This ATM documents the Final Reliability Prediction and Failure Modes and Effects Analysis of the Bendix designed PDU (Power Distribution Unit). The analysis reflects the Array E design as of 9/23/71.

This document is prepared in accordance with the requirements of Section 5.2 of the Reliability Program Plan for Array E, ALSEP-RA-08, Bendix document number BSR 3024, dated 11/30/70.

Reliability prediction data and single point failure summary are also documented herein in accordance with Sections 5.5 and 5.3, respectively, of the Array E Reliability Program Plan.

Rev A incorporates changes resulting from the redesign of the Power Dump PDU. The Power Dump PDU was redesigned to eliminate single point failures, specifically, redundant circuitry provides a means of turning the power dump off in the event of a relay or relay driver failure.

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## 1.0 Introduction

The results of the reliability prediction and failure modes and effects analysis for the ALSEP Array E PDU are documented in this report. This PDU represents the Bendix designed unit which uses proven components. The design provides redundant units in all six PDU functional modules.

The reliability prediction for the PDU (including six experiment modules) is calculated to be 0.999574 for two years of lunar operation. This compares favorably for the goal of 0.992 for the PDU as stated in ATM 889, Section 4.2.

The calculation for the telemetry net and temperature measurement is calculated to be 0.99738. These circuits are external to the PDU, and their failure would have little or no effect on the total PDU probability of mission success since this type of failure would not affect operation of the PDU.

## 2.0 Circuit Description

All of the power control function requirements for the PDU are shown in Figure 1. Figure 2 gives the functional block layout for experiment power control. Relay drivers provide signal voltages. The relays are activated by 29 VDC, controlled by the drivers. Circuit breakers and fuses are provided for sensing, switching and isolating when overloads are encountered.

The uplink and ADP power control have identical configurations. Three relays are used for switching the three voltages between loads A to B. A fourth relay prevents a single point failure condition by independent switching control in case of a failure in one of the other uplink power control relays.

The transmitter power control also supplies a power line to the diplexer. The diplexer is used in conjunction with transmitter B and is turned on with transmitter B.

The DDP power control illustrates the basic circuitry for redundant control of power. One double pole relay in each redundant unit selects load A or B. Two circuit breakers in each redundant unit provide circuit protection.

The experiment power control can be switched to anyone of three modes, "On", "Off", or "Standby". A single line, including a diode provides a single action off function without the need of stepping through the standby condition.

The Power Dump Control provides control for each Load, #1 and #2.

Telemetry information is differentiated through various resistors. Diodes are provided for isolation. A voltage limiting circuit is also provided to interfacing voltage protection.

Temperature measurements are made by redundant thermistors. These are included in the transmitter PAA and are mounted on one transmitter circuit board.

Unswitched EMF's use diodes, resistors and capacitors. The diodes and resistors are mounted on the Power Dump Control Circuit board. The capacitors, providing relay potential reserve, are mounted on the PDU Mother Board.

## 3.0 Single Point Failure Summary

There are no single point failures in the PDU. Single point failure modes are eliminated through additional switching and command control as applicable.

## 4.0 Reliability Prediction

The reliability prediction for the PDU, in the combined operating/ standby redundant configuration is calculated to be0.999574for two years of lunar operation. This predicted value is a compatible apportionment of the overall power subsystem reliability goal of .992 as stated in ATM 889, Section 4.2.

Figure 3 defines the reliability block diagram and mathematical model for the PDU. Energy sources determine whether sections are independently redundant. The uplink and ADP sections are completely redundant. The transmitter, DDP and experiments power control do not have independent redundancy. The modified aspect of redundancy for the transmitter and experiments is due to the source of voltage coming directly from a PCU redundant section without cross-strapping.

Values used in calculating PDU reliability are shown in Figure 3. The failure probabilities for the six experiments are summed to provide the total failure probability of these similar modules.

## 5.0 Failure Mode, Effect and Criticality Analysis

The failure modes were first identified with respect to PDU functions. The parts required to perform a function were then analyzed with respect to their applicable failure modes, including all failure modes listed in ATM 605A, Section 4. After identifying a failure mode, its effect on the immediate assembly and end item (PDU module) was analyzed.

Alpha ($\alpha$) values give failure rate apportionments for the failure modes of the function being analyzed. The numerical value of $\alpha$ is a decimal number to three places, representing the fractional amount of the total failure rate for the function obtained for the parts from the PAA.

The failure probability is based on 2 years (17520 hours) of operation on the moon. The total function failure probability was determined first. Second, the failure probability for each failure mode was determined by multiplying $\alpha$ times the total function failure probability.

Table 1 provides criticality ranking codes. Because of redundancy, the PDU contains the lowest three criticality codes.

Analysis of the effects of various failures indicates that a circuit breaker contact set welded or fixed close in a position for resetting the circuit breaker in the uplink or ADP power control will energize six relays, consuming 2.5 watts continuously. This probability is comparatively low, being $17 \times 10^{-5}$ for a single circuit breaker. Contacts are rated at 500 ma and the total current requirement for six relays is only 87 ma or less than 18% of rated current of the relay. A total of six tripping circuits are in operation at any one time with respect to this failure mode, raising the failure probability for the combination to $102 \times 10^{-5}$.

Drift in relay driver transistors have the highest probability of failure. In the uplink and ADP power control the failure probability is $164 \times 10^{-5}$. In the experiments power control, the failure probability due to transistor drift is $166 \times 10^{-5}$.

6.0 Reliability Calculations

6.1 $R_A$ is the reliability of the unswitched EMF's, Experiments 1-5, Digital Data Processor, Isolation Diodes, Transmitter and their Redundant Path.

| | Q's |
|---|---|
| Isolation Diodes | $20 \times 10^{-5}$ |
| Unswitched EMF's | $21 \times 10^{-5}$ |
| Experiments 1-5 | $5.04 \times 10^{-3}$ |
| Digital Data Processor | $3.36 \times 10^{-3}$ |
| Transmitter | $9.93 \times 10^{-3}$ |
| | $Q_A = 18.7 \times 10^{-3}$ |

$$R_A = 1 - Q_A^2 = 0.999650$$

6.2 $R_B$ is the reliability of the uplink

$$R_B = 1 - Q_B^2 = 0.999967$$

$$Q_B = 5.81 \times 10^{-3}$$

6.3 $R_C$ is the reliability of the ADP

$$R_C = 1 - Q_C^2 = 0.999971$$

$$Q_C = 5.42 \times 10^{-3}$$

6.4 $R_D$ is the reliability of the Power Dump

$$R_D = 1 - Q_D^2 = 0.999986$$

$$Q_D = 3.7 \times 10^{-3}$$

6.5 The total Reliability $R_T$

$$= R_A R_B R_C R_D = 0.999574$$

TABLE 1

Criticality coding in the detail FMECA is in accordance with the following table:

I. Loss of system

II. Loss of system control

III. Loss of one experiment

IV. Loss of housekeeping channel(s)

V. Loss of redundant element

VI. Degradation of a redundant element

## 7.0 RELIABILITY ASSESSMENT

The purpose of performing a reliability prediction and failure mode analysis is to identify inherent design weaknesses. From the results of these analyses, it has been concluded the reliability and design objectives have been fully satisfied.

