FAA TECHNICAL CENTER

TECHNICAL NOTE

MODE S FAULT CONTROL #1
TEST SET DEVELOPMENT

BY

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AUGUST, 1982

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INTRODUCTION

PURPOSE

The purpose of this project was to develop a means of testing the operation of the Fault Control #1 circuit card which is an integral part of the Mode S sensor transmitter.

1. A testing device was designed and constructed to test the the performance of the Fault Control #1 circuit board within the following constraints.

   a. The test set was to be designed using only components available at the Technical Center in order to keep cost low and construction time to a minimum so testing of the failed Fault Control #1 cards could begin as soon as possible.

   b. The test set was required to check all input/output functions of the Fault Control #1 card so that any existing problem would be detected.

   c. A schematic diagram of the test set was required upon completion. In addition, the design was to be flexible so that the test set could be used to test other circuit cards with similar type I/O ports.

2. A written test procedure and theory of operation was required so that maintenance repair technicians could operate the test set and successfully troubleshoot the Fault Control #1 card with little or no knowledge of the overall operation of the card.

BACKGROUND

The Fault Control #1 card is located in the transmitter of the Mode S sensor. Its function is to receive fault occurrence data, light the appropriate fault indicator, and generate the "Transmitter not Available" and "Transmitter Fault" status signals for transmission to the performance monitor.

There are only two spare Fault Control #1 cards for the two existing Mode S sensors. Both units were non-operational and hence were designated as a priority test repair project - (zero spare level-"critical item").

The sensor documentation for this type board was found to be virtually non-existant with only a schematic diagram and a component layout drawing being available. It required an experimental approach to determine how the circuits were supposed to operate in response to simulated input signals.

Testing the Fault Control #1 card while in the transmitter is difficult and dangerous because several functions of the card are critical, and if they are inoperative the transmitter could be damaged.

DISCUSSION

TEST DEVELOPEMENT

When the testing of the Fault Control #1 card began, the Mode S system engineer presented a brief summary of the test objectives, and after reviewing the schematic diagram, noted suggestions for circuits to use to test the various I/O functions of the card.

The test set was designed and built so that modifications were not required on the Fault Control #1 card being tested. The card is plugged into an extender so that all wires from the test set could be connected to pins on the extender card. Since one objective was to keep the test set design simple, power supplies were not built into the test set. A variable dual DC power supply, Hewlett Packard model 6253A, is used to supply +5 volts (VCC) to the test circuits and Fault Control #1 card, and +24 volts for the test lamp and relay driver load. Figure 1 shows a block diagram of the Fault Control #1 test set equipment configuration.

The Fault Control #1 test was developed one function at a time. The schematic and logic levels were studied to understand circuit operation before a test circuit could be designed. The Fault Control #1 and related test cicuits for each function are described below. Detailed test procedures are delineated in appendix A.

FIFTEEN SECOND FAILURE AND POWER RESET.

THEORY OF OPERATION. The 15 SECOND FAILURE function of the Fault Control #1 card is a relay controlling circuit that switches "ON" a relay in the Mode S transmitter (RELAY DRIVER pin 60) if a power failure (loss of +5v DC) occurs for a duration of less than 15 seconds. When this "15 second or less" power failure occurs, the ability to activate the 30 second "preheat" timing circuit (see PREHEAT AND MANUAL RESTART - THEORY OF OPERATION) by way of the "preheat" input is disabled.

The POWER RESET function of the Fault Control #1 card controls only on-board circuitry. When the +5v DC power is turned on the power reset function is activated and is used to clock the 15 SECOND POWER FAILURE signal to the relay driver, reset the fault clock circuitry, clear the "status lines", and clear the fault lamps.

TEST PROCEDURE. A 500 ohm resistor in parallel with a 1N914 diode is used as a load for the relay driver circuit. (see Figure 2, test set schematic "relay test load") The impedance of this load matches the impedance of the relay coil that the circuit controls in the transmitter.

The 15 SEC POWER FAILURE and POWER RESET circuits are tested by placing the load between +24 volts DC and the output of the relay driver transistor and cycling the power off twice, once for 20 seconds and once for 12 seconds. The oscilloscope is used to probe the output of the relay driver transistor (a test point is built into the test set). When the power is turned off for 20 seconds and turned back on the output of the transistor is at +24v DC because the transistor has not turned on. When the power is turned off for 12 seconds, the output is at ground because the transistor was turned on due to the occurrence of a "15 SECOND FAILURE".

A test lead, from the +24v test lamp, is placed on the output of a lamp driver on the Fault Control #1 card that is used to indicate the status of the 30 second "preheat" timing circuit. (The +24v test lamp is used throughout the Fault Control #1 test - a schematic drawing is shown in Figure 2). After the "12 second power off" test, the toggle switch 'PREHEAT' on the test set is activated. The test lamp should not light, showing that the 30 second "preheat" timer cannot be activated by the preheat input after the occurrence of a "15 second or less" power failure.

A more detailed theory of operation of the 30 second "preheat" timing circuit is discribed in the section - PREHEAT AND MANUAL RESTART - THEORY OF OPERATION.

PREHEAT AND MANUAL RESTART

THEORY OF OPERATION. When the transmitter is first powered "ON" it must go through a 3 minute traveling wave tube "PREHEAT" cycle. At the end of the 3 minute cycle, which is controlled by a mechanical timer, the beam supply is switched "ON" and a 30 second "preheat" timing circuit located on the Fault Control #1 card is activated to delay the MAIN triggers, the SLS triggers, and the fault monitoring circuitry to permit the beam supply voltage to stabilize.

There are two ways of activating the 30 second "preheat" timer, one is a relay controlled by the mechanical timer described above and the other is a "X2 RESET" switch. The "X2 RESET" switch, located in the transmitter, is used to restart the transmitter after the occurrence of an "X2 Fault" (an "X2 Fault" is described in the section FAULT LAMP DRIVERS - THEORY OF OPERATION), and to reset the status lines (the status lines are described in the section STATUS LINES - THEORY OF OPERATION). When the "X2 RESET" switch is activated it is called a "MANUAL RESTART".

The 30 second "preheat" timing circuit controls two lamp drivers that, when the "preheat" cycle is active, illuminates two +24v indication lamps in the transmitter.

TEST PROCEDURE. The output of the 30 second timing circuit affects several of the functions of the Fault Control #1 card. Testing the proper operation of the 30 second timer with respect to each function is performed by testing the appropriate function. The PREHEAT and MANUAL RESTART tests verify that the 30 second timing circuit operates from each control input and that the two lamp drivers that indicate a PREHEAT cycle are operational.

The Fault Control #1 test set utilizes two toggle switches, labeled 'PREHEAT' and 'RESTART', to activate the 30 second "preheat" timer. The 'PREHEAT' switch is connected to the input where the mechanical PREHEAT timer relay would be in the transmitter. The 'RESTART' switch is connected to where the "X2 RESET" switch input is in the transmitter. The +24v test lamp is connected to the output of the lamp drivers to verify the operation of the 30 second timer.

The test involves switching the 'PREHEAT' switch with the test lamp connected to one of the lamp drivers and then switching the 'RESTART' switch with the test lamp connected to the other lamp driver.

