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DEPARTMENT OF DEFENSE HANDBOOK

GUIDELINES FOR TROUBLESHOOTING OF AIRCRAFT ELECTRICAL WIRING AND INTERCONNECT SYSTEMS (EWIS)

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FOREWORD

1. This handbook is approved for use by all Departments and Agencies of the Department of Defense.

2. This handbook is a guide for Aircraft Electrical Wiring Interconnect System (EWIS) troubleshooting. In the case of conflict between the aircraft/platform-specific maintenance manual and this handbook, the platform-specific manual will take precedence. Not all possible wire systems' factors have been addressed. This handbook captures in one document, under a suitable subject heading, fundamental troubleshooting criteria guidelines. The opportunity to focus on a single document results in substantial savings to the Government.

3. All aircraft are filled with miles of wiring and hundreds of devices that connect and transfer power and signals to and from electrical components. Virtually all aircraft systems rely heavily on some type of wiring for safe operation. Much like the structural components of an aircraft, the health and integrity of the EWIS can be significantly compromised due to premature aging, damage, and failure of wiring insulation. It is integral to the overall maintenance and sustainment of all aircraft that the EWIS be treated as a system, and as a system be afforded the same level of importance as the aircraft structure and other critical flight control systems.

4. Factors that may contribute to premature aging, damage, and failure of EWIS, include but are not limited to:

a. Frequency of handling.

b. Mishandling/Improper installation.

c. Poor maintenance practices.

d. Contamination.

f. Wire/Bundle location (Severe Wind and Moisture Problem (SWAMP) Areas).

g. Temperature cycling.

h. Lack of and utilization of effective inspection and maintenance training.

5. This handbook was prepared by, and is regularly updated through, the cooperative efforts of Government and industry. Applicable documents are listed in each guideline. Additional information regarding aerospace vehicle wiring requirements is found in SAE AS50881, "Aerospace Vehicle Wiring."

6. When a Joint Service manual is referenced throughout this document, the Navy equivalent is listed in each guideline. See 2.5 for information on how to obtain copies of maintenance manuals referenced in this handbook.

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7. Comments, suggestions, or questions on this document should be addressed to Commanding Officer, Naval Air Warfare Center Aircraft Division Lakehurst, System Standardization and PHS&T Branch, Code BL32600, Mail Stop 120-3, Route 547, Joint Base MDL, NJ 08733-5100 or emailed to LKE-NAVAIRDocComments.fct@navy.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST online database at https://assist.dla.mil. The technical content in this handbook has been provided by NAVAIR Wiring Systems Branch (48298 Shaw Road Bldg. 1461, Patuxent River, MD 20670-1161) through the Joint Service Wiring Action Group (JSWAG) email: jswag@navy.mil; website https://www.navair.navy.mil/jswag/.

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1. SCOPE

1.1 Guidelines applicable to aircraft Electrical Wiring Interconnect Systems (EWIS). This handbook provides guidance and lessons learned in the troubleshooting of EWIS. This handbook is for guidance only and cannot be cited as a requirement.

1.2 Purpose. This handbook is intended to provide a technician with ideas on how a given circuit may be tested and what type of test equipment might be used to perform the test. This handbook is not intended to be directive in nature or to cover every specific test set.

1.3 Precedence. This handbook was developed only to supplement EWIS troubleshooting techniques. As such, the use of all or parts of the content herein does not supersede or replace the technical manuals that govern the applicable platform, system, or component. In the event of a conflict between this handbook and the documents listed in 1.3.a through 1.3.e, the documents listed below take precedence over the information given in this handbook. The order of precedence is as follows (refer to applicable manuals for identified order of precedence):

a. Platform-specific manuals

b. System specific manuals

c. Test equipment manuals

d. General Series manuals

e. This handbook

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed below are not necessarily all of the documents referenced herein but are those needed to understand the information provided by this handbook.

2.2 Government documents.

2.2.1 Specification. The following specifications form a part of this document to the extent specified herein.

DEPARTMENT OF DEFENSE SPECIFICATION

MIL-PRF-32516	-	Electronic Test Equipment, Intermittent Fault Detection and Isolation for Chassis and Backplane Conductive Paths.

(Copies of military documents are available online at https://quicksearch.dla.mil.)

2.2.2 Other Government documents, drawings, and publications. The following other Government document forms a part of this document to the extent specified herein.

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NAVAIR 01-1A-505-1 WP 013 00 - Contacts and Terminals

(Copies this maintenance manual work package is available online at https://mynatec.navair.navy.mil/)

2.3 Non-Government publications.

This section is not applicable to this handbook.

2.4 Individual guidelines. See section 2 of each guideline for a listing of applicable documents. Documents referenced in the individual documents apply to the extent that they are cited herein. (Copies of military documents are available online at https://quicksearch.dla.mil.)

2.5 Copies of maintenance manuals. Copies of maintenance manuals NAVAIR 01-1A-505-1 through -4 (for U.S. Air Force Users, TO 1-1A-14; for U.S. Army Users, TM 1-1500-323-24-1), may be obtained by DoD employees and uniformed users by going to the NATEC site https://mynatec.navair.navy.mil/ using their Common Access Card (CAC) to access the documents. Commercial entities requesting copies of these documents should reference this site for maintenance manual access via the Freedom of Information Act requests.

2.6 Industry addresses. Addresses for obtaining documents referenced in the guidelines but not obtainable from the Government are as follows:

National Electrical Manufacturers Association (NEMA)
1300 North 17th Street Suite 1752
Roslyn, Virginia 22209
Online: http://www.nema.org

Society of Automotive Engineers (SAE)
400 Commonwealth Drive
Warrendale, PA 15096-0001 USA
Online: http://www.sae.org

3. ACRONYMS AND DEFINITIONS

3.1 Acronyms. The following acronyms are applicable to this handbook.

A	Ampere (amps)
AC	Alternating current
AIR	Denotes aviation for terminal lugs (see NAVAIR 01-1A-505-1 WP 013 00)
AS	Aerospace Standard
AWG	American Wire Gauge
BIN	Basic Identification Number
°C	Degrees Celsius
CAC	Common Access Card

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CAGE	Commercial and Government Entity
CAT	Overvoltage Electrical Category Rating
CB	Circuit Breaker
CEA	Cognizant Engineering Authority
COM	Common
CPC	Corrosion Prevention (or Preventive) Compound
CPR	Cardiopulmonary Resuscitation
DC	Direct current
DMM	Digital Multimeter
DoD	Department of Defense
DVI	Detailed Visual Inspection
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
EWIS	Electrical Wiring Interconnect (or Interconnection) System
°F	Degrees Fahrenheit
FOD	Foreign Object Damage
FST	Fleet Support Team
GND	Ground
HAWT	Handheld Aircraft Wire Tester
GVI	General Visual Inspection
Hz	Hertz (1 cycle/sec). Frequency
JSWAG	Joint Services Wiring Action Group
kHz	Kilohertz (1,000 cycles/sec). Frequency
k Ω	Kilohm (1,000 ohms). Resistance
LRU	Line Replaceable Unit
MAF	Maintenance Action Form
MDL	McGuire-Dix-Lakehurst
MIL-DTL	Military Detail Specification
MIL-HDBK	Military Handbook
MIL-PRF	Military Performance Specification
MIM	Maintenance Instruction Manuals
mA	Milliampere (0.001 amps)
M Ω	Megohm (1,000,000 ohms) Resistance
mV	Millivolts (0.001 volts)
NATEC	Naval Air Technical Data and Engineering Service Center
NAVAIR	Naval Air Systems Command
NEG	Negative
nf	Nanofarads (0.000000001 Farads). Capacitance
nS	Nanosiemens (0.000000001 siemens). Conductance (1/ Ω)
NSN	National Stock Number
PPE	Personal Protective Equipment
POS	Positive
QPL	Qualified Products List
RF	Radio Frequency
RFI	Radio Frequency Interference.
RTP	Reference Test Point

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SAE	Society of Automotive Engineers
SE	Support Equipment
SWAMP	Severe Wind and Moisture Problem
TDR	Time Domain Reflectometer
TM	Technical Manuals
TP	Circuit Test Points
WP	Work Package
WO	Work Order
WRA	Weapons Replaceable Assembly
µA	Microampere (0.000001 amps)
µF	Microfarads (0.000001 Farads). Capacitance
%	Percent Annunciator (for duty cycle readings only)
Ω	Ohms. Resistance

3.2 Definitions. The following definitions are applicable to this handbook.

3.2.1 Accuracy. An instrument's degree of veracity - how close its measurement comes to the actual or reference value of the signal being measured.

3.2.2 Airborne, space, aerospace. "Airborne" denotes those applications peculiar to aircraft and missile or other systems designed for operation primarily within the earth's atmosphere; "space" denotes application peculiar to spacecraft and systems designed for operation near or beyond the upper reaches of the earth's atmosphere; and "aerospace" includes both airborne and space applications.

3.2.3 Bend radius. The maximum amount a wire, cable, fiber, or fiber cable can be bent without causing damage to the wire, fiber, or fiber cable. Usually called minimum safe bending radius.

3.2.4 Circuit test points (TP). The conductive point(s) associated with the circuit under test where the leads of test equipment, such as the Digital Multimeter (DMM) meter leads, are electrically attached.

3.2.5 Circuit under test. The circuit being checked to determine if it has a fault or discrepancy.

3.2.6 Coaxial (coax) cable. Cable consisting of two cylindrical conductors with a common axis. The two conductors are separated by a dielectric. The outer conductor or shield, normally at ground potential, acts as a return path for current flowing through the center conductor and prevents energy radiation from the cable. The outer conductor is commonly used to prevent external radiation from affecting the current flowing in the inner conductor. The outer conductor consists of woven strands of wire, a metal sheath or foil wrap.

3.2.7 Connector. Describes all interface devices, either plug or receptacle, used to provide rapid connect/disconnect service for electrical cable and wire interconnections. A fixed connector is used for attachment to a rigid surface and mates with a matching plug or receptacle

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connecting electrical wire and cable. Free connectors perform the same function as fixed connectors but are not attached to a rigid surface. In military applications, connections generally fall into three broad categories: single contact coaxial connectors, circular multi-contact connectors, and rectangular multi-contact connectors.

3.2.8 Continuity. The presence of a complete path for current flow. The opposite of continuity is discontinuity (see discontinuity).

3.2.9 Continuity Check/Test. A rapid test to determine if a circuit has continuity. A standard feature found on most DMM models uses a preset resistance range and an indicating device (such as an audible beeper) to signal when continuity is detected. Not to be confused with a resistance measurement.

3.2.10 Cognizant Engineering Authority (CEA). The platform support engineering services. For the Navy and Marine Corps, the CEA is the Fleet Support Team (FST).

3.2.11 Discrepancy. A clearly identifiable deviation from the original design of the system as identified in the source data.

3.2.12 Discontinuity. The absence of continuity, or an incomplete path where current cannot flow.

3.2.13 Downstream. The point on a circuit further from the power source when compared to another point on the same circuit. See definition for Upstream.

3.2.14 Electrical conductivity (σ). The degree to which a specified material conducts electricity, calculated as the ratio of the current density in the material to the electric field that causes the flow of current. It is the reciprocal of resistivity. The symbol is to denote the Stefan–Boltzmann constant. In relation to the fundamental properties of material, σ is often used to signify electrical conductivity.

3.2.15 Electrical resistivity (ρ). Resistance of a conductor of unit cross-sectional area and unit length. A characteristic property of each material, resistivity, is useful in comparing various materials on the basis of their ability to conduct electric currents. High resistivity designates poor conductors.

3.2.16 Electrical Wiring Interconnect System (EWIS). Known as aircraft wiring, EWIS is defined as any wire, fiber optic link, wiring or fiber device, or a combination of these items (including terminations) installed in any area of the aircraft for the purpose of transmitting electrical energy, signals, or data between two or more electrical end points.

3.2.17 Electromagnetic Interference (EMI). The disruption of the operation of an electronic device when it is in the vicinity of an electromagnetic field that is caused by another electrical or electronic device. There is a wide range of frequencies at which EMI can occur. Shielding materials for the entire EMI spectrum are not readily available.

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3.2.18 Environmentally sealed. A device that is provided with gaskets, seals, grommets, potting, or other means to keep out moisture, dirt, air, or dust which might reduce performance. Does not include non-physical environments such as Radio Frequency (RF) and radiation.

3.2.19 Grommet. A rubber ring or tube through which wires pass. Grommets can be used to provide sealing around wires where they enter a connector or to provide mechanical protection for wires where they pass through a hole in a structure.

3.2.20 Ground (GND). An electrical ground point that has been identified in the wiring schematic as such. See guideline 9 for more information.

3.2.21 Harness. Assembly of wires or cables arranged so they may be installed or removed as a unit.

3.2.22 Intermittent faults. Discrepancies that occur at irregular intervals, not continuous or steady. Intermittent faults may have external forces that contribute to the condition, such as temperature, vibration, moisture, etc. Recreating the condition is typically required to identify intermittent faults. Most commonly associated with intermittent opens and intermittent shorts (see MIL-PRF-32516).

3.2.23 Lacing tape. Flexible, flat fabric tape for tying harnesses and wire bundles, securing sleeves and other items, and general lacing and tying applications. Available in various materials and impregnates.

3.2.24 Open. An incomplete electrical circuit in which there is no current flow. An open can be intentional or designed into the circuit (such as a switch or relay, etc.) or unintentional (such as a broken conductor or blown light bulb, etc.). A tripped circuit breaker or blown fuse creates an open for circuit protection purposes. The terms “open,” “electrical open,” and “open circuit” are used synonymously in this handbook when referring to open circuits.

3.2.25 Plating. Overlaying of a thin coating of metal on metallic components to improve conductivity, provide for easy soldering, or prevent rusting or corrosion.

3.2.26 Polyimide. A trademark of the DuPont Company for their polyimide resin film used as wire insulation. Polyimide (Kapton™) was a popular aircraft wiring insulation from the 1960s through the early 1990s because of its excellent mechanical properties at high temperatures, light weight, low smoke generation, and low flammability. However, weathered polyimide was found to have a high risk of arcing due to hydrolysis (degradation caused by water absorption) and carbon arc tracking (self-propagation of arc faults along the surface of the insulation). Kapton™ polyimide film is transparent and is amber in color. An opaque top coat is applied to provide different colors of wire and a surface for wire printing. Kapton™ wire has poor life characteristics and is no longer recommended for Navy aircraft.

3.2.27 Pouillet’s law. The resistance of a given material will increase with the length but decrease with increasing cross-sectional area.

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3.2.28 Precision. An instrument's degree of repeatability - how reliably it can reproduce the same measurement over and over.

3.2.29 Range. The upper and lower limits that a DMM can measure a value or signal such as amps, volts, and ohms.

3.2.30 Reference Test Point (RTP). The conductive point(s) on an electrical circuit (s) that have been verified operational (known good) and are used to aid in taking measurements or performing checks. Reference test points can be neighboring circuits or ground circuits. The term, reference test point, is used within this handbook to differentiate between test points associated with the faulty circuit (circuit test points) and conductors that have been selected to aid in troubleshooting, used as reference values, or to ground the support equipment (e.g., the ground for the DMM COM probe when performing voltage measurements).

3.2.31 Resolution. The measure of how fine the measurement is. The smallest increment an instrument can detect and display - hundredths, thousandths, millionths of a measured unit.

3.2.32 Routing. The path that is followed by a cable or conductor.

3.2.33 Safety wire. Securing wire is used to prevent the loosening or vibrating free of the attached part.

3.2.34 Severe Wind and Moisture Problem (SWAMP) areas. Areas such as wheel wells, wing folds, areas near wing flaps, and areas directly exposed to extended weather conditions are considered SWAMP areas on aerospace vehicles.

3.2.35 Short. An electrical circuit that allows current to travel along an unintended path with no or little resistance.

3.2.36 Spot tie. See definition for Lacing tape.

3.2.37 Strand. One of the wires or groups of wires of any stranded conductor.

3.2.38 Stranded conductor. Conductor composed of a group of wires or any combination of groups of wires. The wires in a stranded conductor are usually twisted or braided together.

3.2.39 Stress-relief chamfer. The tapering or rounding of an interior or exterior corner of a mechanical part, incorporated in the design to eliminate areas of high-stress concentration.

3.2.40 Tape, pressure-sensitive. Self-bonding, pressure-sensitive tapes contain an adhesive coating applied to the backing material, which allows the backing to be positioned with the application of pressure only. The two primary functions of electrical pressure-sensitive tapes are holding and insulating. Self-bonding silicone tapes are commonly misidentified as "chafe tape" and improperly used as an anti-chafing material.

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3.2.41 Terminal. Metal wire termination devices are designed to handle one or more conductors attached to a board, bus, block with mechanical fasteners or clipped on. Types include ring, tongue, spade, flag, hook, blade, quick-connect, off-set, and flanged. Special types include taper pins, taper tab, and others, either insulated or non-insulated.

3.2.42 Terminal lug. A device designed to be affixed, usually at one end, to a post, stud, chassis, or similar device, and with provision for attachment of an electrical conductor(s) to establish an electrical connection.

3.2.43 Time Domain Reflectometer. An electronic instrument used to perform an electrical test that determines the condition of a wire or cable by analyzing the reflections of short electrical pulses.

3.2.44 Upstream. The point on a circuit closer to the power source when compared to another point on the same circuit. See definition for Downstream.

3.2.45 Wiring diagram. A simplified electrical drawing to show the representation of avionics components and EWIS.

3.2.46 Wiring schematic. A drawing of an electrical system in which the system components are represented by symbols rather than pictures or drawings of actual devices.

4. GENERAL GUIDELINES

4.1 Application. The guidelines contained herein are intended to provide guidance applicable to EWIS, unless otherwise indicated in the guideline (excluding fiber optic links and fiber optic devices).

4.2 Use of selection and application standards. When a selection and application standard is referenced in a guideline, the devices or parts selected should conform to the applicable military or commercial specifications referenced in the standard.

5. DETAILED GUIDELINES

5.1 Individual guidelines for EWIS troubleshooting. The individual guidelines for EWIS are located after the NOTES section 6 of this document.

6. NOTES

6.1 Intended use. The guidelines in this document are intended to provide information on the proper tools and procedures for troubleshooting, repairing, and maintaining the EWIS.

