Bendix

Aerospace Systems Division

Single Point Failure Summary - Array D
Redundant Command Receiver

NO.	REV. NO.
ATM 982	

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DATE 26 Feb. 1971

This Single Point Failure Summary was prepared by Motorola's Government Electronics Division as required under the Bendix/ Motorola subcontract SC-0721 for the ALSEP program.

The ALSEP Redundant Command Receiver is a solid state receiver with active redundancy that may be used to receive either DM or PM-FM type signals. This receiver includes two identical electrically separate receivers, consisting of rf converter, and IF and Audio Amp, and a power isolator. In addition, the redundant receiver has an rf power divider referred to an an rf coupler, and a selection circuit referred to as an audio combiner.

A single point failure is defined as the failure of one electrical piecepart (or one pin in the multipin connector) which will result in the loss of the selected audio output.

There is only one single point failure in the ALSEP Redundant Command Receiver - - the OSM rf input receptacle. This receptacle was a specified interface and could not be eliminated. To reduce the risk of occurrence of this failure mode, the connector was mated with a right-angle adapter coupling following the assembly of this receptacle to the module. All further mating (during assembly, testing, troubleshooting, etc.) was done through the coupling. By this means, the minimum number of matings, prior to central station integration, of the OSM input receptacle will have occurred. The adapter is removed just prior to integration.

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Reference: ARD-439, Para 6.10

20 August 1970

Single Point Failure Summary For ALSEP Redundant Command Receiver BxA Part Number 2345147

"Preliminary - The Bendix Corporation Aerospace Systems Division Approval Pending"

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Subcontract Number: SC-0721

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		A	Revised to FACI Configuration	11/30/70	

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CHK BY

MFG

PROJ NO.

CONTR NO.

RELEASE NOTICE

APPROVED DATE

APPROVED DATE

MATERIAL:

MOTOROLA INC.
Government Electronics Division

8201 EAST McDOWELL ROAD
SCOTTSDALE, ARIZONA 85252

Single Point Failure Summary For ALSEP Redundant Command Receiver BxA Part Number 2345147
Document No: 3875/039
Reference: ARD-439, Para 6.10

SIZE	CODE IDENT NO.	DWG. NO.
A	94990	

SCALE

SHEET 1 OF 8

DWG FORMAT

1.0 INTRODUCTION:

This report is generated on the ALSEP Redundant Command Receiver for Bendix Aerospace Systems in compliance with Task 8 of the Reliability Program Plan for the ALSEP Redundant Command Receiver (Motorola Document No. 3875/001, Rev. A dated 30 April 1970.

This report is considered a final single point failure summary and is submitted in fulfillment of the CDR.

2.0 REQUIREMENTS:

A single point failure is defined as the failure of one electrical piecepart (or one pin in the multipin connector) which will result in the loss of the selected audio output. Electrical piecepart failures resulting in the loss of telemetry, audio A, audio B, CSP A, or CSP B, but not in the loss of the selected audio output were not considered single point failures.

It was assumed that the +12 V supply can supply receiver B, as well as a low impedance path in a failed receiver A without mission degradation.

3.0 SUMMARY OF RESULTS AND CONCLUSIONS:

The results of the FMECA (as reported in Document No. 3875/035) show that there is only one remaining single point failure in the ALSEP Redundant Command Receiver -- the OSM RF input receptacle.

This receptacle is a contractual interface between the Redundant Command Receiver and other equipment, and, therefore, cannot be eliminated or altered. However, occurrence of the failure mode of this receptacle may be held to a minimum through positive control.

This control consists of two major items:

1) All receptacles will be inspected at Receiving and Inspection in accordance with regular procedures.

2) Following assembly of this receptacle to the module, the receptacle will be visually examined and mated with a right-angle adapter coupling. An inspection sticker placed on this mating will guard against and identify its removal. All further mating (during assembly, testing, troubleshooting, etc.) will be done through the coupling. By this means, the RF receptacle will have a minimum number of matings prior to the mission, and the failure mode normally induced through matings and handlings will be eliminated.

This adapter coupling is a right-angle adapter coupling and will provide easy identification whether the coupling is in place at any point in time.

4.0 ANALYSIS DETAILS

4.1 FUNCTIONAL DESCRIPTION

The ALSEP Redundant Command Receiver is a solid state receiver with active redundancy that may be used to receive either PM (Format 1) or PM-FM (Format 2) type signals.