STATUS LINES

THEORY OF OPERATION. The Fault Control #1 card monitors four conditions that, when true, will activate logic which will turn off both the beam supply and the bias supply. These four conditions are called the "STATUS LINES". The four conditions are: engaging the safety switch, opening an interlock, sensing an overtemperature condition, or operating the antenna maintenance switch. Each "status line" controls a lamp driver circuit to indicate an active line. A "manual restart" must be implemented to reinitialize the transmitter after the status condition has been resolved.

TEST PROCEDURE. Toggle switches are used as a means of activating three of the status lines. The 'SAFETY' switch is used to simulate a "safety switch on" status, the 'INTERL' switch is used to activate a "interlock open" status, and the 'ATMNT' switch is used to simulate the "antenna maintenance switch 'ON'" condition. A jumper to ground is used to simulate an "over temperature" status for that single line input.

The +24v test lamp is connected to the respective lamp driver for each of the 4 status line tests. The lamp verifies the occurrence of the associated "status" condition. For each status line the bad status is activated and then immediatly corrected; for example, the safety switch is turned "on" and then "off". The test lamp will light when the safety switch is turned "ON" but will not go "OFF" until the 'RESTART' switch is activated to clear the status line.

The "TRANSMITTER TURN OFF" test will verify that the occurrence of an active status line will activate the appropriate logic to turn the BEAM supply "OFF" and the "TRANSMITTER AVAILABLE" test will verify that the occurrence of an active status line will turn the BIAS supply "OFF".

FAULT LAMP DRIVERS

THEORY OF OPERATION. The Fault Control #1 card monitors 11 conditions for the occurrence of a transmitter fault. The 11 fault lines each control circuitry that, with the occurrence of a fault, will light one of 11 fault lamps in the transmitter which indicate what type of fault occured.

If a fault condition occurs one time for less than 4 seconds, the beam supply would be switched off for the duration of the fault and the appropriate fault lamp would light. In this case the fault lamp can be cleared by switching the "X1 RESET" switch. If a fault occurs more than one time or if the duration of the fault condition exceeds 4 seconds it is called an "X2 Fault" and the beam supply and the bias supply will be turned off. The beam supply is turned "OFF" by the "TRANSMITTER TURN-OFF" signal and the bias supply is turned "OFF" by the "TRANSMITTER AVAILABLE" signal. Restarting the transmitter after the occurrence of an "X2 Fault" requires switching the "X2 RESET" switch. The "X2 RESET" switch activates the 30 second "preheat" timing circuit on the Fault Control #1 card.

TEST PROCEDURE. The test checks the fault detection logic by simulating an error condition for each fault input with the +24v test lamp connected to the appropriate fault lamp driver. A jumper wire connected to ground is connected to the fault inputs to simulate the error conditions. To check the "X2 Fault" clock circuitry an LED logic level indicator on the test set is connected to the output of the logic driving the "TRANSMITTER AVAILABLE" signal (see Figure 2 for the schematic drawing of the LED indicator circuit)

The procedure involves placing the ground jumper on the fault input and then activating the 'RESTART' switch. The test lamp should light at the end of the 30 second "preheat" cycle to indicate that the fault has been detected. The LED should light 4 seconds after the test lamp lights due to the "TRANSMITTER AVAILABLE" signal going to a high level as a result of a "X2 Fault" condition. To test the "X1 FAULT RESET" circuit, an "X1 Fault" is generated by momentarily grounding one of the fault lines with the test lamp on the output lamp driver circuit. A pushbutton switch, labeled "CLR LAMP" is connected to the "X1 FAULT RESET" input of the Fault Control #1 card. When it is pushed the test lamp will go "OFF" verifying that the "X1 reset" circuit is operating correctly.

TRANSMITTER TURN-OFF

THEORY OF OPERATION. The "TRANSMITTER TURN OFF" signal is a control signal used to disable the beam supply when certain conditions exist. The beam supply must be disabled for the duration of an "X1 Fault". If an "X1 Fault" becomes an "X2 Fault", the beam supply will be disabled until the 30 second "preheat" timer (MANUAL RESTART) is activated by the "X2 RESET" switch. The beam supply will also be disabled if a status line becomes active. The status line condition also must be cleared with a "MANUAL RESTART".

TEST PROCEDURE. The test LED is used to indicate the logic state of the "TRANSMITTER TURN OFF" signal. The LED will be "ON" if the signal is active "high", and "OFF" when non-active "LOW". Each of the conditions that turn off the beam supply via the "TRANSMITTER TURN OFF" signal are simulated to verify the controlling logic is operating properly.

Status Lines. The test involves turning the 'SAFETY' switch "ON" to verify that the status lines will activate the "TRANSMITTER TURN OFF" signal. The "RESTART" switch is used to reset the "safety switch 'on'" condition, thus returning the "TRANSMITTER TURN OFF" signal to the non-active state.

"X1 Fault". To simulate an "X1 Fault", a fault input is grounded momentarily and it is verified that the LED is "ON" only as long as the pin is grounded, provided it is not grounded for longer than 4 seconds. This verifies that the Fault Control #1 card will turn the beam supply "OFF" during an "X1 Fault" condition.

"X2 Fault". To simulate an "X2 Fault" the ground jumper is placed on the fault input for longer than 4 seconds. The LED will then light until the fault is cleared by a "MANUAL RESTART". This verifies that the signal is activated by an "X2 Fault" condition.

MAINTENANCE SWITCH.

THEORY OF OPERATION. The main function of the "MAINTENANCE" switch is to send a status bit to the computer which advises that the transmitter is going off-line for maintenance. A dual line driver driver (55183) is used as an output device on the Fault Control #1 card. The maintenance switch also controls a lamp driver circuit that will light a status light on the transmitter to indicate when it is in the maintenance mode. The maintenance switch allows the modulation pulses to be turned "OFF" manually by enabling the "TRIGGER INHIBIT" switch. The "BEAM POWER SUPPLY UNDERVOLTAGE", one of the fault inputs, is dependent on the position of the maintenance switch. This fault input has two input lines, one is enabled only when the maintenance switch is "ON" and the other is enabled only when the maintenance switch is "OFF".

TEST PROCEDURE. A toggle switch, labled "MAINT", is located on the front panel of the test set and is used as the maintenance switch. A line driver test circuit, consisting of a dual line receiver (55182) with its output logic connected to an LED, is connected to the output of the dual line driver that feeds the "maintenance mode" status signal (see Figure 2 "GREEN LED" test circuit logic drawing) The circuit works in negative logic, i.e. when the maintenance switch is active the LED will be "OFF". The +24v test lamp is connected to the output of the lamp driver to verify that when the switch is activated the status light on the front panel of the transmitter will be "ON".

The "FAULT INPUTS/FAULT LAMP DRIVERS" test verifies the effect of the "MAINTENANCE" switch on the "BEAM POWER SUPPLY UNDERVOLTAGE" fault input. The "TRIGGER INHIBIT" switch circuitry is tested in the "TRANSMITTER DISABLE" test and therefore the test of the "MAINTENANCE" switch enabling the "TRIGGER INHIBIT" circuit is verified in that test.

TRANSMITTER FAULT SIGNAL.

THEORY OF OPERATION. The "TRANSMITTER FAULT" signal is the output of a dual line driver used to report the occurrence of a transmitter fault to the performance monitor. The transmitter fault signal will go "active-high" for 15 seconds with the occurrence of an "X1" or an "X2" fault.