6.2 Subject term (key word) listing.

Circular connectors
Corrosion prevention

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Electronics cleaning
Fiber Optics
Maintenance procedures
Pressure sensitive tape
Rectangular connectors
Severe Wind and Moisture Problem Areas
Soldering
Stress relief chamfer

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GUIDELINE 1

EWIS TROUBLESHOOTING INTRODUCTION

1. Purpose. This guideline introduces general EWIS troubleshooting and workflow processes.

2. Applicable documents.

NAVAIR 01-1A-505-1	Installation and Repair Practices, Aircraft Electric and Electronic Wiring

3. General troubleshooting guidelines. The following information should be considered before attempting to troubleshoot EWIS discrepancies.

a. A large part of electrical troubleshooting is understanding wiring schematics and deciphering what may cause a particular discrepancy. The more comfortable you are reading a schematic the more success you will have in troubleshooting EWIS discrepancies. Additional guidance may be available in EWIS component government/non-government specifications (for example, milli-volt drop requirements in SAE AS81824); refer to platform engineering support services for more information. Reviewing schematics throughout the process of troubleshooting simple and complex circuits is an important step to finding the source of discrepancies in EWIS.

b. It is important to understand how data from electrical measurements, such as resistance measurements, indicate specific EWIS faults. The ability to analyze this data is essential since many aircraft maintenance manuals omit baseline resistance and voltage measurements. It is up to the technician to determine what a good or bad measurement is.

c. It is important that the technician have a thorough knowledge of the different pieces of Support Equipment (SE) available to use to troubleshoot EWIS, along with how to operate this equipment and the different features that the SE offers. The NAVAIR 01-1A-505-1 maintenance manual provides details on general aerospace-approved SE that is available for use. Platform-specific manuals provide details on additional SE approved for individual platforms.

d. A good working knowledge of the DMM is essential as the DMM is the most commonly used EWIS troubleshooting SE. Nearly all EWIS troubleshooting will involve the use of a DMM.

e. Look for single faults before considering multiple, simultaneous faults. No matter the complexity of a circuit, it can always be simplified.

f. It is important to note; component failures can damage EWIS, and EWIS failures can damage components. It is strongly recommended to isolate the circuit and perform resistance measurements on the parts of the circuit where the fault may be present before replacing suspected faulty components.

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g. When troubleshooting EWIS, it is important to use a general procedure in specific settings. In other words, there are not specific procedures for every circuit or wire.

h. The fault symptom lets you know that something is wrong with the equipment. So, you have to analyze the fault symptom as it affects the operation of the equipment.

i. Caution should be used when swapping or replacing components in EWIS. Performing wire checks before swapping or replacing avionics/electrical components will greatly reduce the risk of causing additional damage.

j. Understand the system. Review the system's theory of operation. It is important to understand how the system is supposed to function to understand why it is not working. Approach every problem with a clear understanding of what the potential fault is and review the technical manual and applicable wiring diagrams.

k. Use the Maintenance Instruction Manuals (MIM)/Technical Manuals (TM). Comply with all preparatory procedures (i.e., lockout tag-out, PPE), "Warnings," "Cautions," and "Notes," as well as the steps prescribed in the technical manual. There are some instances when the troubleshooting procedures listed in the technical manual fail to uncover the fault or are not detailed enough for EWIS discrepancies. When this occurs, system knowledge and advanced troubleshooting is required.

l. Verify the discrepancy and pay close attention to the fault symptom(s). Test the system to ensure you can duplicate the discrepancy. This systematic and logical troubleshooting process starts with the fault symptom. The fault symptom provides clues that show you where to look for the fault and what the fault type may be. Organize the probable causes to better focus your fault isolation efforts. Understanding what the potential fault is will allow you to select the most effective process at isolating those types of faults. Carefully manipulating the EWIS component by gently bending or pulling may permit duplicating the discrepancy (see flex test in guideline 16).

m. Debrief the work order initiator. On occasion, you may need to speak with the originator of the discrepancy write-up to better understand the observed discrepancy if there is a disparity between the aircrew and maintenance manuals. Some questions to consider are:

(1) Were any other systems operating that may have influenced the fault?

(2) What operating procedures were being followed at the time of the discrepancy?

(3) What was the flight configuration when the discrepancy was observed?

n. Figure 1-1 provides a flowchart of the basic troubleshooting process. Please note that every discrepancy is unique and may require amending, reordering, or omitting certain steps.

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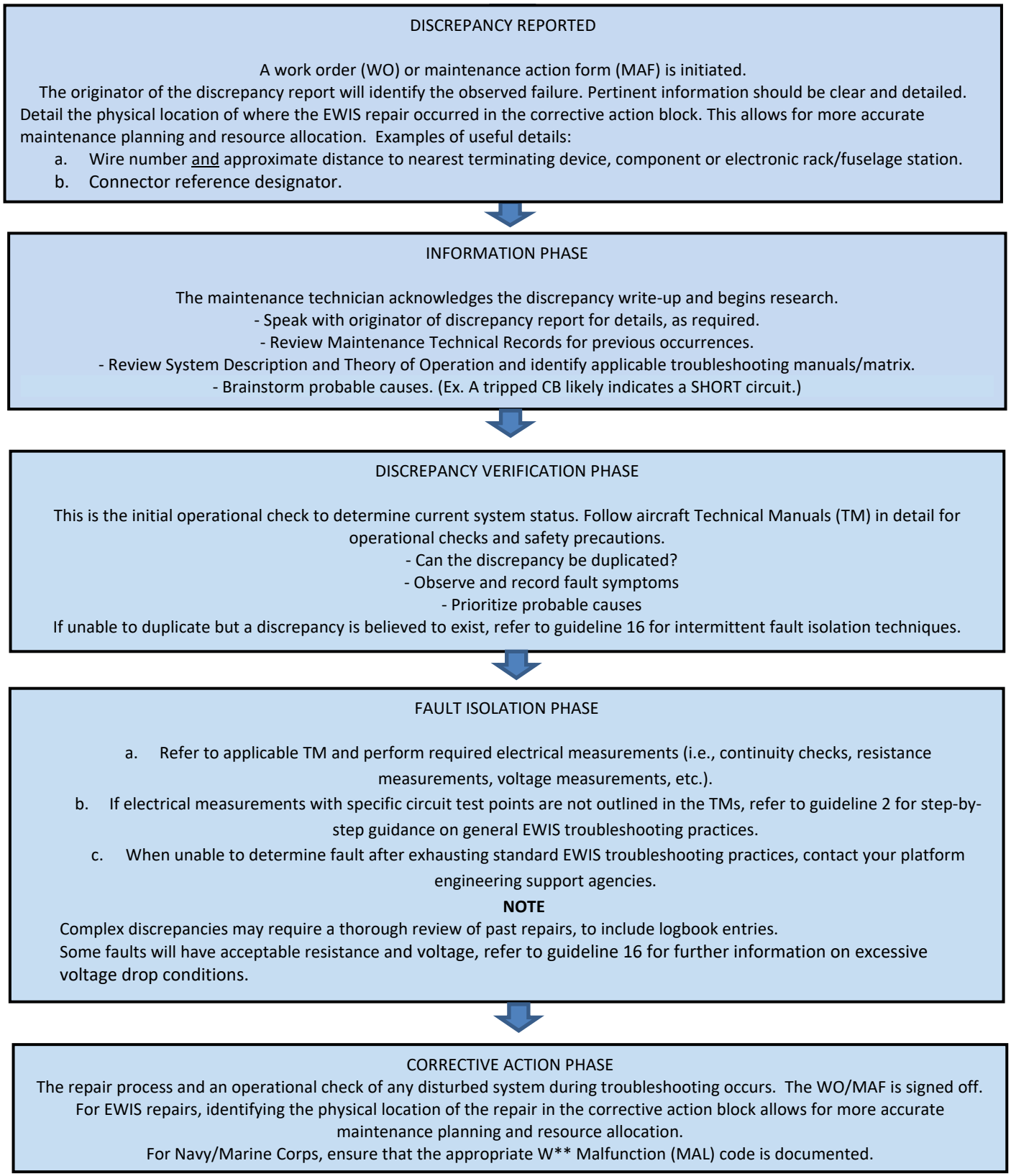


FIGURE 1-1. Basic troubleshooting flowchart.

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GUIDELINE 2

FAULT ISOLATION PHASE

1. Purpose. This guideline provides general and detailed guidance, lessons learned, and recommended practices for effectively and efficiently navigating through the EWIS fault isolation phase of troubleshooting.

2. Applicable documents. The documents listed below are those applicable to this guideline.

NAVAIR 01-1A-505-1	Joint General Series Wire Maintenance Manual
Work Package 004 00	Wire Characteristics, Replacement and Inspection Techniques
Work Package 022 01	SAE AS85485 Filter Line Wire Repair
NAVAIR 17-15-531	Handheld Aircraft Wire Tester (HAWT) TTU-628/E

3. General troubleshooting guidelines.

a. Fault isolation is the process by which the fault is troubleshot and identified. Most often, resistance checks using a standard DMM along with visual inspection will accurately identify the fault.

b. Identifying and preparing relevant circuit test points (TP) are essential steps for isolating a fault. Schematics should be reviewed to determine locations where circuits should be tested. Reference test points should be used to compare conductive point(s) on an electrical circuit that has been verified operational (known good) (see 3.2.30). Refer to guideline 9 for additional information.

c. The fault symptom provides clues that show you where to look for the fault and what the fault type may be. When prioritizing probable faults, observe the following:

(1) Opens are more common than the other fault types.

(2) Moving parts (e.g., switches, relays, etc.) and components that are frequently handled have a higher fail rate than components that are less frequently disturbed.

(3) Shielded wire or cable, especially those transmitting low-voltage signals, are highly susceptible to interference. Even superficial-looking damage, such as a scuff on the insulation, can be a sign of damage affecting the shielded wire/cable performance.

d. Visual inspection is an effective method for confirming the fault and determining what caused the fault. A visual inspection should be performed in conjunction with preparing for and while taking electrical checks/measurements. To prevent the recurrence of a fault, it is essential that the root cause be identified and corrected.

e. Isolating the sections of the circuit causing the discrepancy will help the technician to

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identify which part or parts of the circuit to test. One effective way to isolate discrepancies is to disconnect portions of the circuit (e.g., connectors, terminal boards, ground posts, terminal junctions, etc.) including disconnecting Line Replaceable Unit/Weapon Replaceable Assembly (LRU/WRA) connectors to create series circuits.

f. Only troubleshoot or test one theory at a time. This will help you, as the technician, to isolate the cause of a discrepancy within EWIS.

g. Start with the most logical point of failure and work from there. Limit swapping components until you verified which component is causing the failure. Swapping components without proper troubleshooting can cause more issues than it solves.

h. It is important to note, certain high-resistance faults are undetectable using standard SE. This occurs when the stimulus current of the equipment is significantly less than the current of the circuit during normal operation. A visual inspection is the most effective means of identifying these types of faults. Most high-resistance faults are commonly caused by:

(1) Loose connections (e.g., connectors, terminal lugs, contact crimp, etc.).

(2) Recessed contacts.

(3) Partially broken conductors.

(4) Corrosion or contaminant is disrupting electrical connection (e.g., aircraft structure not properly prepped prior to installing ground lug, etc.).

4. Detailed troubleshooting guidelines. The following procedure provides guidance on assessing the fault symptom, selecting the most appropriate electrical check or measurement, and identifying the type of required test points.

a. Use table 2-I to create a list of probable fault types based on the observed symptoms during the discrepancy verification phase and how the system should operate (system's theory of operation) (see figure 1-1).

b. Use table 2-II to:

(1) Determine the recommended electrical check or measurement based on the probable fault type.

(2) Select the applicable SE. The DMM is the most versatile and simplistic SE for EWIS troubleshooting. Nearly all fault isolation will begin using the DMM.

c. Use table 2-III to identify the type of DMM test points required to perform the selected electrical check or measurement. Refer to guideline 9 for detailed information. Selected test points will vary based on:

(1) Type of fault testing for (open, short, high-resistance, etc.).

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(2) Type of check or measurement to be performed (resistance measurement, voltage measurement, etc.).

(3) Location and type of EWIS components in the circuit based on wiring schematics and maintenance manuals.

(4) Distance between selected test points.

NOTE

When performing resistance measurements or continuity checks, the Divide and Conquer Method effectively isolates most faults while taking the least number of measurements, see guideline 11.

d. Perform the electrical check or measurement and record the values. If using the DMM, refer to guideline 7 for detailed procedures.

NOTE

Refer to platform Maintenance Instruction Manual (MIM)/Technical Manual (TM) for specific electrical values. If these values are unavailable, refer to table 2-IV. The values in table 2-IV are for general guidance on the typical resistance of standard aircraft wiring that are isolated from other components. These values alone should not be the basis for determining a specific fault.

e. Analyze the recorded values to determine what part of the circuit should be visually inspected. Table 2-IV provides common resistance values.

f. Visually inspect applicable EWIS to confirm and identify the fault. When inspecting, pay particular attention to the following areas:

(1) Within 12 inches of terminated ends (connectors, terminal lugs, etc.).

(2) High traffic areas (flight station, main cabin, nacelle, etc.).

(3) SWAMP areas (flap wells, wheel wells, nacelle, etc.).

(4) Places where recent maintenance or modifications in the same areas of applicable EWIS components (connector reinstalled following a component replacement or floorboard reinstallation, etc.).

(5) EWIS near moving parts/components (e.g., wire harness routed along a WRA/LRU chassis, or near a flight control linkage, etc.).

(6) Frequently cycled or handled EWIS components (switches, CBs, relays, connectors, etc.).

(7) Locations where past maintenance or inspections have taken place where EWIS

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components (splices, cable clamps, harness routing, etc.) are located.

g. Determine and correct the root cause of the fault, i.e., the cause of the EWIS damage or the reason the component failed. For example, if a broken wire was identified, what caused the wire to break? A splice will likely fix the broken wire, but if the discrepancy that broke the wire isn't corrected, then it is highly likely that the damage to that wire or other components will continue or worsen.

h. If the fault cannot be identified using troubleshooting techniques outlined in this handbook, observe the following:

(1) For additional troubleshooting capabilities for RF and multi-conductor cable, the TDR is effective in fault isolation and providing distance to fault (such as the Handheld Aircraft Wire Tester (HAWT)).

(2) When approved via platform-specific MIM/TM, the megohm-meter (also called an insulation resistance tester, or megger) is effective in isolating high-impedance faults (i.e. insulation degradation-type faults). For megohm-meter usage on EWIS components or applications not specifically identified in platform MIM/TMs, detailed procedural guidance and approval is required from the Cognizant Engineering Authority (CEA) (e.g., platform FST, etc.) prior to its use.

(3) When the above efforts have not successfully identified the fault, contact your platform engineering support agency/CEA.

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TABLE 2-I. Common electrical faults.

Common Fault Symptoms	Fault Type	What is it?	Common Causes
1. Fully inoperable system 2. Partially inoperable system 3. Erratic operation (fluctuation in indication, etc.) 1/	OPEN	A condition where no current may flow. An interruption in the conductive path.	1. Broken wire/conductor 2. Loose connection/recessed contact 3. Faulty contactor (switch, relay, etc.) 4. Tripped/pulled/faulty circuit breaker (CB) 5. Non-conductive material in the circuit (e.g., proseal/paint under terminal lug tongue, etc.) 6. Corrosion on EWIS components 7. Intermittent fault
1. Tripped circuit breaker 2. Arcing/burning components 3. Erroneous/erratic system operation (system powers on when another system is energized, etc.) 4. Fully or partially inoperable system	SHORT	A condition where current flows to an unintended circuit.	1. Short-to-ground 2. Short-to-another wire/circuit 3. Intermittent fault
1. Low-output/dim lighting 2. Sluggish component operation 3. Fully inoperable system 4. Overheated components/signs of burning 5. Erratic operation	High-resistance	A condition where excessive circuit resistance occurs.	1. Corrosion on EWIS components 2. Loose connection 3. Partially broken wire/conductor 4. Contaminated/dirty contacts/conductors 5. Worn contacts 6. Worn component contactors (switches, relays, CBs, etc.) 7. Intermittent fault
1. Fluctuations in aircraft displays 2. Static noise in audio systems 3. Inoperable system 4. Erratic operation 5. Erroneous operation	Electrical Reflection	A condition where electrical energy does not reach its intended load causing attenuation.	1. Crushed/damaged coax cable 2. Loose connection 3. Over-tightened spot-tie/zip-tie 4. Under sized cable clamp 5. Damage/gaps in shielding 6. Excessive cable bend 7. Intermittent fault
NOTE: 1/ Common in circuits where multiple grounds are present.			

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TABLE 2-II. Common electrical checks/measurements.

Fault Type 1/	Check/Measurement	Purpose	Limitations	Support Equipment
1. OPEN 2. SHORT 3. High-resistance 4. Determine the voltage value	Resistance Measurements	Determine the resistance value of wiring or other electrical components.	Extremely low current produced by standard DMM's may not identify some resistance discrepancies.	DMM resistance function, Ohmmeter or Milli-ohmmeter
1. OPEN 2. High-resistance 3. Determine voltage value	Voltage Measurements	Determine the voltage value of a circuit.	1. Requires energized circuit. 2. No-load voltage measurements may not identify some high-resistance defects. 3. Cannot test wiring disconnected from the power source.	DMM voltage function, Voltmeter
1. Intermittent OPEN 2. Intermittent SHORT	Continuity Check	Provide an audible beep if a complete electrical path exists for current to flow.	1. Continuity check may pass even with improper resistance. 2. Requires resistance measurements or visual inspection to validate.	DMM with a continuity beeper
1. OPEN 2. High-resistance	Current Measurements	Determine the amperage of a circuit.	Increased safety risk due to energized circuit.	DMM amp function, Amperage meter
1. OPEN 2. High-resistance	Voltage Drop Measurement	Determine the amount of dropped voltage between two points.	1. Requires energized circuit. 2. A completed circuit is required. 3. Test points are required to be accessible.	DMM voltage function, Voltmeter
1. SHORT 2, OPEN 3. High-resistance 4. Fluid soaked cable 5. Electrical Reflection	Time Domain Reflectometry	Determines distance to fault and the condition of a wire or cable by analyzing the reflections of short electrical pulses.	1. Various types of TDRs. 2. Requires an equal return path for comparison. 3. Most often used for shielded wire, coax, twisted pair, etc. 4. More complex setup and operation compared to testing with DMM.	TDR (e.g., HAWT, etc.)

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TABLE 2-II. Common electrical checks/measurements - Continued.

Fault Type 1/	Check/Measurement	Purpose	Limitations	Support Equipment
6. Degraded wire insulation	Insulation Resistance	Detect deteriorating or damaged wire insulation where potential current is lost or 'leaked.'	1. Requires applicable EWIS to be completely isolated from WRA(s). 2. Changes in temperature can impact insulation resistance values (compared to baseline readings).	Insulation resistance tester (e.g. megaohm-meter). Requires approval, see 4.h.2.

1/ Intermittent fault isolation may require the EWIS manipulation to validate (flex test) or specialized intermittent fault diagnostic equipment. See guideline 16 for more information.

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TABLE 2-III. Common test points required for DMM.

Common DMM Checks/Measurements		Connecting meter leads to the circuit	
Continuity and Resistance	TP-to-TP *Both circuit test points in reach of DMM	COM meter probe connected to one of the circuit test points.	
		POS meter probe connected to the other circuit test point.	
	TP-to-GND with GND jumper accessory *Both circuit test points NOT in reach of DMM	One circuit test point connected to a verified GND using a jumper wire accessory.	
		The other circuit test point connected as followed:	
			COM meter probe connected to a verified GND.
			POS meter probe connected to the other circuit test point.
Voltage	No-load *series connection	COM meter probe connected to a verified GND.	
		POS meter probe connected to a circuit test point on the power side of the disconnected circuit.	
	Voltage-drop *parallel connection	COM meter probe connected to a test point on the "downstream" side of the circuit.	
		POS meter probe connected to a test point on the "upstream" side of the circuit.	
Current	Series Connection * Requires disconnecting wire under test and inserting DMM inline for measurement.	COM meter probe connected to the "downstream" side of the circuit.	
		POS meter probe connected to the "upstream" side of the circuit.	
Diode	Polarized	COM meter probe connected to the NEG (-) side of the diode.	
		POS meter probe connected to the POS (+) side of the diode.	

