TBC ALL

Intermittent Wiring Inspection and Check - Special Detailed Inspection

A. General

(1) This procedure outlines a method to inspect aircraft wiring for degradation which could cause intermittent system behavior. The steps below are listed in the most logical order considering access required, time to accomplish the inspection, and potential findings, however these steps may be accomplished in any order, in whole or in part, as necessary, to eliminate aircraft wiring as the source of an intermittent fault. It may not be necessary or desirable to accomplish all steps within this procedure depending on the nature of the fault experienced and the system in which the fault occurred.

(2) This task contains the following procedures:
- (a) Electrical Load Test
- (b) Electrical Current Test
- (c) Insulation Resistance Test
- (d) Ultrasonic Short Circuit Detection Test
- (e) Low Resistance Test
- (f) MOHR Time Domain Reflectometry (TDR) Masking
- (g) Electrical Connection Inspection
- (h) Wire Shake Test
- (i) Voltage Drop Inspection
- (j) Reflectometry Inspection
- (k) Automated Intermittent Fault Detection & Integrity Test

B. References

Reference	Title
20-10-39-700-801	Insulation Resistance Testing - Special Detail Inspection (P/B 501)
20-10-78-760-801	Power Quality Checks (P/B 201)
SOPM SWPM 20-20-00	Standard Overhaul Practices Manual

Preliminary Requirements

C. Tools/Equipment

NOTE: When more than one tool part number is listed under the same "Reference" number, the tools shown are alternates to each other within the same airplane series. Tool part numbers that are replaced or non-procurable are preceded by "Opt:", which stands for Optional.

Reference	Description
COM-1793	Multimeter - Digital/Analog (or equivalent meter meets task requirements) **737-10, -7, -8, -8200, -8BBJ, -9** Part #: 117 Supplier: 89536 Part #: 260-8XPI Supplier: 55026 Part #: 287 Supplier: 89536

Reference	Description
	Part #: 289 Supplier: 89536 Part #: 87V Supplier: 89536 Part #: FLUKE 27 II Supplier: 89536 Part #: FLUKE-77-4 Supplier: 89536 Opt Part #: 187 Supplier: 89536 Opt Part #: 189 Supplier: 89536 Opt Part #: 21 Supplier: 89536 Opt Part #: 27 Supplier: 89536 Opt Part #: 77 SERIES III Supplier: 89536 Opt Part #: 87 Supplier: 89536 Opt Part #: FLUKE 27 Supplier: 89536 Opt Part #: MODEL 27 Supplier: 89536
COM-2531	Clamp-On- Current Meter **737-10, -7, -8, -8200, -8BBJ, -9** Part #: 324 Supplier: 89536 Part #: 374 FC Supplier: 89536 Part #: LH41A Supplier: 0JV05 Opt Part #: 321 Supplier: 89536 Opt Part #: 322 Supplier: 89536 Opt Part #: 374 Supplier: 89536 Opt Part #: MODEL 33 Supplier: 89536 Opt Part #: MODEL 36 Supplier: 89536
COM-13811	Multimeter (Analog / Digital with Low/ High Z Impedance functions or equivalent) **737-10, -7, -8, -8200, -8BBJ, -9** Part #: FLUKE 289 Supplier: 89536 Opt Part #: MODEL 8 MK7 Supplier: 00426
COM-13988	Clamp-on - Current, AC/DC (used with Fluke multimeters or other manufacturer's meter) **737-10, -7, -8, -8200, -8BBJ, -9** Part #: i30 Supplier: 89536
COM-17798	Multimeter - Digital, Insulation Resistance **737-10, -7, -8, -8200, -8BBJ, -9** Part #: 1004-745 Supplier: U0146 Part #: 1507 Supplier: 4U744 Part #: 1587 FC Supplier: 4U744 Part #: MIT2500 Supplier: U0146 Part #: MIT410/2 Supplier: U0146 Opt Part #: 1587 Supplier: 89536
COM-18702	Digital Camera - Acoustic **737-10, -7, -8, -8200, -8BBJ, -9** Part #: 9050 Supplier: 4MJL8 Part #: FLK-ii900 Supplier: 4U744 Part #: FLK-ii910 Supplier: 4U744
COM-19603	Reflectometer - Time Domain, Spread Spectrum (SSTDR) **737-10, -7, -8, -8200, -8BBJ, -9** Part #: LWF-1001 Supplier: $1337
COM-19604	Set - Test Lead, Multimeter

Reference	Description
	737-10, -7, -8, -8200, -8BBJ, -9 Part #: TL80A-1 Supplier: 4U744
COM-19606	Power Supply - DC, Portable **737-10, -7, -8, -8200, -8BBJ, -9** Part #: 72-13095 Supplier: 02929 Part #: TP3016M Supplier: $1365
COM-19843	Tool Kit - Contact Retention **737-10, -7, -8, -8200, -8BBJ, -9** Part #: DMC95 Supplier: 11851
COM-20583	Adapter - Stray Voltage **737-7, -8, -8200, -8BBJ, -9** Part #: SV225 Supplier: 4U744
COM-20952	Detector - Intermittent Fault **737-10, -7, -8, -8200, -8BBJ, -9** Part #: USC-IFD-512 Supplier: 350J1
COM-20963	Kit - Tone Generator and Probe **737-10, -7, -8, -8200, -8BBJ, -9** Part #: 26000900 Supplier: 1UQL0 Part #: 33-866 Supplier: 30119 Part #: VDV500-063 Supplier: 75347
COM-23670	Cable Analyzer - TDR (CT100B) **737-10, -7, -8, -8200, -8BBJ, -9** Part #: CT100B Supplier: $1360
SPL-1473	Probe - Kit, Ultrasonic Leak **737-10, -7, -8, -8200, -8BBJ, -9** Part #: B00033 Supplier: 62373 Part #: ST6760A-1 Supplier: 81205
SPL-17763	Reflectometer - Multi Carrier Time Domain (MCTDR) **737-10, -7, -8, -8200, -8BBJ, -9** Part #: W1101 Supplier: FB3T5
SPL-19679	Test Set - Voltage Drop **737-10, -7, -8, -8200, -8BBJ, -9** Part #: C24010-1 Supplier: 88277

Procedure

D. Inspection Method

SUBTASK 20-70-24-700-001

(1) Make sure that adequate voltage is supplied through the circuit using one of the following methods.

(a) Electrical load test (Preferred) or Current draw test (Alternate).

1) If no voltage or current is supplied, a hard short or open is present in the circuit:

a) Find the short or open using continuity, voltage drop, and/or reflectometry testing.

2) If voltage or current supplied is low, high resistance is present in the circuit:

a) Find the source of the voltage loss using voltage drop testing.

3) If the current supplied is high, binding or a partial short is present in the component being driven by the circuit:
   a) Examine the component for binding, drag, or a partial internal short.

SUBTASK 20-70-24-700-002

(2) Make sure that no partial shorts exist in the circuit using an insulation resistance test.
   (a) If partial shorts exist, isolate the location by dividing the circuit.

SUBTASK 20-70-24-700-003

(3) Make sure that all the connections in the circuit are engaged correctly by doing a general visual Inspections, pin engagement checks, or a torque checks as required.
   (a) If connection damage or looseness exists, repair circuit connections as required.

SUBTASK 20-70-24-700-004

(4) Do a wire shake test to find intermittent opens or shorts.
   (a) If intermittent faults are found, repair as required.

SUBTASK 20-70-24-700-005

(5) If all tests pass, the wiring is good and can be ruled out as the source of an intermittent issue.

E. Electrical Load Test

SUBTASK 20-70-24-700-006

(1) Make sure that adequate voltage is supplied through the circuit by doing one of the following methods.
   (a) In-Circuit Electrical Load Test - Backspoon
      1) Install a digital/analog multimeter, COM-1793, across the component, with the electrical leads as close to the component as possible. Refer to the Component Load Testing example (Figure 201).

         NOTE: Any connections which occur between the two leads of the Digital Multi Meter (DMM) will have some amount of voltage drop. If a poor connection is included in this measurement (such as a bad ground), it will show as though the proper voltage is being dropped across the component when in reality a large portion of that voltage is dropping across the poor connection. To prevent accidentally overlooking a potential fault, it is critical that no unnecessary connections be included in this measurement.

         NOTE: While measuring from exposed terminals is ideal, electronic backspooning into the component connector may be necessary. Use caution when installing electronic backspoons so that the connector, wire, pins, or sockets are not damaged. A multimeter test lead set, COM-19604, may be used to help this step.

         a) Connect the positive probe of the DMM as close as possible to the component on the upstream side of the circuit.
         b) Connect the negative probe of the DMM as close as possible to the component on the downstream side of the circuit.
      2) Set the digital/analog multimeter, COM-1793, to measure AC or DC voltage as necessary.
      3) Measure the voltage drop across the component. Apply power to actuate the component if necessary.

         NOTE: For most 28 VDC systems, the voltage measured across the component should be >25 VDC. A more accurate expected drop may be calculated using the applicable wiring specification

         NOTE: For most 115 VAC systems the voltage measured across the component should be >109 VAC. A more accurate expected drop may be calculated using the applicable wiring specification.

      4) If the voltage measured is <0.005 V, no voltage is present at the component:

a) An open or short exists in the circuit.
   <1> Test the circuit using voltage drop or continuity testing as necessary to find where the open or short is located.
   <2> If the open or short occurs in a wire, do the reflectometry test to find the location of the fault.

5) If the voltage drop measured is below the appropriate value listed above:
   a) High resistance may be present in the circuit:
      <1> Compare the measurement with a similar circuit or review the circuit design to make sure that the voltage is not meant to be at this low level.
      <2> Find the voltage loss in the circuit if the voltage drop is low (Refer to Voltage Drop Inspection).

6) If the voltage drop across the component is above the applicable value listed above:
   a) The circuit is supplying sufficient power to the component.

(b) Low Current Load Test
   1) Remove power from the circuit to be inspected.
   2) Disconnect the electrical connector or Line Replaceable Unit (LRU).
   3) Set the multimeter with Low/ High Z Impedance functions, COM-13811, to measure AC or DC voltage as necessary.
   4) Connect the positive lead to the multimeter with Low/ High Z Impedance functions, COM-13811, positive voltage connection.
   5) Connect the negative lead to the multimeter with Low/ High Z Impedance functions, COM-13811, negative voltage connection (ground connection).
   6) Apply power to the circuit to be inspected.
   7) Measure the voltage drop across the component (unloaded measurement).
      a) If the voltage drop measured is <0.005 V no voltage is present at the component:
         <1> An open or short exists in the circuit.
            <a> Test the circuit using voltage drop or continuity testing as necessary to find where the open or short is located.
            <b> If the open or short occurs in a wire, do the reflectometry test to find the location of the fault.

   8) After 10 seconds to stabilize, use the REL % mode to set the measured voltage value as a reference value.

      NOTE: Refer to the multimeter with Low/ High Z Impedance functions, COM-13811, operator's manual for operating instructions.

      NOTE: The measurement value at the time that relative percent mode is enabled, is stored as the reference value. The reference value and real-time measurement will be shown on the display. A relative percentage measurement which indicates the difference between the real-time and reference value will also be shown on the display.

      a) Make sure that the display shows a stable relative percentage measurement of 0.0% and a stable reference voltage measurement.

   9) Remove electrical power from the circuit to be inspected.
   10) Attach the adapter, COM-20583, to the multimeter with Low/ High Z Impedance functions, COM-13811 (Figure 208).
      a) Connect the positive lead to the adapter, COM-20583, positive voltage connection.

b) Connect the negative lead to the adapter, COM-20583, negative voltage connection (ground connection).

11) Apply power to the circuit to be inspected.

12) Measure the voltage drop across the component with the adapter, COM-20583, attached to the multimeter with Low/ High Z Impedance functions, COM-13811 (loaded measurement).

a) After 10 seconds, make sure that the relative percentage measurement is <1% and is stable.

b) If the relative percentage measurement is <1%:

<1> It is possible that there are broken wire strands or bad circuit connections. Shake the harness to find the location of the fault.

<a> Monitor the voltage on the multimeter with Low/ High Z Impedance functions, COM-13811, with the adapter, COM-20583, attached while another technician shakes the harness.

13) If necessary, do the loaded and unloaded measurement test again on a similar system.

NOTE: For example, left to right, forward to aft or a on similar airplane.

a) On the similar system, make sure that loaded relative percentage measurement is <10%.

<1> If the loaded measurement is >10%, this is possibly due to an output issue, either LRU or interconnected wiring.

<2> Refer to the engineering document such as Component Maintenance Manual (CMM) or Specification Control Drawing (SCD) to identify the correct output of the specific LRU.

(c) Electrical Load Testing Using A DC Power Supply (Alternate)

NOTE: This procedure is used to load test individual wires including isolated wiring shields such as audio wiring shields and PERG grounds.