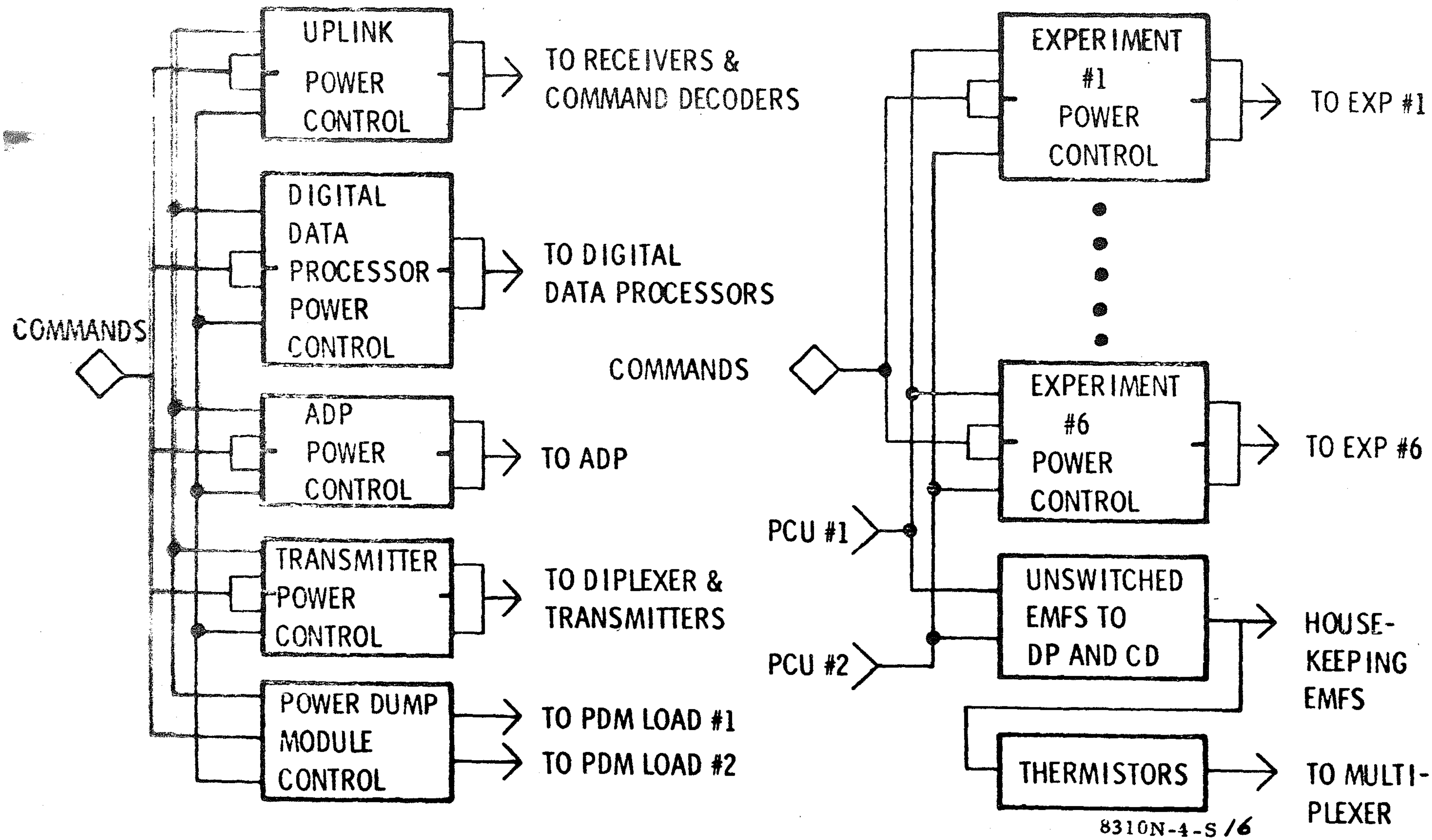


FIGURE 1 ARRAY E PDU FUNCTIONAL BLOCK DIAGRAM

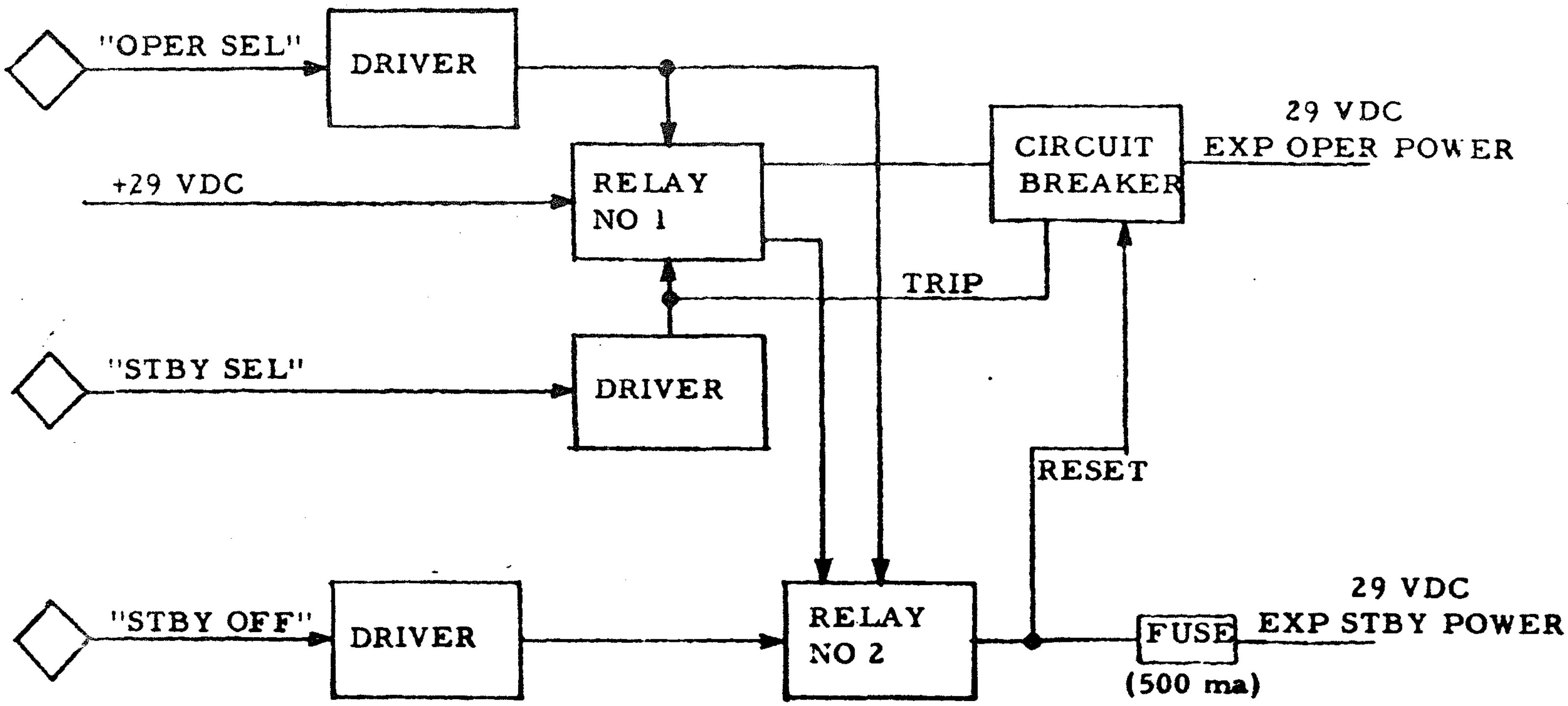


FIGURE 2

ARRAY E EXPERIMENT POWER CONTROL

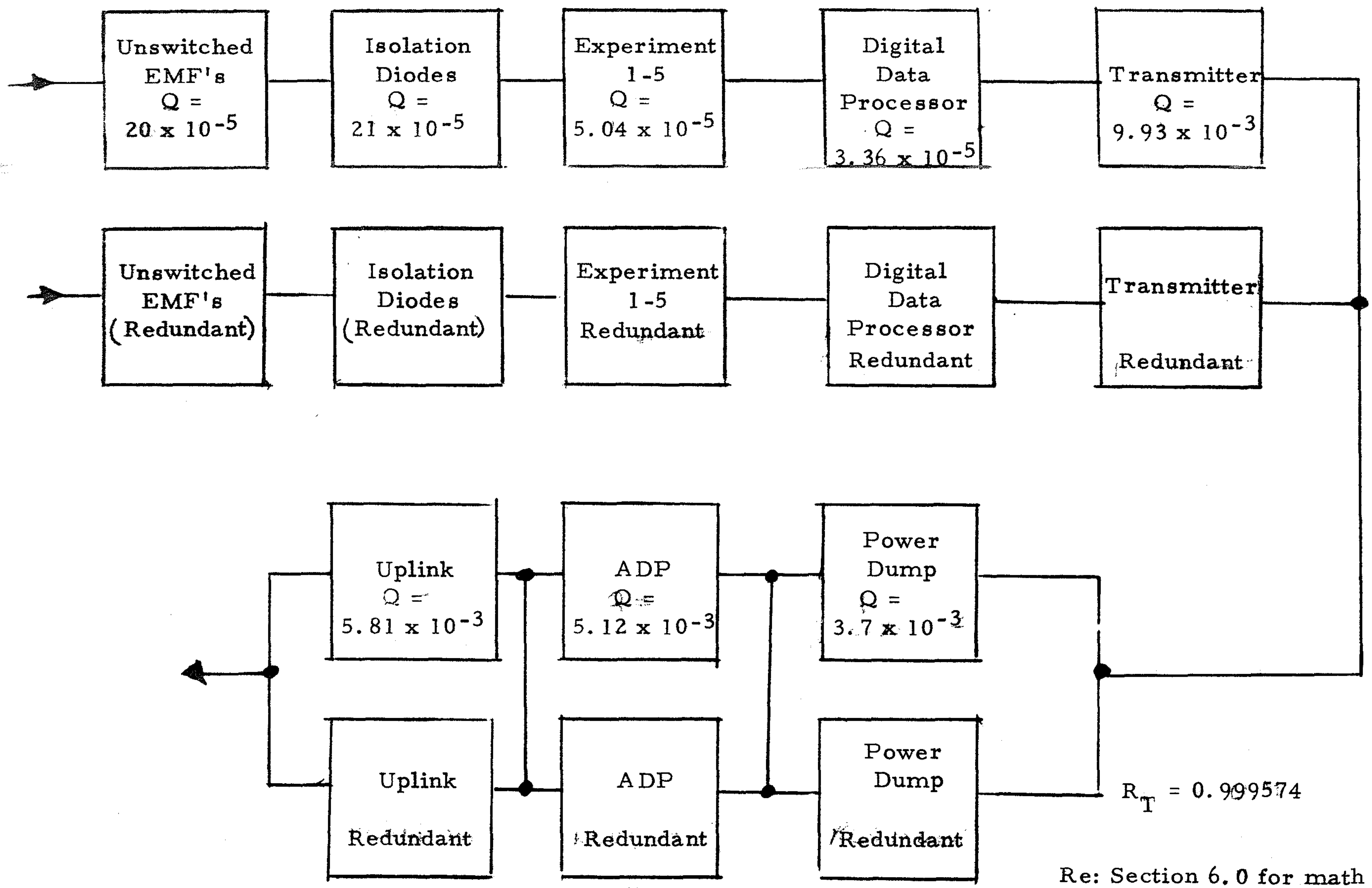


Figure 3 Reliability Block Diagram

Re: Section 6.0 for math model and calculations

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| ASS'Y Power Dump | DWG NO. 2349156 | DATE 9-23-71 | |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE | (α) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY Q x 10⁻⁵ | CRITIC-ALITY |
|---|---|---|---|---|---|---|
| .0 Isolation diodes CR13 and CR14 | 1.1 Open. | 0.200 | 1.1 No circuitry continuity. | 1.1 No outputs. | 7 | IV |
| | 1.2 Shorted. | 0.400 | 1.2 Does not provide isolation. | 1.2 Does not provide isolation. | 13 | IV |
| .0 By-pass diodes CR15 and CR16 | 2.1 Open. | 0.200 | 2.1 Limits discharge of capacitors. | 2.1 Reduced current output. | 7 | IV |
| | 2.2 Shorted. | 0.400 | 2.2 Allows power drain if secondary shorting failure occurs in capacitor. | 2.2 Reduced output potential. | 13 | IV |
| 3.0 Limiting Resistor R13, 14 (12.1 K) | 3.1 Open. | 0.100 | 3.1 Prevents charging of capacitor | 3.1 Not able to supply coil energizing power. | 1 | IV |
| | 3.2 Shorted. | 0.0 | 3.2 Allows power drain if secondary shorting failure occurs in capacitor. | 3.2 Reduced output potential. | 0 | - - - |

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| ASS'Y Uplink or ADP Relays | DWG NO. 2349146 | DATE 9-23-71 | |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE (α)* | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE * PROBABILITY Q x 10⁻⁵ | CRITICALITY |
|---|---|---|---|---|---|
| 1.0 Overload sensing and switching components CB1 thru CB6 | 1.1 Open tripping coil in CB-1 thru CR-6 .080/.080 | 1.1 Circuit functions thru diode, either CR5, 8, 11, 13, 17 or 20, by-passing open coil. | 1.1 Circuit does not provide overload protection. | 8/8 | V |
| | 1.2 Shorted tripping coil in CB-1 thru CB-6 0.170/.170 | 1.2 Overload protection for particular line segment is lost. | 1.2 Same as above. | 17/17 | V |
| | 1.3 Contacts remain open after tripping current is applied. 0.410/.410 | 1.3 Relays K1, K2 and K4 will not be activated. | 1.3 Switching to alternate loads will not be accomplished. | 41/42 | V |