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TABLE 2-IV. Common resistance values of standard EWIS components.

Component	Test points (TP)		Ideal Resistance
	TP1	TP2	
Wire	Wire-end	Other wire-end (same wire)	Less than 0.02 ohms per foot 1/
Wire to ground	Wire-end	Ground	1. OPEN (MΩ+) Non-ground wire 2. Less than 0.02 ohms per foot-Ground wire
Wire to shield 2/	Wire-end	Shield	1. OPEN (MΩ+) Wires not terminated to shield in schematic. 2. Less than 0.02 ohms per foot-wires terminated to shield braiding.
Wire to wire	Wire-end	Wire-end of another wire	1. OPEN (MΩ+) Schematic indicates wires are isolated from each other. 2. Less than 0.02 ohms per foot for wires connected to each other (e.g., pigtail, connected to a bus, etc.).
Shield overbraid to ground	Shield braiding	Ground	Less than 0.5 ohms (typically grounded through connector shell)
Wire to component	Wire-end	Conductive part of component (e.g., connector shell, metallic LRU/WRA case, etc.	1. OPEN (MΩ+) for wires not terminated to a component as identified in schematic. 2. Less than 0.02 ohms per foot. Ground wires terminated to component or chassis.
Single pole switch contactor	Terminal	Terminal	1. Less than 0.02 ohms. When the contactor is closed. 2. OPEN (MΩ+) When the contactor is open.
	The wiring schematic will indicate which terminals are connected. Note that some contacts are normally closed (NC) when the switch is off.		
Relay contactor	Terminal	Terminal	1. Less than 0.02 ohms. When the contactor is closed. 2. OPEN (MΩ+) When the contactor is open.
	The wiring schematic will indicate which terminals are connected. Note that some contacts are normally closed (NC) when the switch is off.		

NOTES
1/ Copper-core wire; exact resistance maximums vary on plating material and AWG. See NAVAIR 01-1A-505-1 WP 004 00.
2/ Non-metallic shield materials have higher resistivity compared to copper (e.g., filterline wire, see NAVAIR 01-1A-505-1 WP 022 01).

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GUIDELINE 3

ELECTRICAL SAFETY

1. Purpose. This guideline introduces electrical safety concepts.

2. General troubleshooting guidelines. The following concepts and practices should be considered when troubleshooting parts of the EWIS system.

a. Understanding the dangers of lower voltage levels. Electrical shocks have the ability to disrupt normal heart rhythm and, in rare cases, can cause a condition called delayed lethal arrhythmia. It is important to understand that even symptom-free cases of an electrical injury may have fatal consequences, months or even years later, if not properly treated. High-voltage can kill instantly, whereas low-voltage may take a while longer. You should immediately seek medical attention following any electrical shock.

b. The use of PPE. PPE can be uncomfortable, restrictive, and slow down the workflow. But the reality is, aircraft electrical systems can fail at any time. Wearing PPE while simply opening an electrical bay or taking a quick measurement can mean the difference between injury and safety. For example, wearing gloves without any conductive materials while taking voltage measurements reduces the risk of electrical injury caused by accidental contact with energized conductors.

c. Using outdated or defective support equipment. If the meter leads are damaged, or the readings seem strange, it may be time to replace worn or outdated SE. Examples of readings or other problems resulting from outdated or defective SE include:

(1) Unreadable display screens.

NOTE

Erratic readings could also be signs of the circuit discrepancy.

(2) Getting different readings when the same measurement is taken multiple times.

(3) Loose meter lead connections in the DMM.

(4) Not safety rated for your work environment. It is essential that electrical SE and accessories are rated for the electrical inputs they may be exposed to.

d. Performing adequate preventative maintenance on EWIS is important. Performing preventative maintenance on EWIS greatly reduces the risk of component failure. A properly maintained and operating system minimizes risk to personnel or equipment.

e. Neglecting to properly inspect SE and accessories. Always inspect SE for signs of defects/damage and the current calibration date (where applicable) prior to performing any troubleshooting. Faulty SE can pose a risk to the safety of the technician or maintainer. The use

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of faulty SE can also result in replacing perfectly good avionics or negatively affecting EWIS when no repair is needed.

f. Multitasking while working on an energized circuit. When working on live circuits, it is essential that your attention is focused on the exposed conductors and test points. One of the most common distractions is having to focus on the DMM display. Using the HOLD feature and specialized meter lead accessories can drastically reduce the risk of losing focus on your safety.

g. Working alone. It is not recommended to work on electrical systems alone. When feasible, work in pairs or groups. Electrocution may incapacitate the individual. It is highly encouraged to be CPR qualified when working on electrical systems. Refer to applicable service or agency policies for personnel health and safety qualification requirements.

WARNING

Never hold a CB in that will not stay set on its own. A CB that will not remain set indicates a faulty CB, over current condition, or an electrical short. Holding a CB in that will not set on its own may result in electrical injury or damage to aircraft or component.

WARNING

Setting a CB that tripped due to an electrical short before the condition is corrected may result in electrocution to personnel or extensive damage to EWIS or associated equipment.

WARNING

Severe arc-tracking may occur if a CB is set with shorted polyimide (Kapton™) insulated wire and may result in extensive damage and possible fire. Never hold a CB in that will not stay set on its own.

h. Circuit breaker (CB) safety is often overlooked or misunderstood. The cause or reason a CB is tripped/pulled should always be confirmed prior to setting the CB. Confirm via maintenance documentation if the CB was pulled for maintenance and if it is safety/authorized to be set/pushed in. If the CB tripped, the fault that caused the CB to trip (short or excessive current draw) should first be corrected prior to setting the CB. Polymide insulated (Kapton™) wiring has a significant risk for uncontrolled arc tracking. When energized, shorted Kapton™ can catch fire and burn surrounding wire and other components. If the surrounding wire is also Kapton™, the damage can exponentially increase. See figure 3-1.

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FIGURE 3-1. Example of damage due to a shorted Kapton™ wire.

A single shorted Kapton™ wire resulted in the above damage when the CB was repeatedly reset during troubleshooting in an attempt to isolate the short.

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GUIDELINE 4

DIGITAL MULTIMETER (DMM) FAMILIARIZATION

1. Purpose. This guideline introduces the functions, configurations, and capabilities of the DMM.

2. General troubleshooting guidelines. A good working knowledge of the DMM is essential as it is the most commonly used EWIS troubleshooting SE. Nearly all EWIS troubleshooting will involve the use of a DMM. Far too often, discrepancies are inaccurately labeled 'intermittent," or a component is blamed for a wiring fault simply because the capabilities and limitations of the DMM are not thoroughly understood. The results of these misidentified faults may have significant impacts to mission readiness, flight safety, and operating costs. Basic and advanced DMM functions along with recommended practices when using a DMM are as follows:

a. Basic DMM functions are typical with most DOD-approved DMM models. They consist of the following:

(1) Ohmmeter.

(2) Voltmeter-AC and DC.

(3) Amperage meter-AC and DC.

(4) Millivolt meter.

(5) Milliamp meter.

(6) Continuity check/test. Specific resistance values that activate the continuity beeper vary among DMM models.

(7) Diode test-Not to be confused with the Continuity Test function.

b. Selector knob settings:

(1) Primary function in white.

(2) When features share a selector knob setting, the secondary function is in yellow.

NOTE

Basic and advanced features, accuracy, and range are some of the main variances between DMM manufacturers/models.

Fluke DMM's have built-in features designed to limit distractions while performing electrical checks or measurements, such as MIN/MAX and HOLD features.

c. Advance features of DMMs include (see guideline 8):

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(1) Displayed Reading Hold.

(2) Temperature.

(3) Frequency.

(4) Display lighting.

(5) MIN MAX Function.

(6) Relativity Function.

d. It is important to thoroughly understand the proper usage of meter leads, advanced DMM features, and safety precautions prior to using the DMM on electrical systems.

e. Always verify the test leads are connected to the appropriate input terminal, and the selector knob is set to the respective function prior to testing a circuit.

f. The Fluke 77 and 87V DMMs (see figure 4-1) are widely used throughout the DOD. As such, they are referenced throughout this manual. Certain features may not be available on all models, and enabling/disabling them may vary between models. The functionality of the available features should be relatively the same. Always refer to the manufacturer's manual for specific guidance, usage, and limitations. Manufacturer's user manuals are typically located on the manufacturer's website, also see table 4-I.

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FIGURE 4-1. Fluke 87 V True RMS Digital Multimeter.

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TABLE 4-I. Fluke 77, 27 II, and Fluke 87V specifications.

Setting		Fluke 77	Fluke 27 II	Fluke 87
Resistance	Range	50 MΩ	0.1 to 50 MΩ	50 MΩ
	Best Accuracy	plus or minus (0.5% +1) on 6 kΩ to 6 MΩ scales	plus or minus (0.5% +1) on 6 kΩ to 6 MΩ scales	plus or minus (0.2% +1) on 6 kΩ to 6 MΩ scales
	Best Resolution	0.1 Ω	0.1 Ω	0.1 Ω
Continuity	Detects opens and shorts of:	250 µS or longer.	1 mS or longer.	250 µS or longer.
	Resolution	1 Ω	1 Ω	0.1 Ω
Voltage DC	Range	6.000 - 1000 V	0.1 mV - 1000 V	1000 V max
	Best Accuracy	plus or minus (0.3% +1)	plus or minus (0.1% +1)	plus or minus (0.05% +1)
	Best Resolution	0.1 mV	0.1 mV	10 µV
Voltage AC	Range	600.0 mV - 1000V	0.1 mV - 1000V	1000 V max
	Best Accuracy	plus or minus (2.0% +2)	plus or minus (0.5% +3)	plus or minus (0.7% +2) True RMS
	Best Resolution	1.0 mV	1.0 mV	0.1 mV
Amps DC	Range	60.00 mA - 10 A	0.1 µA - 10 A	10A (20 A for 30 seconds)
	Best Accuracy	1.5% +2	0.2 +4	plus or minus (0.2% +2)
	Best Resolution	0.01 mA	0.01 mA	0.01 µA
Amps AC	Range	60.00 mA-10 A	0.1 µA-10 A	10A (20A for 30 seconds)
	Best Accuracy	2.5% +2	1.5% +2	plus or minus (1.0% +2) True RMS
	Best Resolution	0.01 mA	0.01 mA	0.01 µA
Capacitance	Range	1nF - 9,999 µF	1nF - 9,999 µF	9,999 µF
	Best Accuracy	plus or minus (1.2% +2)	plus or minus (1.2% +2)	plus or minus (1% +2)
	Best Resolution	1 nF	1 nF	0.01 nF

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TABLE 4-I. Fluke 77, 27 II, and Fluke 87V specifications - Continued.

Setting		Fluke 77	Fluke 27 II	Fluke 87
Frequency	Range	99.99 Hz-99.99 kHz	0.5 Hz-199.99 kHz	200 kHz max
	Best Accuracy	plus or minus (0.1% +1)	plus or minus (0.1% +1)	plus or minus (0.005% +1)
	Best Resolution	0.01 Hz	0.01 Hz	0.01 Hz
Display	Numerical (Digital), updates	6000 counts, 4 times/second	6000 counts, 4 times/second	6000 counts, 4 times/second
	Bar graph updates	33 segments 32 times/second	33 segments 32 times/second	32 segments 40 times/second

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g. The DMM display (see figure 4-2) provides the following:

(1) Numerical readout of the measurement.

(2) Bar graph and selected range.

(3) Indication of enabled primary or secondary basic functions.

(4) Enabled advanced feature, when applicable.

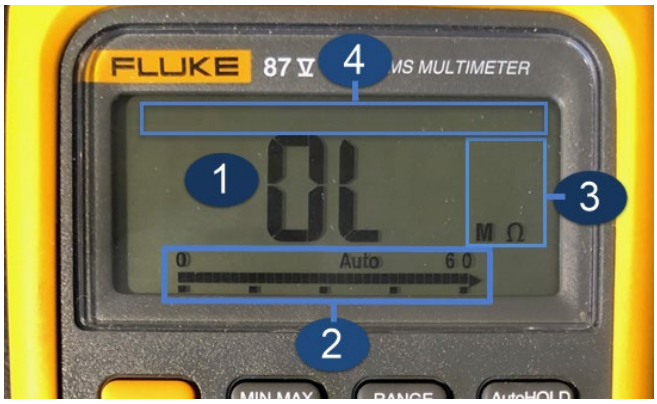


FIGURE 4-2. DMM display.

h. The higher the resolution, the finer the measurements will be displayed; i.e., the decimal place value increases. Lower resolution will have fewer decimal points. The lower the acceptable range, the higher the displayed resolution. Lower resolution is a less accurate measurement and is likely rounded to the applicable decimal point. For example, a measured value of 120.0 VDC has a higher resolution than a 120 VDC reading (see figure 4-3).



Higher resolution Lower resolution

FIGURE 4-3. DMM resolution.

i. Resolution and accuracy vary between DMM manufacturers and models. Always ensure the DMM is capable of meeting specific input requirements of the circuit under test prior to

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performing required electrical checks/measurements. This is critical when precise measurements are required.

j. The DMM range is displayed just below the numerical readout. On figure 4-2, the range is 0-60 ohms.

k. The DMM defaults to the Auto range when the selector knob is set to the desired setting. The Auto range will automatically select the lowest acceptable range based on the measured input and provide the highest resolution for that specific measurement. When the Auto range is selected, “Auto” will appear above the bar graph (see figure 4-4).

l. If a measurement exceeds the selected range, “OL” or overload, will be displayed.

m. The bar graph shows rapid changes visually and more accurately than the numerical display.

(1) The bar graph updates approximately 40 times per second (see figure 4-4 green arrow) compared to just four times per second of the numerical display (see figure 4-4 red arrow).

(2) The bar graph functions like the needle on an analog meter but without the overshoot.

(3) The bar graph is not visible for capacitance, frequency counter functions, temperature, or peak min max.



Red arrow showing numerical reading (0.6 ohms).

Green arrow shows bar graph reading (infinite ohms).

Note: Pictured is the moment at which the DMM detected the change when the meter leads were removed from the circuit.

FIGURE 4-4. Delay shown during a change in resistance.

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n. When to use the bar graph:

(1) To verify rapid changes when a specific measurement is not required (e.g., verify a changing analog signal, etc.).

(2) When making fine adjustments to a component, the bar graph is more responsive than the digital display (i.e., the bar will indicate a change in the electrical measurement before the numerical display will).

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GUIDELINE 5

DMM METER LEADS AND ACCESSORIES

1. Purpose. This guideline introduces common DMM meter leads and meter lead accessories. This guideline also gives guidance on how the DMM leads should be connected to an EWIS circuit or system.

2. General troubleshooting guidelines.

WARNING

Meter leads are rated for specific voltages. Ensure meter leads are capable of handling the applied voltages prior to connecting them to an energized circuit. Refer to the manufacturer's specifications or the printing on the meter lead for the specific overvoltage electrical category (CAT) rating.

Failure to use quality meter leads that are appropriately rated may result in serious burns or electrocution.

CAUTION

Never use meter leads or accessories that cause damage to aircraft or electrical components.

NOTE

Prior to using any meter lead or accessory, ensure all local tool control policies are closely followed.

a. The meter lead (test lead) connects to the DMM and is used to probe electrical circuits. Each meter lead includes the following components (see figure 5-1):

(1) A connector which is used to plug into DMM connector ports.

(2) Wire, which is used to connect DMM to the test probe.

b. The following procedure should be followed::

(1) Always connect the black meter lead to the black common (COM) input terminal. This lead is referred to as the COM meter lead.

(2) Always connect the red meter lead to one of the red positive (POS) input terminals (based on measurement being taken). This lead is referred to as the POS meter lead.

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FIGURE 5-1. Meter lead components.

NOTE

Wire is a common point of failure for many meter leads. Over time and with continued use, the wire conductor may break down, resulting in erroneous readings.

(3) The test probe, which is attached to the end of the wire, is used to complete the connection between the DMM and the EWIS component or system tested. The test probe consists of a non-conductive grip and a metallic tip. It should be equipped with finger stops to prevent slipping into the conductive tip or circuit (see figure 5-2). Table 5-I provides guidance on blunt and fine tip probes, which are used to troubleshoot EWIS systems.

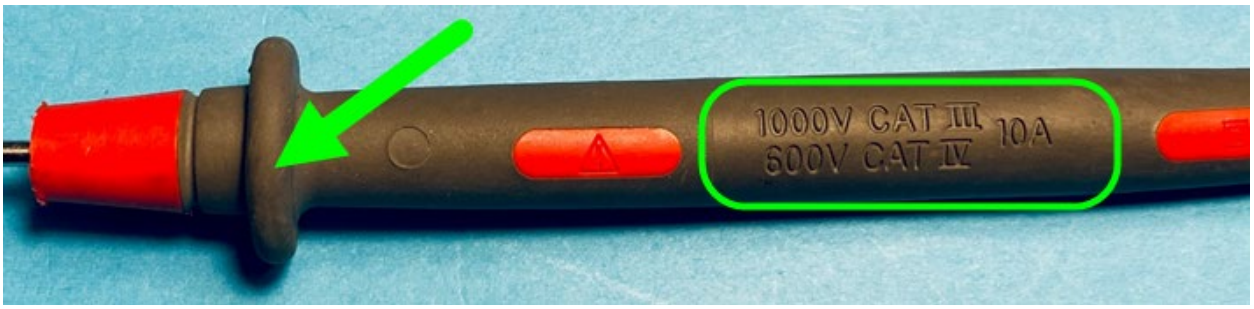


FIGURE 5-2. Meter lead finger stop (green arrow) and voltage/current rating (green box).

CAUTION

Only use meter leads rated for the applied voltages (see figure 5-2).

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TABLE 5-I. Types of probes used to troubleshoot EWIS systems.

Type of probe	Application
Blunt tip probes	Blunt tip probes are the most common DMM test probes (see figure 5-3). The larger surface area of the probe tip makes it easier to obtain a good connection with larger circuit Test Points (TP) and accessories.
Fine tip probes	Fine tip probes are best used for small contact points or when contacts are in close proximity to one another. The reduced surface area can make it difficult to establish a good connection with certain test points.

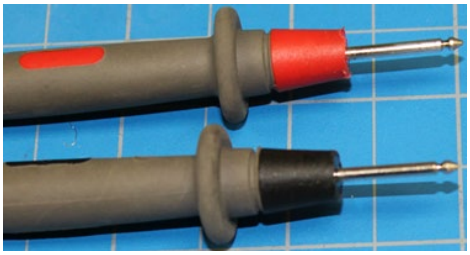


FIGURE 5-3. Blunt tip probes.

CAUTION

The exposed metal at the end of the probe should be minimal in high-voltage applications. Meter leads with less exposed metallic probe ends reduce the chances of arcing (see figure 5-4).

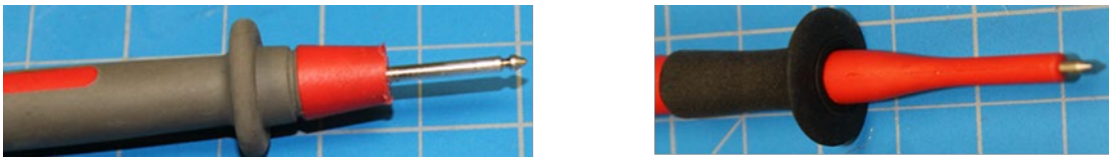


FIGURE 5-4. Probe tip exposure.