NOTE: While low current multimeter resistance tests normally measure, or default to a "good" reading with an intermittent connection, the load tests normally measure, or default to a "bad" reading with a low current, intermittent, connection. This test will help to identify recessed pins, poor connections when shaking the wire harness.

1) Remove power from the circuit to be inspected.

2) Review the wiring diagram and then disconnect all ends of the circuit to be tested.

a) Make sure that all branch circuits are identified and isolated from the aircraft.

3) Connect a portable dc power supply, COM-19606, to the upstream end of the circuit to be tested (where the circuit was disconnected from the aircraft power source). Refer to the Load Testing Using a Power Supply Example (Figure 202).

a) Make sure that the power supply is OFF.

b) Connect the positive terminal of the power supply to the circuit to be tested.

c) Connect the negative terminal of the power supply to aircraft ground.

4) Connect the test set, SPL-19679, to the downstream end of the circuit to be tested (where the circuit was disconnected from the component). Refer to the Load Testing Using a Power Supply Example (Figure 202).

a) Connect the circuit to be tested to the positive terminal of the test set, SPL-19679.

b) Connect the negative terminal of the test set, SPL-19679, to aircraft ground.

5) Connect a digital/analog multimeter, COM-1793, across the test set, SPL-19679. Refer to Load Testing Using a Power Supply Example (Figure 202).

a) Connect the positive lead of the digital/analog multimeter, COM-1793, to the positive terminal of the test set, SPL-19679.

b) Connect the negative lead of the digital/analog multimeter, COM-1793, to the negative terminal of the test set, SPL-19679.

c) Set the meter to read volts DC.

6) Turn on the portable dc power supply, COM-19606, and set it for 28.0 VDC at 1.0 Amps.

CAUTION	DO NOT APPLY HIGH LEVELS OF CURRENT (>0.040A) FOR AN EXTENDED TIME. A CURRENT SETTING ABOVE THAT LEVEL CAN CAUSE DAMAGE TO THE LOAD TEST-BOX EQUIPMENT.

7) Adjust the test set, SPL-19679, to apply a 0.040A load to the circuit.

8) Make sure that the voltage drop across the load is >25.0 VDC.

NOTE: Limit the duration of current application >0.040A to only that which is required to take the voltage drop measurement(s).

a) If the voltage drop measured is <0.005 V, no voltage is present at the component:

<1> An open or short exists in the circuit.

<a> Test the circuit using voltage drop or continuity testing as necessary to find where the open or short is located.

<b> If the open or short occurs in a wire, do the reflectometry test to find the location of the fault.

CAUTION	DO NOT APPLY HIGH LEVELS OF CURRENT (>0.040A) FOR AN EXTENDED TIME. A CURRENT SETTING ABOVE THAT LEVEL CAN CAUSE DAMAGE TO THE LOAD TEST-BOX EQUIPMENT.

9) Adjust the test set, SPL-19679, to apply a load to the circuit which is similar to the normal operating load of the system.

NOTE: If the normal load of the system exceeds the capability of the test set, SPL-19679, voltage drop across the load may be calculated using Ohm's Law (Refer to Figure 205).

10) Make sure that the voltage drop across the load remains >25.0 VDC.

a) If the voltage drop across the load is <25.0 VDC, there is a voltage loss in the circuit. Refer to Voltage Drop Inspection to find the source of voltage loss.

b) If the voltage drop across the load is >25.0 VDC, the circuit is delivering adequate power to the load.

11) Turn OFF the portable dc power supply, COM-19606, and disconnect it from the circuit.

12) Disconnect the test set, SPL-19679, from the circuit.

13) Connect the circuit to the aircraft (Refer to the appropriate Wiring Diagram Manual (WDM)).

14) Do an operational check of the system(s) which was/were disturbed.

F. Electrical Current Test

SUBTASK 20-70-24-700-007

(1) This method requires that the expected current through the circuit to be known. This can be done through one of the following methods.

(a) Most common method is by comparison with equivalent systems.

1) Current draw data may be collected from similar circuits on the same aircraft (ex. left and right), or other aircraft (ex. same circuit different aircraft) for comparison.

2) Each data point collected using this method increases the level of confidence in what a “good” circuit should measure.

3) If no similar circuits are available as a reference this method cannot be used.

(b) By comparison to CMM values.
   1) Most CMMs provide a maximum current draw limit and some CMMs also provide a normal expected current.
      a) The upper limit is provided when the maximum current draw is given in the CMM, but the normal operating current is not available at this time. If measured current draw is reaching the maximum limit, it may be cause for further investigation.

SUBTASK 20-70-24-700-021

(2) Make sure that adequate power is flowing through the circuit as follows.
   (a) Get access to the circuit to be tested at the most convenient location.

   NOTE: This is often at the circuit breaker panel, however, any point along the circuit is acceptable.

WARNING MAKE SURE THAT YOU ARE CAREFUL WHEN YOU ARE NEAR ENERGIZED CIRCUITS. AN ELECTRICAL SHOCK CAN CAUSE AN INJURY.

   (b) Connect an appropriately rated current clamp to the circuit to be tested. Refer to the tool manufacturer`s operating manual.

   NOTE: The AC/DC current clamp, COM-13988, is recommended for DC current or when the expected current is less than 1 amps, otherwise clamp-on current meter, COM-2531, is recommended.

   (c) Energize the circuit to be tested.
   (d) Measure single phase circuit current.
      1) Refer to Power Quality Checks, TASK 20-10-78-760-801 for 3-phase circuits. Use the power quality analyzer to make sure that simultaneous calibrated measurements are taken to prevent misdiagnosis, when you measure 3-phase current using a single ammeter or three individual ammeters.
   (e) Compare the measured current to established limits or a similar system.
      1) If current draw is found to be >10% low, there is a restriction in the circuit. To locate the source of restriction refer to the Voltage Drop Inspection.
      2) If current draw is found to be >10% high, inspect the component for signs of binding and/or resistance to actuation.
         a) If no signs of binding exist, do an insulation resistance test of the component (Refer to Insulation Resistance Test).
      3) If current draw is found to be in-range, the circuit is delivering sufficient power to the component.
   (f) Remove the AC/DC current clamp, COM-13988, or clamp-on current meter, COM-2531.
   (g) Put back any necessary access which was opened to do this test.

G. Insulation Resistance Test

SUBTASK 20-70-24-700-008

(1) Make sure that no partial short circuits exist by doing the following insulation resistance tests.
   (a) Remove power from the circuit under test.
   (b) Disconnect the wires to be tested from the aircraft at each end.
   (c) Examine the wiring diagram to make sure that no branch circuits exist and that the circuit to be tested is isolated from the aircraft.
   (d) If a load test was not done previously, do the following:
      1) Measure the continuity of each wire to be tested from end to end using a digital/analog multimeter, COM-1793, to make sure that no opens exist.

a) If an open exists, test the circuit using the voltage drop or continuity testing to find the location of the open.
<1> If the open is found in a wire, do the reflectometry test to find the location of the open.

2) Measure the resistance between each wire to be tested and aircraft ground using a digital/analog multimeter, COM-1793, to make sure that no direct shorts exist.
a) If a direct short exists, test the circuit using voltage drop or continuity testing to find the location of the short.
<1> If the short is found in a wire, do the reflectometry test to find the location of the short.

⚠ **WARNING**	DO NOT APPLY MORE THAN 2500 VDC TO AIRCRAFT WIRING OR COMPONENTS. IF YOU DO TESTS AT 3000 VDC OR MORE, YOU CAN CAUSE ARCING BETWEEN AIRCRAFT CONNECTOR PINS IN HIGH HUMIDITY. IF YOU DO NOT FOLLOW INSTRUCTION, DAMAGE TO THE AIRPLANE AND INJURY TO PERSONNEL CAN OCCUR.

(e) Set up the insulation resistance multimeter, COM-17798, as follows:
1) Perform circuit isolation test to prevent damage at higher voltages by setting the test voltage to lowest setting - 50 VDC.
a) Set the test voltage to 50 VDC.
b) Test circuit to ground.

NOTE: If you disconnect a connector, to open the circuit to do a test, there is no connection to the structure. Thus, there is not an electrical path from the backshell to ground. In this condition you will not find a short to the backshell when you do this test. To prevent this, use a jumper wire to connect the backshell to a sufficient ground on the airplane structure.

c) Press and hold the test button for at least 5 seconds.
d) Make sure that each measurement is >5 MΩ.
<1> If an insulation resistance value <5 MΩ is recorded, review WDM and connections to ensure circuit is isolated.
<2> Repeat test until assured isolation. If circuit isolation is confirmed, disconnect sections as applicable to further isolate.

(2) Do the Insulation Resistance test at 500 VDC.
(a) Set the test voltage to 500 VDC then do a test of the following:
- Test each wire in the damaged system to ground.
- Do a test on each wire in the damaged system to each other wire in the same wiring harness.
- If wires are shielded, test each wire to its shield.

1) Make sure that each measurement is >50 MΩ.
2) If an insulation resistance value <50 MΩ is recorded, divide the circuit into smaller pieces and repeat the test to locate the partial short.

(3) Do the Insulation Resistance test at 1000 VDC.

NOTE: Any wiring or components that have been tested at 1000 VDC or more could be damaged by arcing. Upon test completion, it is recommended that the system be retested at 500 VDC to check for degraded insulation.

NOTE: A test of more than 500 VDC can be used when there is a possibility of a intermittent short circuit in the aircraft wiring and further investigation is required.

(a) Set the test voltage to 1000 VDC then do a test of the following:
- Test each wire in the damaged system to ground.
- Do a test on each wire in the damaged system to each other wire in the same wiring harness.
- If wires are shielded, test each wire to its shield.

1) Make sure that each measurement is >100 MΩ.
2) If an insulation resistance value <100 MΩ is recorded, divide the circuit into smaller pieces and repeat the test to locate the partial short.
3) Re-test the wiring at 500 VDC to check for degraded insulation.

WARNING: DO NOT APPLY MORE THAN 2500 VDC TO AIRCRAFT WIRING OR COMPONENTS. IF YOU DO TESTS AT 3000 VDC OR MORE, YOU CAN CAUSE ARCING BETWEEN AIRCRAFT CONNECTOR PINS IN HIGH HUMIDITY. IF YOU DO NOT FOLLOW INSTRUCTION, DAMAGE TO THE AIRPLANE AND INJURY TO PERSONNEL CAN OCCUR.

CAUTION: MAKE SURE THAT YOU ISOLATE THE AIRCRAFT WIRING FROM ALL COMPONENTS BEFORE YOU APPLY THE 2500 VDC IN TIGHT AREAS. THIS CAN BE AIR CLEARANCES OF LESS THAN 2 MM, FOUND IN RELAYS, SWITCHES OR LIGHT BULBS. A VOLTAGE OF 2500 VDC CAN CAUSE AN ARC THROUGH THE CLEARANCE OF APPROXIMATELY 0.059 INCH (1.5 MM). TOO MUCH ARCING INTO THESE COMPONENTS CAN CAUSE DAMAGE TO THE COMPONENT SURFACE.

(4) Do the Insulation Resistance test at 2500 VDC.

NOTE: Any wiring or components that have been tested at 1000 VDC or more could be damaged by arcing. Upon test completion, it is recommended that the system be retested at 500 VDC to check for degraded insulation.

NOTE: A test of more than 500 VDC can be used when there is a possibility of a intermittent short circuit in the aircraft wiring and further investigation is required.

(a) Set the test voltage to 2500 VDC then do a test of the following:
- Test each wire in the damaged system to ground.
- Do a test on each wire in the damaged system to each other wire in the same wiring harness.
- If wires are shielded, test each wire to its shield.

1) Make sure that each measurement is >250 MΩ.
2) If an insulation resistance value <250 MΩ is recorded, divide the circuit into smaller pieces and repeat the test to locate the partial short.
3) Re-test the wiring at 500 VDC to check for degraded insulation.

(b) If all insulation resistance measurements are 250 MΩ or more at 2500 VDC then the circuit insulation is in good condition.

(5) Connect the circuit to the airplane (Refer to the appropriate WDM).

(6) Do an operational check of the system(s) that was/were changed.

H. Ultrasonic Short Circuit Detection Test

SUBTASK 20-70-24-700-009

(1) Do an Insulation Resistance (IR) test.

NOTE: Most intermittent faults randomly occur during engine operation or in-flight, and do not occur during a ground test. Thus, if wet, cold or heavy vibration conditions applied to a wire bundle are too much, a fault can occur. A wire bundle that has damage because of airplane pressurization can also give a fault condition.

NOTE: If you do the Method 1 test and do not find a fault, then do the Method 2 test.

⚠ WARNING	MAKE SURE THAT YOU DO NOT USE A POSSIBLE IGNITION SOURCE AROUND OPEN FUEL TASKS, FUEL VENTS OR SPILLED FUEL. 500V DC TESTERS CAN BE AN IGNITION SOURCE. FUEL FUMES CAN BE NOT STABLE AND CAUSE POSSIBLE IGNITION. IF YOU DO NOT OBEY, INJURY TO PERSONNEL AND DAMAGE TO EQUIPMENT CAN OCCUR.