The Redundant Command Receiver includes two identical electrically separate receivers, consisting of an RF converter, an IF and Audio Amp, and a power isolator. Each receiver (A and B) is a dual conversion superheterodyne receiver with a center frequency of 2119 MHz. In addition, the Redundant Command Receiver has an RF power divider referred to as an RF coupler and a selection circuit referred to as an audio combiner. The overall block diagram is shown in Figure 1.

The RF input power is provided to the receiver through a single RF connector interface and is divided by a power divider and applied to receivers A and B. The local oscillator injection for each converter is provided from a crystal oscillator at 110.9631 MHz. Selectivity is provided by a 3-pole preselector preceeding the mixer, a 3-pole filter in the first IF, and a 5-pole filter following the second mixer. Integrated circuits are used in the receiver for most of the IF gain and the subcarrier and audio circuitry. After amplification and gain leveling, a limiter and a Travis discriminator circuit are used to demodulate the receiver signal. After the first discriminator, the signal is processed in accordance with the format selected and then proceeds to the active filter output amplifier, which provides a narrow post detector bandwidth to reduce output audio noise.

A narrow band detector is used to recognize and indicate the presence of a 1 KHz synchronizing tone. The filter has a noise bandwidth of approximately 100 Hz. The output of the detection circuit is a bi-level signal, identified as a Command Signal Presence Indicator (CSP). The CSP is used within the audio combiner circuitry to implement the redundancy switch for switching from receiver A to receiver B.

The Redundant Command Receiver is designed to receive modulated signals in either of two types of modulation designated as Format 1 or Format 2. The format is selected by means of appropriate connections in the wiring harness external to the receiver.

The modulating signals are constructed as follows:
Digital data is bi-phase modulated onto a 2 KHz subcarrier and a 1 KHz synchronizing tone is added. This combination then constitutes the composite audio signal and is used in either format. In Format 1, the composite audio signal is phase modulated directly onto the S-band carrier at 3 radians peak. In Format 2, the composite audio signal is frequency modulated onto a 70 KHz subcarrier at 5 KHz peak deviation.

After the first discriminator in the IF and Audio Module of the receiver, the signal processing is dependent upon the format. In Format 1 operation, an integrator having a corner frequency of approximately 80 Hz is used to restore the original composite audio form. This is necessary because the received PM signal is demodulated by a FM discriminator. The output amplifier is combined with an active filter to provide a narrow post-detection bandwidth to reduce the output audio noise.

In Format 2 operation, the first discriminator output is the 70 KHz subcarrier with its frequency modulation. This signal is further processed through an Integrator (corner frequency of 30 KHz), a limiter, and a pulse counting discriminator. The composite audio signal from the discriminator goes to the active filter output amplifier.

The implementation of redundancy in this receiver is a major design characteristic. Figure 2 shows the reliability model for the Redundant Command Receiver. Both receivers A and B are operating during the mission. When the CSP from receiver A indicates the presence of a command signal from the output of receiver A, receiver A is selected by the audio combiner. When CSP does not appear, either due to failure of A or due to no command signal, then receiver B will be selected.

All single point failure modes have been eliminated through the use of part redundancy, except the RF input receptacle which is a contractually specified interface. All functions, except telemetry, have redundant pin connections within the multipin connector.

4.2 SINGLE POINT FAILURE MODES:

As described in the functional description, as shown in Figure 2, and as verified by the FMECA report (Document No. 3875/035), the redundant receivers (receivers A and B) are electrically and failure isolated. The only single point failure modes that could exist would be in the RF coupler and the audio combiner.

To discuss the single point failures in the audio combiner configurations as the design matured is seemingly out of the scope of this report and would require the introducing of several previous revisions of the schematics.

However, what is pertinent is that in the present configuration of the audio combiner (reference schematic 63-P11356B revision B) there are three redundant circuits which eliminated three single point failures.

These include: a)parallel C4 and C5 eliminating the "open" failure mode; 2) parallel R21 and R24 eliminating the "open" failure mode; and 3) parallel R14-Q8 and R15-Q6 eliminating "open" failure modes in the resistor or the transistor.

The only remaining single point failure is in the RF coupler, the RF input receptacle J102 on schematic 63-P11356B.