TEST PROCEDURE. The line driver test circuit, descibed in the "MAINTENANCE SWITCH - TEST PROCEDURE" section, is used to indicate the logic level at the output of the line driver which is gating the "transmitter fault" status bit. The green LED on the test set, which is on the output of the line driver test circuit, is "ON" when the transmitter fault signal is not active. A fault is simulated on one of the fault input lines and it is verified that the green LED goes "OFF" for 15 seconds to show that the fault signal is working properly.

TRANSMITTER DISABLE.

THEORY OF OPERATION. The modulation pulses or triggers can be disabled by the transmitter causing a "TRANSMITTER DISABLE" status signal to be sent to the performance monitor. The signal will become active if the "TRIGGER INHIBIT" switch is engaged (the "MAINTENANCE" switch must be "ON" to enable the "TRIGGER INHIBIT" switch), or the "PM TRANSMITTER INHIBIT" line is active or if the transmitter modulation overload detection becomes active. The "transmitter disable" status signal is gated by a dual line driver device (55183) and it controls a lamp driver that will turn "ON" a status light to indicate when the transmitter has been disabled.

TEST PROCEDURE. The line driver test circuit described in MAINTENANCE SWITCH - TEST PROCEDURE is used to indicate the logic level of the line driver that drives the "transmitter disable" signal. The +24v test lamp is connected to the output of the lamp driver controlled by the "transmitter disable" signal. When the conditions exist to disable the transmitter, the "transmitter disable" signal will cause the test lamp to turn "ON" and the LED that is driven by the line driver test circuit to turn "OFF". A toggle switch, 'TRIG INHIBIT', is used as the TRIGGER INHIBIT switch for testing purposes. The 'MAINT' and 'TRIG INHIBIT' switches are both engaged to verify that their being activated together will disable the transmitter. The test set was designed with a circuit that allows a pulse generator to be connected to the transmitter modulation overload section of the Fault Control #1 card. The test circuit consists of a NAND gate with the inputs connected to VCC through a pull-up resistor and to a BNC connector. (see Figure 2 "COMPOURLD" for a logic drawing of the test circuit). The output of the test circuit is a "low" level when the pulse generator is not connected so that the "transmitter disable" signal will not be active. Testing the modulation overload circuits with the pulse generator is performed in the TRANSMITTER MODULATION PULSE TEST.

However the modulation overload disable logic is tested in the TRANSMITTER DISABLE test by lifting the test wire from the modulation overload input, therefore causing the input to float to a high level. This will activate the "transmitter disable" circuitry and it may then be verified with the test set circuitry. A test circuit was designed to control the state of the PM TRANSMITTER INHIBIT logic. A line driver (55183), with the inputs connected to VCC through a pull-up resistor, and a DIP switch also connected to the inputs and to ground, is used as a control circuit (see Figure 2 "PM TRANS INHIBIT" test circuit logic drawing). The DIP switch is turned "OFF" to activate the PM TRANSMITTER INHIBIT function. The test lamp and LED will verify that the "transmitter disable" circuits were activated.

TRANSMITTER AVAILABLE SIGNAL

GENERAL OPERATION. The "TRANSMITTER AVAILABLE" signal is an output control function of the Fault Control #1 card. Its control function is to shut down the BIAS supply after the occurrence of an "X2 fault" or if a status line becomes active. The output signal is driven by a dual line driver (55183) and the signal also controls a lamp driver circuit.

TEST PROCEDURE. The test lamp is connected to the output of the lamp driver circuit which is controlled by the "TRANSMITTER AVAILABLE" signal. The test lamp will light when the transmitter is "not available". The line driver test circuit is connected to the output of the line driver controlling the "TRANSMITTER AVAILABLE" signal. The LED controlled by the test circuit will be "OFF" when the transmitter is "not available". The "SAFETY" switch is used to activate a STATUS LINE so the person testing the card may verify that the transmitter is "not available" with a status line active. An "X2 FAULT" is then simulated to verify that with its occurrence the transmitter becomes "not available".

TRANSMITTER MODULATION PULSES

THEORY OF OPERATION. The modulation "pulses" or "triggers" are gated through the Fault Control #1 card so that they may be disabled via the occurrence of one of several types of "fault" conditions. Both the MAIN and SLS modulation pulses are passed through the card. There are several conditions that will disable the transmitter modulation pulses.

The "TRIGGER INHIBIT" switch. If the transmitter is in the "maintenance" mode (the maintenance switch engaged), the trigger inhibit switch can then be activated. As long as the trigger inhibit switch is engaged the modulation pulses are disabled at the Fault Control #1 card.

The "PM TRANSMITTER INHIBIT" function. If the "PM TRANSMITTER INHIBIT" input signal is active, the modulation pulses will be disabled.

The "MODULATION OVERLOAD" detection. The transmitter has a modulation pulse overload protecton circuit on the Fault Control #1 card. The signal "COMPOVRLD" controls a ONE-SHOT device (54121) so that the modulation duty cycle cannot exceed a predetermined "ON" time that may damage the transmitter. The signal "COMPOVRLD" is controlled by the Fault Control #2 card. When the signal goes to a high level, the ONE-SHOT device will disable the modulation pulses for one hundred milliseconds.

The 30 second "PREHEAT" cycle. The modulation pulses are disabled during the 30 second delay after the initial power on, and also each time the 30 second timer is activated by the "X2 RESET" switch.

The "STATUS LINES". The modulaton pulses are disabled if one or more of the status lines are activated. After a status line has been activated the modulation pulses can not be reenabled until a "MANUAL RESTART" has been initiated by the "X2 RESET" switch.

An "X2 FAULT". After the occurrence of an "X2 FAULT" condition the modulation pulses will be disabled until the "X2 RESET" switch initiates the 30 second "MANUAL RESTART" cycle.

TEST PROCEDURE. A function generator is connected to the test set through a BNC input port. The positive lead of the BNC connector is wired to the inputs of two line driver gates, one for the MAIN channel and one for the SLS channel. The outputs of the line drivers are connected to the input line receivers for the two modulation pulse channels. The pulse generator is set to generate a 1 microsecond square wave as a standard testing frequency. An oscilloscope is used to monitor the output gates driving the two modulation waves to verify that the square waves are being passed through the card and to observe that they go to a low level when they are disabled by the "fault" conditions. After it is verified that the Fault Control #1 card will pass the 1 microsecond square waves to the output gates, each of the "faults" are simulated and it must be then verified that the square wave goes to a low level as the pulses are disabled.

The "TRIGGER INHIBIT" switch. The 'MAINT' and 'TRIG INHIBIT' switches are both switched to the "ON" position and it is verified that the 1 microsecond pulses go to a low level at the output gates. The pulses return when the switches are turned to the "OFF" position.

The "PM TRANSMITTER INHIBIT" function. With the "TRANSMITTER INHIBIT" test circuit connected to its input on the Fault Control #1 card, the DIP switch on the test set is turned to the "OFF" position. This causes the "PM TRANSMITTER INHIBIT" to activate. While the DIP switch is in the "OFF" position the pulses are at a "low" level on the modulation pulse output gates. When the switch is returned to the "ON" position the pulses return.

The "MODULATION OVERLOAD" detecton. For the "MODULATION OVERLOAD" test the function generator is connected to the "MODULATION OVERLOAD" test circuit (COMPOVRLD) which is described in the section "TRANSMITTER DISABLE - TEST PROCEDURE". The function generator is set to produce a high going pulse at the rate of 50 hertz. The oscilloscope is used to observe the input and output pulses of the ONE-SHOT device. The test procedure verifies that the output pulses from the ONE-SHOT go to a high level with the rising edge of each input pulse and that they stay high for 100 milli-seconds.