CAUTION

Most EWIS components and plating materials are extremely delicate. DMM accessories, test probes, or troubleshooting practices should never cause any damage to EWIS or aircraft components. Even surface scratches in plating materials can compromise electrical circuits.

c. Meter lead accessories are used with meter leads to improve the connection between the circuit test point and the meter lead. Some of the most common and readily available meter lead accessories are test contacts, alligator attachments (also referred to as alligator clips), mini-hook,

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(jumper)/patch set), and jumper wires. Specific troubleshooting requirements will dictate which meter lead accessory should be employed.

(1) To verify the integrity of meter lead accessories, perform the DMM Pre-operational Check prior to each use and periodically during extensive use of meter leads and meter lead accessories. Refer to guideline 6.

(2) For precise measurements when using meter lead accessories, use the Relative function to automatically subtract the resistance of the meter leads and accessories. Refer to guideline 8 for more information.

d. Test contacts are electrical connector contacts (pins/sockets) that are repurposed as meter lead accessories. They are used to provide a more stable connection to the circuit under test (see figure 5-5).

(1) Test contacts should be used on circuit test points where the test probes will not fit (see figure 5-6) or provide a stable connection.

(2) Test contacts should also be used when using alligator attachments. This allows the use of alligator attachments without concern for damaging circuit test points.

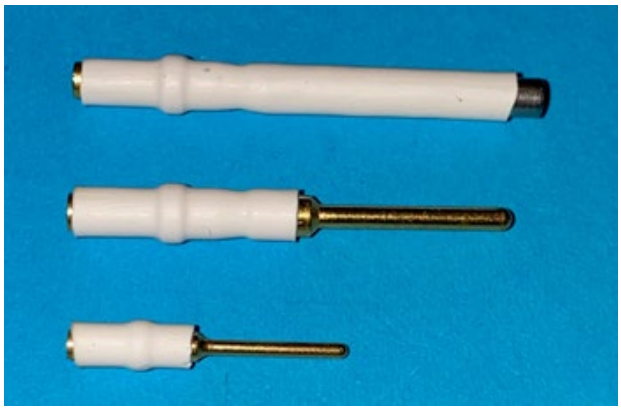


FIGURE 5-5. Examples of test contacts with heat shrink around contact barrels to prevent accidental shorting.

e. When selecting the test contact:

(1) Ensure the barrel, shoulder, and outer part of the socket (for socket-type contacts) are properly insulated to prevent accidental shorting (see figure 5-6).

(2) Select test contacts that are the same size but opposite configuration as the circuit test point contacts (e.g., if the test point is a size 16 pin, then use a size 16 socket as a test contact (see figure 5-5 and figure 5-6 green arrows).

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(3) Undersized test contacts should not be used because they do not provide adequate contact with the test point and may result in erroneous/inaccurate measurements. (see figure 5-6 red arrow).

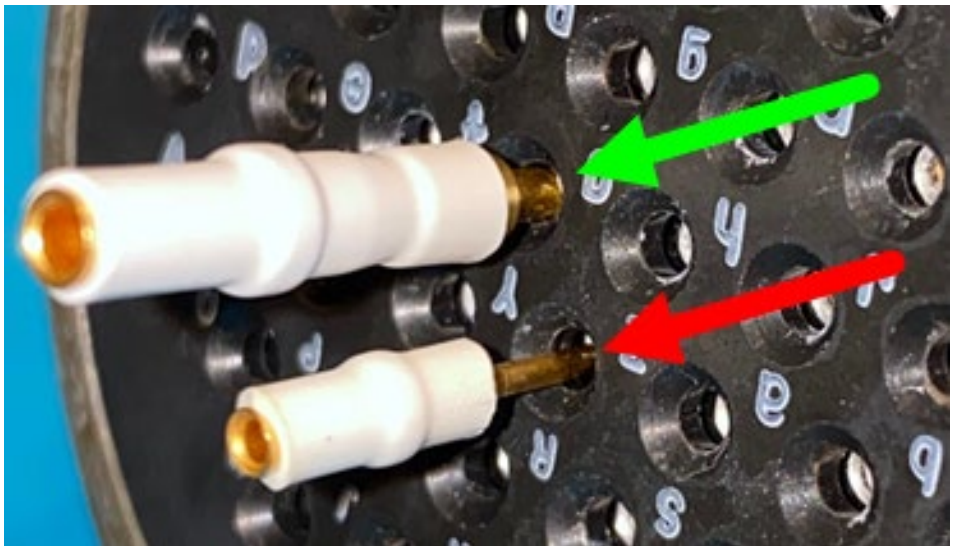


FIGURE 5-6. Properly sized vs. undersized test contacts.

f. When using test contacts, the following procedure should be used:

(1) Align the meter lead probe tip to the test contact barrel opening (see figure 5-7). The barrel end of the test contact provides the best electrical connection when using standard DMM meter leads.

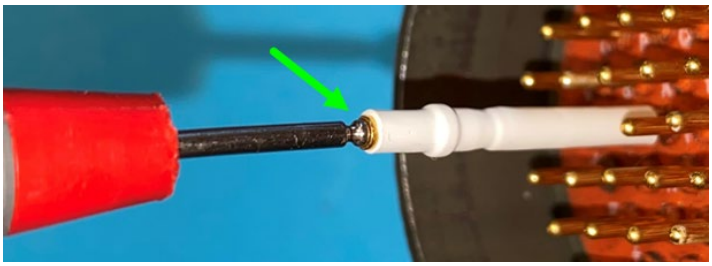
(2) Meter leads should be pressed into the contact barrel with light pressure and not pulling/pushing contacts side-to-side.

(3) Ensure test contact barrels do not short to each other when used in close proximity of one another (see figure 5-8).

(4) The rounded sides of the contact reduce the surface area for the probe and the paint for the BIN code is a poor conductor; both may cause erroneous readings (see figure 5-9).

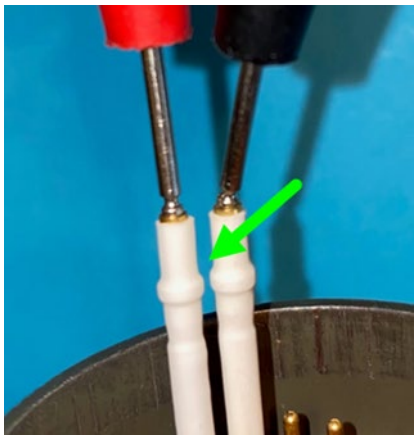
(5) It is important that test contacts be appropriately sized to ensure that they do not short to surrounding contacts or other conductors used in multi-conductor contacts (see figure 5-10 green arrow; test contact attached to the center conductor does not touch the inner conductor).

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NOTE: Ensure that a stable connection is maintained throughout electrical measurement or test.

FIGURE 5-7. Probing the test contact barrel.



Proper probing (green arrow). Positive separation is maintained.

FIGURE 5-8. An example of proper probing.

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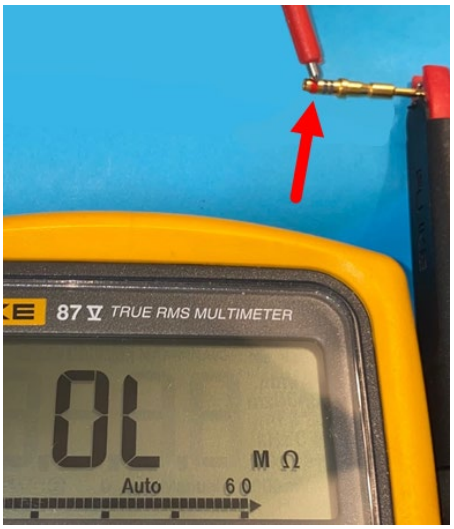
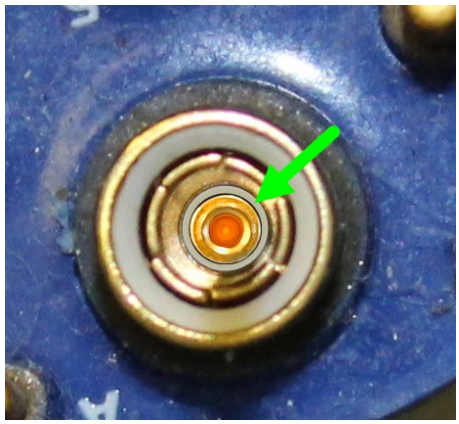


FIGURE 5-9. UNACCEPTABLE. Resistance added from painted BIN code.



NOTE: Ensure test contact does not short to the inner conductor (green arrow).

FIGURE 5-10. Multi-conductor contact with test contact inserted on the center conductor.

g. Alligator clip attachments provide a more stable and secure connection to the test point compared to test probes (see figure 5-11). Alligator clip attachments are recommended when taking continuous/numerous readings or when connecting to terminal lug posts.

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FIGURE 5-11. Alligator clips in the open and closed position.1

CAUTION

Teeth may scratch or dent delicate components, such as contacts and circuit boards. Alligator clip attachments should not be used on contacts or other delicate aircraft EWIS components or LRU/WRAs.

(1) Unlike contacts that are a part of the circuit, alligator clips can be attached to test contacts (see figure 5-12). When using alligator clips, the following should be considered:

a. Avoid connecting the alligator clip to the colored BIN band. The paint may add resistance to the measurement.

b. Use caution when installing test contacts to pin-type contacts (see figure 5-13 red arrow). The added weight and length can easily bend pins. Attaching probes and accessories should not be used on small-sized contacts that are susceptible to this type of damage.

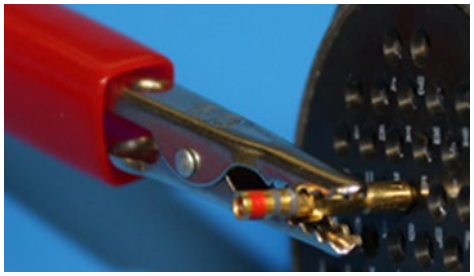


FIGURE 5-12. Alligator clip attachment connected to test contact.

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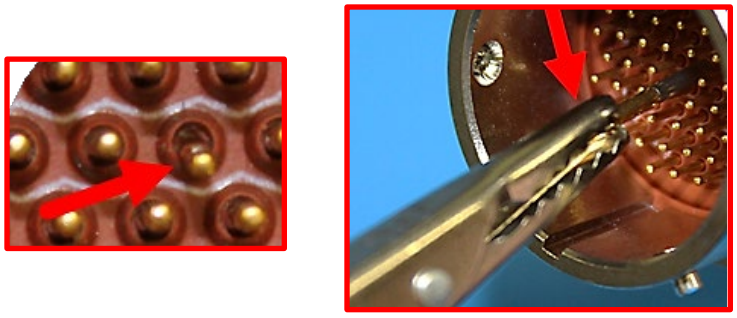


FIGURE 5-13. UNACCEPTABLE. Contact bent from the weight of the meter lead accessory.

h. Jumper wires provide excellent connections and versatility between test points and the DMM (see figure 5-14).

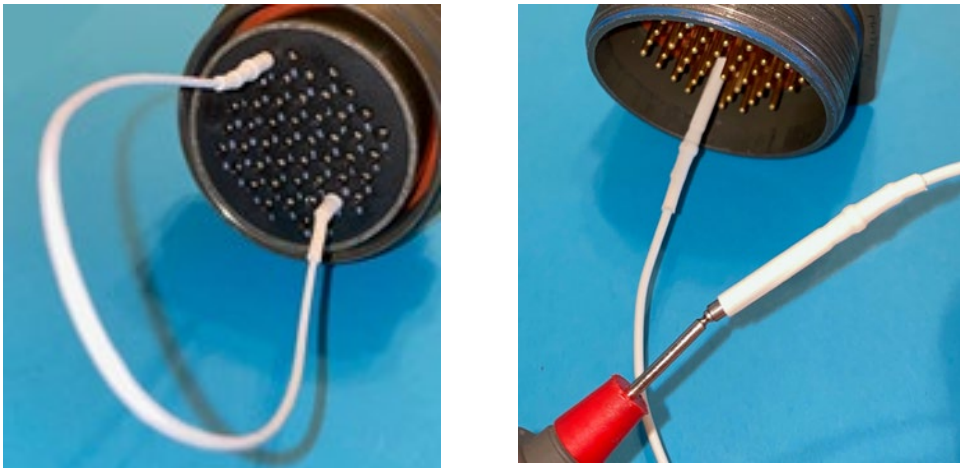


FIGURE 5-14. Typical uses of jumper wire.

(1) Jumper wires can be used to:

a. Extend the reach of DMM test leads.

b. Perform continuity checks or resistance measurements on two wires at the same time.

c. Short a wire to the aircraft ground to perform continuity or resistance measurements.

d. Provide a more stable connection point for electrical measurements.

(2) Jumper wires can be made from a variety of EWIS components based on specific needs. Some of the components that can be used to make jumper wires are:

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a. Wire or cable.

b. Terminal lugs.

c. Contacts (pins/sockets).

d. Alligator clips, etc.

(3) Jumper wires should be assembled using the same methods as assembling EWIS components to ensure reliability and accuracy.

NOTE

Heat shrink tubing should be around exposed parts of contacts (see figure 5-15) or terminal lugs to reduce the risk of shorting the jumper wire to other components.

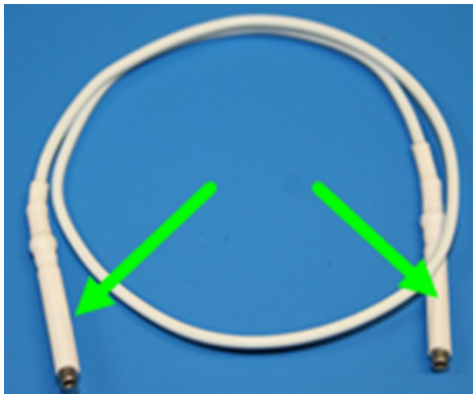


FIGURE 5-15. Jumper wire with sockets and heat shrink (green arrows).

WARNING

Using materials (such as safety wire, etc.) or adapters that are not designed for electrical applications may result in personal injury, electrical shock, or damage to aircraft. Only tester accessories or EWIS components designed for electrical applications (such as connector contacts, alligator clips, etc.) should be used for EWIS troubleshooting. The use of other materials (such as safety wire, etc.) or components not designed for electrical applications may result in erroneous readings, damage to aircraft/avionics, or electrical shock.

i. Meter Lead Accessory Precautions. The following items should NOT be used as test probe accessories:

(1) Safety wire. Risks associated with using safety wire as meter lead attachments include (see figure 5-15):

a. Electrical shock hazard.
b. Coiled safety wire creates resistance that may result in false readings (see

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figure 5-16).

c. Sharp cut ends may damage EWIS components (e.g., connector grommets/seals, etc.).

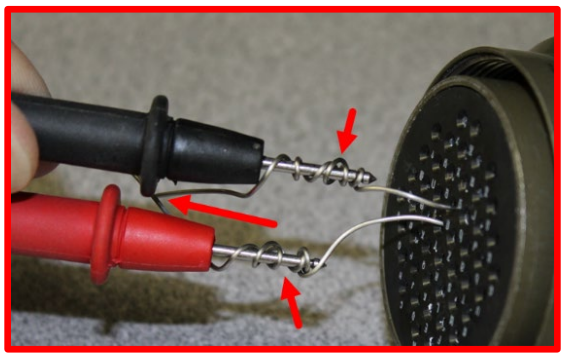


FIGURE 5-16. UNACCEPTABLE. Safety wire being used as a meter lead accessory.

(2) Non-conductive or poor conductive components/materials. Such as composites or steel.

(3) Accessories that damage EWIS or other components. Such as insulation piercing test probes.

(4) Poor quality meter leads or accessories.

(5) Un-insulated contact test probes. It is essential that test accessories be insulated to prevent shorting out against adjacent conductive components and to eliminate the risk of personnel injury from electrocution. Employ insulated, approved accessories rated to the applicable circuit voltage/current to be tested.

j. The yellow Fluke case includes 2-meter lead holders. These meter lead holders are typically used to store the meter leads when not in use; however, an additional purpose is to hold a meter lead while taking measurements. This design feature allows the DMM operator to increase their attention at the circuit test points resulting in safer operation and more accurate electrical measurements (see figure 5-17).

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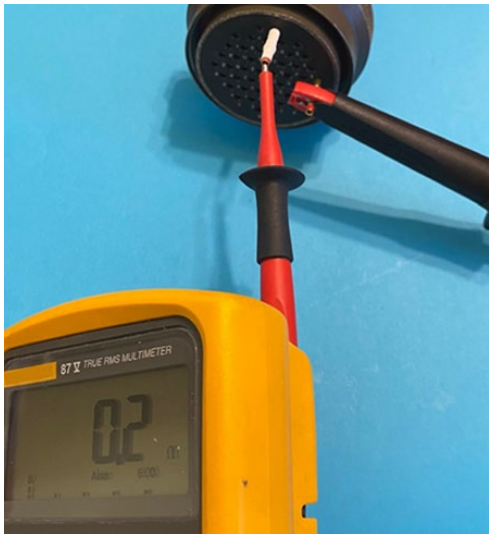




FIGURE 5-17. DMM meter lead holder.

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GUIDELINE 6

DMM PRE-OPERATIONAL INSPECTION

1. Purpose. This guideline demonstrates DMM pre-operational check inspection techniques.

2. General troubleshooting guidelines. Faulty meter leads and accessories have resulted in incorrect readings. By performing the pre-operational checks, you will have increased confidence that the meter leads will not negatively impact your readings.

3. Detailed troubleshooting guidelines. The following procedures should be performed before each use and periodically during extensive use of the DMM, meter leads, and accessories.

a. DMM visual inspection. Performing a DMM visual inspection helps to verify the physical condition of the DMM and treats any minor contaminants that may affect obtaining accurate electrical measurements. Contaminants may cause the DMM not to function properly or provide false readings, especially at the DMM Connection Ports (see figure 4-1), test lead connections, and probe tips. Contaminants at these locations may increase tester resistance. When visually inspecting the DMM, the following items should be checked:

(1) Ensure DMM is clean and dry. Inspect for any contaminants that could damage DMM.

(2) Ensure DMM Connection Ports are free from FOD and other damage.

NOTE

If meter lead(s) are loose or fall out of connection ports, or any damage is identified in step 3, turn in the DMM, meter leads, or meter lead accessories for service or replacement.

(3) Verify meter leads and any applicable accessories are free from damage. Check for the following:

a. Nicks, cuts, or signs of overheating in insulation.

b. Gaps or cracks between the insulated wire and the molded probes at each end.

c. Debris and damage at the connector ends.

(4) Verify that the meter leads remain firmly in place when inserted fully in the connection ports.

b. DMM meter lead pre-operational check (see figures 6-1A through 6-1F). The DMM meter lead pre-operational check verifies the condition of the meter leads, meter lead accessories (if used), and the basic functioning of the DMM. This pre-operational check procedure can be modified to incorporate meter lead accessories. The following procedure should be followed when doing this check.

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WARNING

It is essential that only serviceable DMM, test leads, and test adapters be employed in the testing of EWIS. Faulty or damaged test equipment may result in inaccurate readings, incorrect component replacement damage to aircraft/components, or electrical injury.

(1) Insert meter leads into DMM:

a. Red (pos) V, Ohm input terminal.

b. Black (com) input terminal.