(a) Intermittent Insulation Resistance Test With Audio – Visual Detection - Dry (Method 1).

1) Prepare for testing by following: Insulation Resistance Testing - Special Detail Inspection, TASK 20-10-39-700-801.

2) Review the WDM to make sure that sensitive components are isolated from high voltage.

a) Give a special attention to all terminal blocks and splices for circuit under test.

3) Examine electrical connectors for bent or broken pins/sockets, dirt, moisture and damage.

4) On the applicable LRU, install a conductive dust cap and a connector cover.

5) Technician A - Set up the insulation resistance multimeter, COM-17798, as follows:

a) Connect the insulation resistance multimeter, COM-17798, to circuit under test.

NOTE: If you disconnect a connector, to open the circuit to do a test, there is no connection to the structure. Thus, there is not an electrical path from the backshell to ground. In this condition you will not find a short to the backshell when you do this test. To prevent this, use a jumper wire to connect the backshell to a sufficient ground on the airplane structure.

b) Perform circuit isolation test to prevent damage at higher voltages by setting the test voltage to 50 VDC, which is the lowest setting.

<1> Set the test voltage to 50 VDC.

<2> Test circuit to ground.

<3> Press and hold the test button for at least 5 seconds.

<4> Make sure that each measurement is >50 MΩ.

<a> If an insulation resistance value <50 MΩ is recorded, review the WDM and connections to make sure that the circuit is isolated.

<b> Repeat the test to Isolate and if circuit isolation is confirmed, disconnect sections as applicable to further isolate.

6) Technician B - Follow the acoustic digital camera, COM-18702, operator’s instruction to turn on the device and monitor for ultrasonic wave created during any insulation resistance breakdown (Figure 206).

7) Technician C - Follow the ultrasonic leak probe, SPL-1473, operator’s instructions to turn on device and connect the non-conductive hollow probe (Figure 207).

8) Technician A -Set the test voltage to 500 VDC when the circuit is isolated at 50 VDC.

a) Do not apply more than 500 VDC to aircraft wiring or components.

NOTE: Any wiring or components tested at 1000 VDC or more shall be re-tested at 500 VDC to make sure that the insulation resistance health is good before return them to service.

9) Test circuit(s) to ground as follows:

a) Press and hold the test button for at least 5 seconds but up to 2 minutes.
b) Make sure that each measurement is >50 MΩ.
<1> If an insulation resistance value <50 MΩ is recorded, notify Technicians B and C to listen and watch for an ultrasonic wave (arcing).
<2> If an audible or visual signature is not found, divide the circuit into smaller pieces and repeat the test to find the short.
c) Do a test on each wire in the damaged system to each other wire in the same wiring harness.
d) Make sure that each measurement is >50 MΩ.
<1> If an insulation resistance value <50 MΩ is recorded, notify Technicians B and C to listen and watch for an ultrasonic wave (arcing).
<2> If an audible or visual signature is not found, divide the circuit into smaller pieces and repeat the test to find the partial short.
e) If wires are shielded, test each wire to its shield.
f) Make sure that each measurement is >50 MΩ.
<1> If an insulation resistance value <50 MΩ is recorded, notify Technicians B and C to listen and watch for an ultrasonic wave (arcing).
<2> If an audible or visual signature is not found, divide the circuit into smaller pieces and repeat the test to find the partial short.

10) If all insulation resistance measurements are 50 MΩ or more at 500 VDC, then the circuit insulation is good.
a) Reinstall all disconnected connectors (Refer to applicable WDM).

11) Do an operational check of the systems that were disconnected.

(b) Intermittent Insulation Resistance Test With Audio – Visual Detection - Wet (Method 2).
1) Perform a detailed inspection of the insulation resistance testing, do this task: Insulation Resistance Testing - Special Detail Inspection, TASK 20-10-39-700-801.
2) Review the WDM to make sure that sensitive components are isolated from high voltage.
a) Give a special attention to all terminal blocks and splices for circuit under test.
3) Disconnect all connectors related to the wire being tested.
4) Examine the electrical connectors for bent or broken pins/sockets, dirt, moisture and damage.
5) On the applicable LRUs, install conductive dust cap and connector cover.
6) Technician A - Set up the insulation resistance multimeter, COM-17798, as follows:
a) Connect the insulation resistance multimeter, COM-17798, to circuit under test.

NOTE: If you disconnect a connector, to open the circuit to do a test, there is no connection to the structure. Thus, there is not an electrical path from the backshell to ground. In this condition you will not find a short to the backshell when you do this test. To prevent this, use a jumper wire to connect the backshell to a sufficient ground on the airplane structure.

7) Technician B- Follow ultrasonic leak probe, SPL-1473, operator’s instructions to turn on device and connect the non-conductive hollow probe.
a) While wearing insulated gloves, listen for static noise when shake wiring harness and spraying a fine water mist (Figure 207).
8) Technician C- Follow the acoustic digital camera, COM-18702, operator’s instruction to turn on device and monitor for ultrasonic wave created during any insulation resistance breakdown (Figure 206).
9) Technician A - Set the test voltage to 500 VDC.

a) Do not apply more than 500 VDC to aircraft wiring or components.

NOTE: Any wiring or components tested at 1000 VDC or more shall be re-tested at 500 VDC to make sure that the insulation resistance health is good before a return to service.

10) Test circuit(s) to ground.
   a) Press and hold the test button for at least 5 seconds, but up to 2 minutes while Technician B shakes the harness.
11) Make sure that each measurement is >50 MΩ.
   a) If an insulation resistance value <50 MΩ is recorded, notify Technicians B and C to listen and watch for an ultrasonic wave (arcing).
   b) If an audible or visual signature is not found, divide the circuit into smaller pieces and repeat the test to find the partial short.
12) Do a test on each wire in the damaged system to each other wire in the same wiring harness.
13) Make sure that each measurement is >50 MΩ.
   a) If an insulation resistance value <50 MΩ is recorded, notify Technicians B and C to listen and watch for an ultrasonic wave (arcing).
   b) If an audible or visual signature is not found, divide the circuit into smaller pieces and repeat the test to find the partial short.
14) If wires are shielded, test each wire to its shield.
15) Make sure that each measurement is >50 MΩ.
   a) If an insulation resistance value <50 MΩ is recorded, notify Technicians B and C to listen and watch for an ultrasonic wave (arcing).
   b) If an audible or visual signature is not found, divide the circuit into smaller pieces and repeat the test to find the partial short.
16) If all insulation resistance measurements are 50 MΩ or more at 500 VDC the circuit insulation is good.
   a) Reinstall all disconnected connectors (Refer to the appropriate WDM).
17) Do an operational check of the system systems that were disconnected.

I. Low Resistance Test

SUBTASK 20-70-24-700-016

CAUTION MAKE SURE THAT YOU ISOLATE SENSITIVE COMPONENTS IN THE CIRCUIT. THE TEST EQUIPMENT USES 10 MILLIAMP CURRENT AT AN OPEN CIRCUIT VOLTAGE OF 20 VOLTS. IF YOU DO NOT OBEY, DAMAGE TO THE CIRCUIT CAN OCCUR.

(1) Do a Low Resistance Test using one of the following methods.
   (a) Low Resistance Test - Wiring and Connections (Method 1).

NOTE: This method uses the multimeter with Low/ High Z Impedance functions, COM-13811, 50-ohm application to measure low resistances. The meter amplifies defects by using 10mA and up to 20V at 0.001-ohm resolution. In this test the multimeter with Low/ High Z Impedance functions, COM-13811, meter is zero calibrated across a known “good” circuit which is then compared to a suspected “defective” circuit.

NOTE: When testing a circuit with less than approximately 20 ft of wiring, e.g. a switch or switch panel, then you must use a 0.5 ohm resistor in series with the measurement to prevent unstable readings.

1) Prepare for testing:

a) Examine the WDM to make sure that sensitive devices in the circuit are isolated from the high power low ohm test (20V/10mA).
   <1> Make sure that branch circuits are not connected to sensitive devices.

b) Make sure that “good” wiring and suspected “defective” wiring under test are the same type and length.

c) Disconnect the wires to be tested from LRUs as necessary.

d) On the applicable LRU install a conductive dust cap and a connector cover.

e) Examine the electrical connectors for bent or broken pins/sockets, dirt, moisture and damage.

f) Select the 50-Ohm low resistance function.

NOTE: Refer to the multimeter with Low/ High Z Impedance functions, COM-13811, operator’s manual for operating instructions.

2) Do the low resistance test:

a) Measure the resistance of the known “good” circuit.
   <1> Connect the positive lead of the multimeter with Low/ High Z Impedance functions, COM-13811, to one end of the circuit.
      <a> When testing a circuit with less than approximately 20 ft of wiring, use a 0.5 ohm resistor in series with the measurement to prevent unstable readings.
   <2> For the negative lead of the multimeter with Low/ High Z Impedance functions, COM-13811:
      <a> If the circuit is short, connect the negative lead to the other end of the circuit.
      <b> If the circuit is long, connect the negative lead to aircraft ground and then connect the other end of circuit to aircraft ground with a jumper wire.
   <3> Wait 10 seconds to make sure that resistance value is stable.

   NOTE: It may be necessary to repeat the measurement more than one time to make sure that the real-time resistance value is stable. If the measurement remains unstable, this is a sign of a bad connection.

   <4> Use the REL % mode to set the measured resistance value of the known “good” circuit as a reference value.

   NOTE: Refer to the multimeter with Low/ High Z Impedance functions, COM-13811, operator’s manual for operating instructions.

   NOTE: The measurement value at the time that relative percent mode is enabled, is stored as the reference value . The reference value and real-time measurement will be shown on the display. A relative percentage measurement which indicates the difference between the real-time and reference value will also be shown on the display.

      <a> Make sure that the display shows a stable relative percentage measurement of 0.0% and a stable reference resistance measurement.

b) Measure the resistance of the suspected “defective” circuit (Figure 209).
   <1> Connect the positive lead of the multimeter with Low/ High Z Impedance functions, COM-13811, to one end of the circuit.
      <a> When testing a circuit with less than approximately 20 ft of wiring, use a 0.5 ohm resistor in series with the measurement to prevent unstable readings.
   <2> For the negative lead of the multimeter with Low/ High Z Impedance functions, COM-13811:

<a> If the circuit is short, connect the negative lead to the other end of the circuit.

<b> If the circuit is long, connect the negative lead to aircraft ground and then connect the other end of circuit to aircraft ground with a jumper wire.

<3> Compare the real-time resistance measurement of the suspected “defective” circuit with reference measurement of the “good” circuit.

<a> Make sure that the relative percentage measurement is <2% and is stable in <10 seconds.

NOTE: NOTE: The real-time resistance measurement of the suspected “defective” circuit should stabilize near the reference measurement in <10 Seconds. Typical low resistance measurements result in a rapid decrease in resistance followed by a final slow decrease to the final measurement; For example, a 63.2% drop in first time constant (t) and then a slower, yet gradual decrease to final resistance in 5 time constants (5t).

c) If the relative percentage measurement is >2% difference or there is unstable real-time resistance measurement between the two circuits, do one of the following:

<1> Do the MOHR TDR masking procedure to find the exact location of the deviation (preferred).

<2> If the TDR is not available, then shake the harness to simulate flight vibration, pressurization and temperature changes to locate the fault:

NOTE: For circuits <10ft, expect large fluctuations of >25% when shaking the wiring. Pay special attention to the reference and real-time resistance measurements as you shake the wiring on small circuits.

<a> Technician B - Shake harness wiring, focusing on connections and feed-thrus.

<b> Technician A - Make sure that the relative percentage measurement does not fluctuate while technician B is shaking the harness.

<3> Review the WDM and do the same test on individual branches to isolate the degraded circuit section in the suspected “defective” circuit.

3) Connect the circuit to the aircraft (refer to the appropriate WDM).

4) Do an operational check of the system(s) which was/were disturbed.

(b) Low Resistance Test - Contacts (Method 2).

NOTE: This test is a repeatability test for low ohm connections such as relays and switches.

1) Prepare for testing:

a) Examine the wiring diagram to make sure that sensitive devices in the circuit are isolated from high power low ohm test (20V/10mA).

<1> Make sure that branch circuits are not connected to sensitive devices.

b) Disconnect the contacts to be tested from LRUs as necessary.

c) On the applicable LRU install a conductive dust cap and a connector cover.

d) Examine the electrical connectors for bent or broken pins/sockets, dirt, moisture and damage.

e) Select the 50-Ohm Low Resistance function.

NOTE: Refer to the multimeter with Low/ High Z Impedance functions, COM-13811, operator’s manual for operating instructions.

2) Do the Low Resistance test:

a) Connect the positive lead of the multimeter with Low/ High Z Impedance functions, COM-13811, to one end of the contact.