5.0 CONCLUSIONS AND RECOMMENDACTIONS:

Motorola presents the control and corrective action plan for the RF input receptacle - the only single point failure - as the most feasible and optimum plan when considering other tradeoff factors and restrictions. Motorola recommends that Bendix make provisions internally for accepting the receiver in this condition, with the adapter coupling attached. Furthermore, it is recommended that Bendix use the adapter coupling on any subassembly tests and remove it just prior to final assembly and acceptance test. It is, of course, recommended that the adapter coupling be removed and the mating that will be relied upon during the mission be the one acceptance tested.

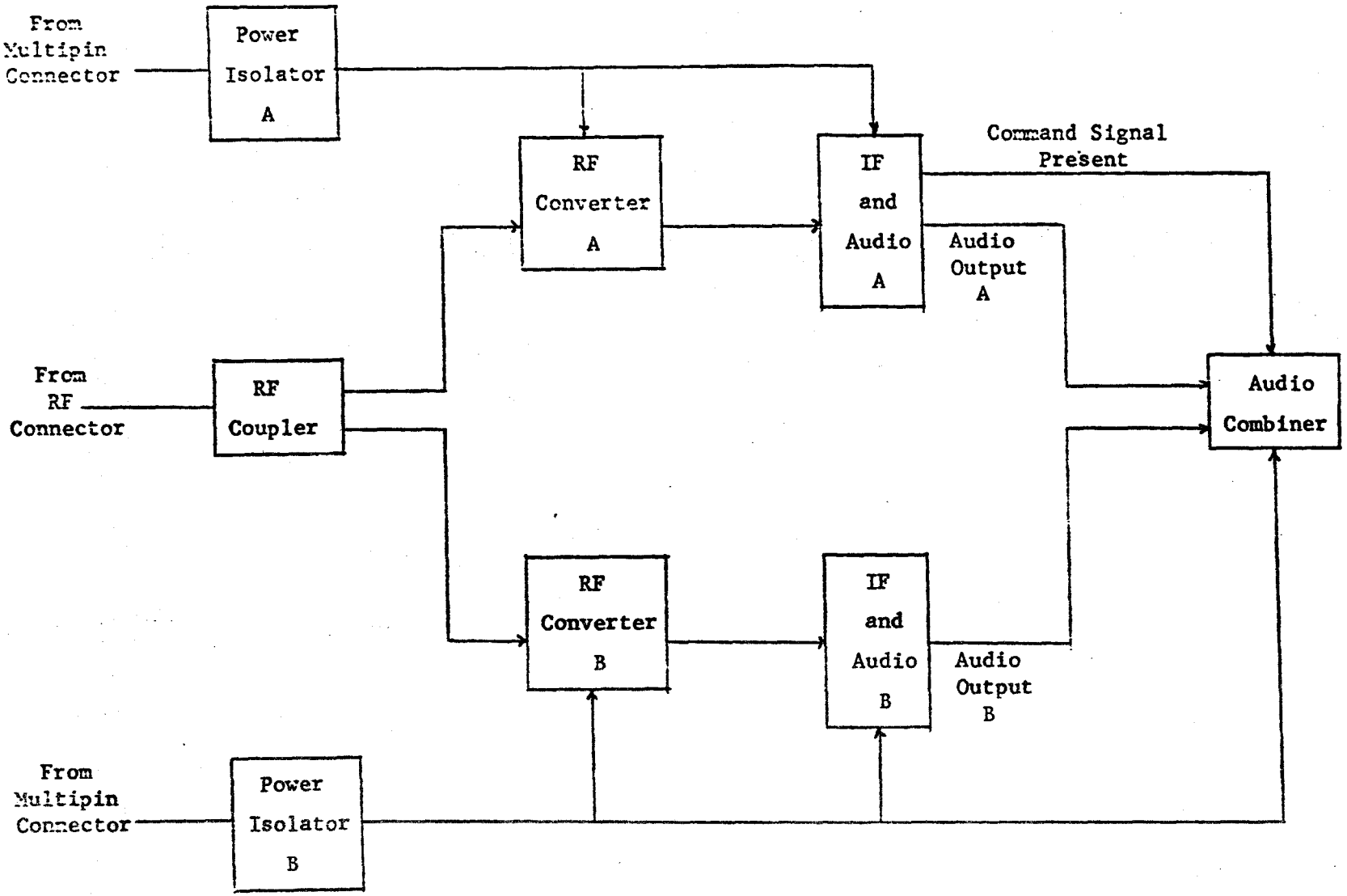

Figure 1

ALSEP Redundant Command Receiver

Functional Block Diagram

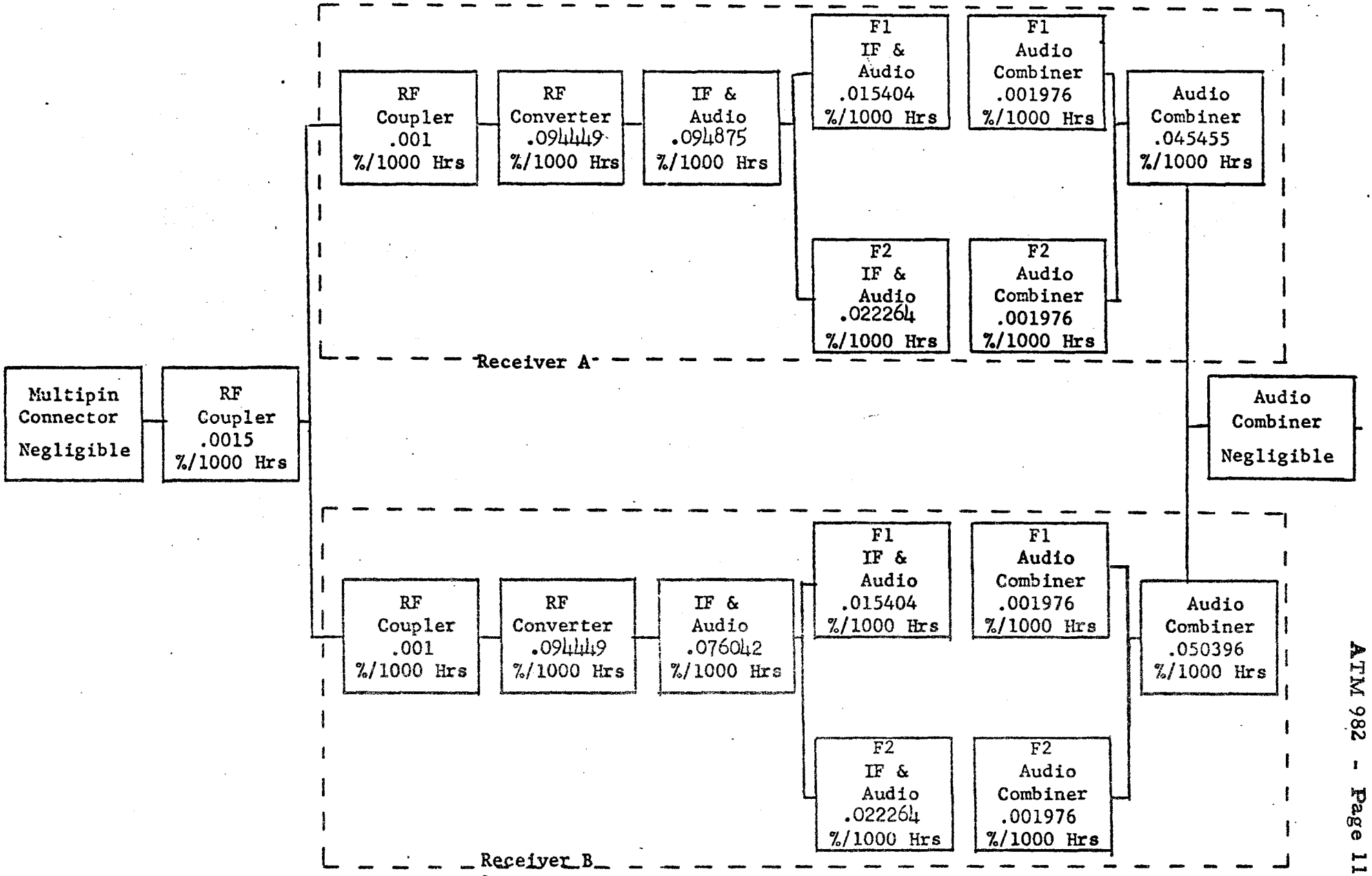

Figure 2

ALSEP Redundant Command Receiver Reliability Block Diagram