NOTE

Ensure the connectors are fully seated by firmly pressing each connector end until they stop, approximately 0.5 inch.

(2) Turn the selector knob to the Ω (ohm) setting and place DMM on a stable surface.

(3) Verify display reads "OL Ω" or "OL MΩ" (see figure 6-1A).



FIGURE 6-1A. DMM with meter leads installed.

NOTE

To ensure an accurate reading is taken, it is important that test probes (metallic ends) remain in firm, constant contact with each other for the duration of the test.

(4) Short the POS and COM test probes together (see figure 6-1B).

(5) Verify a stable reading of less than 0.5 ohms (see figure 6-1B).

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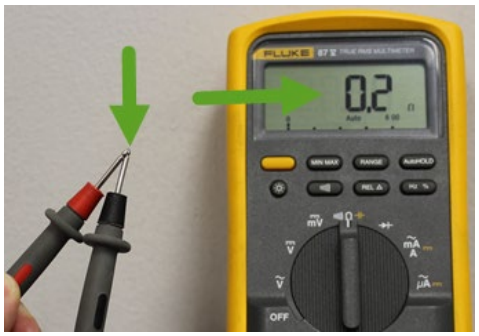


FIGURE 6-1B. DMM with POS and COM test probes shorted together to test the probes.

(6) While firmly holding meter leads in one hand, carefully flex the meter lead cables from end-to-end (see figure 6-1C).

(7) Verify resistance reading does not fluctuate and remains less than 0.5 ohms (see figure 6-1C).



FIGURE 6-1C. DMM with POS and COM test probes shorted together to test the meter lead cables.

(8) If readings remained stable and less than 0.5 ohms, the meter leads are ready to use (see figure 6-1D).

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FIGURE 6-1D. DMM after test probes and meter leads have been confirmed serviceable and ready for use.

(9) If erroneous readings are observed:

a. Verify test probes maintained a constant, firm connection (see figure 6-1E).

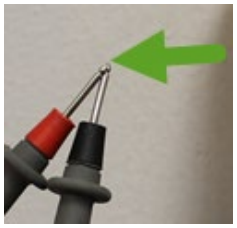


FIGURE 6-1E. DMM test probes maintaining constant, firm contact.

b. Verify meter lead connectors are firmly seated in the DMM connector ports (see figure 6-1F).



FIGURE 6-1F. Meter lead pre-operational check-with meter leads firmly seated in the DMM.

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(10) Repeat pre-operational check with a different pair of meter leads. If these meter leads pass, then replace the first pair. It is common for the test leads to degrade over time.

(11) If the DMM is suspected faulty, turn the DMM in for servicing or replacement.

c. DMM fuse resistance inspection (see figures 6-2A through 6F). Perform this inspection prior to taking current measurements. These fuses are designed to protect the DMM and operator from voltage build-up and current overload. This procedure verifies the condition of the DMM internal fuses. The following procedure is for the Fluke 27II, 77, and 87V. For all other models, verify with the manufacturer's manual for specific testing or limits.

WARNING

Always verify the DMM internal fuses are operational prior to taking current measurements. An open fuse may allow high voltage build-up and current overload, which may result in false readings, damage to aircraft/components, or electrical injury.

(1) Plug the POS meter lead into the red Ω (ohms) DMM connector port. (see figure 6-2A, lower right arrow).

(2) Turn the rotary selector knob to Ω (ohms) (see figure 6-2A top arrow).

(3) Verify the display reads "OL Ω" or "OL M Ω."



FIGURE 6-2A. DMM selector settings and connections needed to do a DMM fuse resistance inspection.

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NOTE

On Fluke 27II and 87V DMM's, the receptacles of the input terminals contain split contacts. Be sure that you touch the test probe to the half of the receptacle contact that is nearest the Liquid Crystal Display (LCD) in steps (4) and (6) (see figure 6-2B).

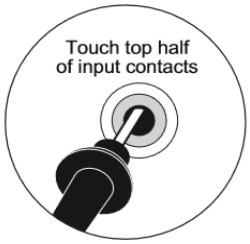


FIGURE 6-2B. Example of the proper way to insert the test probe when using the Fluke 87V DMM.

(4) Insert test probe into the red A (amperage) connector port and touch it to the upper portion of the port (see figure 6-2A lower left arrow and figure 6-2B).

(5) Verify resistance is less than 0.5 Ω (ohms) (see figure 6-2C). This tests the 10A (11 A for Fluke 77) 1000V fuse.

a. If the display reads OL (overload), the fuse needs to be replaced.

b. If the display reads any other value, have the meter serviced.



FIGURE 6-2C. Example of a resistance reading for a 10A, 1000V fuse.

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(6) Move the test probe to the mA/µA (milliamp micro-amp) DMM connector port (see figure 6-2D).



FIGURE 6-2D. DMM with test probe inserted into the mA µA (milliamp micro-amp) connector port.

(7) For the Fluke 27 II and 87V, verify resistance is 1kΩ (kilo-ohms) (+/- 0.005 kΩ) (see figure 6-2E). This tests the 400 mA, 1000V fuse. For the Fluke 77, verify the resistance of the 440mA fuse is less than 12 Ω.

a. If the display reads OL (overload), the fuse needs to be replaced.

b. If the display reads any other value, have the meter serviced.



FIGURE 6-2E. Example of a resistance reading for a 400mA, 1000V fuse.

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GUIDELINE 7

DMM SETUP AND OPERATION

1. Purpose. This guideline demonstrates DMM setup and operation techniques.

2. General troubleshooting guidelines. Use of the setup and operational procedures given in section 3 of this guideline will ensure that the DMM is properly configured prior to performing electrical measurements or tests.

3. Detailed troubleshooting guidelines.

CAUTION

Always be mindful of your surroundings when taking electrical measurements. Refer to guideline 3 and aircraft-specific and local safety procedures anytime working on or near electrical systems.

CAUTION

Do not over-flex wiring when positioning EWIS components to take electrical measurements. Always observe bend-radius limitations and handle with care.

NOTE

The connection between the test probes and the circuit test point is vital in taking accurate measurements.

a. DMM setup procedure. The following procedure should be performed prior to fault isolating with the DMM.

(1) Determine the required electrical checks/measurements; see guideline 2 for more information on the fault isolation phase.

(2) Review system schematics to determine circuit test points and reference test points. Reference guideline 9 for detailed guidance on selecting test points.

NOTE

Using the DMM HOLD feature or meter lead accessories will aid in taking safe and accurate measurements without the need to focus on the DMM display. Refer to guideline 5 and guideline 8 for more information.

(3) Select meter leads or accessories as required.

(4) Perform DMM pre-operational checks (see guideline 6).

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WARNING

Locking out circuit power or aircraft power prevents the circuit or surrounding circuits from accidentally being energized. Failure to properly lock out and tag electrical systems may result in damage to equipment or electrical shock.

(5) De-energize circuit and lockout applicable circuit breaker(s) or aircraft power.

(6) Locate and verify circuit test points are free of contaminants or other materials that may impede a good electrical connection with the test probes.

(7) Locate a stable location to place the DMM near the selected test points.

NOTE

Always connect the COM meter lead to the same location it was connected to during step (8) verifications. If verified at the terminal lug tongue, do not connect to the unverified terminal lug post during troubleshooting. The terminal lug post may have defects or contaminants that will affect resistance. If a different ground reference test point is needed, repeat step (8).

(8) Perform Ground Reference Test Point Resistance Verification per guideline 10, when applicable.

(9) Perform applicable electrical measurements/checks.

b. When taking measurements, the following practices should be followed.

(1) Stabilize the component under test:

a. Ideally, use a solid surface or fixture.

b. Alternatively, use hands/fingers to stabilize the component (see figure 7-1).

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FIGURE 7-1. Acceptable stabilization of the component under test: Hands and connector are stable while performing measurement with meter leads.

(2) Use meter lead accessories, such as alligator attachment(s) or insulated contacts or test adapters to improve the connection between test probes and circuit test points (TP).

CAUTION

Never forcefully insert a test probe or other accessory into a connector cavity (see figure 7-2). Forcing the test probe or other accessory into the cavity may result in damage to the connector.

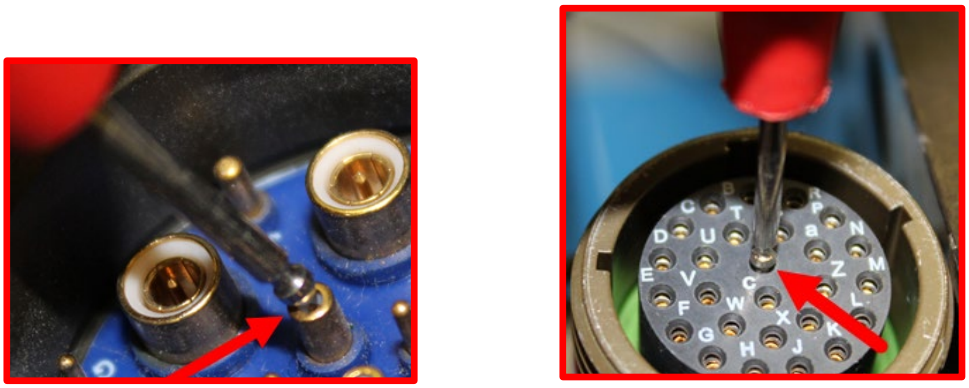


FIGURE 7-2. Unacceptable meter lead size. Isolated contact with conductor under test is not achieved.

(3) Stabilize your hands or arms on non-conductive components to reduce movement when probing the circuit TPs.

c. Continuity checks. The procedure for performing a continuity check is as follows:

(1) Perform the DMM setup procedure given in this guideline.

(2) Isolate circuit, as required. Refer to aircraft-specific MIMs/TMs for removing and reinstalling components.

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(3) Select the continuity mode on the selector knob of the DMM. It is likely shared with the resistance, Ω (ohms), setting.

NOTE

If continuity setting is shared with resistance setting, you'll likely have to perform step (4). When enabled, the continuity symbol will appear on the display.

(4) If required, press the continuity or secondary function button to enable the continuity test.

(5) Verify continuity symbol is displayed (see figure 7-3).

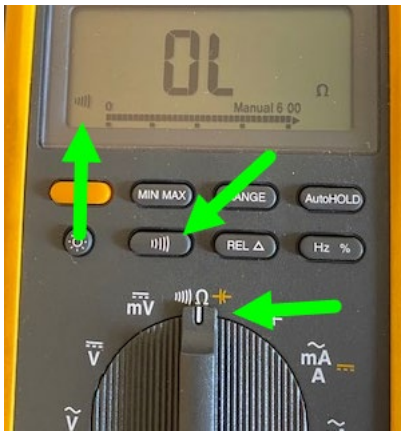


FIGURE 7-3. Continuity test setup.

(6) Setup DMM meter leads as follows:

a. Insert the red POS meter lead connector into the red A or mA input terminal, depending on the anticipated amperage being measured.

b. Insert the black COM meter lead connector into the black COM input terminal.

(7) Enable DMM advanced feature when applicable.

CAUTION

Never connect the meter leads to an energized circuit when the continuity check is selected. Damage to DMM will occur.

(8) Attach meter leads to circuit and ground test points identified in steps (6) and (8) of the DMM setup procedure in this guideline.

a. If continuity is detected, the DMM will beep.

b. If no continuity is detected, the DMM will not beep.

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(9) Record and analyze results.

(10) If multiple sets of circuit test points were identified for the test, repeat steps (8) and (9).

(11) Remove meter leads and accessories from the circuit.

(12) Remove DMM and turn selector knob OFF.

NOTE

Continuity checks are not the same as resistance measurements. For more information, refer to guideline 11.

d. Resistance measurements. The procedure for doing resistance measurements is as follows:

(1) Perform the DMM setup procedure in this guideline.

NOTE

When taking resistance measurements, the DMM will calculate the total resistance of all possible paths using ohm's law. Isolate circuit as required to ensure only applicable parts of the circuit are measured. Refer to guideline 8 for DMM features that aid in taking precise measurements (such as increased resolution, 'freezing'/holding the displayed measurement after meter leads are removed, auto-calculate difference in measurements, etc.). Refer to guideline 11 for more information on performing resistance measurements.

(2) Isolate circuit, as required. Refer to aircraft-specific MIMs/TMs for removing and reinstalling components.

(3) Select Ω (ohms) on the selector knob.

(4) Display should show "OL Ω" or "OL M Ω."

(5) Setup DMM meter leads as follows:

a. Insert the red POS meter lead connector into the red Ω connection port.

b. Insert the black COM meter lead connector into black "COM" connection port.

(6) Enable the applicable DMM advanced feature, as required.

CAUTION

Never connect the meter leads to an energized circuit when the resistance setting is selected. Damage to DMM will occur.

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NOTE

Body contact with the metal probe tips or circuit can affect resistance measurements because the human body becomes a parallel resistance path.
Recall: parallel resistance lowers total resistance.

(7) Attach meter leads to circuit and ground test points identified in steps (6) and (8) of the DMM setup procedure, this guideline.

NOTE

If resistance measurements do not identify a fault, refer to guideline 16 for additional fault isolation methods for intermittent discrepancies.

(8) Record and analyze measurements.

(9) If multiple sets of the circuit test points were identified for resistance measurements, repeat steps (7) and (8).

(10) Remove meter leads and accessories from the circuit.

(11) Remove DMM and turn selector knob OFF.

e. Voltage measurements. The procedure for performing voltage measurements is as follows:

(1) Perform the DMM setup procedure, step (3)a of this guideline.

WARNING

Injury or damage to DMM may occur if connected to a circuit with voltage exceeding the rated input/setting. Ensure the voltages of the circuit being tested are within the range of the DMM and desired setting before connecting the DMM to the circuit.

NOTE

Refer to guideline 8 for DMM features that aid in taking precise measurements (such as increased resolution, 'freezing'/holding the displayed measurement after meter leads are removed, auto-calculate difference in measurements, etc.).

(2) Select desired voltage setting on selector knob:

a. VDC for volts DC.

b. VAC for volts AC.

c. mVDC for millivolts DC.

(3) Setup DMM meter leads as follows (see figure 7-4):

a. Insert the red POS meter lead connector into the VΩ, Ohm input terminal.

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b. Insert the black COM meter lead connector into black “COM” connection port.



FIGURE 7-4. Example of a DMM with the POS and COM meter leads connected.

(4) Enable applicable DMM advanced feature, as required.

NOTE

For multiple circuit test points, complete steps (5) thru (9) for each circuit test point before moving to the next test point.

(5) Attach the COM meter lead probe to a verified ground test point identified in step (8) of the DMM setup procedure, this guideline.

(6) Attach the POS meter lead probe to circuit test point identified in step (6) of the DMM setup procedure, this guideline.

WARNING

Use extreme caution while working on or near live electrical loads. Handling energized conductors risks electrical shock, which may cause serious injuries or death.

(7) Energize the circuit.

NOTE

Most DMMs automatically detect polarity. A negative symbol (-) is displayed before the numerical value if the meter leads are connected to the circuit in reverse. If voltage measurements do not identify a fault, refer to guideline 16 for additional fault isolation methods for intermittent discrepancies.

(8) Record and analyze measurement.

(9) De-energize circuit.

(10) Remove meter leads and accessories from the circuit.

(11) Remove DMM and turn selector knob OFF.

f. Current measurements. The procedure for performing current measurements is as follows:

(1) Perform the DMM setup procedure in this guideline.

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CAUTION

Ensure meter lead connectors are inserted into the appropriate DMM ports prior to turning the DMM on. Failure to ensure the function setting and probe setup is correct may damage the DMM. If uncertain of the circuit amperage, set DMM up for A (amp) rating first.

NOTE

Refer to guideline 8 for features that aid in taking accurate and precise measurements.

(2) Set up DMM meter leads as follows (see figure 7-5):

a. Insert the red POS meter lead connector into the red A or mA input terminal, depending on the anticipated amperage being measured.

b. Insert the black COM meter lead connector into the black COM input terminal.



FIGURE 7-5. Example of DMM setup for current measurements.

(3) Turn the selector knob to one of the following settings:

a. A for circuits up to specific DMM amperage rating.

b. mA for circuits below the DMM's maximum milliamp rating.

CAUTION

It is essential that meter lead probes never be attached in parallel with any circuit or component when meter leads are connected to the DMM current terminals. Connecting the DMM in parallel with the circuit under test may result in damage to the DMM or component.

(4) Connect the meter leads in series with the circuit test points identified in 3.a(6) (this guideline) as follows:

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a. Connect COM meter lead probe to downstream (load side) circuit test point.

b. Connect POS meter lead to the upstream (bus-side) circuit test point.

WARNING

Use extreme caution while working on or near live electrical loads. Ensure steps (5) through (8) are followed in exact order to prevent voltage build-up at meter leads. Handling energized conductors risks electrical shock, which may cause serious injuries or death.

(5) Energize circuit.

(6) Record the measurement.

(7) De-energize circuit.

(8) Remove meter leads and accessories from the circuit.

(9) Remove DMM and turn selector knob OFF.

(10) When applicable maintenance and troubleshooting is complete, remove lockouts and return aircraft or system to original configuration per applicable technical manuals.

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GUIDELINE 8

ADVANCED DMM FEATURES

1. Purpose. This guideline provides overviews of common advanced DMM features and functions.

2. General troubleshooting guidelines. The following advanced features are common on DMMs. Please note that advanced features vary between manufacturers/models. Common advanced DMM features include but are not limited to:

a. HOLD/AutoHOLD.

b. MANUAL

c. MIN MAX.

d. Relativity (REL)

3. Detailed troubleshooting guidelines.

NOTE

All advanced DMM features are disabled when the DMM is turned on or the selector knob is changed to another function.

a. The HOLD/AutoHOLD feature keeps the last stable measurement displayed even after test probes are removed from the circuit (see figure 8-1). Use of this feature also does the following:

(1) Promotes operator safety. Use of this feature allows you to maintain focus on your proximity to energized circuits to reduce the risk of electrical injury.

(2) Allows your focus to be on taking an accurate reading. This is essential because the connection of the meter lead to the circuit test point may be easily interrupted while taking electrical measurements.

(3) Allows DMM to be placed in a safe/secure location even if out of sight.

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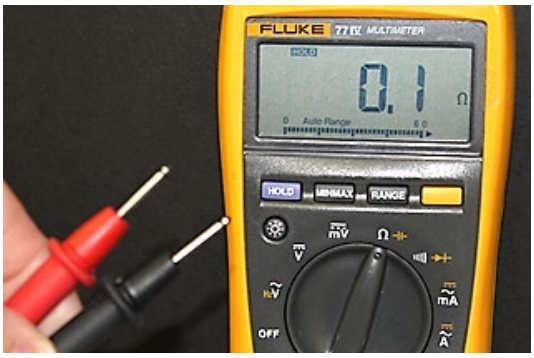


FIGURE 8-1. Meter leads are disconnected from a circuit, but measured reading remains displayed.

b. To enable the hold feature:

(1) Configure DMM per guideline 7.

(2) Press HOLD or AutoHOLD (depending on model) once (see figure 8-2 lower green arrow).

(3) “HOLD” surrounded by a black box should appear on the upper part of the display (see figure 8-2 upper green arrow).