The "PREHEAT" and "STATUS LINES". The "SAFETY" switch is switched to the "ON" position to simulate an active status line. The 1 microsecond pulses will go to a low level on the output of the modulation pulse gates as long as the status line is active. The status line will remain active after the "SAFETY" switch is turned "OFF" due to the fact that the status lines must be cleared by a "MANUAL RESTART". The 'RESTART' switch on the test set is used to activate the 30 second "MANUAL RESTART" cycle. The test procedure verifies that the pulses do not return on the output until the 30 second timer cycle is over.

The "X2 FAULT". Pin #31 on the fault inputs requires a ground to simulate good status. The "MODULATION PULSE" test utilizes the removal of the ground jumper to create an "X2 FAULT". The pulses on the output of the modulation pulse lines will go to a low level after the "X2 FAULT" is simulated. The 'RESTART' switch is used to start the 30 second timing circuit to reset the fault condition.

RESULTS

The efforts of developing a test set and procedure to check the Fault Control #1 card were successful. The problems that existed with the two spare cards were detected by the tests described and were resolved. Serial number 4 would not respond to the "PREHEAT" test. The cause was found to be an "open" in the 30 second preheat timer. Two of the fault lamp driver tests also failed due to a bad inverter (5406) in the fault lamp driver circuits. Serial number 5 failed the "TRANSMITTER AVAILABLE TEST". The output of an inverter (54LS04) in the fault detection timing circuit was floating.

During the testing of the Fault Control #1 cards, it was discovered that the voltage level of the +5 (VCC) was critical. The "PREHEAT TIMER" would not function if the +5 volt supply was less than 4.6 volts.

Prior to the development of the test procedure, a design error was found in the "PREHEAT TIMING CIRCUIT" on the Fault Control #1 circuit board. There was a problem with the resistance values. An ECN modification was initiated and the problem was corrected.

After the two spare Fault Control #1 cards were repaired, and the ECN modifications added, they both passed the all of the tests. They were both installed in the Mode S transmitter at the sensor site 1 and were observed to operate properly.