<1> When testing a circuit with less than approximately 20 ft of wiring, use a 0.5 ohm resistor in series with the measurement to prevent unstable readings.

b) Connect the negative lead of the multimeter with Low/ High Z Impedance functions, COM-13811, to the other end of the contact.

c) Close the contact by energizing the relay or valve coil or by toggling a switch, or manually rotating a valve.

d) Measure the resistance in the circuit.

<1> Wait 10 seconds to make sure that the resistance value is stable.

NOTE: It may be necessary to repeat the measurement more than once to make sure that the real-time resistance value is stable. If the measurement remains unstable, this is a sign of a bad connection.

<a> A typical measurement directly across a contact (not including wiring) is <200 milli-ohms (0.200 ohms).

<2> Use the REL % mode to set the measured resistance value as a reference value.

NOTE: Refer to the multimeter with Low/ High Z Impedance functions, COM-13811, operator’s manual for operating instructions.

NOTE: The measurement value at the time that relative percent mode is enabled, is stored as the reference value. The reference value and real-time measurement will be shown on the display. A relative percentage measurement which indicates the difference between the real-time and reference value will also be shown on the display.

<a> Make sure that the display shows a stable relative percentage measurement of 000.00% and a stable reference resistance measurement.

e) Open the contact.

<1> The multimeter with Low/ High Z Impedance functions, COM-13811, will show a high reading.

f) Close the contact.

<1> Make sure that the relative percentage measurement is <1% and is stable in <10 seconds.

g) Cycle the contact at least 3 times and measure the resistance.

<1> Make sure that the relative percentage measurement is <1% and is stable in <10 seconds.

3) Connect the circuit to the aircraft (refer to the appropriate WDM).

4) Do an operational check of the system(s) which was/were disturbed.

J. MOHR TDR Masking

NOTE: This procedure is used to compare similar wiring and identify areas of degradation that lead to intermittent opens and shorts in-flight.

SUBTASK 20-70-24-700-017

(1) Prepare for testing:

(a) Follow the TDR, COM-23670, operator’s manual to set up for testing and power on.

(b) Connect MOHR reference cable (Blue 50 ohm cable with Bayonet Neill-Concelman (BNC) connectors) to the TDR, COM-23670.

(c) Select an adapter from the pin and socket probe kit.

1) Connect the adapter to the reference cable.

(d) Review the WDM to identify similar wiring, type and length, and then disconnect these wires from LRUs as necessary.

(e) De-energize the applicable circuit to be tested.

SUBTASK 20-70-24-700-018

(2) Set up the trace.

(a) Connect the TDR, COM-23670, to the known “good” wire circuit.

(b) Press the "Blue" menu button:

1) Change cable length to short (<300ft) or as applicable.

2) Change Resolution to NORMAL.

NOTE: Refer to the tool manufacturer`s operating manual.

(c) Select the Velocity of Propagation (VOP) of the wire type to be tested.

NOTE: If the VOP value of the wire to be tested is unknown select a generic 0.68 VOP. An accurate VOP is necessary for accurate cable length and Distance-to-Fault calculations.

(d) Use the “AUTOFIT” button to show entire circuit on the TDR, COM-23670, display.

(e) Measure the beginning and end of the wire circuit where the impedance starts to change:

1) Put the forward cursor at the beginning of the circuit:

NOTE: This is the initial connection where the impedance starts to increase. This can be confirmed by temporarily disconnecting TDR adapter from the circuit.

2) Move the aft cursor to the end of the circuit.

NOTE: The end of the circuit is the next spike in the circuit where the impedance start to change again.

3) Measure the distance measured between the two cursors.

NOTE: The distance between the two cursors represents entire circuit. This will show as a “Δft(M)” value.

SUBTASK 20-70-24-700-019

(3) Follow the TDR, COM-23670, operator’s manual to create a mask from the trace (Figure 210):

NOTE: The mask creates an area around a scanned trace that functions as a test limit for the live TDR trace. Any point of the trace that extends into the masked area will cause the background to turn red. This can be used for creating acceptance criteria for wires and connectors. If the live TDR trace fits within the mask, it will appear with a green background.

(a) Do a scan of the live trace.

NOTE: To create a mask of the entire circuit displayed on the screen, make sure that "Snapshot" is displayed on bottom of screen. To create mask of only the wiring run between both forward and aft cursors, make sure that "Cursor" is displayed on bottom of screen.

NOTE: The scanned trace will turn red.

(b) Create a mask from the trace.

NOTE: Refer to the TDR, COM-23670, operator’s manual for operating instructions.

NOTE: The screen will turn green to show that the live TDR trace fits within the mask.

(c) Use the Change Vertical Margin button to adjust the mask boundaries around the trace.

1) Make sure that the vertical margin is 25mp.

NOTE: Normally the TDR mask stabilizes between 25mp to 50mp.

SUBTASK 20-70-24-700-020

(4) Connect the TDR, COM-23670, to the defective circuit and wait 10 seconds for the measurement to stabilize.

(a) If the mask is green, the original and comparison measurements are within the recommended 25mp to 50mp margin.

(b) If the mask is red, the measurements are not within the recommended margin. Do the distance-to-fault evaluation procedure:

1) Position the aft cursor on the reflection caused by the cable fault.

NOTE: This is the start of the change separation between the “good” and “defective” measurements.

2) Measure the distance to fault or impedance mismatch.

NOTE: Distance to fault or impedance mismatch is displayed by the ΔFt(M) indication. Higher impedance is displayed by a rise in value; more “open” connection. Low impedance is displayed by a decrease in value; more “shorted” connection.

3) Do this step to make the fault larger to get a more accurate measurement of Distance-to-Fault.

a) Increase the vertical margin of both the “good” (red) and the suspected “defective” (white) trace to 200mp/div.

4) Move the aft cursor to show the rise or fall in impedance.

a) Distance to fault, or impedance change, is indicated by the ΔFt(M) display.

(c) Connect the circuit to the aircraft (refer to the appropriate WDM).

(d) Do an operational check of the system(s) which was/were disturbed.

K. Electrical Connection Inspection

SUBTASK 20-70-24-700-010

(1) Make sure that proper engagement of all connections are within the circuit by doing the following.

NOTE: This inspection contains steps to access all connections in the circuit. Some connections may be more difficult to get to than others, such as potted connectors or connections behind lavatories, etc. Where desired, connections may be temporarily skipped during this inspection to allow the inspection to fit airline operational requirements. Any connection omitted in this way cannot be ruled out as a potential cause of the intermittent issue. To ensure potential causes are not overlooked, any missed connection should be properly noted for future evaluation.

(a) Remove power from the circuit under test.

(b) For each connector in the circuit:

1) Get access to the connector.

2) Disconnect the connector.

3) Do a visual inspection of the mating surfaces of the connector for contamination, corrosion, signs of arcing, or other damage.

4) Do a connector lock retention check for each pin and socket in the circuit under investigation using one of the following methods:

NOTE: The proper retention of pins and sockets cannot be given by doing a visual inspection only. The manual check is necessary to find if correct retention is provided.

a) Pull on each wire behind the connector or press on each pin or socket from the front side of the connector with an appropriate tool.

b) Press on each pin and socket using the applicable retention test tool from the contact retention kit, COM-19843, and make sure that the contact lock resists the appropriate pressure.

NOTE: Refer to the connector specification for required contact locking strength. Refer to the contact retention kit manufacturer's instructions for tool selection.

c) Repair any connections which are not properly retained.

5) Reassemble the connector backshells.

6) Reconnect the connector using the appropriate torquing procedure.

7) Put back any necessary access which was opened to do this inspection.

(c) For each terminal connection:

1) Get access to the connection.

2) Do a visual inspection of the wire insulation, terminal, and terminal lug for any signs of damage, contamination, or corrosion.

3) Do a torque-check of the connection.

4) Make sure that the wire is properly retained in the terminal.

5) Put back any necessary access which was opened to do this inspection.

(d) For each terminal block or relay base:

1) Get access to the terminal block or relay base.

2) Do a visual inspection of the terminal block or relay base for contamination, corrosion, signs of arcing, or other damage.

3) Do a pin retention check for each pin in the circuit under inspection.

a) Pull on each wire at the terminal block or relay base to ensure all wires are properly retained.

b) Repair any connections which are not properly retained.

4) Put back any necessary access which was opened to do this inspection.

L. Wire Shake Test

NOTE: Because of the increased voltage between the test wire and negative meter connection, more capacitance will be made. This will cause the IR value to continue to increase a long period of time until it becomes stable. It is not necessary to apply voltage until the value becomes stable. As long as the value is more than the expected MΩ value for the applied test voltage and continues to increase continuously after 5 seconds, the value can be considered good and test voltage can be removed. If there value increases and then decreases, this means that an arcing event occurred. This can be considered an unsuccessful test and the source of the defect must be isolated.

SUBTASK 20-70-24-700-011

(1) Make sure that no intermittent shorts or opens exist by doing a wire shake test using one of the following methods:

(a) Reflectometry:

1) Do a reflectometry inspection of the circuit for intermittent faults (Refer to Reflectrometry Inspection).

NOTE: Use a TDR capable of intermittent fault analysis such as multi carrier time domain reflectometer, SPL-17763 or TDR, COM-23670.

(b) Continuity:

NOTE: This intermittent continuity test uses the "Lo Ohm" function of the or equivalent, which applies up to 10mA of current to capture low resistance changes and records the measurement. When using the record function, the user may review the trend results on the meter to quickly identify intermittent connections. An analog multimeter with Low/ High Z Impedance functions, COM-13811, Simpson 260 or equivalent, may also be used, but only on the Rx1 scale which will apply up to 10mA of current.

1) Remove power from the circuit under test.
2) Disconnect the wires to be tested from the aircraft at each end.
3) Examine the wiring diagram to make sure that no branch circuits exist and that the circuit to be tested is isolated from the aircraft.
4) Test each wire in the circuit for intermittent opens as follows:
   a) Connect the positive lead of the multimeter with Low/ High Z Impedance functions, COM-13811, to the "Lo Ohm" function, to one end of the wire under test.
   b) Connect the negative lead of the multimeter with Low/ High Z Impedance functions, COM-13811, to the "Lo Ohm" function, to the other end of the wire under test.

      NOTE: Use a jumper wire to aircraft ground or a spare wire to complete the circuit as necessary.

   c) Set the meter to record continuity and begin data collection.

      CAUTION DO NOT USE TOO MUCH FORCE ON THE WIRE. TOO MUCH FORCE CAN CAUSE DAMAGE TO THE WIRE.

   d) Work from one end of the wire under test to the other manually disturbing (shaking) the harness as you go.
   e) Make sure there is continuity between both ends of the wire under test throughout the entire test.
      <1> Review the meter “trend” recording for dips and spikes. If continuity is lost at any point (resistance goes to OL (Overload) or very high) an intermittent open is present.
   f) Do the test again in the suspect area until the location of the intermittent open is found.
   g) Repair any wire damage that you find.
5) Test each wire in the circuit for intermittent shorts to ground as follows:
   a) Connect the positive lead of the multimeter with Low/ High Z Impedance functions, COM-13811, to the "Lo Ohm" function, to one end of the wire under test.
   b) Connect the negative lead of the multimeter with Low/ High Z Impedance functions, COM-13811, to the "Lo Ohm" function, to aircraft ground.
   c) Set the meter to record continuity and begin data collection.

      CAUTION DO NOT USE TOO MUCH FORCE ON THE WIRE. TOO MUCH FORCE CAN CAUSE DAMAGE TO THE WIRE.

   d) Work from one end of the wire under test to the other manually disturbing (shaking) the harness as you go.
   e) Make sure that there is no continuity between the wire under test and aircraft ground throughout the entire test.
      <1> Review the meter "trend" recording for dips and spikes. If any amount of continuity exists at any point during the test, an intermittent short is present.
   f) Do the test again in the suspect area until the location of the intermittent open is found.

g) Repair any wire damage that you find.

6) Test each wire in the circuit for intermittent shorts to other wires in the circuit as follows:

a) Connect the positive lead of the multimeter with Low/ High Z Impedance functions, COM-13811, to the "Lo Ohm" function, to one end of the wire under test.

b) Jumper each other wire in the circuit together at either end of the circuit.

c) Connect the negative lead of the multimeter with Low/ High Z Impedance functions, COM-13811, to the "Lo Ohm" function, to any of the other wires in the circuit which were jumpered together in the previous step.

d) Set the meter to record continuity and begin data collection.

CAUTION DO NOT USE TOO MUCH FORCE ON THE WIRE. TOO MUCH FORCE CAN CAUSE DAMAGE TO THE WIRE.

e) Work from one end of the wire under test to the other manually disturbing (shaking) the harness as you go.

f) Make sure there is no continuity between the wire under test and any other wire in the circuit throughout the entire test.

<1> Review the meter "trend" recording for dips and spikes. If any amount of continuity exists at any point during the test an intermittent short is present.

g) Do the test again in the suspect area until the location of the intermittent short is found.

h) Repair any wire damage that you find.