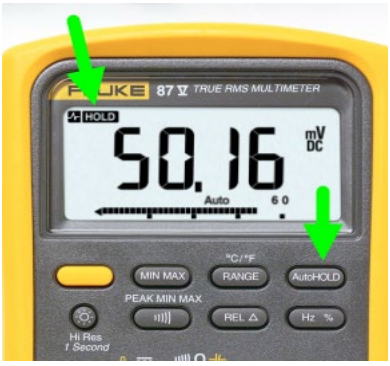


FIGURE 8-2. Hold feature enabled.

c. To disable the HOLD feature:

(1) Press the HOLD/AutoHOLD button once. “HOLD” in the upper part of the display will not be visible.

(2) Or, turn the selector knob to “OFF.”

d. MANUAL range allows the user to adjust the range amongst several preset ranges. To display the highest resolution while in manual mode, select the lowest range setting where the measurement will not exceed the selected range.

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e. To enable MANUAL range.

(1) Configure DMM per guideline 7.

(2) Press the RANGE button to cycle between the various manual modes.

(3) Verify that “Manual” is displayed below the numerical reading (figure 8-3, arrow on the right of the figure).

(4) Verify the desired maximum range is displayed.



FIGURE 8-3. Manual mode.

f. To return to AUTO range, press and hold RANGE until “Auto” appears above the bar graph.

g. The MIN MAX feature records the minimum and maximum measurements and calculates the average. A maximum (MAX), minimum (MIN), or average (AVG) reading can be viewed on the display. An audible MIN MAX alert indicates when a new minimum or maximum value has been recorded.

h. When to use the MIN MAX Recording Mode:

(1) To continuously measure during an ongoing test.

(2) Take readings while you are operating the equipment under test and cannot watch the meter.

(3) To assist with:

a. Catching intermittent and turn-on or turn-off surges.

b. Verifying electrical performance.

c. Catching temporary voltage losses.

d. Taking temperature measurements.

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e. Catching frequency fluctuations over time.

NOTE

The response time is the length of time an input stays at a new value for the DMM to record the full change.

i. On the Fluke 87V, for recording minimum and maximum readings, you can select response times of either:

(1) 100 millisecond - best for recording power supply surges, switch-on surge currents, and finding intermittent failures. This mode follows the update time of the analog display.

(2) millisecond (Peak) - ideal for recording transients, especially from intermittent power circuits or connections. This mode can also be used to measure the + and – peak values of sinewaves up to about 450 Hz, for easy measurement of both peak line voltage and line current measurements of power supplies and electrical equipment.

(3) 1 second (high accuracy) - records signal extremes lasting longer than 250 µS.

NOTE

Ensure a stable connection is maintained while using the MIN MAX feature. The DMM cannot differentiate between a poor connection of the meter leads to the test point(s) and a fault in the circuit being tested.

NOTE

The use of meter leads or accessories that connect to the circuit test point, such as alligator clips, are ideal when using the MIN MAX feature. Holding the meter leads by hand is likely to cause a loss of connection prior to reviewing the min, max and average recordings. This loss of connection will skew the results.

j. To enable the MIN MAX mode (see the bottom arrow on figure 8-4):

(1) Setup DMM per guideline 7.

(2) Press the MIN MAX button.

(3) Verify “MIN MAX” surrounded by a black box is displayed in the upper portion of the display (see upper left-hand arrow in figure 8-4).

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FIGURE 8-4. Average (AVG) calculation displayed while MIN MAX mode enabled.

NOTE

When a new high or low value is reached, the DMM will activate an audible beep and record the new value. Only one value of each category is stored in the DMM memory. Review and record readings per step (5) before taking subsequent measurements.

NOTE

The DMM cannot differentiate between changes in the circuit and removing the meter leads from the circuit. The disconnected meter leads will overwrite the MIN value during voltage and current measurements and the MAX value during resistance measurements. Perform step (5) before disconnecting the meter leads.

(4) Perform measurements per guideline 7.

(5) Press the MIN MAX button to cycle through the recorded values (see bottom arrow on figure 8-4). The displayed value will be identified by either “MIN,” “MAX,” or “AVG” next to the “MIN MAX” icon (figure 8-4 upper right arrow).

NOTE

Disabling MIN MAX mode will delete the MIN, MAX, and AVG recordings. Review and write down these recordings prior to disabling the MIN MAX feature.

k. To disable MIN MAX mode, do the following:

(1) Press and hold the “MIN MAX” button.

(2) MIN MAX icons visible during enable mode will no longer be displayed.

l. The Relative (REL) or Delta **(Δ)** feature automatically calculates and displays the difference between the present and previously stored readings.

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m. The REL function:

(1) Displays the actual circuit measurement without the added value of the meter leads and any jumper test lead.

(2) Allows you to see changes in the reading in real-time.

(3) Displays the differences, whether positive or negative values, between an initial baseline and subsequent readings.

n. A baseline reading is taken and becomes the reference value. All subsequent readings will be added or subtracted to the reference value. The product or difference will be displayed as the numerical value on the screen. If the new reading is the same as the reference value, the display will be zero.

o. The bar graph displays the present measurement. For example, if the reference value is 15.00V and the present reading is 14.10V, the display will indicate -0.90V. The bar graph would indicate 14.10.

p. To enable the Relative (REL) or Delta **(Δ)** REL feature perform the following:

(1) Setup DMM per guideline 7.

(2) Take a baseline reading at the circuit test points identified in the previous step.

(3) While maintaining a stable reading, press "REL Δ" (see the bottom arrow on figure 8-5).

(4) Verify the display changes to "0" and the "Δ" appears on the display (see the arrow on the far left side of figure 8-5).

NOTE

When taking readings in REL mode, the loss of input when the probe leads are removed from the circuit will be recorded as a change from the baseline measurement.

NOTE

The bar graph displays the present reading, and the numerical readout displays the difference of the measurements.

(5) Take subsequent measurements.

NOTE

If the measurement increases, the displayed value will be positive. If the measurement decreases, the displayed value will be negative, and a "-" (negative sign) will be visible in front of the numerical value (see the top arrow on the left side of figure 8-5).

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FIGURE 8-5. Relative feature enabled.

q. To disable Relative (REL) or Delta (Δ)REL feature:

(1) Press and hold the “REL Δ.”

(2) Verify the “Δ” is no longer displayed.

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GUIDELINE 9

REFERENCE TEST POINTS AND CIRCUIT TEST POINTS

1. Purpose. This guideline provides criteria for selecting and using reference and circuit test points.

2. General troubleshooting guidelines.

a. The term reference test point is used within this handbook to differentiate between test points associated with the faulty circuit (circuit test points) and test points that have been selected to aid in troubleshooting, used as reference values, or to ground the support equipment. Reference test points may be neighboring circuits or the electrical ground circuit, effectively extending the reach of the meter leads.

b. Reference test points are used to:

(1) Ground the DMM for measurements requiring a ground reference, such as voltage measurements.

(2) Connect a circuit under test to the aircraft ground system when performing continuity checks or resistance measurements.

(3) Connect a circuit under test to a known good circuit when performing continuity checks or resistance measurements.

c. Jumper wires can be used to short circuit test points to reference test points (see figure 9-1).

d. There are two types of electrical grounds used on the aircraft:

(1) Aircraft structure. Electrical circuits utilize the aircraft's conductive structure to act as electrical grounds (referred to as aircraft ground). On most aircraft, these ground points can be located relatively easily with ground circuit identifiers. As such, aircraft grounds are excellent reference test points for EWIS troubleshooting.

(2) Wired ground. A wire extends from the component back to the power source. Not as common as using aircraft structure due to increased costs and weight.

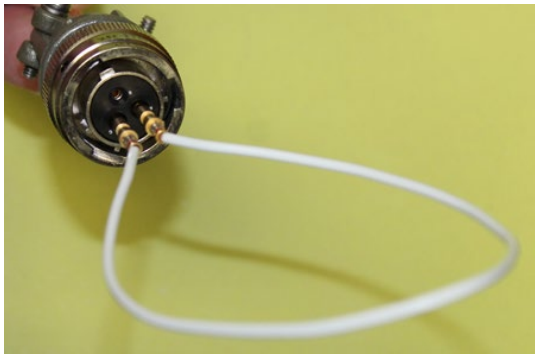
e. Circuit test points.

(1) Are the points of the circuit where the DMM connects, via meter leads, to perform a measurement or test to determine if a fault exists in the selected part of the circuit.

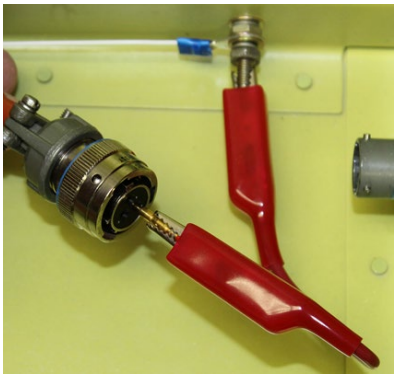
(2) May be provided by MIM/TM maintenance troubleshooting procedures.

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(3) Can be determined by reviewing system schematics and identifying the test points required for a specific electrical measurement or check.



Jumper wire connecting neighboring reference test point wire to a circuit test point.



Jumper wire connecting a circuit test point to a ground reference test point.

FIGURE 9-1. Examples of the use of jumper wire.

WARNING

Always refer to the appropriate maintenance manual prior to disassembling and testing a circuit. Failing to follow the required removal procedures and any "Notes, Cautions, or Warnings" provided by the maintenance procedures may result in damaging system components or personnel injury/death.

f. Circuit test points and reference test points can be any EWIS component of the respective circuit where the conductor is accessible or can be made accessible. Such as:

(1) Connector contacts (pins or sockets)

(2) Terminal lugs

(3) Shield

(4) Aircraft structure that is electrically connected to the aircraft ground system

(5) Grounded LRU/WRA chassis

(6) Bonding jumper strap/wire. Exposed uninsulated strap or wire is an effective aircraft ground."

g. Continuity and resistance measurements require end-to-end testing to confirm the integrity of a wire or circuit component. Examples of the purpose for common test points are as follows:

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(1) Wire-end to another wire-end will determine if a short exists between the two wires.

(2) Wire-end to ground will determine if a short exists between the wire and ground or if an open exists in a ground circuit.

(3) Wire-end to connector shell will determine if a short to connector condition exists.

(4) Wire-end to component will determine if a short to the component exists or an open exists in a chassis ground circuit.

NOTE

Always confirm with the wiring schematic to determine if any of the conditions (1) through (4) above are supposed to exist (e.g., In some systems, the wires may be spliced/terminated together, or to ground.)

h. When selecting circuit test points, the following factors should be considered:

(1) It is important that circuit test points are relevant to the fault type (open, short, etc.) and the measurement or test being performed (resistance measurement, voltage measurement,etc.). See guideline 2 for more information on determining a probable fault type and selecting the appropriate measurement or test.

(2) It is important that when accessing selected test points that the applicable circuitry not be disrupted. For example, a connector in the middle of the harness should not be disconnected to perform continuity checks on the entire wire length.

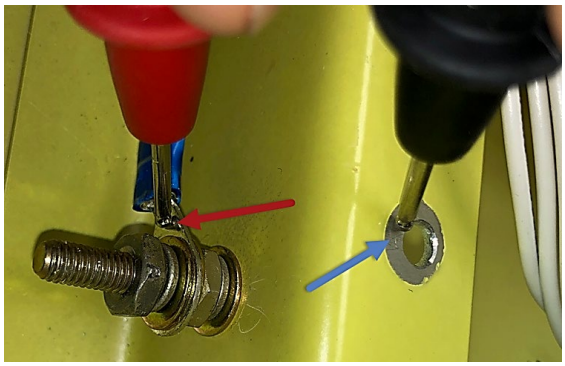
(3) When performing isolated end-to-end measurements, the schematic will indicate a closed circuit between the circuit test points. If a switching component (e.g., switch, relay, etc.) is inline, it is important that the respective switching circuit be electrically closed.

(4) Prior to using reference test points to extend the reach of the meter leads, it is essential that the applicable circuit has been verified as operational (good), and that a complete electrical path between the respective reference test points has been made. See guideline 10 for more information.

i. Even when there are no obvious signs of contaminants or corrosion, cleaning the surface with an approved cleaning agent for the specific type of material may be necessary to perform accurate electrical measurements. For example, bare aluminum alloy can oxidize enough to increase its resistance by 100x in 24-48 hours.

j. Many discrepancies are attributed to poor ground connections. Figure 9-2 provides examples of test points chosen to measure the resistance of the ground terminal lug connection to aircraft ground.

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POS meter lead connected to terminal lug eyelet, test point 1 (red arrow)

COM probe connected to aircraft ground test point 2 (blue arrow).

FIGURE 9-2. Example of performing a resistance measurement of the ground terminal lug connection to aircraft ground.

3. Detailed troubleshooting guidelines.

a. To select circuit test points:

(1) Determine which electrical measurement(s) or test(s) will be performed (e.g., continuity, no-load voltage, etc.). Refer to guideline 2 for more information on determining electrical measurements or checks.

NOTE

Steps (2) and (3) will typically be performed simultaneously to determine required circuit test points (TP) and reference test points (RTP).

(2) Determine the type of test point required for the electrical measurements. See table 2-III in guideline 2 for additional information.

(3) Review the applicable aircraft or system wiring schematics to identify the circuit test points. Test points will typically be in sets. For example, when measuring the resistance of wire 123, the set of test points are connector P1 pin A to P4 pin H. This is because the schematic indicates wire 123 is terminated at those contacts.

(4) Inspect the circuit test point and reference test points for:

a. Obvious signs of damage.

b. Dirt, CPC, oil, or other contaminants.

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GUIDELINE 10

VERIFYING REFERENCE TEST POINTS

1. Purpose. This guideline provides criteria for inspecting and verifying reference test points prior to using them for electrical testing.

2. General troubleshooting guidelines.

a. It is important that the circuit of the reference test points(s) be electrically verified as fault-free prior to using the reference test point(s). The DMM cannot differentiate between the circuit under test and reference test points.

b. Prior to using the ground reference test point, it is important that the test point:

(1) Be electrically connected to the same ground circuit as the circuit under test. Verify with the system's wiring schematic. Most electrical systems are grounded to the aircraft ground system.

(2) Be free of contaminants, corrosion/oxidation, paints, CPCs, or any other non-conductive materials at the point where the meter lead will connect to the ground point.

(3) Have verified resistance of less than 1.0 Ω (ohm). See the detailed troubleshooting guidance in section 3 of this guideline.

(4) Be in close proximity to the circuit test point. While connected to the DMM, it is important to be able to connect both circuit test points with some slack in the meter leads and meter lead's accessories, when applicable.

CAUTION

Do not remove aircraft paint from the structure to expose bare metal to create a ground test point. This practice destroys the protective coatings and may structurally damage the aircraft.

NOTE

Not all metallic aircraft components have low-resistance connections to the primary aircraft structure. A metallic component may be mounted on a non-conductive composite frame. Failure to verify a ground point may result in erroneous or false readings.

3. Detailed troubleshooting guidelines.

a. To electrically verify that the circuit of the reference test points(s) is fault-free, the following procedure should be used:

(1) Perform the DMM pre-operational procedure per guideline 6.

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(2) Setup DMM for resistance measurements.

(3) Connect the COM meter lead probe to the selected ground reference test point.

NOTE

In step (4), the GND is used as a reference to determine the resistance of the selected reference test point. To ensure an accurate measurement, it is essential that the GND not be attached to the same component or structure as the reference test point. The idea is to find two ground points with the least number of common components but connected to the same ground system.

(4) Locate a GND that is in reach of the POS meter lead, but that is not attached to the same structure or component as the reference test point.

(5) Connect the POS meter lead probe to the ground point located in the previous step.

(6) Ideal resistance is less than 1.0 Ω (ohm) and stable. The reference test point is verified good.

(7) If erroneous readings are observed or resistance is greater than 1.0 Ω (ohm):

a. Check that both meter lead connections are secure.

b. Verify both ground points are clean and free of any contaminants that would create resistance.

c. Select another GND and retest.

d. If the selected reference test point was chosen as a ground point for the DMM, the reference test point may not be a suitable ground. Select another reference test point and retest until a suitable ground reference test point is located.

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GUIDELINE 11

CONTINUITY CHECKS AND RESISTANCE MEASUREMENTS

1. Purpose. This guideline provides criteria for performing continuity checks and resistance measurements.

2. General troubleshooting guidelines.

a. Resistance measurements and continuity checks require the circuit under test to be completely isolated from any other circuit.

b. Continuity checks are not the same as resistance measurements. Continuity is the presence of a complete path for current flow. As such, good continuity does not necessarily indicate good resistance. Most DMM's will display a low-resolution resistance measurement when the continuity check is enabled.

c. Continuity testing determines if an electrical connection exists, and resistance measurements determine what degree of restriction exists within the circuit under test. An audible beep is observed when the DMM detects continuity and ceases when no continuity is detected (discontinuity). The continuity check can accurately indicate the presence of a fault where shorts, opens, or certain high-resistance (see below) occur lasting 250 micro-seconds or longer. Because of this response rate, the continuity check should be used when troubleshooting intermittent faults with the flex test method (see section 4 of guideline 16)."

d. The Continuity Test feature should not be confused with the Diode Test feature, which measures and displays the voltage drop across a diode. Similar to the resistance measurement feature, the indicated measurements of the diode test occur at a much slower rate than the continuity test, which may result in certain shorts and opens going undetected. On many DMM models, the Continuity Test, Resistance Measurement, and Diode Test features share the same selector knob setting. See guideline 4 or manufacturer's operator manual for more information.

e. When testing for continuity, the DMM produces an audible beep if the circuit's measured resistance is within a predetermined range, indicating "good" continuity.

f. For Fluke 77 and 87V:

(1) If the range is set to 600 Ω, the DMM beeps if the component has a resistance of 40 Ω or less.

(2) If the range is set to 6k Ω, the DMM beeps if the resistance is 200 Ω or less.

g. A wire tested end-to-end should have low-resistance continuity. If it is tested and fails continuity, that means the DMM measured more than 200 ohms on the 6k ohm scale. But if it passed continuity testing, the result means the resistance was less than 200 ohms.

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h. Examples of using the continuity test are given in the subparagraphs below.

(1) When tested to each other, two (2) isolated wires should have ‘no continuity’ and infinite resistance. Since the DMM indicates ‘no continuity’ as resistance above 200 ohms (on the 6k Ω scale), a continuity test alone is not sufficient to determine the two wires are, in fact, isolated from each other. To confirm, verify the resistance measured between the two wires.

(2) If a harness is being tested to ensure no wires are shorted together, a continuity test would quickly identify if a low-resistance (below 200 ohms) short exists. But it will not determine if there is a high-resistance (above 200 ohms) short.

NOTE

The bus side of a circuit is rarely the focus of a specific system discrepancy. If it is not isolated from the load-side, you may be incorporating the generation/distribution resistance into your readings because a DMM takes the total resistance of all paths.

i. Things to consider when testing for continuity/performing resistance measurements:

(1) This test requires isolating the circuit.

(2) Resistance of the DMM and leads/accessories will be added to the total resistance measurement.

j. Isolating the circuit under test ensures the resistance of other circuits is not calculated into the total measured resistance by the DMM. Total resistance:

(1) Increases in a series circuit.

(2) Decrease in a parallel circuit.

k. If the circuit is NOT isolated:

(1) An open or high-resistance condition may not be detected in a parallel circuit when measured.