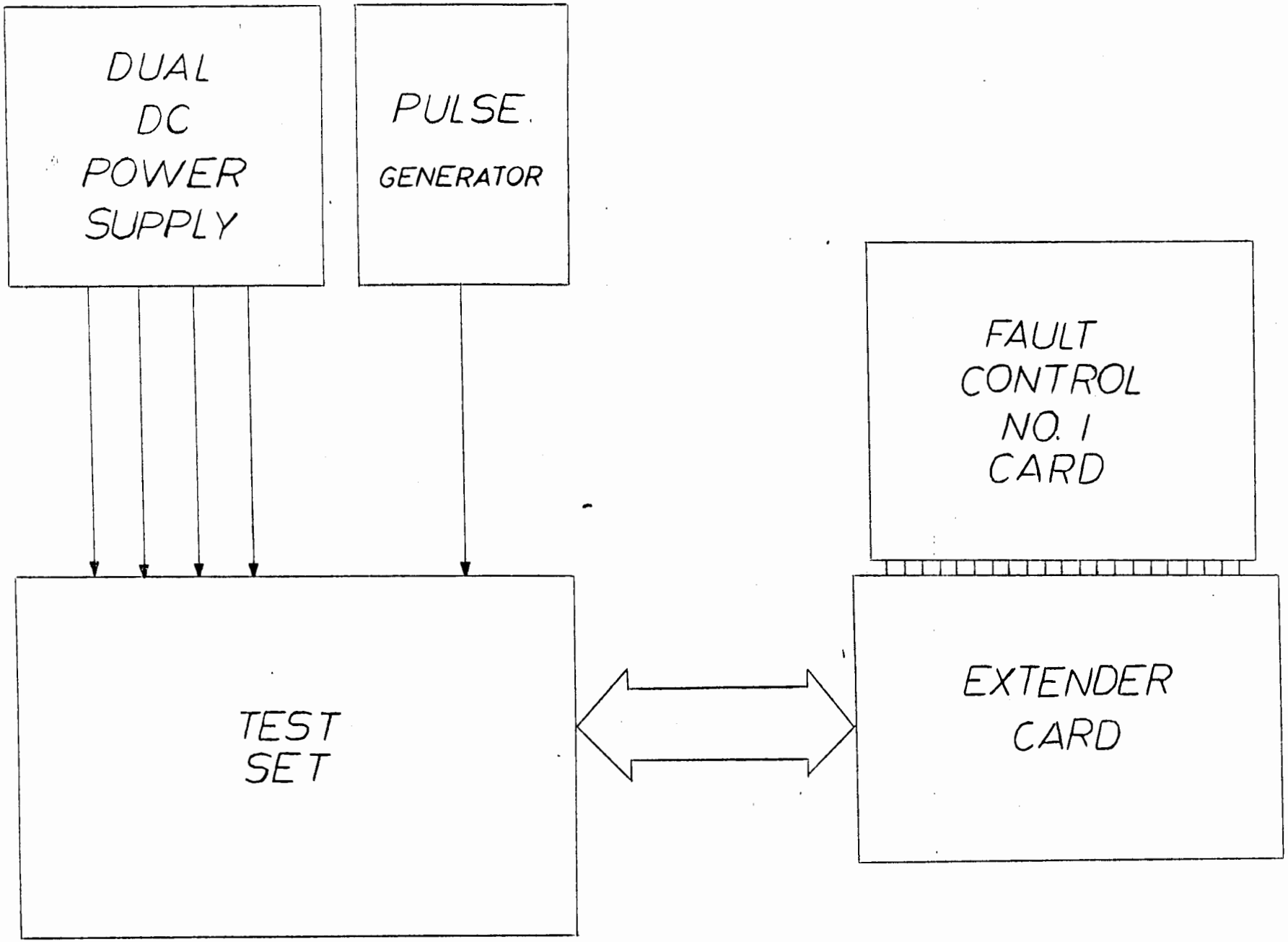


Fig. 1 Fault Control no. 1 Test Setup Block Diagram

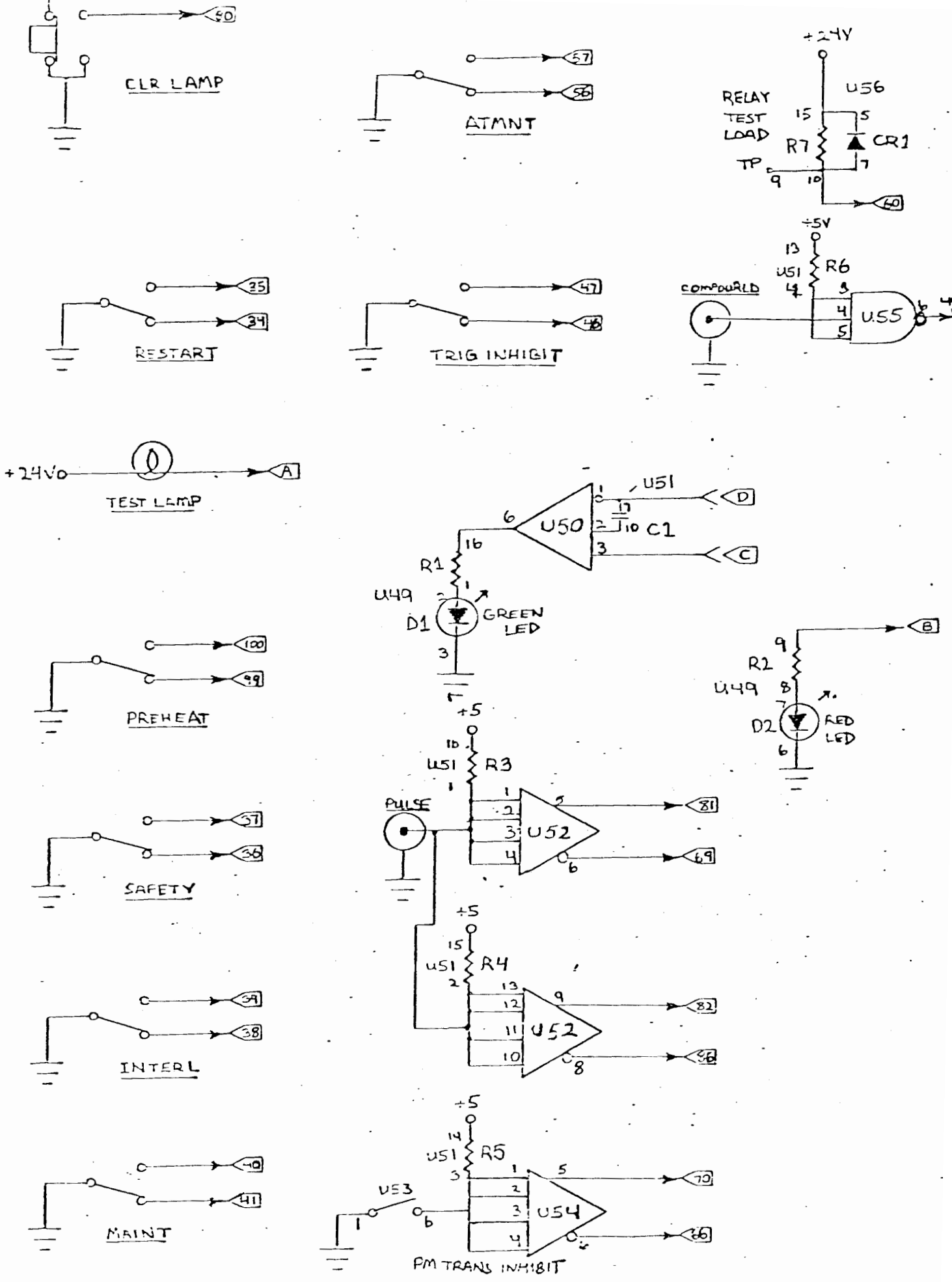


Fig. 2 FC no.1 Test Set Schematic Diagram

APPENDIX A

TEST PROCEDURE

FOR THE

MODE S

FAULT CONTROL #1 BOARD

SCOPE

This test procedure was designed to test and verify the proper operation of the Mode S Fault Control #1 card (ASSY. 325764-1C). It was designed to test each of the I/O functions of the Fault Control #1 card and should detect any error in the logic circuitry associated with each function of the card.

TEST EQUIPMENT

A. Fault Control #1 test set.
B. Extender card (ASSY. 873750-1 MDC subsystem)
C. Dual DC power supply 5v,24v (HP 6253A or equivalent)
D. (4) banana-jack test leads
E. (2) 2'-3' Coax cable
F. (1) Coaxial T connector
G. Function Generator (TEKTRONIX FG 501 or equivalent)
H. Oscilloscope (TEKTRONIX 7904 or equivalent)
I. (2) Dip clips
J. A Watch (to measure time delay circuits)

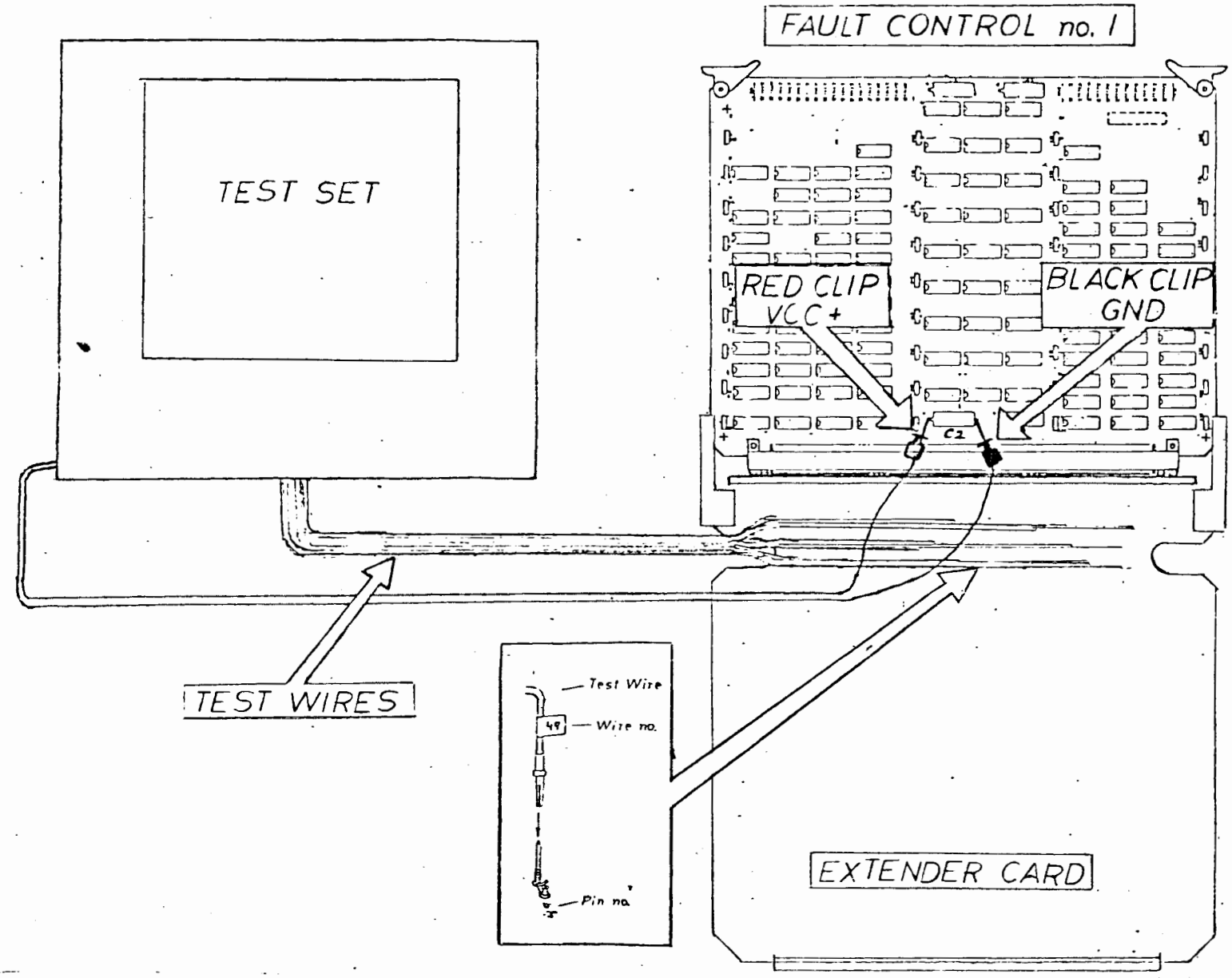


Figure A1 - Fault Control #1 Test Set Layout.