| | 1.4 Welded or mechanically fixed closed contacts. 0.170/.170 | 1.4 Maintains holding voltage on K1,K2 and K3. Maintains holding voltage on reset coils of three circuit breakers. | 1.4 Loss of capability to command transfer of power to alternate load. Loss of overload protection function of three circuit breakers. Six relays remain evergized. Consumption: 2.5 W | 17/17 | V |
| | 1.5 Shorted or open magnetic saturation limiting diodes, CR5, 8, 11, 13, 17 or 20. 0.120/.120 | 1.5 Short condition causes by-passing of tripping coil. Open will permit tripping coil to reach saturation, depending on nature of overload. | 1.5 Short condition by-passes protection function. Open condition may allow coil saturation, negating tripping action. | 12/12 | V |
| 2.0 **Alternating load relays K1, K2, K4** | 2.1 Open coil in either K1, 2 or 4 relay. .050/.060 | 2.1 Unable to switch or cycle contacts. | 2.1 Loads A and B will be provided with power simultaneously in the form of either +12VDC or -12VDC, depending on specified relay coil failure if relays are commanded to switch circuits. | 8/6 | V |
| | 2.2 Shorted coil in either K1, 2 or 4 relay 0.130/.110 | 2.2 Possible intermittent operation; possible continuous "on" condition; possible non-operation. | 2.2 Unpredictable switching or sensing response; lock-up of contacts to one load plus added load of powered coil; shorted condition, by-passing coil prevents load selection and adds undue drain on power supply. | 18/12 | V |
| | 2.3 Open contacts. 0.320/.280 | 2.3 Incomplete circuit for sensing or supplying power to one of loads | 2.3 Power is supplied via redundant circuit. | 45/31 | VI |
| | 2.4 Welded or mechanically fixed closed contacts. 0.130/.110 | 2.4 Contacts cannot switch. | 2.4 Cannot completely switch to alternate loads. | 18/12 | V |
| | 2.5 Shorted inductive kick diodes, CR3, 4, 9, and 22. 0.140/.180 | 2.5 Shorted condition allows coil to be by-passed. | 2.5 Shorted diode prevents cycling a relay to alternate loads. | 20/20 | V |
| | 2.6 Open diode. CR3, 4, 9 and CR 22. .070/.090 | 2.6 Allows inductive kick to destroy relay driver output transistor via collector at this transistor. | 2.6 Relay driver will become inoperable | 10/10 | V |