(2) A good circuit may appear shorted if there is continuity through another part of the circuit.

l. When to use resistance measurements and continuity checks:

(1) Resistance measurements are used to determine the resistance value of a wire or component. By comparing the measured resistance with a known acceptable value, a determination of the wire or component’s condition can be made.

(2) Continuity checks can quickly indicate that a fault may be present. If the continuity

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check indicates a fault; a resistance measurement is needed to confirm this finding. The continuity check beeper has a quicker response than the DMM display, which makes the feature ideal for catching rapid shorts or opens when performing flex tests. See guideline 16 for more information.

WARNING

De-energize the circuit prior to taking resistance measurements. Failure to ensure that the circuit is de-energized will damage the DMM and may injure the operator.

m. See table 2-IV of Guideline 2 for a list of common resistance values for standard EWIS components.

NOTE

Always verify the condition of your test gear and accessories prior to and throughout the course of use. Ensure only properly sized accessories are used to create the best connections (e.g., appropriately sized test contact, etc.). The DMM cannot differentiate between the circuit under test and meter leads/accessories. Failure to use properly sized and serviceable accessories may result in erroneous readings.

n. Test leads and accessories add to the total resistance measured. When precise resistance measurements are required, enable the Relative function. See guideline 8 for more information.

o. Most discrepancies will have easy-to-identify bad electrical readings/tests. Some examples of bad electrical readings/tests include:

(1) Infinite resistance when measuring a wire.

(2) 0 VAC when there should be 115 VAC.

(3) If all sections read 1.3 ohms except for one section that reads 2 mega-ohms, this is an indication that the section with the 2 mega-ohms should be troubleshot.

p. It is always important to note variations in readings, even when they are subtle or slightly off. These conditions may need further troubleshooting if no obvious discrepancies are uncovered. One example of a potential discrepancy is as follows: 3 out of 4 wires read 0.8 ohms, but 1 wire reads 1.1 ohms. While 1.1 ohms may normally indicate an acceptable measurement, there may be cases when this is an indication of a fault, such as in certain signal circuits where any changes in impedance can affect system operation.

3. Detailed troubleshooting guidelines.

a. Detailed instructions on how to perform continuity checks and resistance measurements with a DMM are outlined in guideline 7.

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b. Discrepancies in your SE or connection points may be mistaken for discrepancies in the circuit. If you suspect false readings or you are continuously seeing erroneous readings while performing resistance measurements or continuity checks:

(1) Verify the connections to the circuit test point (TP) and the reference test point (RTP).

(2) Perform the DMM pre-operational inspection on the meter leads and accessories (see guideline 6).

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GUIDELINE 12

ISOLATING AN OPEN CIRCUIT

1. Purpose. This guideline gives troubleshooting guidance on isolating an open condition in an EWIS circuit.

2. General troubleshooting guidelines.

a. An open circuit is a condition where there is no electrical connection between two or more points. This condition may be intentional, such as a switch in the 'off' position or the product of a circuit fault, such as a broken wire.

b. The amount of resistance required to cause an open varies between circuits. For some designs, an open may be any measured value greater than 100 ohms, while for others it may be greater than 200 kilo-ohms. In all cases, an open is infinite ohms or 'OLΩ" as displayed on the DMM.

c. Resistance measurements are the most effective means of identifying opens.

d. Continuity checks can quickly identify most opens, but these opens are required to be greater than 200 ohms. Resistance measurements are required if continuity checks do not identify the open. For example, a signal circuit where 150 ohms will cause an open, the continuity beeper would indicate good continuity.

e. Common symptoms of an open in EWIS:

(1) Inoperable system. The open can occur on the power or ground side of the circuit.

(2) Partial system operation occurs when only part of the system operation is affected. For example, an open on a signal wire may only affect part of the WRA/LRU operation/function.

(3) Erratic operation occurs when the system fluctuates or provides erroneous outputs. These are common with an open in the ground circuit, shielding, or signal circuits with multiple ground sources.

(4) No power conditions are most often attributed to opens. Note, a tripped CB may cause a no power indication or fault code. The fault that requires troubleshooting would be the short that caused the CB to trip. The observed open is the result of the CB isolating power to the shorted circuit.

f. Common causes of an open:

(1) Most often, wires are broken from deterioration by corroding, improper handling, collateral damage (severed while cutting safety wire, etc.), excessive bending, or being pinched in cable clamp.

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(2) Conductor pulled from the crimp. Many of these faults are not easily visible. Lightly pulling the associated wire at the base of the connector or terminal lug will typically reveal the discrepancy. In most cases, this occurs due to under-crimped connector contacts, terminals, or splices during installation, corrosion internal to the connector, excessive bending at base of contact or terminal lug, improperly installed, or lack of strain-relief.

(3) Recessed contact in connector. If a pin is recessed, a failure to mate with the socket contact despite a fully mated connector can result in an open circuit condition.

(4) Insufficient crimp depth or incorrectly positioned crimp. Loose crimps are a result of improper crimping at the installation of the contact. Loose crimps can be very daunting to locate because visual inspections may not clearly identify the issue, and continuity checks will likely check good. This issue causes an excessive voltage drop at the crimp resulting in an observed system discrepancy. See guideline 13 for additional information.

(5) Faulty switch, relay, circuit breaker. Continuity checks can narrow down switches, relays, and circuit breakers that are internally faulted, causing an open.

(6) Disconnected terminal lug or connector.

(7) Faulty component. For example, brown fuse, light bulb filament, etc.

3. Detailed troubleshooting guidelines.

NOTE

This procedure combines physical inspections with electrical measurements using the divide and conquer method. This procedure, with modifications, could be used to troubleshoot other conditions.

NOTE

A common practice is to isolate the system from the power distribution circuit by pulling the CB. While this is usually the most efficient way to isolate the majority of the circuit, it does leave out the CB itself and the wiring that connects the CB to the distribution bus.

NOTE

If the circuit under test is not electrically isolated from all other circuits, the DMM will measure the total resistance of all possible paths, resulting in false readings. Fully isolate the circuit under test from all other circuits and branches that you do not intend to measure.

a. Perform the following steps to isolate an open in a circuit:

(1) Configure DMM for resistance measurements per guideline 7.

(2) Isolate the circuit wiring from the load and any circuits/branches not related to the

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discrepancy. While less common, this may include wiring from the distribution bus to the CB.

(3) While performing steps (4) through (6), thoroughly inspect associated EWIS components for defective:

a. Connectors: improperly mated, bent pins, recessed contacts, broken or separated wires at contacts.

b. Wiring: broken, evidence of burning, severely crushed.

c. Terminal lugs: excessively bent, loose, broken, or separated wire at the crimp.

d. All EWIS: corrosion. For signal/low-power circuits, minor corrosion may cause an open.

NOTE

If at any point a defect is identified while performing steps (4) through (6), correct the discrepancy before continuing to troubleshoot the open.

NOTE

In most cases, a discrepancy will have significant variations in resistance when compared to a properly functioning comparative component. For example, if all wires read 0.6 ohms except for one wire which reads 32 mega-ohms, it is obvious which wire is faulty.

If at any point the resistance of both halves does not equal the approximate value of the previous step, thoroughly inspect the connection point. Some opens are caused by faults at the connection points that are temporarily corrected when handled (e.g., misaligned pin to the socket in a connector, broken wire realigned when connector handled, etc.).

(4) Perform resistance measurements on the entire run of the wiring of the circuit under test.

(5) Verify the total resistance. Most wire schematics do not provide total resistance for EWIS components (see table 2-IV of guideline 2).

NOTE

The divide and conquer troubleshooting method is a highly effective method to isolate the fault while taking the least number of measurements.

(6) If open or high-resistance is verified, perform the divide and conquer method as follows:

a. Isolate the wiring at the mid-point or as close to the midpoint as accessible.

b. Perform the resistance measurement again on both halves to determine which half

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has the open.

c. Repeat this isolation and testing technique until the fault is isolated.

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GUIDELINE 13

TROUBLESHOOTING OF ELECTRICAL CONNECTORS

1. Purpose. This guideline provides guidance on troubleshooting common discrepancies associated with electrical connectors.

2. Applicable documents.

NAVAIR 01-1A-505-1	Installation and Repair Practices, Aircraft Electrical and Electronic Wiring
NAVAIR 01-1A-505-1 WP 004 01	Aircraft Wiring System Inspection
NAVAIR 01-1A-505-1 WP 013 01	Crimp Tools
NAVAIR 01-1A-505-2 WP 020 00	Military Standard Circular Connectors
NAVAIR 01-1A-505-2 WP 013 01	Contacts and Terminals

3. General troubleshooting guidelines.

a. Often referred to as a “cannon plug,” the electrical connector is a common source of system discrepancies. “Cannon plug” is derived from the company ITT Cannon who is a manufacturer of electrical connectors.

b. Improperly mated connectors are common causes for system discrepancies. Visually inspect the connector to determine if the connector is fully mated. Even a thread or two shy of fully mated may result in a system discrepancy (see figure 13-1).

c. Reseating a connector does not correct a discrepancy. Common reasons discrepancies are believed to have been corrected following reseating the connector:

(1) Worn contacts may result in increased resistance due to fretting or non-uniform contact surfaces. The friction from demating and mating the connector temporarily removes the resistance-causing contaminants. Inspect the contacts for fretting or signs of wear on the contact plating

(2) Numerous parts of the system were handled/inspected prior to performing operation checks. The fault was inadvertently corrected but cannot be identified. Only troubleshoot one component at a time and verify (either operational check or electrical measurement) prior to testing a different component.

(3) The discrepancy could not be duplicated during troubleshooting, and the corrective action was inaccurately identified as a “reseated connector.” If a discrepancy cannot be duplicated during troubleshooting, the documentation should reflect that. Inaccurately identifying components lengthens future troubleshooting efforts and wastes resources.

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d. Connector discrepancies account for a majority of wiring malfunction code faults throughout the DoD. Loose or improperly mated connectors are a common discrepancy found on all Type/Model/Series aircraft. Guidance on symptoms, causes, faults, how to identify, and the corrective action to take to resolve discrepancies caused by electrical connectors are as follows:

(1) Common symptoms: System inoperative, overheating, erratic operation. On figure 13-1, the excessive voltage drop created by a loose connection can be seen in the thermal images.

(2) Common causes: The connector is not properly installed, or damaged/worn/contaminated connector coupling nut or receptacle threads are preventing full engagement.

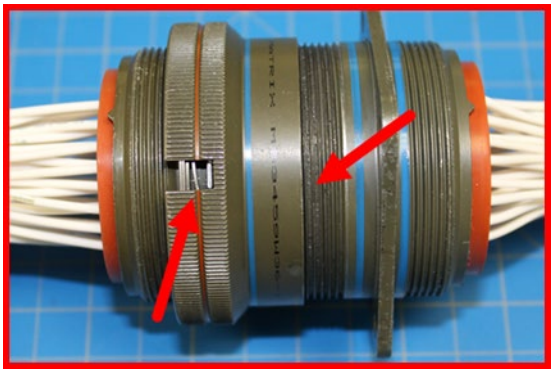
(3) Common faults: Open, intermittent open, excessive heat, or erroneous readings on the DMM.

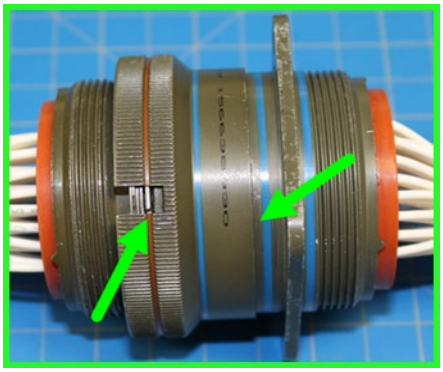
(4) How to identify: Visual inspection of the suspected faulty connector. Inspect mating indicator/band (if equipped, see NAVAIR 01-1A-505-1 WP 020 00), or perform measurement comparison of coupling nut depth and receptacle threads. Continuity checks may aid in narrowing down problematic circuit components. Visually inspect all connectors prior to disconnecting for continuity checks.

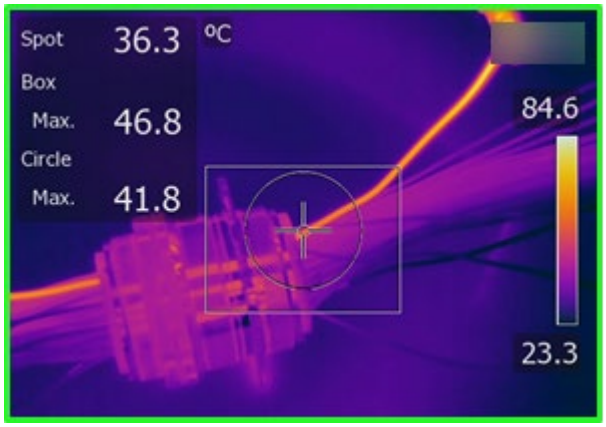
(5) Potential troubleshooting issue: Depending on the amount of engagement with its respective contact in a mated connector, a recessed contact may still have good continuity and no-load voltage measurements when reading across this connection. Visual inspection is the most effective method for identifying if this issue is present.

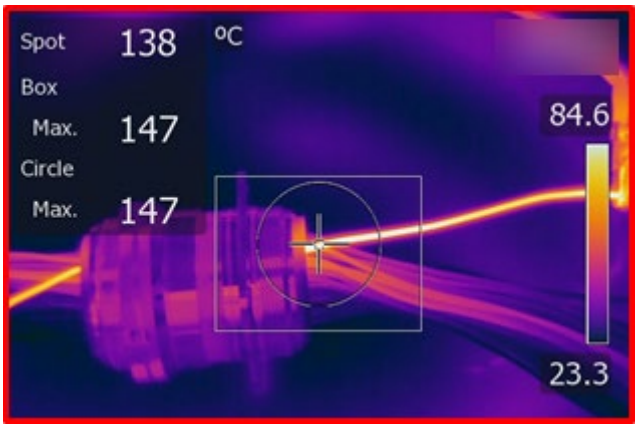
(6) Corrective action**:** Tighten connector to fully mated position or replace the defective connector or receptacle (see figure 13-1 and NAVAIR 01-1A-505-1).

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ACCEPTABLE. Connector fully mated

UNACCEPTABLE. Connector not fully mated.

NOTE: In the image on the top right, the connector is threaded to the point where a 0.8-ohm reading registered on the DMM. The connector was approximately 50-55% mated. The lower images are the thermal measurements of the properly and loosely mated connectors with 10-amps applied.

FIGURE 13-1. Connector fully mated vs. not fully mated.

e. Some connector discrepancies that are “hidden” when the connector is removed for troubleshooting. For example, a contact internally shorted to the connector, or a damaged connector causes contacts to shift and short when connected; alternately, a partially recessed contact may appear to be partially seated upon initial inspection. Guidance on symptoms, causes, faults, how to identify, and the corrective action to take to resolve discrepancies that are “hidden” in electrical connectors is as follows:

(1) Common symptoms: System is inoperable, erratic operation.

(2) Common causes: Contact not fully installed, retaining clip faulty, or contact faulty.

(3) Common faults: Open, intermittent open, excessive heat, or erroneous readings.

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(4) How to identify: Basic inspections: Visual inspection-tilting connector slightly helps expose the edge of sockets, allowing for depth perception when looking for recessed sockets. Perform continuity checks to identify an open. The following troubleshooting process can also be used:

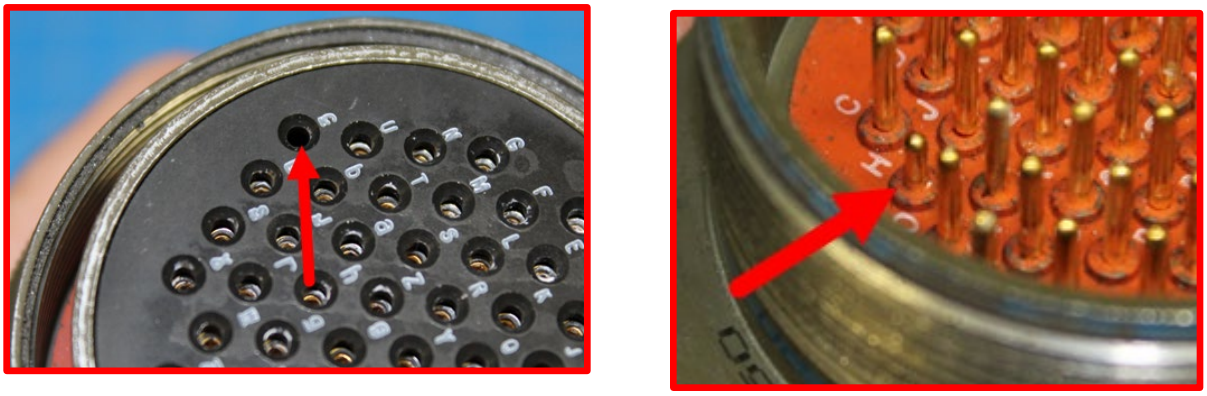
a. Perform continuity checks from contact to connector outer shell.

b. Perform continuity checks of the contact-to-connector or contact-to-contact from a different location (i.e., another connector or terminal board, etc.) while that connector is connected.

c. Perform a visual inspection. Pay particular attention to partially recessed contacts. Recessed contacts occur when the contact is not fully seated into the cavity and the retaining clip is not engaged to hold it in place (see figure 13-2).

(5) Potential troubleshooting issue: Depending on the amount of engagement with its respective contact in a mated connector, a recessed contact may still have good continuity and no-load voltage measurements when reading through this connection (similar to an under-mated connector, see below). Carefully inspecting the contacts is the most effective method for identifying the recessed contact.

(6) Corrective action: For recessed contacts, reseat contact into connector cavity or replace connector as necessary (see NAVAIR 01-1A-505-1 WP 020 00 for circular connectors). If the determined connector is internally shorted or damaged, replace the connector.



Tilting the connector slightly (shown in both images) improves the ability to detect recessed contacts.

FIGURE 13-2. Recessed contacts.

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f. Insufficient crimp depth or crimp position of contacts. Loose crimps are a result of improper crimping at the installation of the contact. Loose crimps can be very daunting to locate because visual inspections may not clearly identify the issue, and continuity checks will likely check good. The issue causes an excessive voltage drop at the crimp resulting in an observed system discrepancy (see figure 13-3 for a thermal representation of the excessive voltage drop). Guidance on symptoms, causes, faults, how to identify, and the corrective action to take to resolve discrepancies caused by insufficient crimp depth or positioned crimps is as follows:

(1) Common symptoms: System inoperable, erratic operation.

(2) Common fault**:** Erroneous system operation, excessive heat. The thermal image on figure 13-3 represents the heat generated due to the excessive voltage drop created by the loose crimp.

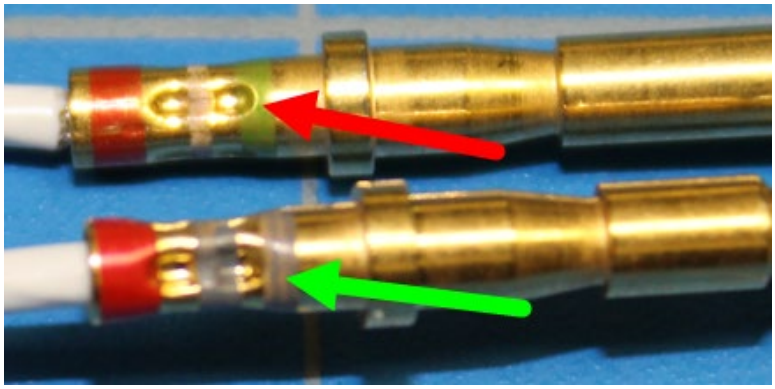
(3) Common cause: Improper crimp tool/setting, wire insulation in the barrel of crimp.