A. Refer to figure A1 to set up the test set.
Plug the card to be tested into the extender card.
Lay the card and extender flat on a non-conductive surface.

B. Attach each numbered test wire to the same number pin on the extender card - wire #34 to pin #34, wire #35 to pin #35 etc.
There is a total of 24 numbered wires.
The location of the 4 lettered wires, A, B, C and D, will be determined in part IV "TEST PROCEDURE".

C. To Supply the +5v DC to the Fault Control #1 card, attach the red clip lead from the test set to the positive (+) side of C2 and the black clip lead to the negative side of C2. C2 is on the Fault Control #1 card. (see Fig. A1 for the location of C2)

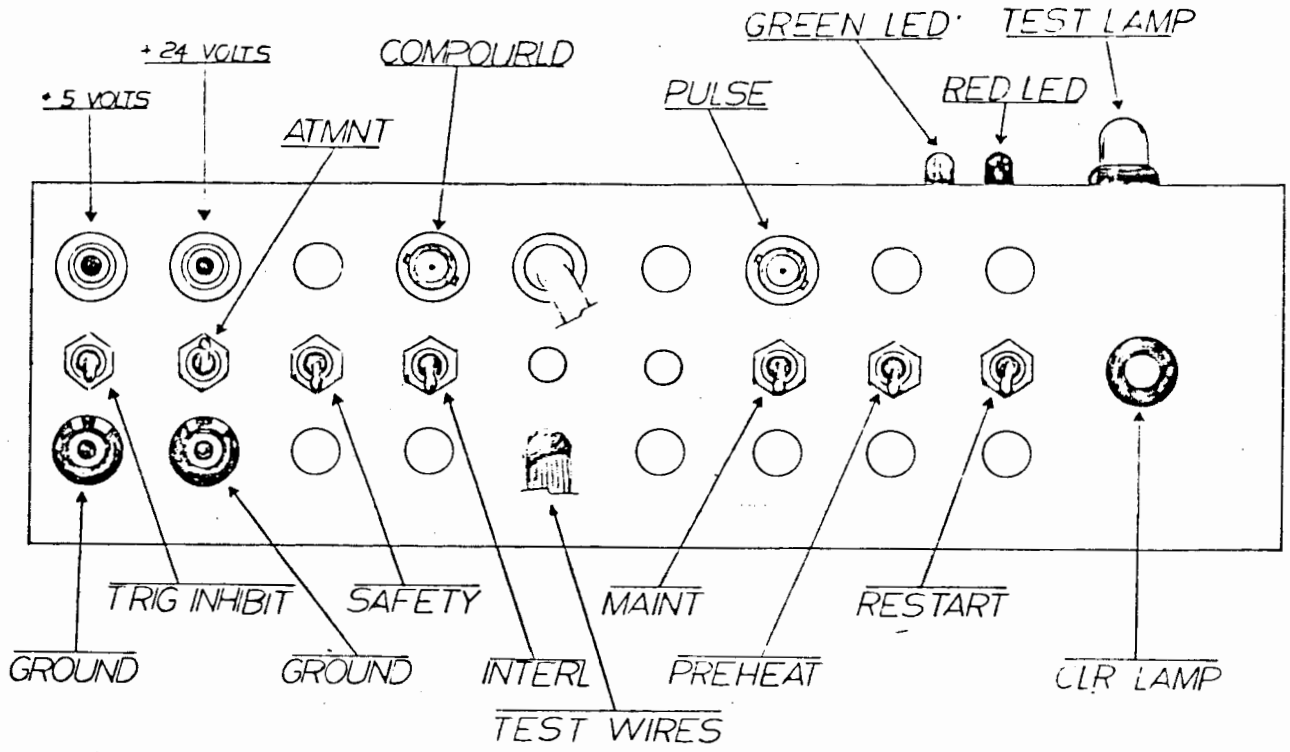


Figure A2 - Fault Control #1 Test Set Front Panel

D. Set the DC voltages from dual power supply to 5v and 24v. Using the banana tip leads, connect the +24v to the red input jack below the 24v label on the front of the test set and connect the 24v return to the black input jack located below the +24v jack. Connect the +5v to the red input jack below the 5v label on the front of the test set and connect the 5v return to the black input jack located below the +5v input. (see Fig. A2 for a the location of the DC voltage inputs)

E. Set all toggle switches on the front of the test set to the down position except the switch labeled 'ATMNT' which should be in the up position. (see Fig. A2 for the location of the switches)

F. Set U53 DIP switch #1 on the test set to the "on" position. (see Fig. A4 on page 24 for the location of the switch)

G. Jumper pins #31 and #40 on the extender card together.

TEST PROCEDURE

A. PREHEAT TEST

1. Attach test wire "A" (24V TEST LAMP) to pin #9 on the extender card.
2. Turn the power supplies on.
3. Switch the 'PREHEAT' switch "UP" then "DOWN".

- The test lamp on the test set should go out approximately 30 seconds after the 'PREHEAT' switch was switched to the 'DOWN' position.

B. RESTART TEST

1. Move test wire "A" to pin #10 on the extender card.
2. Switch the 'RESTART' switch "UP" then "DOWN"

- The test lamp should go out approximately 30 seconds after the 'RESTART' switch was switched "DOWN".

3. Leave test wire "A" on pin #10 for part C.

C. POWER UP RESET/RELAY DRIVER TESTS

1. Place the oscilloscope channel 1 at 10v per div. Put the channel 1 probe on the test point (TP) located next to the 500 ohm resistor on the test set. (see Fig. A4 for the location of the test point(TP))
2. Turn the power supplies "OFF" for 20 sec. Then turn them back "ON". If separate power supplies are used it is only necessary to turn off the +5v supply.

- Channel 1 on the oscilloscope should show a +24v DC level. (see Fig. A3 'test C2')

3. After the 'PREHEAT' cycle is over (30 sec.), turn the power supplies "OFF" for 10-12 sec. Then turn them back "ON".

- Channel 1 on the oscilloscope should now show a 0v DC level. (see Fig. A3 'test C3')

4. Switch the 'PREHEAT' switch "UP" then "DOWN".

- Verify that the test lamp does not light.

D. FAULT INPUTS/FAULT LAMP DRIVERS TEST

1. Attach test wire "B" (test logic LED) to pin #88.
2. Refer to table "A1" and do the following:

   a) Jumper the "INPUT PIN" on the extender card to ground.
   b) Attach test wire "A" to the "OUTPUT PIN" on the extender card.
   c) Switch 'RESTART' "UP" then "DOWN".