*First value is for Uplink; second value is for ADP.

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| ASS'Y Uplink or ADP Relays | DWG NO. 2349146 | DATE 9-23-71 | |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE | ($\alpha$) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY $Q \times 10^5$ | CRITICALITY |
|---|---|---|---|---|---|---|
| 3.0 Auto-toggle Uplink K3 | 3.1 Open coil in K3 relay | 0.10/0.10 | 3.1 Unable to switch or cycle contacts. | 3.1 Unable to alternate between +5V power sources 1 and 2. | 3/2 | V |
| | 3.2 Shorted coil in K3 relay. | .200/.200 | 3.2 Possible intermittent operation; possible continuous "on" condition; possible non-operation. | 3.2 Unpredictable switching response; lock-up to a single +5V power source; shorted condition, by-passing coil prevents +5V power source selection and adds undue drain on power supply. | 7/4 | V |
| | 3.3 Contacts open | 0.500/.500 | 3.3 One +5V path open | 3.3 Output voltage available from one +5V source only. | 17/10 | V |
| | 3.4 Welded or mechanically fixed closed contacts. | 0.200/.200 | 3.4 One set of contacts uncontrollable. | 3.4 Same as 3.3 above. | 7/4 | V |
| 4.0 Relay Driver Q1,3,5,7,9,11(2N2907A) Q2,4,6,8,10,12(2N2222A) R1,4,7,10,13,16(21K Ω) R2,5,8,11,14,17(681Ω) R3,6,9,12,15,18,(56.2Ω) C1-6 (82nf) | 4.1 $R_1$ et al., open. | .003 | 4.1 Q1,Q2 et al., turned on. | 4.1 Relay coil is continuously energized. | 1 | V |
| | 4.2 $R_1$ et al., short. | 0.0 | 4.2 Excessive current flow in $Q_1$ collector base junction. | 4.2 Failure of relay friver | 0 | |
| | 4.3 $R_1$ et al., drift. | .029 | 4.3 Drift high approaches para. 4.1 conditions. Drift low approaches para. 4.2 conditions. | 4.3 Same as paras. 4.1 and 4.2 respectively | 8 | V |
| | 4.4 $R_2$ et al., open | .007 | 4.4 Second driver transistor cannot be turned on | 4.4 Relay driver inoperative. | 2 | V |
| | 4.5 $R_2$ et al., short | 0.0 | 4.5 Excessive current flow in relay driver | 4.5 Relay driver destroyed | 0 | V |
| | 4.6 $R_2$ et al., drift | .036 | 4.6 Drift high approaches para. 4.4 conditions. Drift low approaches para. 4.5 conditions. | 4.6 Same as paras. 4.4 and 4.5 respectively | 10 | V |
| | 4.7 $R_3$ et al., open | .003 | 4.7 Second transistor (2N2222A) turn-off delayed. | 4.7 Relay coil energized for excessive period. | 1 | V |
| | 4.8 $R_3$ et al., shorted | 0.0 | 4.8 Causes second transistor's base voltage to remain at zero. | 4.8 Relay driver inoperative | 0 | V |
| | 4.9 $R_3$ et al., drift | .029 | 4.9 Drift high approaches para. 4.7 conditions. Drift low approaches para. 4.8 conditions. | 4.9 Same as paras. 4.7 and 4.8 respectively | 8 | V |
| | 4.10 C1 et al., open | 0.0 | 4.10 No time delay in relay driver | 4.10 Insufficient "on" time to operate relay | 0 | V |
| | 4.11 C1 et al., shorted | <.001 | 4.11 First transistor in relay driver stays "on". | 4.11 Relay coil is continuously energized. | 0 | V |
| | 4.12 C1 et al., drift | 0.0 | 4.12 Drift high approaches para. 4.10 conditions. Drift low approaches para. 4.11 conditions | 4.12 Same as para. 4.10 and 4.11 respectively | 0 | V |

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| ASS'Y Uplink or ADP Relays | DWG NO. 2349146 | DATE 9-23-71 | |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE (α) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY $Q \times 10^{5}$ | CRITICALITY |
|---|---|---|---|---|---|
| | 4.13 Drift in Q1 et al., or Q2 et al. 0.600 | 4.13 Beta and therfore drive or output current reduced. | 4.13 Sufficient drift could reduce relay driver capability to inoperative state. Relay cannot be operated. | 164 | V |
| | 4.14 Base-emitter short in Q1 or Q2, et al .044 | 4.14 Relay driver inoperative | 4.14 Relay cannot be operated. | 12 | V |
| | 4.15 Collector-base short in Q1 or Q2, et al .044 | 4.15 Relay driver "on" continuously | 4.15 Relay coil energized continuously. | 12 | V |
| | 4.16 Open junction (base, emitter or collector) in Q1 or Q2, et al. .018 | 4.16 Relay driver inoperative | 4.16 Relay cannot be operated | 49 | V |
| 5.0 Isolation diodes CR1, CR2 in Dwg 2349196 and CR1, 2, 6, 7, 10, 12, 14, 15, 18 and 19 in Dwg 2349146. | 5.1 Open 0.200 | 5.1 CR1 or CR2 (2349196) will prevent re-setting circuit breaker and if circuit breaker is tripped, a load switching relay will be continuously evergized. CR1, 2 et al. (2349146) opens prevent a through circuit to source voltage. | 5.1 Uplink power control may require added unscheduled power consumption. Uplink power control will be limited in load selection (CR1 or CR2, Dwg 2349196). CR1, 2 et al. (2349146) opens limit loads to one voltage source. | 20/21 | V |
| | 5.2 Short 0.400 | 5.2 CR1 or CR2 (2349196) shorted will provide voltage path through load relay coil to load. | 5.2 Uncontrolled power leakage through Uplink power control circuit. | 42/41 | V |