7) If wires in the circuit are shielded, test each wire in the circuit for intermittent shorts to shield as follows:

a) Connect the positive lead of the multimeter with Low/ High Z Impedance functions, COM-13811, to the "Lo Ohm" function, to one end of the wire under test.

b) Connect the negative lead of the multimeter with Low/ High Z Impedance functions, COM-13811, to the "Lo Ohm" function, to the shield.

c) Set the meter to record continuity and begin data collection.

CAUTION DO NOT USE TOO MUCH FORCE ON THE WIRE. TOO MUCH FORCE CAN CAUSE DAMAGE TO THE WIRE.

d) Work from one end of the wire under test to the other manually disturbing (shaking) the harness as you go.

e) Make sure there is no continuity between the wire under test and its shield throughout the entire test.

<1> Review the meter "trend" recording for dips and spikes. If any amount of continuity exists at any point during the test an intermittent short is present.

f) Do the test again in the suspect area until the location of the intermittent short is found.

g) Repair any wire damage that you find.

8) Reconnect the circuit to the aircraft (Refer to the appropriate WDM).

9) Do an operational check of the system(s) which was/were disturbed.

M. Voltage Drop Inspection

SUBTASK 20-70-24-700-012

(1) Make sure that the condition of connections throughout the circuit as follows:

WARNING	MAKE SURE THAT YOU ARE CAREFUL WHEN YOU ARE NEAR ENERGIZED CIRCUITS. AN ELECTRICAL SHOCK CAN CAUSE AN INJURY.

(a) Spoon Probe Voltage Drop Test:

1) Install a digital/analog multimeter, COM-1793, across the component with the electrical leads as close to the component as possible. Refer to Component Load Testing Example (Figure 201).

NOTE: Any connections which occur between the two leads of the DMM will have some amount of voltage drop. If a poor connection is included in this measurement (such as a bad ground) it will appear as though the proper voltage is being dropped across the component when in reality a large portion of that voltage is dropping across the poor connection. To prevent accidentally overlooking a potential fault it is critical that no unnecessary connections be included in this measurement.

NOTE: While measuring from exposed terminals is ideal, electronic backspooning into the component connector may be necessary. Use caution when installing electronic backspoons so that the connector, wire, pins, or sockets are not damaged. A multimeter test lead set, COM-19604, may be used to facilitate this step.

a) Connect the positive probe of thedigital/analog multimeter, COM-1793, as close as possible to the component on the upstream side of the circuit.

b) Connect the negative probe of the digital/analog multimeter, COM-1793, as close as possible to the component on the downstream side of the circuit.

2) Set the digital/analog multimeter, COM-1793, to measure AC or DC voltage as required.

3) Measure the voltage drop across the component. Apply power to actuate the component if necessary.

a) For most 28 VDC systems the voltage drop across the component should be >25 VDC.

b) For most 115 VAC systems the voltage drop across the component should be >109 VAC.

4) If the voltage drop measured is <0.005 V no voltage is present at the component:

a) An open or short exists in the circuit.

<1> Test the circuit using voltage drop or continuity testing as necessary to find where the open or short is located.

<2> If the open or short occurs in a wire, do the reflectometry testing to find the location of the fault.

5) If the voltage drop measured is below the appropriate value listed above:

a) High resistance may be present in the circuit.

<1> Compare the measurement with a similar circuit or review the circuit design to make sure that the voltage is not intended to be at this low level.

<2> If the voltage drop is indeed low locate the voltage loss in the circuit.

6) If the voltage drop across the component is above the applicable value listed above:

a) The circuit is delivering adequate power to the component.

(b) Testing voltage drop across a fixed connection.

1) Install a digital/analog multimeter, COM-1793, across the fixed connection (connection to ground, splice, electrical connector, etc.) with the electrical leads as close to the connection as possible. Refer to Voltage Drop Across Connections Example (Figure 203).

NOTE: Any connections which occur between the two leads of the DMM will have some amount of voltage drop. For example, in a ground connection if the positive meter probe is placed on the wire going in to the ring terminal and the negative meter probe is placed on the aircraft structure, the voltage drop measurement will include the resistance of the wire to ring terminal connection and the resistance of the ring terminal to ground connection. Move the meter leads as necessary to evaluate each connection if needed.

NOTE: While measuring from exposed terminals is ideal, electronic backspooning into the component connector may be necessary. Use caution when installing electronic backspoons so that the connector, wire, pins, or sockets are not damaged. A multimeter test lead set, COM-19604, may be used to facilitate this step.

a) Connect the positive probe of the digital/analog multimeter, COM-1793, as close as possible to the component on the upstream side of the circuit.

b) Connect the negative probe of the digital/analog multimeter, COM-1793, as close as possible to the component on the downstream side of the circuit.

2) Set the digital/analog multimeter, COM-1793, to measure AC or DC voltage as required.

3) Measure the voltage drop across the component. Apply power to actuate the component if necessary.

4) If the voltage drop across the connection exceeds 0.100V for AC or DC circuits:

a) High resistance is present in the connection.

NOTE: If desired, high resistance can also be confirmed using an appropriately sized bonding meter. Refer to SOPM SWPM 20-20-00. For wires larger than American Wire Gauge (AWG) 8 the Amptec 620LK or the T477W bonding meters are preferred. Smaller bonding meters lack an adequate power output for testing larger ground bonds.

5) If the voltage drop across the connection is less than 0.100V for AC or DC circuits the connection is in good condition.

6) Disconnect the digital/analog multimeter, COM-1793, from the circuit.

7) Repair any damaged connections that you find.

(c) Testing voltage drop across relay contacts.

1) Install a digital/analog multimeter, COM-1793, across the relay connection under test with the electrical leads as close to the connection as possible. Refer to Voltage Drop Across Connections Example (Figure 203).

NOTE: If the measurement cannot be taken directly at the relay base due to access, any connections which occur between the two leads of the DMM will have some amount of voltage drop. For example, the voltage drop measurement will include the resistance of any wire to pin connections, any pin to pin connections, and the resistance relay contacts themselves. Move the meter leads as necessary to evaluate each connection if needed.

NOTE: While measuring from exposed terminals is ideal, electronic backspooning into the component connector may be necessary. Use caution when installing electronic backspoons so that the connector, wire, pins, or sockets are not damaged. A multimeter test lead set, COM-19604, may be used to facilitate this step.

a) Connect the positive probe of the digital/analog multimeter, COM-1793, as close as possible to the component on the upstream side of the circuit.

b) Connect the negative probe of the digital/analog multimeter, COM-1793, as close as possible to the component on the downstream side of the circuit.

2) Set the digital/analog multimeter, COM-1793, to measure AC or DC voltage as required.

3) Measure the voltage drop across the component. Apply power to actuate the component if necessary.

NOTE: In order to do this test the relay contacts under test must be closed and at or near the designed operating current should be flowing through the contacts.

4) If the voltage drop across the relay contacts is not stable within 10 seconds, or does not repeat the same measurement within 1% after each cycle of the relay contacts, then the connection is poor or degraded.

5) If the voltage drop across the connection is stable within <10 seconds, and repeats within 1% with each cycle of the relay contacts, then the connection is in good condition.

6) Disconnect the digital/analog multimeter, COM-1793, from the circuit.

7) Repair any damaged connections that you find.

N. Reflectometry Inspection

SUBTASK 20-70-24-700-013

NOTE: The multi carrier time domain reflectometer, SPL-17763, and TDR, COM-23670, is used on de-energized circuits only and provides highly accurate distance-to-fault for even minor impedance changes. The spread spectrum time domain reflectometer, COM-19603, while not as accurate, is a simplified TDR simply displaying complete opens or shorts on both de-energized & energized circuits. The Tone probe included in the kit, COM-20963, is a hand-held Tone Probe attachment that traces individual wires and identify fault locations. This is helpful when identifying the exact location of an open wire or failed open relay contacts or limit switches, especially on series spliced switches. For an example, cargo Door circuits.

NOTE: Use the TDR Masking procedure to compare like wiring and identify areas of degradation, such as recessed pins, broken wiring strands, loose connections, that lead to intermittent opens and shorts in-flight.

(1) Make sure that no shorts or opens exist in the circuit as follows:

(a) Prior to using the multi carrier time domain reflectometer, SPL-17763, remove power from the circuit under test and disconnect the wires to be tested from the aircraft at each end.

1) Review the wiring diagram to ensure no branch circuits exist and that the circuit to be tested is isolated from the aircraft.

(b) Set up the multi carrier time domain reflectometer, SPL-17763, or spread spectrum time domain reflectometer, COM-19603, or TDR, COM-23670, as follows:

1) Select or enter the wire impedance which most closely matches the wire type to be tested.

NOTE: If the impedance of the wire to be tested is unknown select the most similar wire type from the list. Differences between the expected impedance and actual impedance will affect the resolution of test (ie. The height of spikes or dips in the signal) but will only prevent you from doing the test in extreme cases. As long as the impedance selected is within 25% of the actual wire impedance you may progress with the test.

2) Select or enter the wire VOP which most closely matches the wire type to be tested.

NOTE: If the VOP value of the wire to be tested is unknown select the most similar wire type from the list. Differences between the expected VOP and actual VOP will only affect the accuracy of the distance-to-fault function of the test, not the tests ability to detect the presence of a fault. The error in the distance to fault calculation will be directly proportional to the error in the VOP estimate. If you are off by 10% VOP the distance to fault will also be off by 10%. Significant time should not be lost trying to attain the exact VOP value as even wires produced by the same manufacturer under the same product specification can have minor variations.

(c) Test each wire in the circuit for opens or shorts as follows:

1) Note the approximate length of the wire under test.

2) Connect the positive lead of the multi carrier time domain reflectometer, SPL-17763, or spread spectrum time domain reflectometer, COM-19603, or TDR, COM-23670, to the wire under test.

3) Connect the negative lead of the multi carrier time domain reflectometer, SPL-17763, or spread spectrum time domain reflectometer, COM-19603, or TDR, COM-23670, to any parallel return path. For an example, the wire's shield, another wire in the same bundle, or in the case of a short to structure, you may use aircraft ground.

NOTE: To ensure the most accurate fault location and to prevent false opens or shorts near the start of the measurement, ensure the TDR test leads are wrapped together and/or not separated by more than 3 inches. The return path selected needs to be the same length as the wire under test and remain within 3 inches from the wire under test along the entire run. If the return path is shorter or longer than the wire under test a jumper wire may be used to match the two lengths so long as the jumper wire observes the 3 inch separation requirement above. When separation exceeds 3 inches the TDR signal is significantly attenuated (weakened) decreasing the resolution of the test and limiting the maximum length of wire which can be tested. Greater separation may be possible for short wires with the above effect in mind.

4) Start the test.

5) Evaluate the TDR scan as follows (Refer to Figure 204):

NOTE: Simplified TDR tools such as the spread spectrum time domain reflectometer, COM-19603, may only display "OPEN" or "SHORT" and distance to fault rather than the full graphical display described in this step. The spread spectrum time domain reflectometer, COM-19603, may also be used on energized circuits to show distance to opening/closing relay or limit switch contacts during system operation. This is helpful to find the location of series connected relays and switches. For an example, Cargo Door circuits.

a) Note the spike where the wire under test connects to the test cable.

NOTE: Refer to the tool manufacturer's manual to determine if the tool automatically accounts for the length of the test lead when making distance to fault calculations. It may be necessary to subtract out the length of the test cable from the distance to fault.

b) If the wire is shielded, note the dip where the shielding starts.

NOTE: If the shielding is cut back, this dip will be moved to the right a corresponding distance.

6) Start the intermittent fault test on the multi carrier time domain reflectometer, SPL-17763, or have another technician monitor SSTDR.

7) Work from one end of the wire under test to the other manually disturbing (shaking) the harness as you go.

8) Review the recorded continuity data.

a) There should be no intermittent faults recorded during the test.

b) If a fault is found, continue disturbing the wire under test in the area shown by the distance-to-fault function until the fault is located.

NOTE: Use the Tone Probe included in the kit, COM-20963, to further isolate the exact wire and location. The Tone probe will detect the end of the open wire, relay contact or switch, but an intermittent short circuit is not detected while hard shorted. It will identify the short circuit location only when shaking the circuit open. Go to distance-to-short location identified on TDR, then use the tone and probe in this area while shaking. The tone will appear when the open wire, relay contact or switch is detected.

9) Repair any faults that you find.
10) Disconnect the multi carrier time domain reflectometer, SPL-17763, from the circuit.
11) Reconnect the circuit to the airplane (Refer to the appropriate WDM).
12) Do an operational check of the system(s) which was/were disturbed.

O. Automated Intermittent Fault Detection & Integrity Test

SUBTASK 20-70-24-700-015

(1) Do an Automated Intermittent Fault Detection using Voyager FC.