- Verify that the test lamp goes "ON" after 30 seconds and the red LED goes "ON" after 34 seconds with each fault line tested unless otherwise noted -

Fig. A3 Results of POWER UP RESET/RELAY DRIVER TEST

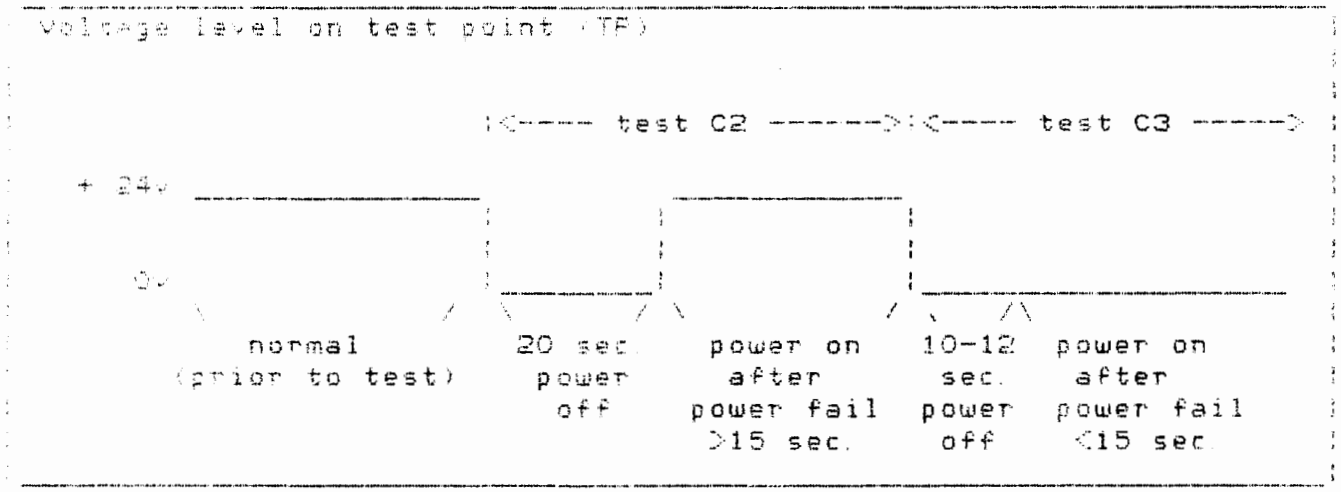


Table A1 Fault Inputs/Fault Lamp Drivers Test

input pin #	output pin #	'MAINT' switch position	results (after 30 sec. RESTART)	
			TEST LAMP	RED LED
32	22	down	on	on (after 4 sec.)
33	23	down	on	on (after 4 sec.)
67	25	down	on	on (after 4 sec.)
79	27	down	on	on (after 4 sec.)
95	28	down	on	on (after 4 sec.)
96	15	down	on	on (after 4 sec.)
97	16	down	on	on (after 4 sec.)
89	17	down	on	on (after 4 sec.)
84	18	down	on	on (after 4 sec.)
43	24	down	on	on (after 4 sec.)
55	24	up	on	on (after 4 sec.)
*31	26	down	off	off
*30	26	down	off	off
--	26	down	on	on (after 4 sec.)

*Note: the test lamp should not light with pin #31 or #30 grounded. It will only light if neither are grounded.

K. STATUS LINE TESTS

1. Attach test wire "B" to pin #88 on the extender card.
2. For each step in Table A2 do the following:

   a) Attach test wire "A" to the indicated pin number on the extender card.
   b) Switch the indicated "STATUS SWITCH" on the test set "UP" then "DOWN".
      - In the step no. 4 touch pin #68 to ground. (no switch)
   c) Check for proper results.
   d) Switch the 'RESTART' switch "UP" then "DOWN".
   e) check for proper results.

Table A2 STATUS LINE TESTS

step no.	pin # to wire "A"	status switch	results	RESTART	results after restart
1	11	'SAFETY'	Check that the TEST LAMP and the RED LED are on.	Check that the TEST LAMP and the RED LED are off.	
2	12	'INTERL'			
3	13	'ATMNT'			
4	14	touch pin # 68 to ground			

K. MAINTENANCE SWITCH TEST

1. Attach test wire "A" to pin #8 on the extender card.
2. Attach test wire "C" to pin #90 on the extender card.
3. Attach test wire "D" to pin #89 on the extender card.
   (wires "C" and "D" from test LINE RECEIVER)

- Verify that the green LED is "ON" -

4. Switch the 'MAINT' switch "UP".

- Verify that the green LED goes "OFF" and the light goes "ON".

5. Return 'MAINT' switch back to the "DOWN" position.

L. TRANSMITTER MODULATION PULSE TEST

1. Set the function generator output amplitude at 5v level. Set the function duration at 1us.
2. Move test wire "A" to pin #10 on the extender card.
3. Switch the 'RESTART' switch "UP" then "DOWN" continue when the test lamp goes "OFF". (end of 'PREHEAT' cycle)
4. Using the coaxial cable connect output of function generator to the BNC input on the test set marked 'PULSE', and turn the function generator "ON".
5. Connect channel 1 of the oscilloscope to pin #10 on U15 and and connect channel 2 of the oscilloscope to pin #12 on U15.

- The 1us pulses should be seen on both channels.

: Perform each of the following steps, verifying that the 1us. square waves, as seen on both channels on the scope, go to a low voltage level with each test.

a) Switch the 'MAINT' and 'TRIG INHIBIT' switches "UP".

- Verify that channels 1 and 2 on the scope are "LOW".

b) Return the 'MAINT' and 'TRIG INHIBIT' switches to the "DOWN" position. (pulses return) Turn U53 DIP switch #1 on the test set to the "OFF" position.

- Verify that channels 1 and 2 on the scope are "LOW".

c) Turn U53 DIP switch #1 back "ON". (pulses return) Switch the 'SAFETY' switch "UP" then "DOWN".

- Verify that channels 1 and 2 on the scope are "LOW".

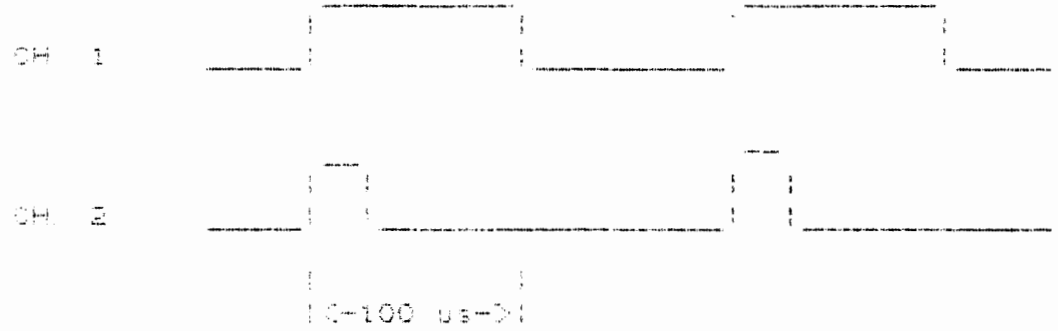
d) Switch the 'RESTART' switch "UP" then "DOWN". (pulses return after 30 sec.) Remove the ground jumper from pin #31 (extender card).

- Verify that channels 1 and 2 on the scope are "LOW".

e) Replace the ground jumper to pin #31. (pulses return)

- Set the output of the function generator at 50 hz.
B Connect the function generator to the BNC input on the test set labeled 'COMPOVLD'
C Attach channel 1 of oscilloscope on U84-5 and channel 2 on U84-4

- Verify that the signal on channel 1 goes high for 100 milliseconds at each rising edge of channel 2.



M. TRANSMITTER FAULT TEST

1. Disconnect the function generator from the test set.
2. Switch the 'RESTART' switch "UP" then "DOWN". Testing may continue in 30 seconds.
3. Connect test wire "C" to pin #104 and test wire "D" to pin #101 on the extender card.

- Verify that the green LED is "ON".

4. Simulate a fault condition by removing the ground jumper from pin #31 on the extender card.

- Verify that the green LED goes "OFF" for approximately 15 seconds then comes back "ON".