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| ASS'Y Transmitters | DWG NO. 2349166 | DATE 9-23-71 | |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE (α) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY $Q \times 10^{-5}$ | CRITICALITY |
|---|---|---|---|---|---|
| 1.0 Overload sensing and switching components CB1 and CB2 and CB 3 | 1.1 Open tripping coil in CB1 and CB2 circuit breakers. .092 | 1.1 Circuit functions through diode, bypassing open coil. | 1.1 Circuit does not provide overload protection. | 10 | V |
| | 1.2 Shorted tripping coil in CB1 or CB2, or CB3. 0.184 | 1.2 Overload protection for particular line segment is lost. | 1.2 Same as above. | 21 | V |
| | 1.3 Contacts remain open after tripping current is applied. 0.461 | 1.3 Relay coil and circuit breaker reset coil will not be activated. | 1.3 Switching to alternate loads will not be accomplished. Continued high circuit current will flow. | 53 | VI |
| | 1.4 Welded or mechanically closed contacts. 0.184 | 1.4 Maintains holding voltage on magnetic latching relay coil and circuit breaker reset coil consumption 841 mw. | 1.4 Loss of capability to command transfer of power to alternate load. Loss of further protection utilization. | 21 | V |
| CR3, 6, 11 | 1.5 Shorted or open diodes (used to limit magnetic saturation at tripping coil.) .047 | 1.5 Shorted condition causes bypassing of tripping coil. Open will permit tripping coil to reach saturation, depending on nature of overload. | 1.5 Short condition by-passes protection function. Open condition may allow coil saturation, negating tripping action. | 5 | V |
| 2.0 Alternating Load Relay K1 and K2 | 2.1 Open coil in K1 or K2 relay. 0.070 | 2.1 Unable to switch or cycle contacts. | 2.1 Loads A and B will be provided with power simultaneously when commanded to switch circuits. | 20 | V |
| | 2.2 Shorted coil in K1 and K2 relay. 0.130 | 2.2 Possible intermittent operating; possible continuous "on" condition; possible non-operation. | 2.2 Unpredictable switching or sensing responce; lock-up of contacts to one load plus added load to continously passing coil prevents load selection and adds undue drain on power supply. | 37 | V |
| | 2.3 Open Contacts 0.330 | 2.3 Incomplete circuit for overload sensing/supplying power or resetting circuit breaker. | 2.3 Required functions provided by redundant circuit. | 93 | VI |
| | 2.4 Welded or mechanically fixed closed contacts. 0.130 | 2.4 Contacts cannot switch. | 2.4 If contacts are in load circuit, both loads will be supplied simultaneously. If contacts are in CB reset circuit, one circuit breaker will not have reset capability. | 37 | V |

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# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE (α) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY Q x $10^{-5}$ | CRITICALITY |
|---|---|---|---|---|---|
| CR 2, 5, 8, 9, 12, 14 | 2.5 Shorted inductive kick diodes. 0.140 | 2.6 Shorted condition allows coil to be by-passed. | 2.5 Shorted diode prevents cycling relay to alternate position. | 39 | V |
| | 2.6 Open inductive kick diodes. 0.070 | 2.6 Allows inductive kick to destroy | 2.6 Relay driver becomes inoperative when coil is cycled. | 20 | V |
| 3.0 Relay driver Q1, 3, 4, 7 (first transistors) | 3.1 Open in R5 et al. .020 | 3.1 First transistor turned on. | 3.1 Relay coil is continuously energized. | 12 | V |
| | 3.2 Short in R5 et al. 0.0 | 3.2 Excessive current flow in first transistor | 3.2 Failure of relay driver. | 0 | V |
| Q2, 5 (second transistors) | 3.3 Drift in R5 et al. 0.180 | 3.3 Drift high approaches para. 3.1 conditions. Drift low approaches para. 3.2 conditions. | 3.3 Same as paragraphs 3.1 and 3.2 respectively. | 110 | V |
| R5, 8, 12, 15 (21 kΩ) R6, 9, 13, 16 (681 Ω) | 3.4 Open in R6 et al. .020 | 3.4 Second transistor cannot be turned on. | 3.4 Relay driver inoperative. | 12 | V |
| R3, 7, 10, 14 (56.2 KΩ) | 3.5 Short in R6 et al. 0.0 | 3.5 Excessive current flow in both relay driver transistors. | 3.5 Relay driver destroyed. | 0 | V |
| | 3.6 Drift in R6 et al. .200 | 3.6 Drift high approaches para. 3.4 conditions. Drift low approaches para. 3.5 conditions. | 3.6 Same as paragraphs 3.4 and 3.5 respectively. | 120 | V |
| | 3.7 Open in R3 et al. .020 | 3.7 Second transistor turn-off delayed. | 3.7 Relay coil energized for excessive period. | 12 | V |
| | 3.8 Short in R3 et al. 0.0 | 3.8 Causes second transmitter based boltage to remain at zero. | 3.8 Relay driver inoperative. | 0 | V |
| | 3.9 Drift in R3 et al. 0.180 | 3.9 Drift high approaches para. 3.7 conditions. Drift low approaches para. 3.8 condition. | 3.9 Same as para. 3.7 and 3.8 respectively. | 110 | V |
| | 3.10 Drift in first or second relay driver transisters. .270 | 3.10 Beta and therefore drive or output current reduced. | 3.10 Sufficient drift could reduce relay driver capability to inoperative state. Relay cannot be operated. | 165 | V |
| | 3.11 Base-emitter short in first or second relay driver transistors. .020 | 3.11 Relay driver inoperative. | 3.11 Relay cannot be operated. | 12 | V |