NOTE: Most intermittent faults randomly occur during engine operation or in-flight and do not occur during a ground test. Thus, if wet, cold or heavy vibration conditions applied to a wire bundle are too much, a fault can occur. A wire bundle that has damage because of airplane pressurization can also give a fault condition.

NOTE: To help locate the fault on the ground, this automated tester self-maps the circuit when connected. It will do simultaneous and continuous intermittency tests on a maximum of 512 test points, which can include connector pins. The unit tests wiring, relays, circuit breakers, connectors, terminal blocks, and passive components. The unit detects permanent and intermittent shorts, opens, instability and Electro-Magnetic Interference (EMI) events occurring down to 50 nS.

(a) Prepare for testing by de-energizing the applicable circuit to be tested.
(b) Review the WDM to ensure the intermittent fault detector, COM-20952, is isolated from any voltage.
  1) Pay special attention to all terminal blocks and splices for circuit under test.
(c) Examine the electrical connectors for bent or broken pins/sockets, dirt, moisture and damage.
(d) Install conductive dust cap and connector cover on the applicable LRUs.
(e) Connect the intermittent fault detector, COM-20952, to the aircraft wiring under test as follows:
  1) Follow the intermittent fault detector, COM-20952, operator’s manual to set up for testing.
  2) Follow power on procedures for the intermittent fault detector, COM-20952, and prepare to perform automapping.
(f) Do the Voyager Automap procedure and verify automap matches current aircraft circuit configuration.
(g) Examine passive LRUs (e.g. relay and actuator coils) resistance readings to Aircraft Maintenance Manual (AMM)/Fault Isolation Manual (FIM)/CMM specifications.
(h) If all indications are good, shake or stress applicable airplane wiring by:
  1) Manually shaking harness
  2) Pressurizing airplane
  3) Operating Flight Control.
(i) If all indications are good, the circuit(s) is correct.
(j) Disconnect the intermittent fault detector, COM-20952, from the aircraft.
(k) Install all disconnected connectors (Refer to the appropriate WDM).
(l) Do an operational check of the system(s) that were disconnected.

Figure 201 Component Load Testing (Example)

--------- END OF CONTENT ---------

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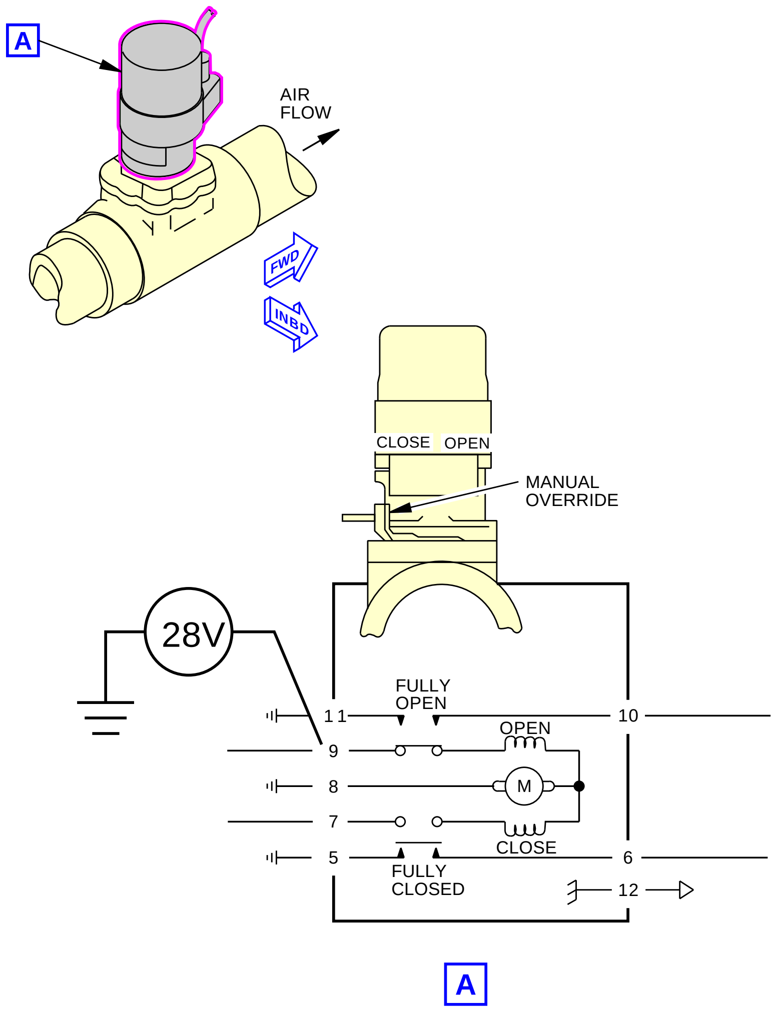
INTERMITTENT FUNCTION OF AN AIR SHUTOFF VALVE IS REPORTED. UPON INSPECTION IT'S FOUND THAT THE VALVE INTERMITTENTLY FAILS TO GET TO THE COMMANDED POSITION. IF VOLTAGE DROP ACROSS THE VALVE ACTUATOR IS MEASURED FROM PIN 9 TO AIRCRAFT GROUND, THE DMM INDICATES 28 VDC.



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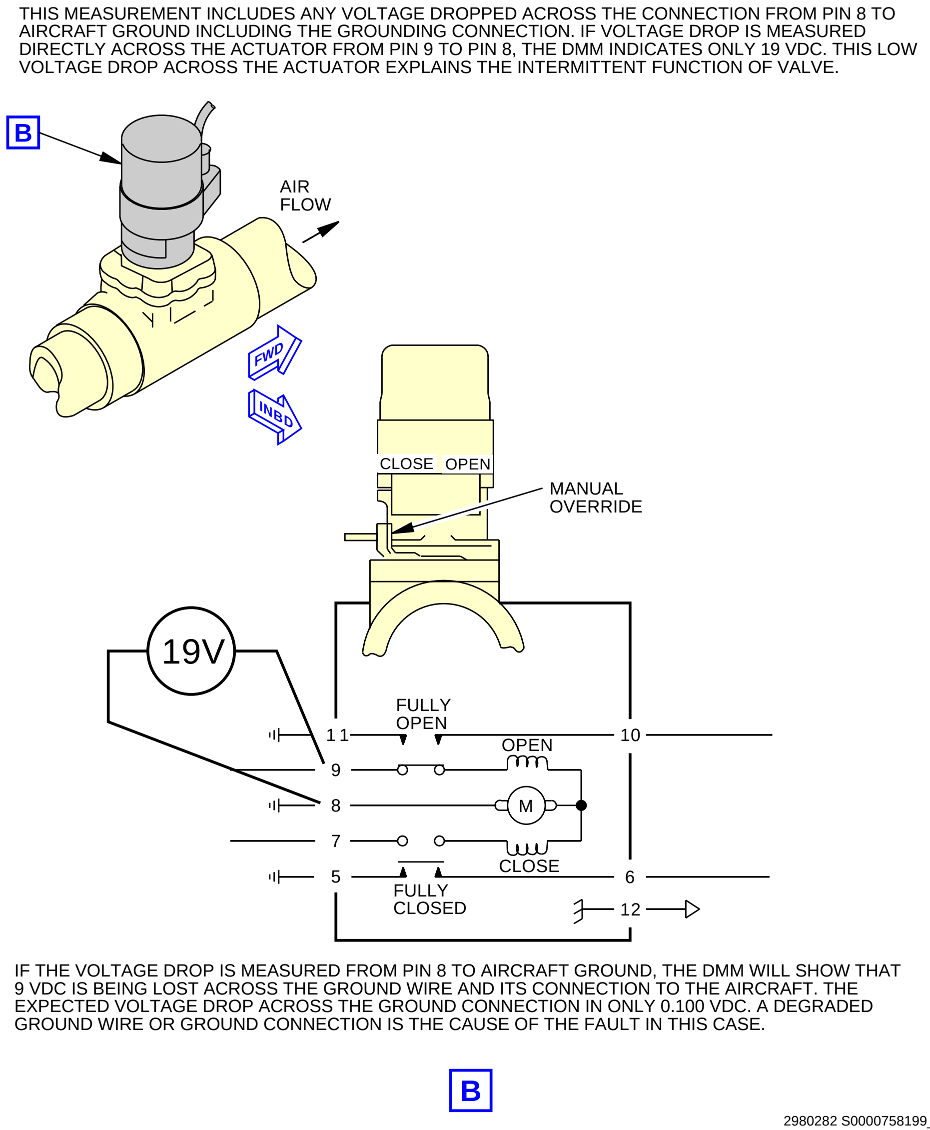
Component Load Testing (Example)
Figure 201/20-70-24-990-801 (Sheet 1)
Graphic Rev Date: 15 Sep 2021



Component Load Testing (Example)
Figure 201/20-70-24-990-801 (Sheet 2)
Graphic Rev Date: 15 Sep 2021

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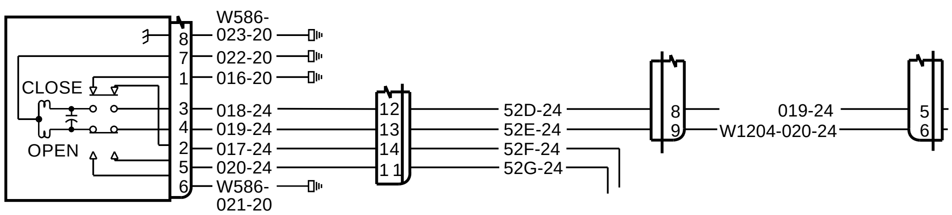

INTERMITTENT FUNCTION OF AN AIR SHUTOFF VALVE IS REPORTED. UPON INSPECTION IT IS FOUND THAT THE VALVE INTERMITTENTLY FAILS TO ACHIEVE THE COMMANDED POSITION. FOR THIS EXAMPLE ASSUME IT IS IMPRACTICAL TO LOAD TEST THE CIRCUIT USING AIRCRAFT POWER. AS AN ALTERNATE TO AIRCRAFT POWER THE CIRCUIT CAN BE LOAD TESTED USING A POWER SUPPLY AND VOLTAGE DROP TEST SET FOLLOWING THE STEPS OUTLINED IN THIS PROCEDURE.

2980283 S0000758196_V1

Load Testing Using a Power Supply (Example)
Figure 202/20-70-24-990-802 (Sheet 1)
Graphic Rev Date: 15 Sep 2021

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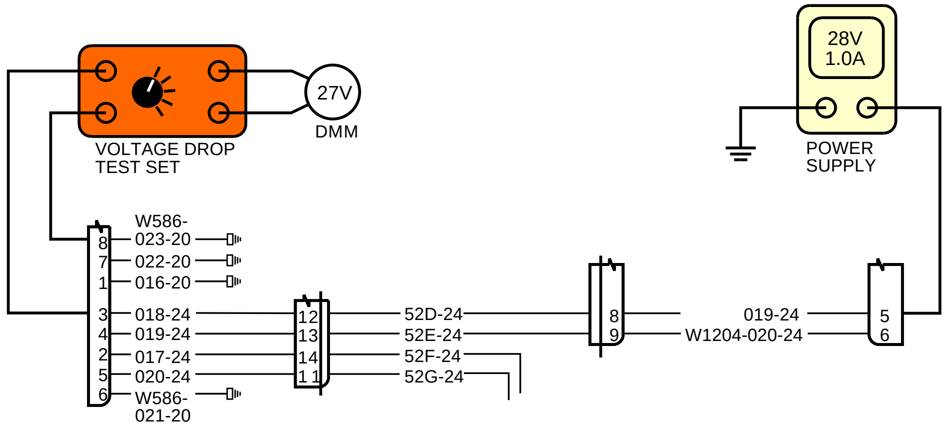
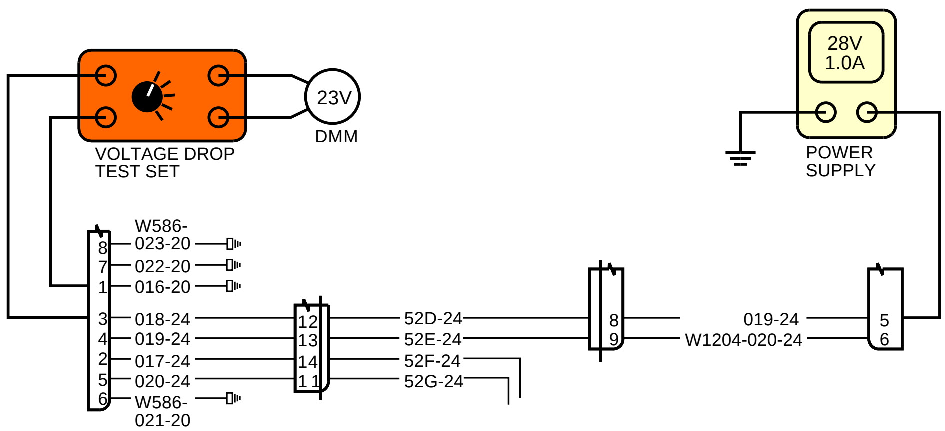


WHEN THE LOAD IS CONNECTED TO THE GROUND AT PIN 8 ABOVE, 27 VDC IS MEASURED ACROSS THE LOAD INDICATING THAT THE CIRCUIT BETWEEN THE POWER SUPPLY AND THE GROUND AT PIN 8 IS IN GOOD CONDITION. HOWEVER, WHEN THE LOAD IS CONNECTED TO THE GROUND AT PIN 1 BELOW, ONLY 23 VDC IS MEASURED ACROSS THE LOAD INDICATING THAT 4 VDC IS BEING LOST SOMEWHERE IN THE CIRCUIT BETWEEN THE POWER SUPPLY AND THE GROUND AT PIN 1.



