4 to 60 milliseconds.

Based on 1000 trials, 534 conflicts were prevented, for an effectiveness of 53 percent.

This Page Intentionally Left Blank

3.0 RECOMMENDATIONS

3.1 Analysis of Effectiveness for Type B Simultaneous Voice Transmissions Using Recommended Values for Transmitter Rise Time

3.1.1 Type B Simultaneous Transmissions

This document recommends that new transmitter designs limit transmitter rise times to a maximum of 15 milliseconds. The simulation in paragraph 2.4.2 was repeated with the transmitter rise time limits of 2 to 15 milliseconds and an activity detector response time of 2 to 60 milliseconds.

Based on 1000 trials, 658 conflicts were prevented, for an effectiveness of 66 percent.

3.1.2 Type B Simultaneous Voice Transmissions (with a random clock)

The simulation in paragraph 2.4.3 was repeated with the transmitter rise time limits of 2 to 15 milliseconds and an activity detector decay time 4 to 60 milliseconds.

Based on 1000 trials, 713 conflicts were prevented, for an effectiveness of 71 percent.

3.2 Analysis of Effectiveness for Type B Simultaneous Voice Transmissions Using Recommended Value for Activity Detector Response Time

3.2.1 Type B Simultaneous Voice Transmissions

This document recommends that new receiver designs limit activity detector response times to 20 milliseconds, maximum. The simulation in paragraph 2.4.2 was repeated with the activity detector response time limits of 2 to 20 milliseconds and a transmitter rise time of 2 to 70 milliseconds.

Based on 1000 trials, 638 conflicts were prevented, for an effectiveness of 64 percent.

3.2.2 Type B Simultaneous Voice Transmissions (with a random clock)

The simulation in paragraph 2.4.3 was repeated with activity detector response time limits of 2 to 20 milliseconds and activity detector decay time 6 to 60 milliseconds.

Based on 1000 trials, 686 conflicts were prevented, for an effectiveness of 69 percent.

3.3 Analysis of Effectiveness for Type B Simultaneous Voice Transmissions Using Recommended Values for Transmitter Rise Times and Activity Detector Response Times

3.3.1 Type B Simultaneous Voice Transmissions

Using an activity detector response time of 2 to 20 milliseconds and a transmitter rise time of 2 to 15 milliseconds, based on 1000 trials, 860 conflicts were prevented, for an effectiveness of 86 percent.

3.3.2 Type B Simultaneous Voice Transmission (with a random clock)

Using an activity detector response time of 2 to 20 milliseconds and an activity detector decay time of 6 to 60 milliseconds, based on 1000 trials, 869 conflicts were prevented, for an effectiveness of 87 percent.

3.4 Analysis Summaries

The results of the analyses taken are listed in Tables A-1 and A-2. The distribution reflected is approximately uniform, and the applicable paragraphs are noted below each simulation number. As a result of additional tests to determine PTT response times that more closely simulate actual cockpit conditions during the flight, take-off, en route and landing phases (see Appendix A, paragraph 2.3.1), Table A-1 was reanalyzed, and the results are depicted in Table A-3.

4.0 Effectiveness Summary

The analysis of the effectiveness of devices to prevent simultaneous voice transmissions in this MOPS deals only with Type B conflicts and, therefore, does not provide overall effectiveness rates that can be expected if the devices are implemented in air traffic control communications.

Even though good radio discipline is maintained and operators wait for frequencies to clear, conflicts can occur. Timing has a major influence on effectiveness such that any two transmitters that are activated at exactly the same time with the same response times cannot be kept from interfering with each other. However, because there are variations in the inherent time delays of various radios and operator PTT reaction times, a measure of protection can be obtained from Type B simultaneous voice transmissions. A uniform distribution was chosen because it was not expected that a different distribution would give widely varying results. However, for example, in Appendix A paragraph 2.4.2, use of a Gaussian distribution yielded 18 percent as opposed to an effectiveness of 48 percent when uniformly distributed time values were used. Similarly, a PTT response time difference of 220 ms was assumed, but a broader spread of PTT response time when applied to the analysis (see NOTE to Appendix A, paragraph 2.3.1) resulted in a higher predicted effectiveness (see Table A-3). Limited information on response times, equipment delay times and an accurate knowledge of the number and types of communication conflicts which have occurred and the number of different types of equipment in the field have made it impossible to accurately determine overall effectiveness.

However, the devices in this document provide nearly complete protection from Type A simultaneous voice transmissions. Therefore, the total effectiveness of the devices will increase in direct proportion to the number of Type A conflicts. The greater the number of Type A conflicts, the greater the overall effectiveness of the devices.

Use of new generation transmitters, with improved rise time, is anticipated to increase combined effectiveness. Further improvement may be achieved by reducing the activity detector response time. The efficiency of the ATC voice communication system will improve because the number of conflicting messages will be minimized, thus reducing the need for retransmissions.

TABLE A-1 SIMULATED TYPE B CONFLICTS (NO RANDOM DELAY)

Simulation	1 para 2.4.2	2 para 3.1.1	3 para 3.2.1	4 para 3.3.1
Number of Trials	1000	1000	1000	1000
PTT Response Time (ms)	0 to 220	0 to 220	0 to 220	0 to 220
Equipment Decay Time	N/A	N/A	N/A	N/A
TX Delay Time (ms)	2 to 70	2 to 15	2 to 70	2 to 15
Equipment Response Time (ms)	2 to 60	2 to 60	2 to 20	2 to 20
Conflicts Prevented	485	658	638	860
Effectiveness	49%	66%	64%	86%

TABLE A-2 SIMULATED TYPE B CONFLICTS (WITH RANDOM DELAY)

Simulation	5 para 2.4.3	6 para 3.1.2	7 para 3.2.2	8 para 3.3.2
Number of Trials	1000	1000	1000	1000
PTT Response Time (ms)	N/A	N/A	N/A	N/A
Random Delay (ms)	0 to 200	0 to 200	0 to 200	0 to 200
Equipment Decay Time	4 to 60	4 to 60	6 to 60	6 to 60
TX Delay Time (ms)	2 to 70	2 to 15	2 to 70	2 to 15
Equipment Response Time (ms)	2 to 60	2 to 60	2 to 20	2 to 20
Conflicts Prevented	534	713	686	869
Effectiveness	53%	71%	69%	86.9%

TABLE A-3 SIMULATED TYPE B CONFLICTS (NO RANDOM DELAY)

Simulation	1 para 2.4.2	2 para 3.1.1	3 para 3.2.1	4 para 3.3.1
Number of Trials	1000	1000	1000	1000
PTT Response Time (ms)	0 to 400	0 to 400	0 to 400	0 to 400
Equipment Decay Time	N/A	N/A	N/A	N/A
TX Delay Time (ms)	2 to 70	2 to 15	2 to 70	2 to 15
Equipment Response Time (ms)	2 to 60	2 to 60	2 to 20	2 to 20
Conflicts Prevented	681	810	784	908
Effectiveness	68%	81%	78%	91%

This Page Intentionally Left Blank

RTCA, Inc.
1140 Connecticut Avenue, N.W. Suite 1020
Washington, D.C. 20036