N. XMIT DISABLE TEST

1. Connect test wire "C" to pin #92, test wire "D" to pin #91, and test wire "A" to pin #20.

- Verify that the test lamp is "OFF" and the green LED is "ON".

2. Switch the 'MAINT' and the 'TRIG INHIBIT' switches "UP".

- Verify that the test lamp is "ON" and the green LED is "OFF"

3. Return the 'MAINT' and 'TRIG INHIBIT' switches to the "DOWN" position.
4. Lift test wire number 49 from pin #49 (extender card).

- Verify that the test lamp is "ON" and the green LED is "OFF".

5. Return test wire #49 to pin #49 on the extender card.
6. Set U53 DIP switch #1 on the test set to the "OFF" position.

- Verify that the test lamp is "ON" and the green LED is "OFF".

7. Return U53 DIP switch #1 to the "ON" position.

O. XMIT AVAILABLE

1. Connect test wire "C" to pin #103 on the extender card, test wire "D" to pin #102 on the extender card, and test wire "A" to pin #21 on the extender card.

2. Switch the 'RESTART' switch "UP" then "DOWN" and wait 30 sec.

- Verify that after 30 seconds the test lamp is "OFF" and the green LED is "ON"

3. Switch the 'SAFETY' switch "UP" then "DOWN".

- Verify that the test lamp is "ON" and the green LED is "OFF".

4. Switch the 'RESTART' switch "UP" then "DOWN".

- Verify that the test lamp is "OFF" and the green LED is "ON".

5 Remove the ground jumper from pin #31 on the extender card.

- Verify that the test lamp is "ON" and the green LED is "OFF".

6 Switch the 'RESTART' switch "UP" then "DOWN".

P. TRANSMITTER TURN OFF TEST

1 Connect test wire "B" to pin #29 on the extender card.

- Verify that the red LED is "OFF".

2 Switch the 'SAFETY' switch "UP" then "DOWN".

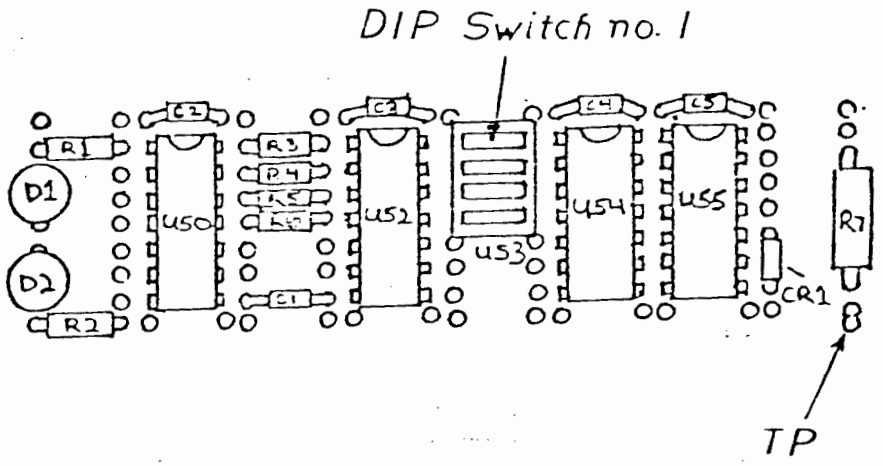
- Verify that the red LED goes "ON".

3 Clear the LED by switching the 'RESTART' switch "UP" then "DOWN".
4 Ground pin #96 on the extender card for at least 4 seconds.

- Verify that the red LED turns "ON"

5 Switch 'RESTART' "UP" then "DOWN".
6 Repeat step P.4 for pin #97.

. . . . THIS COMPLETES THE FAULT CONTROL #1 CARD TESTS. . . . . .



REFERENCE DESIGNATOR	DESCRIPTION OR NOMENCLATURE
C1	CAPACITOR .01 uF
C2, C3, C4, C5	CAPACITOR .001 uF
CR1	DIODE 1N914
D1	LED GREEN
D2	LED RED
R1, R2	RESISTOR 390 ohms 1/4 W
R3, R4, R5, R6	RESISTOR 1K ohms 1/4 W
R7	RESISTOR 500 ohms 1/2 W
U50	IC 55182
U52, U54	IC 55183
U53	IC SWITCH PACK
U55	IC 5410

Fig. A4

Fault Control no. 1 Test Set - Electronic Component Layout/Parts List

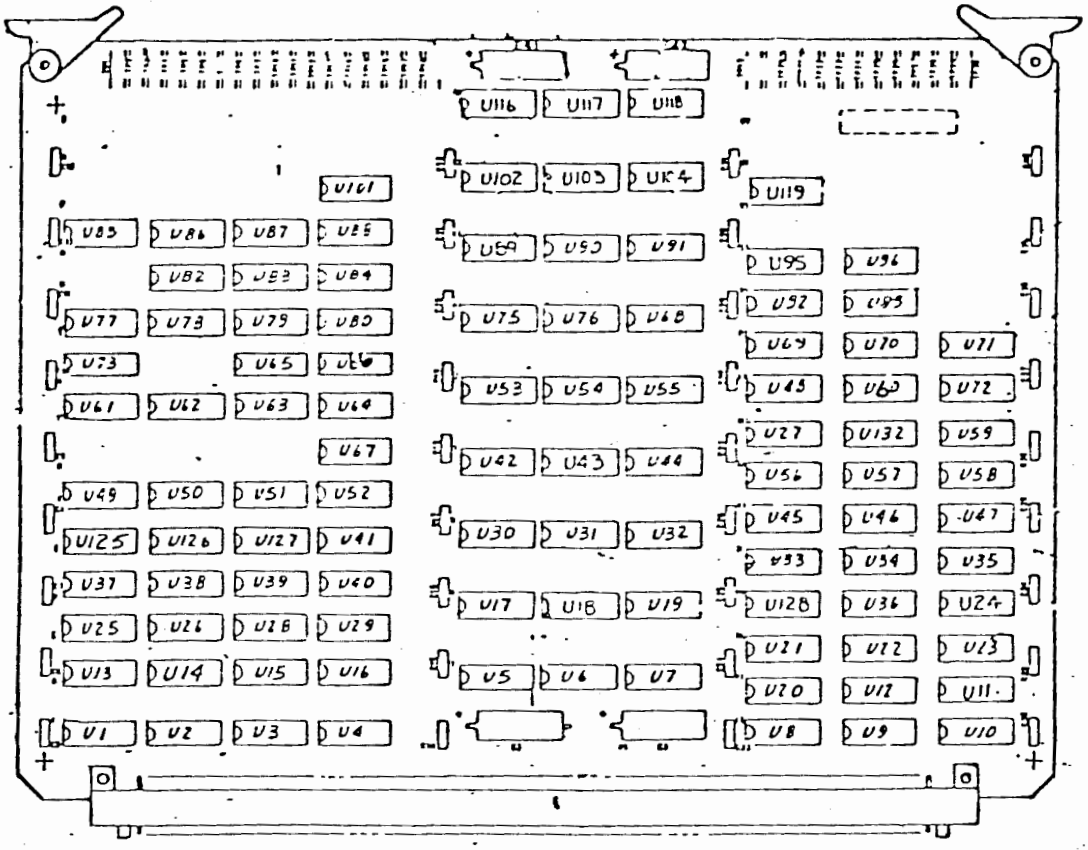


Fig A5 Fault Control no. 1 – Compont layout