| SYSTEM ALSEP | PREPARED BY | NO. | REV. A |
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| END ITEM PDU | DWG NO. | PAGE 16 of 26 | |
| ASS'Y Transmitters | DWG NO. 234126 | DATE 9-23-71 | |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE (α) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY $Q \times 10^{-5}$ | CRITICALITY |
|---|---|---|---|---|---|
| | 3.12 Collector-base short in first or second relay driver transistors. .020 | 3.12 Relay driver "on" continuously. | 3.12 Relay coil energized continuously. | 12 | V |
| | 3.13 Open junction (base, emitter or collector) in first or second relay driver transistor. .080 | 3.13 Relay driver inoperative. | 3.13 Relay cannot be operated. | 49 | V |
| 4.0 Isolation diodes CR 1, 4, 7, 10 and 13. | 4.1 Open 0.180 | 4.1 CR1, 4 and 10 will isolate loads (transmitter B, diplexer and transmitter A, respectively), CR13 will prevent resetting CB3. | 4.1 Loss of circuit redundancy. Voltage for resetting circuit breaker will be unavailable. | 8 | V |
| | 4.2 Short 0.440 | 4.2. Circuit isolation is compromised. | 4.2 Loss of protection against secondary failures in PCU/PDU. Supply line, +5V, and +29V. Loss of isolation between ±29V 1 or +29V 2 and +29V Z. | 19 | V |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE (α) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY $Q \times 10^{5}$ | CRITICALITY |
|---|---|---|---|---|---|
| 1.0 Overload sensing and switching components CB1 and CB2. | 1.1 Open tripping coil in CB1 or CB2 circuit breakers .095 | 1.1 Circuit functions through diode, by passing open coil. | 1.1 Circuit does not provide overload protection. | 7 | V |
| | 1.2 Shorted tripping coil in CB1 and CB2 0.189 | 1.2 Overload protection for particular line segment is lost. | 1.2 Same as above. | 14 | V |
| | 1.3 Contacts remain open after tripping current is applied. 0.473 | 1.3 Relay coil and circuit breaker reset coil will not be activated. | 1.3 Switching to alternate loads will not be accomplished. Continued high circuit current will flow. | 35 | V |
| | 1.4 Welded or mechanically closed contacts. 0.189 | 1.4 Maintains holding voltage on magnetic latching relay coil and circuit breaker reset coil. Comsumption: 841mw | 1.4 Loss of capability to command transfer of power to alternate load. Loss of further protection utilization. | 14 | V |
| | 1.5 Shorted or open diodes (used to limit magnetic saturation at tripping coil) .054 | 1.5 Shorted condition causes bypassing of tripping coil. Open will permit tripping coil to reach saturation, depending on nature of overload. | 1.5 Short condition bypasses protection function. Open condition may allow coil saturation, negating tripping action. | 4 | V |
| 2.0 Alternating Load Relay K1 | 2.1 Open coil in K1 relay. .061 | 2.1 Unable to switch or cycle contacts. | 2.1 Loads A and B will be provided with power simultaneously when commanded to switch circuits. | 5 | V |
| | 2.2 Shorted coil in K1 relay 0.122 | 2.2 Possible intermittent operating; possible continuous "on" condition; possible non-operation. | 2.2 Unpredictable switching or sensing response; lock-up of contacts to one load plus added load to continously powered coil; shorted condition, by-passing coil prevents load selection and adds undue drain on power supply. | 10 | V |
| | 2.3 Open Contacts 0.310 | 2.3 Incomplete circuit for overload sensing/supplying power or resetting circuit breaker. | 2.3 Required functions provided by redundant circuit. | 27 | VI |
| | 2.4 Welded or mechanically fixed closed contacts. 0.122 | 2.4 Contacts cannot switch. | 2.4 If contacts are in load circuit, both loads will be supplied simultaneously. If contacts are in CB reset circuit, one circuit breaker will not have reset capability. | 10 | V |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| T/COMPONENT SYMBOL | FAILURE MODE (α) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY $Q \times 10^{-5}$ | CRITICALITY |
|---|---|---|---|---|---|
| | 2.5 Shorted inductive kick diodes. 0.153 | 2.5 Shorted condition allows coil to be by-passed. | 2.5 Shorted diode prevents cycling relay to alternate position. | 13 | V |
| | 2.6 Open diode. .075 | 2.6 Allows inductive kick to destroy second transistor via collector of second transistor of the relay driver. | 2.6 Relay driver becomes inoperative when coil is cycled. | 6 | V |
| Relay driver Q1, Q3 (First transistors) | 3.1 R1, R6 open .004 | 3.1 First transistor turned on. | 3.1 Relay coil is continuously energized. | 1 | V |
| | 3.2 R1, R6 short 0.0 | 3.2 Excessive current flow in first transistor | 3.2 Failure of relay driver | 0 | V |
| Q2, Q4 (second transistors) | 3.3 R1, R6 drift .029 | 3.3 Drift high approaches para. 3.1 conditions. Drift low approaches para. 3.2 conditions. | 3.3 Same as paragraphs 3.1 and 3.2 respectively. | 5 | V |
| R1, R6 (21 KΩ) | | | | | |
| R2, R7 (681 Ω) | 3.4 R2, R7 open .004 | 3.4 second transistor cannot be turned on. | 3.4 Relay driver inoperative. | 1 | V |
| R4, R8 (56.2KΩ) | 3.5 R2, R7 shorted 0.0 | 3.5 Excessive current flow in both relay driver transistors. | 3.5 Relay driver destroyed. | 0 | V |
| | 3.6 R2, R7 drift .033 | 3.6 Drift high approaches para. 3.4 conditions. Drift low approaches para. 3.5 conditions. | 3.6 Same as paragraphs 3.4 and 3.5 respectively. | 6 | V |
| | 3.7 R4, R8 open .004 | 3.7 Second transistor turn-off delayed. | 3.7 Relay coil energized for excessive period. | 1 | V |
| | 3.8 R4, R8 shorted. 0.0 | 3.8 Causes second transmitter base voltage to remain at zero. | 3.8 Relay driver inoperative. | 0 | V |
| | 3.9 R4, R8 drift. .029 | 3.9 Drift high approaches para. 3.7 conditions. Drift low approaches para. 3.8 condition. | 3.9 Same as para. 3.7 and 3.8 respectively. | 5 | V |
| | 3.10 Drift in first or second relay driver transisters. .586 | 3.10 Beta and therefore drive or output current reduced. | 3.10 Sufficient drift could reduce relay driver capability to inoperative state. Relay cannot be operated. | 110 | V |
| | 3.11 Base-emitter short in first or second relay driver transistors. .042 | 3.11 Relay driver inoperative. | 3.11 Relay cannot be operated. | 8 | V |

| SYSTEM ALSEP | PREPARED BY AWR | NO. | REV. A |
|---|---|---|---|
| END ITEM PDU | DWG NO. | PAGE 19 of 26 | |
| ASS'Y Digital Data Processor | DWG NO. | DATE 9-23-71 | |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE (α) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY Q x $10^5$ | CRITICALITY |
|---|---|---|---|---|---|
| | 3.12 Collector-base short in first or second relay driver transistors. .042 | 3.12 Relay driver "on" continuously. | 3.12 Relay coil energized continuously. | 8 | V |
| | 3.13 Open junction (base, emitter or collector) in first or second relay driver transistor. .314 | 3.13 Relay driver inoperative. | 3.13 Relay cannot be operated. | 31 | V |
| 4.0 Isolation Diodes CR1, 5 and 9 | 4.1 Open .200 | 4.1 CR1 will prevent supply power circuit continuity. CR5 and CR9 will isolate loads A and B respectively. | 4.1 Loss of circuit redundancy. Voltage for resetting circuit breaker will be unavailable. | 5 | V |
| | 4.2 Short .400 | 4.2 Circuit isolation is compromised | 4.2 Loss of protection against secondary failures in PCU/PDU. Supply line, +5V and +29V. Loss of isolation between +29V 1 or +29V 2 and +29V Z. | 9 | V |

| SYSTEM ALSEP | PREPARED BY AWR | NO. | REV. A |
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| END ITEM PDU | DWG NO. | PAGE 20 of 26 | |
| ASS'Y Experiment | DWG NO. 2349116 | DATE 9-23-71 | |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE (α) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY Q × 10⁻⁵ | CRITICALITY |
|---|---|---|---|---|---|
| 1.0 Overload sensing and switching components CB1 | 1.1 Open tripping coil in CB1 circuit breaker. .054 | 1.1 Circuit functions through diode, by passing open coil. | 1.1 Circuit does not provide overload protection. | 0 | V |
| | 1.2 Shorted tripping coil in CB1. .108 | 1.2 Overload protection for particular line segment is lost. | 1.2 Same as above. | 1 | V |
| | 1.3 Contacts remain open after tripping current is applied. 0.270 | 1.3 Relay coil and circuit breaker reset coil will not be activated. | 1.3 Source to excessive load circuit will not be interrupted. | 2 | V |
| | 1.4 Welded or mechanically closed contacts. 0.108 | 1.4 Maintains holding voltage on magetic latching relay coil and circuit breaker reset coil. Consumption: 841mw | 1.4 Loss of relay command action and further protection utilization. | 1 | V |
| | 1.5 Shorted or open diodes (used to limit magnetic saturation at tripping coil) 0.460 | 1.5 Shorted condition causes by-passing of tripping coil. Open will permit tripping coil to reach saturation, depending on nature of overload. | 1.5 Short condition by-passes protection function. Open condition may allow coil saturation, negating tripping action. | 3 | V |
| 2.0*Fuse Protection F3 thru 12, phase F14 and F15. | 2.1 Failure to protect circuit. (Does not open when excess currents are encountered) 0.20 | 2.1 Excess current can damage contacts at relays. | 2.1 Loss of protective function. | 7 | V |
| *Fuses are on Mother Board, Dwg #2349176. | 2.2 Opens prematurely. 0.80 | 2.2 No current flow. | 2.2 Isolation at source voltage and experiment standby load. | 27 | V |
| 3.0 Control relays K1, K2 | 3.1 Open coil in K1 or K2 relay. .069 | 3.1 Unable to switch or cycle contacts. | 3.1 Supplies, +29V 1 and 2 will be tied together when switching commands are cycled. | 15 | V |
| | 3.2 Shorted coil in K1 or K2 relay. 0.138 | 3.2 Possible intermittent operating possible continuous "on" condition; possible non-operation. | 3.2 Unpredictable switching or sensing response; lock-up of contacts to one load plus added load to continously powered coil; shorted condition, by-passing coil prevents load selection and adds undue drain on power supply | 29 | V |
| | 3.3 Open contacts 0.345 | 3.3 Incomplete circuit for overload sensing/ supplying power or resetting circuit breaker. | 3.3 Required functions provided by redundant circuit. | 74 | VI |
| | 3.4 Welded or mechanically fixed closed contacts. 0.138 | 3.4 Contacts cannot switch. | 3.4 K1 &K2 first set of contacts will cause circuit board reset coil to be energized or if welded in opposite position, isolation of source voltage. The relays have contact poles providing redundant functions so there is no effect. | 29 | V |