SINCE WE KNOW THE CIRCUIT BETWEEN THE POWER SUPPLY AND THE VOLTAGE DROP TEST SET IS GOOD FROM THE FIRST TEST ABOVE, WE CAN CONCLUDE THE 4 VDC LOSS IS OCCURRING SOMEWHERE BETWEEN PIN 1 AND ITS ASSOCIATED GROUND CONNECTION. IN THIS EXAMPLE, DOING A VOLTAGE DROP INSPECTION OF THE CONNECTIONS FOUND THAT PIN 1 HAD BEEN POORLY CRIMPED TO THE GROUND WIRE RESULTING IN HIGH RESISTANCE.

2980284 S0000758198_V1

Load Testing Using a Power Supply (Example)
Figure 202/20-70-24-990-802 (Sheet 2)
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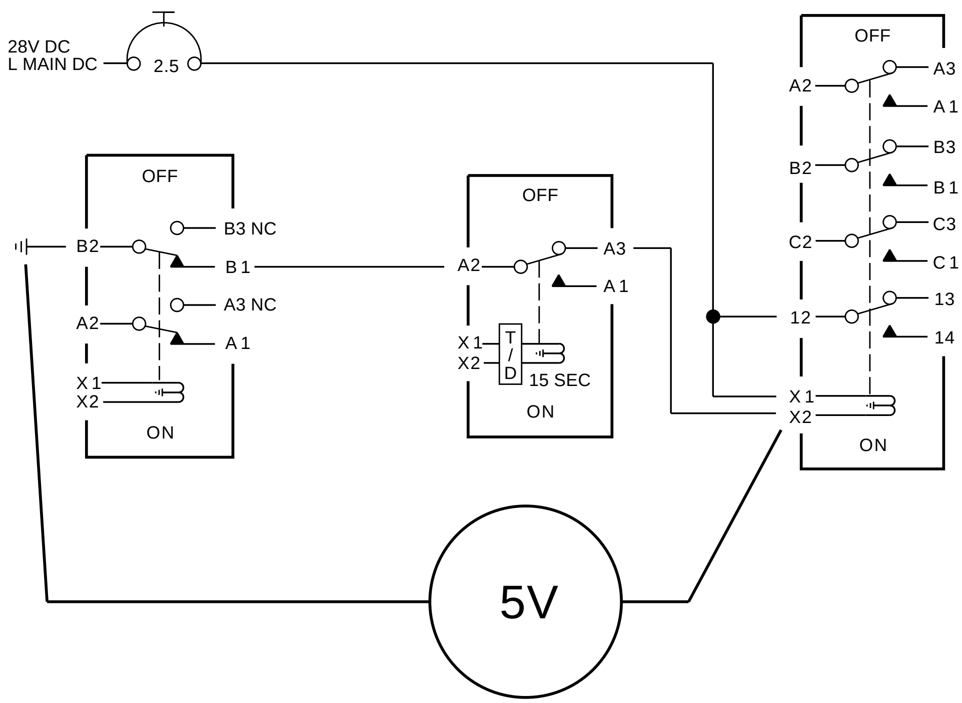
INTERMITTENT LOW FUEL PRESSURE WARNINGS REPORTED ON A FUEL JETTISON PUMP. UPON INSPECTION THE PUMP IS FOUND TO INTERMITTENTLY CUT OUT.



WHEN VOLTAGE DROP FOR THE ENTIRE GROUND CIRCUIT OF THE 3-PHASE CONTROL RELAY IS MEASURED IT IS FOUND TO BE 5 VDC. THIS INCLUDES THE VOLTAGE DROP ACROSS ALL CONNECTIONS BETWEEN THE DMM LEADS.

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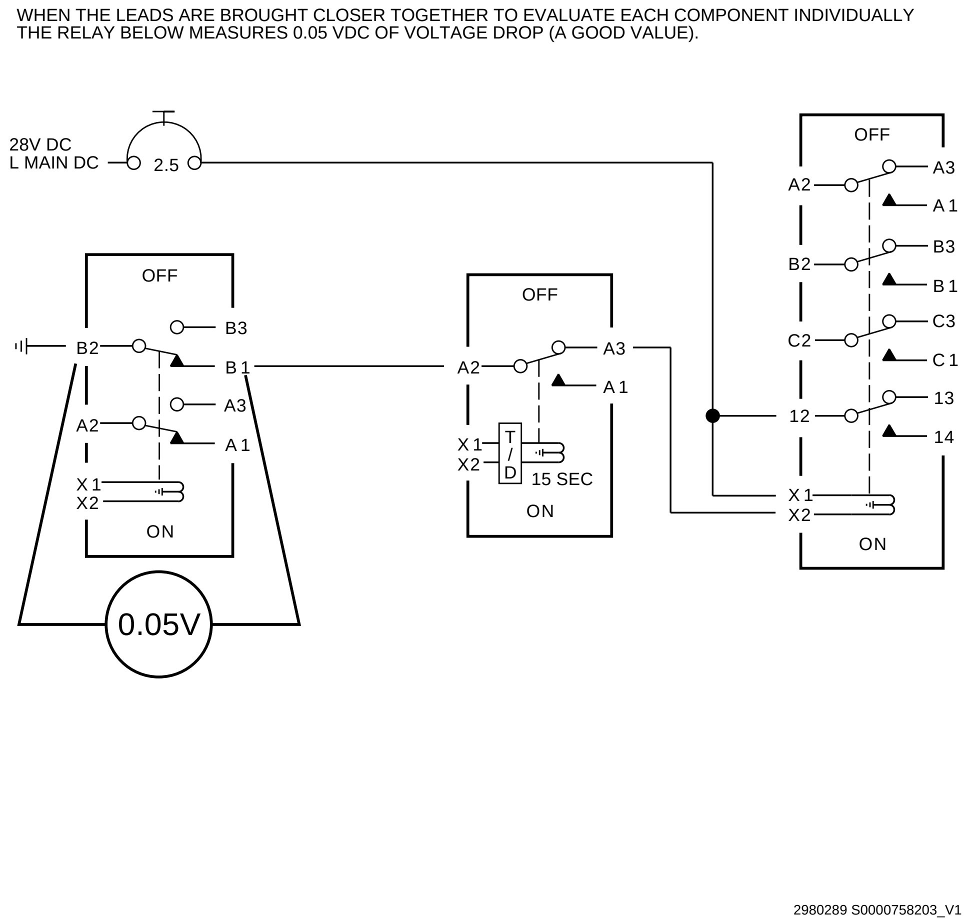
Voltage Drop Across Connections (Example)
Figure 203/20-70-24-990-803 (Sheet 1)
Graphic Rev Date: 15 Sep 2021



Voltage Drop Across Connections (Example)
Figure 203/20-70-24-990-803 (Sheet 2)
Graphic Rev Date: 15 Sep 2021

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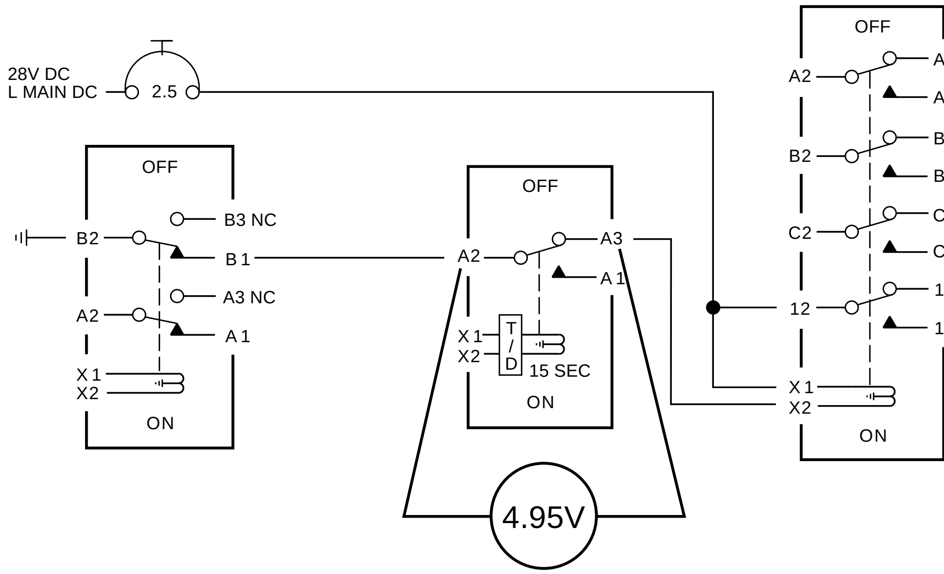

THE RELAY ABOVE MEASURES 4.95 VDC (A BAD VALUE). IN THIS EXAMPLE, DAMAGED RELAY CONTACTS WERE CAUSING AN EXCESSIVE VOLTAGE DROP ACROSS THE RELAY. THIS EXCESSIVE DROP ACROSS THE RELAY REDUCED THE AMOUNT OF VOLTAGE AVAILABLE TO ENERGIZE THE COIL OF THE 3-PHASE RELAY ALLOWING IT TO INTERMITTENTLY RELAX.

NOTE:

IF THE VOLTAGE DROP ACROSS A RELAY IS MEASURED BY BACKPROBING, THIS VOLTAGE DROP INCLUDES THE DROP ACROSS THE RELAY CONTACTS BUT ALSO THE VOLTAGE DROP ASSOCIATED WITH ANY PIN CONNECTIONS IN THE BASE ITSELF. BY REPLACING THE RELAY AND RETESTING IT CAN BE VERIFIED THAT THE VOLTAGE DROP WAS DUE TO THE RELAY AND NOT THE BASE.

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Voltage Drop Across Connections (Example)
Figure 203/20-70-24-990-803 (Sheet 3)
Graphic Rev Date: 15 Sep 2021

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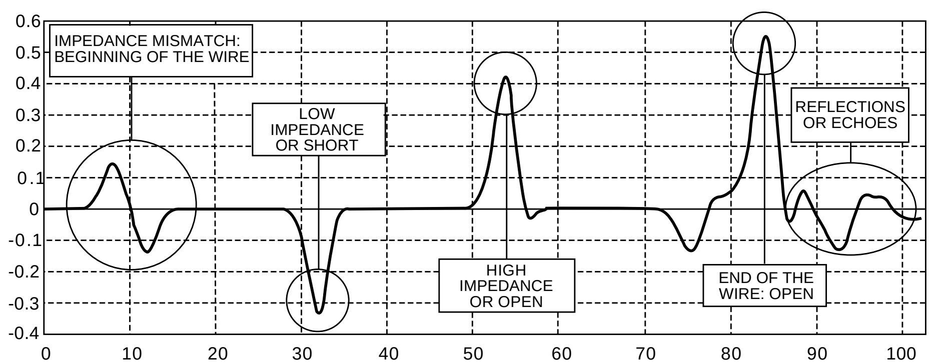

TDR Scan (Example)
Figure 204/20-70-24-990-804 (Sheet 1)
Graphic Rev Date: 15 Sep 2021

EXAMPLE:

USING A POWER SUPPLY SET TO SUPPLY 28 VDC AT 1 AMP AND A VOLTAGE DROP TEST SET SET TO A 1 AMP LOAD THE MEASURED VOLTAGE DROP ACROSS THE LOAD IS FOUND TO BE 27 VDC. THIS MEANS THAT 1 VDC IS LOST IN THE CIRCUIT. IF THE NORMAL OPERATING CURRENT FOR THE CIRCUIT IS 10 AMPS THE VOLTAGE LOSS UNDER OPERATING CONDITIONS CAN BE CALCULATED AS FOLLOWS:

USING OHMS LAW IT CAN BE SHOWN THAT A 1 VDC LOSS AT 1 AMP EQUATES TO AN EQUIVALENT RESISTANCE OF 1 OHM IN THE CIRCUIT. THIS RESISTANCE COULD BE PRIMARILY LOCATED AT A SINGLE CONNECTION OR SPREAD OUT OVER MULTIPLE CONNECTIONS.