| SYSTEM ALSEP | PREPARED BY AWR | NO. | REV. A |
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| END ITEM PDU | DWG NO. | PAGE 21 of 26 | |
| ASS'Y Experiment | DWG NO. 2349116 | DATE 9-23-71 | |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE (α) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY Q x 10⁵ | CRITICALITY |
|---|---|---|---|---|---|
| | 3.5 Shorted inductive kick diodes. 0.123 | 3.5 Shorted condition allows coil to be by-passed. | 3.5 Shorted diode prevents cycling relay to alternate position. | 26 | V |
| | 3.6 Open diode. .002 | 3.6 Allows inductive kick to destroy second transistor via collector of second transistor of the relay driver. | 3.6 Relay driver becomes inoperative when coil is cycled. | 13 | VI |
| 4.0 Relay driver Q1,3,5,(First transistor(s) Q2,4,6(Second transistor(s) R1,2,6(21kΩ) R4,7,8 (681Ω) R5,9,10(56,2kΩ | 4.1 Open in R1 et al. .037 | 4.1 First transistor turned on. | 4.1 Relay coil is continuously energized. | 1 | V |
| | 4.2 Short " " " " 0.00 | 4.2 Excessive current flow in first transistor. | 4.2 Failure of relay driver | 0 | V |
| | 4.3 Drift " " " " 0.330 | 4.3 Same as para. 3.1 and 3.2 respectively | 4.3 Same as para. 3.1 and 3.2 respectively. | 8 | V |
| | 4.4 Open " R4 " " .004 | 4.4 Second transistor cannot be turned on. | 4.4 Relay driver inoperative. | 1 | V |
| | 4.5 Short " " " " 0.00 | 4.5 Excessive current flow in both relay driver transistors. | 4.5 Relay driver destroyed. | 0 | V |
| | 4.6 Drift " " " " .004 | 4.6 Drift high approaches para. 3.4 conditions. Drift low approaches para. 3.5 conditions. | 4.6 Same as paras. 3.4 and 3.5 respectively. | 9 | V |
| | 4.7 Open " R5 " " .004 | 4.7 Second transistor turn-off delayed. | 4.7 Relay coil energized for excessive period. | 1 | V |
| | 4.8 Short " " " " 0.00 | 4.8 Causes second transmitter base voltage to remain at zero. | 4.8 Relay driver inoperative. | 0 | V |
| | 4.9 Drift " " " " .003 | 4.9 Drift high approaches para. 3.7 conditions. Drift low approaches para. 3.8 condition. | 4.9 Same as para. 3.7 and 3.8 respectively. | 8 | V |
| | 4.10 Drift in first or second relay driver transistors. 0.670 | 4.10 Beta and therefore drive or output current reduced. | 4.10 Sufficient drift could reduce relay driver capability to inoperative state. Relay cannot be operated. | 166 | V |
| | 4.11 Base-emitter short in first or second relay driver transistors. .048 | 4.11 Relay driver inoperative. | 4.11 Relay cannot be operated. | 12 | V |
| | 4.12 Collector-base short in first or second relay driver transistors. .048 | 4.12 Relay driver "on" continuously. | 4.12 Relay coil energized continuously. | 12 | V |
| | 4.13 Open junction (base, emitter or collector) in first or second relay driver transistor. .019 | 4.13 Relay driver inoperative. | 4.13 Relay cannot be operated. | 47 | V |

| SYSTEM ALSEP | PREPARED BY AWR | NO. | REV. A |
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| END ITEM PDU | DWG NO. | PAGE 22 of 26 | |
| ASS'Y Experiment | DWG NO. | DATE 9-23-71 | |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE | (α) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY $Q \times 10^{5}$ | CRITICALITY |
|---|---|---|---|---|---|---|
| 0 Isolation diodes CR 1,4,6,8,11. | [illegible] Open | 0.200 | 5.1 CR 11 will prevent K1 from receiving "off" command. CR 1,4,6 or 9. Isolate load or reset capability. | 5.1 Experiment will continue in "on" mode after receipt of "off" command. CR1,4,6, or 9 have no effect as circuit is redundant. | 12 | V |
| | [illegible].2 Short | 0.400 | 5.2 Circuit isolation is compromised. CR11 will allow K2 circuits to be opened if (A) stdby command is transmitted, or (B) tripping circuit is activated. | 5.2 Shorted CR11 will cause K2 to be energized if standby command or circuit breaker reset contacts are implemented. | 24 | V |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| SYSTEM | PREPARED BY | NO. | REV. |
|---|---|---|---|
| ALSEP | AWR | | A |
| END ITEM: PDU | DWG NO. | PAGE 23 of 26 | |
| ASS'Y: Power Dump | DWG NO. 2349156 | DATE 9-23-71 | |

| | PART/COMPONENT SYMBOL | FAILURE MODE | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY $Q \times 10^{-5}$ | CRITICALITY |
|---|---|---|---|---|---|---|
| | 1.0 *Fuse protection F1, F2 | 1.1 Failure to protect circuit. (Does not open when excess currents are encountered) .200 | 1.1 Excess currents can damage contacts of relays and over stress diodes. | 1.1 Loss of protective function. | 7 | VI |
| | *Fuses are on Mother Board, Dwg #2349176 | 1.2 Opens prematurely. .800 | 1.2 No current flow. | 1.2 Isolation of source voltage from either PDM load #1 or #2. | 27 | VI |
| | 2.0 Power Ctrl relays K1 through K4 | 2.1 Open coil in relay K1, et al .008 | 2.1 Unable to switch or cycle contacts. | 2.1 Either load #1 or #2 will remain in either the energized or off condition. | 2 | |
| | | 2.2 Shorted coil in K1, et al. .016 | 2.2 Possible intermittent operation; possible continuous "on" condition; possible non-operation. | 2.2 Unpredictable switching or sensing response; lock-up of contacts to one position plus added load to continuously powered coil; shorted condition, by-passing coil prevents command control and adds undue drain on power supply. | 5 | |
| | | 2.3 Open contacts. 0.392 | 2.3 Incomplete circuit. | 2.3 NONE. Redundancy provided. | 120 | --- |
| | | 2.4 Welded or mechanically fixed closed contacts 0.16 | 2.4 Contacts cannot switch. | 2.4 " " " | 5 | --- |
| | | 2.5 Shorted inductive kick diodes .086 | 2.5 Shorted condition allows coil to be by-passed. | 2.5 Shorted diode prevents cycling relay to alternate position. | 26 | VI |
| | | 2.6 Open diode .043 | 2.6 Higher failure rate of $Q_2$ | 2.6 Relay driver becomes inoperative when coil is cycled. | 13 | VI |
| | 3.0 Relay Driver | 3.1 Open in $R_4$ .008 | 3.1 $Q_2$ remains Off | 3.1 Relay remains in prior commanded position | 0.48 | |
| | | 3.2 Short In $R_4$ .0 | 3.2 $Q_1$ Fails | 3.2 Relay Driver Inoperative | 0 | |
| | Q1, 3,5,7,9,11,13,15 First Transistor | 3.3 $R_4$ Drifts .069 | 3.3 None | 3.3 None | 4.08 | |

| SYSTEM ALSEP | PREPARED BY AWR | NO. | REV. A |
|---|---|---|---|
| END ITEM PDU | DWG NO. | PAGE 24 of 26 | |
| ASS'Y Power Dump | DWG NO. 2349156 | DATE 9-23-71 | |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| | PART/COMPONENT SYMBOL | FAILURE MODE | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY $Q \times 10^{-5}$ | CRITICALITY |
|---|---|---|---|---|---|---|
| | Q2, 4, 6, 8, 10, 13, 14, 16 Second Transistor | 3.4 Open in R3 .008 | 3.4 Increase in Quiscent current of Q1 | 3.4 None | 0.48 | VI |
| | R4, 8, 12, 16, 20, 24, 28, 52(56, 2K) | 3.5 Short In R3 .0 | 3.5 Q1 Inoperative | 3.5 Relay Driver Inoperative | 0 | VI |
| | R3, 7, 11, 15, 17, 23, 27, 31 (21K) | 3.6 Drift In Rs .069 | 3.6 Changed in quiescent current of Q1 | 3.6 None | 4.08 | VI |
| | | 3.7 Open in R5 .009 | 3.7 No current to Q1 | 3.7 Relay Driver Inoperative | 0 | VI |
| | R5, 9, 13, 17, 21, 25, 24, 33 | 3.8 Short in R5 0.0 | 3.8 Increased Power Dissipation of Q1 | 3.8 Shortened Life | 4.08 | VI |
| | (681Ω) | 3.9 Drift in R5 .076 | 3.9 None | 3.9 None | 4.08 | VI |
| | R6, 13, 14, 18, 22, 26, 30, 34 (332Ω) | 3.10 Open In R6 .009 | 3.10 Increase in Quiescent current | 3.10 None | 0.48 | VI |
| | | 3.11 Short In R6 .0 | 3.11 Q2 Inoperative | 3.11 Relay Driver Inoperative | 0 | |
| | | 3.12 Drift In R6 .076 | 3.12 None | 3.12 None | 4.08 | VI |
| | | 3.13 Drift In Q1 or Q2 0.531 | 3.13 Output current reduced | 3.13 Relay Driver Inoperative | 170.00 | VI |
| | | 3.14 Basemitter Short In Q1, or Q2 .039 | 3.14 Relay Driver Inoperative | 3.14 Relay Driver Inoperative | 12.00 | VI |
| | | 3.15 Collector-Base Short Q1, or Q2 .035 | 3.15 Realy coil remains energized | 3.15 Relay Driver Inoperative | 12.00 | VI |
| | | 3.16 Open Junction (Base, emitter or Collector) in Q1 or Q2 .016 | 3.16 Relay Driver Inoperative | 3.16 Relay Driver Inoperative | 50.00 | VI |
| | 4.0 Isolation diodes CR3, 4, 7 through CR14 | 4.1 Open .116 | 4.1 CR3 and CR4 will prevent supply power circuit continuity. | 4.1 Loss of supply power redundancy. | 7 | VI |
| | | 4.2 Short .282 | 4.2 Circuit isolation is compromised. | 4.2 Loss of protection against secondary failures in PCU/PDU supply line, +29VDC, 1 or 2. | 16 | VI |

| SYSTEM ALSEP | PREPARED BY AWR | NO. | REV. A |
|---|---|---|---|
| END ITEM PDU | DWG NO. | PAGE 25 of 26 | |
| ASS'Y Transmitter (Temp. Measurem't) | DWG NO. 2349126 | DATE 9-23-71 | |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE | (α) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY $Q \times 10^{-5}$ | CRITICALITY |
|---|---|---|---|---|---|---|
| 1.0 Thermistor RT1 | 1.1 Open. | 0.667 | 1.1 Open circuit. | 1.1 No temperature data output. | 4 | IV |
| | 1.2 Shorted. | 0.333 | 1.2 Thermistor inoperative. | 1.2 No temperature output. | 2 | IV |
| 2.0 Potential Dividing Resistor R1, R2 | 2.1 Open. | .010 | 2.1 R1 causes open circuit. R2 causes increased voltage output. | 2.1 No temperature data with R1 open. Unreadably high voltage caused by open R2. | 61 | IV |
| | 2.2 Shorted. | 0.0 | 2.2 R1 causes increased voltage applied to thermistor. R2 diverts power. | 2.2 R1 causes erroneous temperature reading outputs. R2 causes temperature voltages to approach zero. | 0 | IV |

| SYSTEM ALSEP | PREPARED BY AWR | NO. | REV. A |
|---|---|---|---|
| END ITEM PDU | DWG NO. | PAGE 26 of 26 | |
| ASS'Y Telemetry Network | DWG NO. 2349186 | DATE 9-23-71 | |

# FAILURE MODE, EFFECT & CRITICALITY ANALYSIS

| PART/COMPONENT SYMBOL | FAILURE MODE | (α) | EFFECT OF FAILURE: ASSEMBLY | EFFECT OF FAILURE: END ITEM | FAILURE PROBABILITY Q × 10<sup>5</sup> | CRITICALITY |
|---|---|---|---|---|---|---|
| 1.0 Identification Resistors R1, 2, 3, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16, 17 | 1.1 Open. | .010 | 1.1 Circuit open | 1.1 No signal transmission. | 4 | IV |
| | 1.2 Shorted. | 0.0 | 1.2 Little or no voltage drop in circuit. | 1.2 Activates resistor/diode net where applicable to keep voltage down to 9.1 volts. | 0 | IV |
| 2.0 Isolation diodes CR1 through CR14 | 2.1 Open. | 0.200 | 2.1 No circuit continuity. | 2.1 No output. | 39 | IV |
| | 2.2 Shorted. | 0.400 | 2.2 Does not provide isolation. | 2.2 Does not provide isolation. | 79 | IV |
| 3.0 Voltage level Resistor R4, 9, 14, 18, 21 | 3.1 Open. | 0.100 | 3.1 Diode would zener. | 3.1 Output would be constant at 9.1 volts. | 1 | IV |
| | 3.2 Shorted. | 0.0 | 3.2 Reduces voltage to zero. | 3.2 No signal established. | 0 | IV |
| 4.0 Voltage limiting Diode VR1 through VR 4 | 4.1 Shorted. | 0.300 | 4.1 Reduces voltage to zero. | 4.1 No signal established. | 55 | IV |
| | 4.2 Open. | 0.100 | 4.2 No protection against secondary failure. | 4.2 No protection provided status tlm against secondary failure. | 18 | VI |