$$V = IR \rightarrow R = \frac{V}{I}$$

$$R = \frac{1\ \text{VDC}}{1\ \text{AMP}} = 1\ \text{OHM}$$

IF WE THEN MULTIPLY THE RESISTANCE WE CALCULATED FOR THE CIRCUIT BY THE OPERATING CURRENT OF THE CIRCUIT THE LOSS UNDER OPERATING LOAD IS FOUND TO BE 10 VDC! THIS IS A SIGNIFICANT LOSS WHICH WILL ALMOST CERTAINLY CAUSE INTERMITTENT OPERATION OF THE SYSTEM. ADDITION TROUBLESHOOTING SHOULD BE ACCOMPLISHED TO DETERMINE THE SOURCE OF THIS VOLTAGE LOSS.

$$V = IR$$

$$V = 10\ \text{AMPS} \times 1\ \text{OHM} = 10\ \text{VDC}$$

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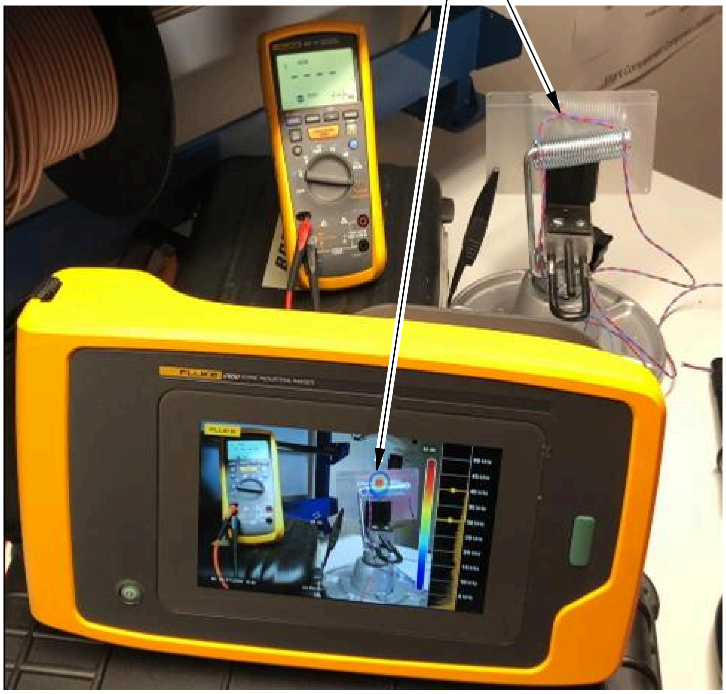
Calculating Voltage Drop (Example)
Figure 205/20-70-24-990-805 (Sheet 1)
Graphic Rev Date: 15 Sep 2021

SHORT CIRCUIT
VISUAL DETECTION



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Insulating Resistance check with Acoustic Digital Camera
Figure 206/20-70-24-990-806 (Sheet 1)
Graphic Rev Date: 15 Sep 2021

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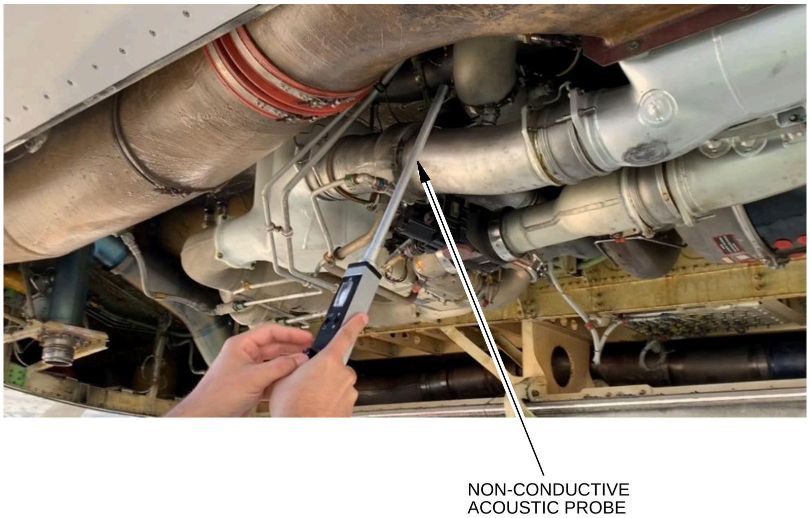

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Insulating Resistance check with Ultrasonic Leak Probe
Figure 207/20-70-24-990-807 (Sheet 1)
Graphic Rev Date: 15 Sep 2021

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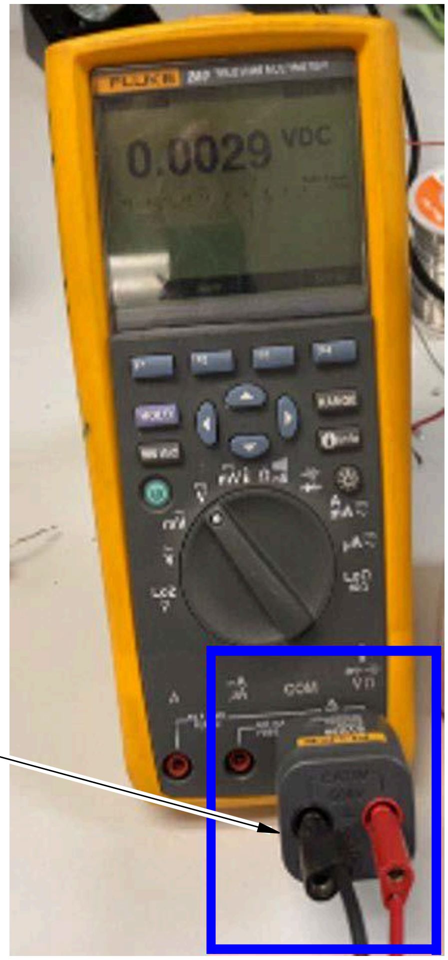
STRAY VOLTAGE ELIMINATOR



(EXAMPLE)

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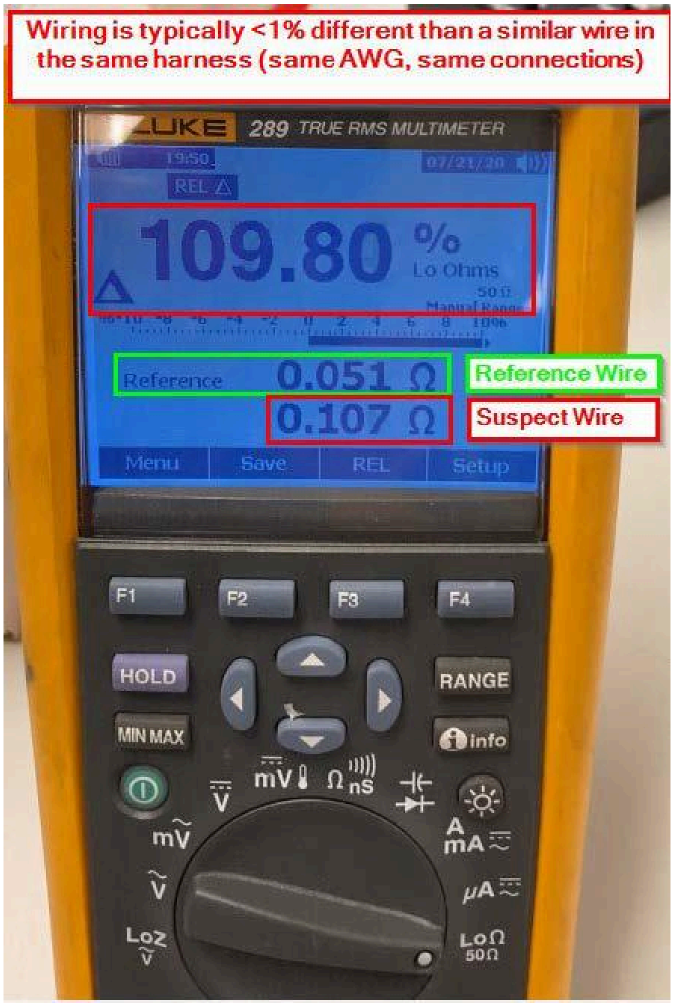
Stray Voltage Eliminator
Figure 208/20-70-24-990-808 (Sheet 1)
Graphic Rev Date: 15 May 2024



(EXAMPLE)

3060607 S0000823876_V1

Low Resistance Test
Figure 209/20-70-24-990-809 (Sheet 1)
Graphic Rev Date: 15 May 2024

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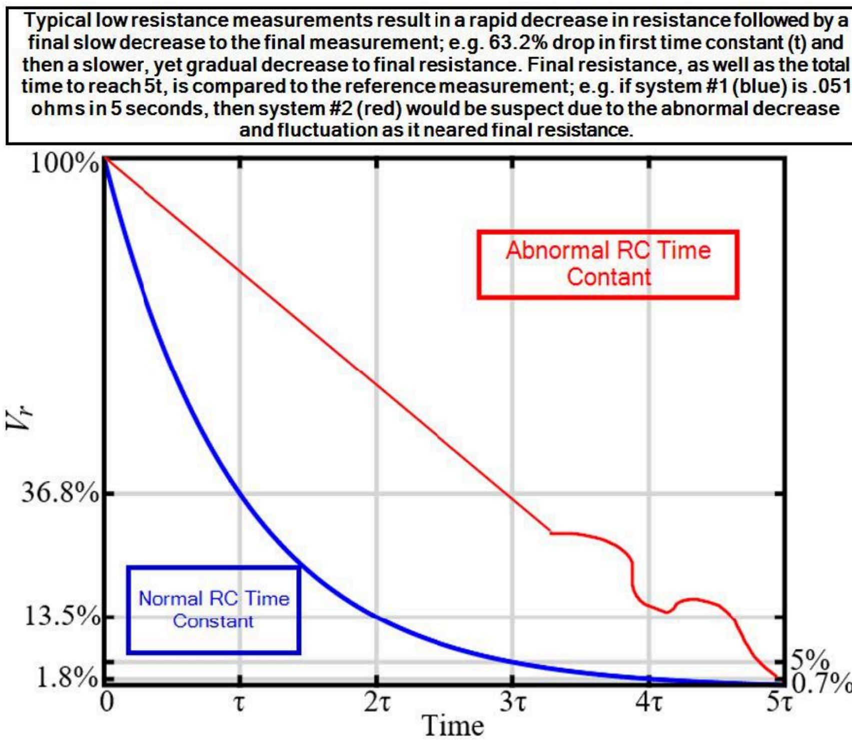

(EXAMPLE)

3060608 S0000823877_V1

Low Resistance Test
Figure 209/20-70-24-990-809 (Sheet 2)
Graphic Rev Date: 15 May 2024

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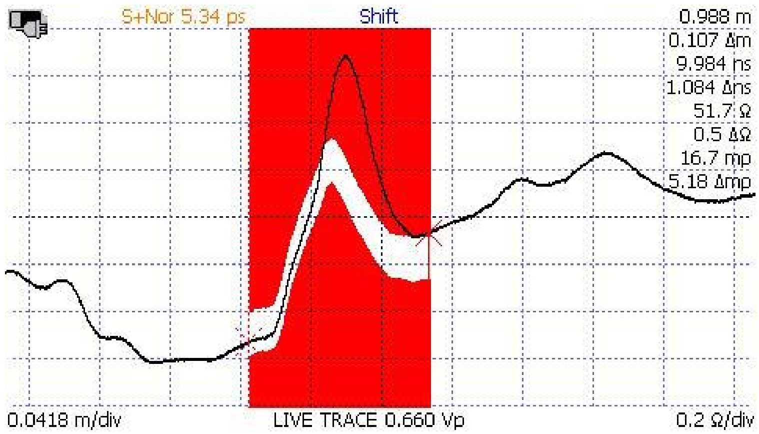
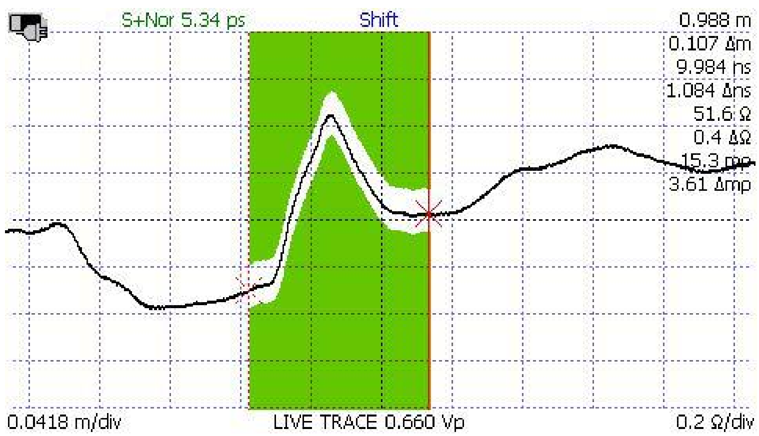


A TRACE THAT FAILS THE MASK TEST.
(EXAMPLE)



A TRACE THAT PASSES THE MASK TEST.
(EXAMPLE)

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MOHR TDR Mask
Figure 210/20-70-24-990-810 (Sheet 1)
Graphic Rev Date: 15 May 2024