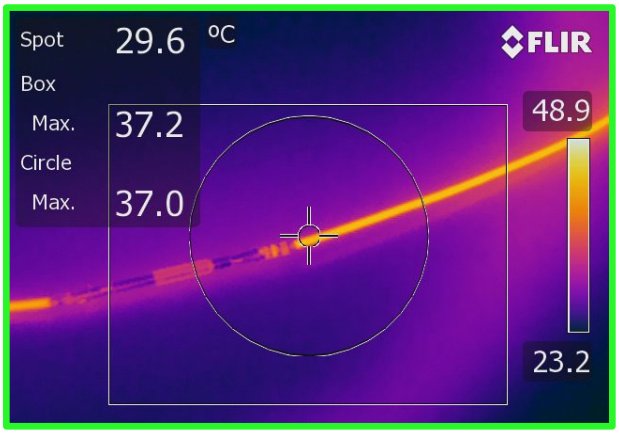
(4) How to identify**:** Visual inspection of the crimp; compare the crimp indents to a known good crimp of same type wire and contact.

(5) Potential troubleshooting issue: The under-crimp will most likely have good continuity and no-load voltage measurements when reading through this connection. The fault occurs when current flows across the loose connection resulting in an excessive voltage drop.

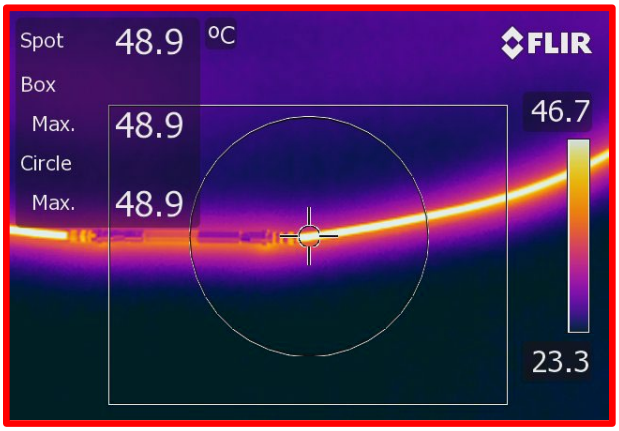
(6) Corrective action: Replace improperly crimped contact per NAVAIR 01-1A-505-1 WP 013 00 and 013 01.

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ACCEPTABLE: Green arrow (top image) and lower left image, contact was crimped on an 18 AWG wire using the 18 AWG crimp setting.



UNACCEPTABLE. Top image red arrow and lower right image. The wire is an 18 AWG but crimped with the largest (12 AWG) setting on the crimp tool.

Note: The thermal images show the heat measurement of the properly and improperly crimped contacts with 10 amps applied.

FIGURE 13-3. Contact properly crimped vs. under crimped contact.

g. Less obvious cases occur when the misaligned pin inserts itself in between the socket and the grommet (rubberized surrounding). See figures 13-4 and 13-5. Guidance on symptoms, causes, faults, how to identify, and the corrective action to take to resolve discrepancies that are caused by misaligned pin inserts are as follows:

(1) Common fault: Erroneous system operation, excessive heat, inoperable system.

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(2) Common cause: Pin bent during installation, handling, or during electrical measurements/checks.

(3) How to identify: Visual inspection – look for signs of wear in the surrounding grommet. The pin will be bent or misaligned when looking straight on.

(4) Potential troubleshooting issue: Depending on the amount of contact with the socket, continuity checks and resistance measurements may indicate a good connection. The fault occurs when the current flows across the bad connection resulting in an excessive voltage drop.

(5) Corrective action: Realign contact per NA01-1A-505-1 WP 004 01. If required, replace contact per NAVAIR 01-1A-505-1 WP 013 00.

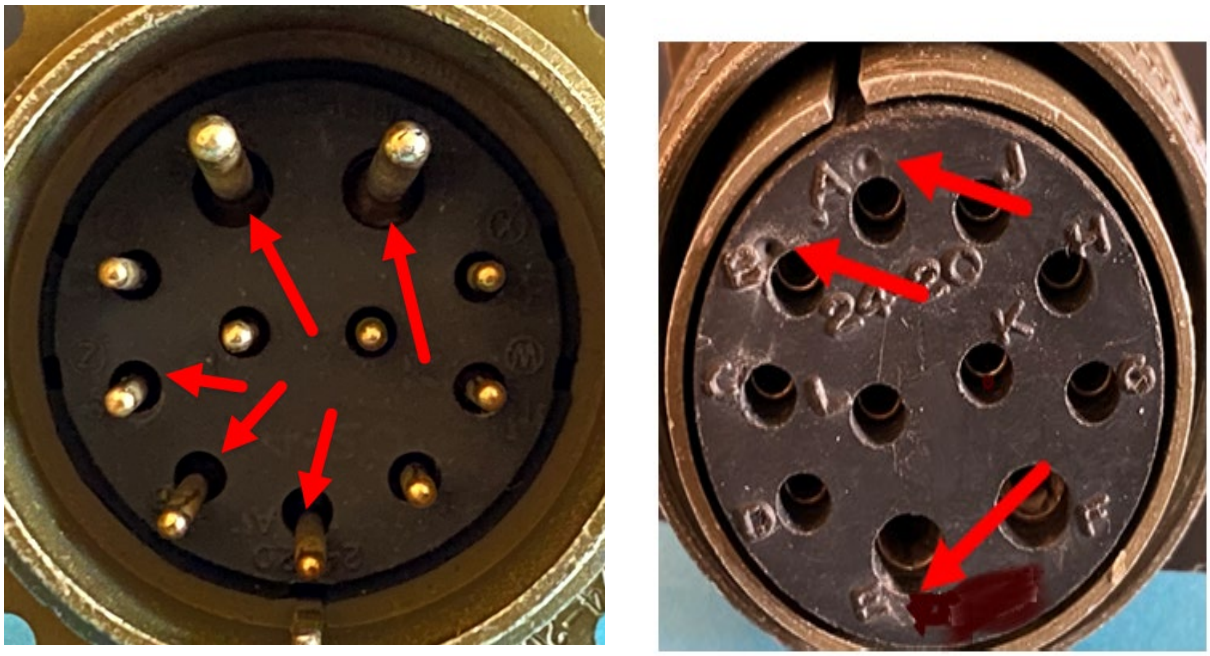
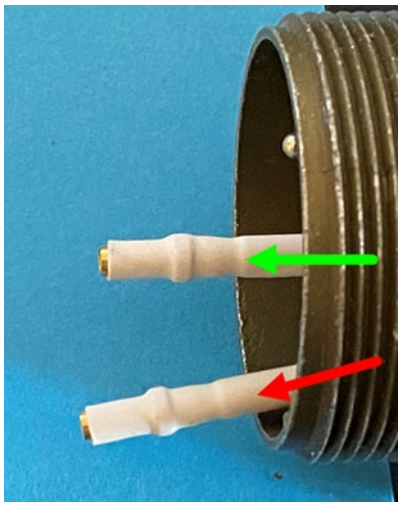


FIGURE 13-4. Electrical connector with bent pins.

NOTE: Bent pins may be more noticeable when looking straight on the connector. Likewise, indentations and markings on the receptacle insert may indicate bent pins.

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The use of test contacts can be used to verify bent pins.

FIGURE 13-5. Test contacts confirming bent pins.

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GUIDELINE 14

TROUBLESHOOTING OF CIRCUIT BREAKERS (CB)

1. Purpose. This guideline provides guidance on troubleshooting common discrepancies associated with circuit breakers.

2. Applicable document.

NAVAIR 01-1A-505-1 WP 028 00 Protective Devices Installation

3. General troubleshooting guidelines.

a. A circuit breaker (CB) is used to help provide automatic protection that will limit an electrical fault to a single circuit. The CB isolates the fault from the power source so that the non-faulted circuits can be kept functioning in a normal manner.

b. When troubleshooting, pulling a CB (or deactivating the CB):

(1) De-energizes the circuit.

(2) Isolates the circuit from the bus-side (power circuit). This ensures no other circuit will be measured by the test equipment (such as, taking resistance measurements or continuity checks with the DMM).

WARNING

Never reset a pulled/tripped CB before identifying the reason why the CB pulled/tripped. A CB may have been pulled to electrically isolate a system where maintenance is being performed. Setting the CB may result in electrocution to personnel or damage to associated equipment.

c. CB's most often fail internally. Verifying the condition of a CB can be achieved by comparing the force required to pull/push it with a known good CB of the same rating. Resistance measurements can also be taken across the terminal lug mating flanges in both the pulled and set (pushed in) positions (see detailed procedures in 4.a).

d. Standard circuit breakers are not designed to operate as switches. Repeated opening and closing of the contacts can lead to damage and premature failure of the circuit breakers. Pay particular attention to circuits where it is common practice (whether by maintenance or aircrew) to pull/set CBs during flight or following circuit operation.

e. Circuit breaker failures are at a higher risk of being latent in nature compared to other components. You won't know they have failed until you need them.

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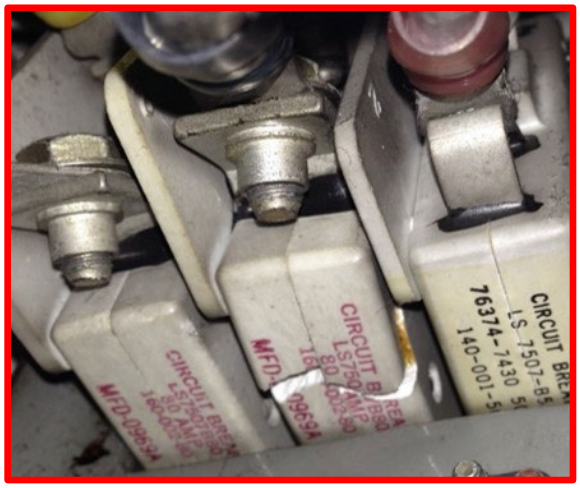


FIGURE 14-1. Damaged circuit breaker.

4. Detailed troubleshooting guidelines.

WARNING

Resetting a CB that tripped due to an electrical short before the condition is corrected may result in electrocution to personnel or extensive damage to EWIS or associated equipment. Severe arc-tracking may occur if a CB is reset with shorted polyimide (Kapton™) insulated wire resulting in extensive damage and possible fire.

Never hold a CB in that will not stay set on its own. A CB that will not remain set indicates a faulty CB or an electrical short. Holding a CB in that will not set on its own may result in electrical injury or damage to aircraft/component.

a. Prior to setting a CB, perform continuity checks to determine if a short to ground exists. Correct any shorts prior to setting the CB. Refer to NAVAIR 01-1A-505-1 WP 028 00.

b. With no power applied to the aircraft, cycle the CB to determine if a weak CB exists. Observe the following:

(1) Cycle a known good de-energized CB of the same rating to establish a baseline feel.

(2) Note the force required to pull it. Pay close attention to how it sounds.

(3) Set the CB noting the force it takes to set it and the audible click(s).

(4) With the baseline established, cycle the suspected faulty CB. Compare how the circuit breakers sound and feel.

(5) If suspected faulty CB sounds or feels different, replace it, refer to NAVAIR 01-

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1A-505-1 WP 028 00.

c. Verify that the CB remains set when de-energized. If the CB does not remain set, it is faulty. Replace the CB. Refer to NAVAIR 01-1A-505-1 WP 028 00 for replacement procedures.

d. Perform resistance measurements on the CB contact per guideline 7, using the following procedure:

(1) Remove attached wires from CB to isolate from the rest of the circuit. See applicable TM/MIM or NAVAIR 01-1A-505-1 for removal of terminal lugs from CB.

(2) Test points: each CB terminal lug mating flange.

(3) With CB pulled: verify resistance is infinite (∞) Ω (ohms).

(4) Set CB: verify resistance is less than 0.5 Ω.

(5) If resistance measurements are within limits, reinstall wires per applicable TM/MIM or NAVAIR 01-1A-505-1. If resistance measurement(s) are not within limits, replace CB per applicable TM/MIM or NAVAIR 01-1A-505-1.

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GUIDELINE 15

TROUBLESHOOTING OF TERMINAL LUGS

1. Purpose. This guideline provides guidance in troubleshooting discrepancies associated with terminal lugs.

2. Applicable documents.

NAVAIR 01-1A-505-1	Installation and Repair Practices, Aircraft Electric and Electronic Wiring
NAVAIR 01-1A-505-1 WP 013 00	Contacts and Terminals
NAVAIR 01-1A-505-1 WP 019-00,	Bus Bar and Terminal Board
NAVAIR 01-1A-505-1 WP 026 00	Cleaning and Preservation

3. General troubleshooting guidelines.

a. Terminal lugs are the source of many EWIS faults. The unprotected conductors are more susceptible to corrosion and arcing when compared to environmentally sealed terminating devices (e.g., connectors, terminal junction systems, etc.).

b. Ground circuits heavily rely on terminal lugs to connect to aircraft grounds, resulting in a high number of ground failures at these locations.

c. Improper stack-up (e.g., washer under the terminal lug tongue, etc.). Improper stack-up may increase circuit resistance (see figure 15-1).

d. Loose connections will drastically increase resistance even when the DMM indicates resistance in the normal range. This occurs because the circuit current is greater than the extremely low current produced by the DMM (see figure 15-2A).

e. The use of hardware made from materials (e.g., steel, etc.) that are poorly conductive may also create excessive resistance resulting in overheating/burning. See NAVAIR 01-1A-505-1 and the applicable technical manual for additional information. Resistance measurements may not detect the excessive resistance using standard support equipment (such as DMM). See figure 15-2A.

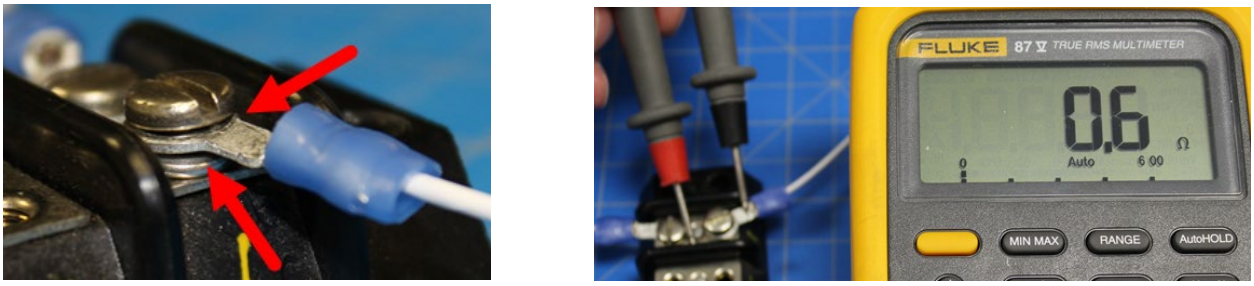
f. A large voltage drop across the loose connection results in excessive heat (represented in the thermal image on figure 15-2B). The left terminal lug (red arrow) was loosened; the three others were properly torqued. The heat continued to increase until power was secured/removed. All terminal lugs pictured are a part of the same circuit (see figure 15-2B).

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Washer (red arrow) improperly located under the terminal lug tongue (green arrow).

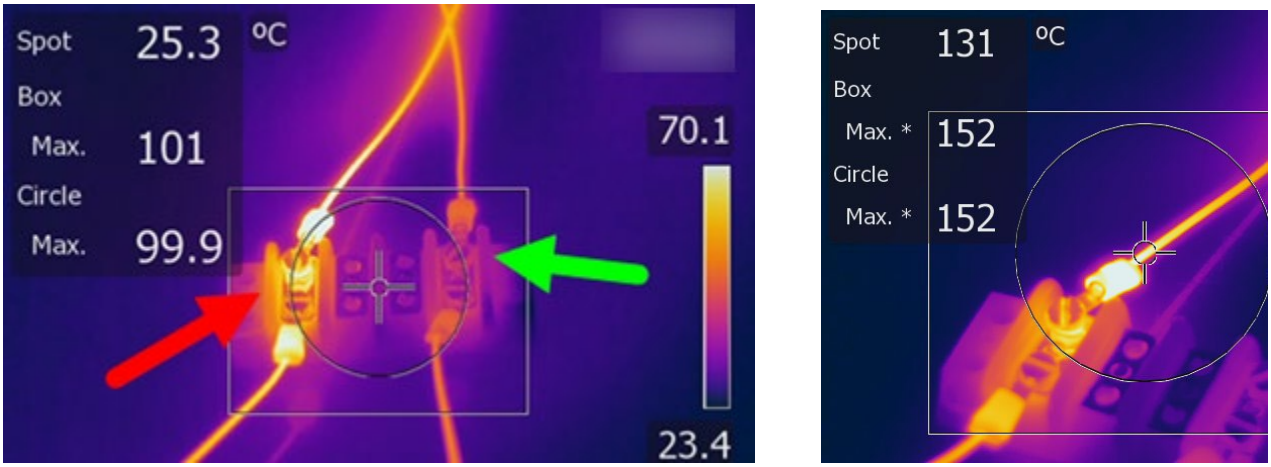
FIGURE 15-1. Improper terminal lug stack-up.



The left image (red arrows) shows gaps in the connecting points of the terminal lug tongue, attaching screw, and terminal. The washer is improperly placed under the terminal lug tongue. The right image shows “good” resistance of the condition identified in the left image.

FIGURE 15-2A. Loose terminal lug.

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The left image shows excessive heat created from the excessive voltage drop (red arrow) compared to a properly installed terminal lug (green arrow) with the same amperage applied. The right image is a close-up of the loose terminal lug.

FIGURE 15-2B. Loose terminal lug - excessive heat.

g. Over-bent or flexed terminal lug. Cracks easily form in terminal lugs when they are bent and unbent multiple times, resulting in excessive resistance. For bending restrictions for terminal lugs, refer to NAVAIR 01-1A-505-1 WP 013 00.

h. Because there are typically no baseline voltage limits, voltage drop measurements should only be used as a reference to a potential fault and not the determining factor. Generally, the voltage drop across an electrical connection should be less than 0.0025 V (2.5 mV). However when, the specific value of a voltage drop will affect system operation depends on the applicable system requirements (e.g., power circuits require greater voltage drops to affect system operation compared to signal circuits). As such, readings above 2.5 mV may require additional inspection.

i. Corrosion is a common cause for excessive voltage drop at a terminal lug connection as a result of improper surface preparation and post-installation corrosion protection. Other notable causes are under crimping of the terminal lug to the conductor and loose terminal lug connection to securing post.

j. Guidance on symptoms, causes, faults, how to identify, and the corrective action to take to resolve discrepancies that are caused by loose terminal lugs are as follows:

(1) Common faults: Opens, large current draws, excessive heat, arcing, intermittent opens/shorts, burnt insulation/terminal lug.

(2) Common causes**:** Improper torque, improper hardware, faulty hardware/terminal block.

(3) How to identify: Visual inspection or voltage drop measurement.

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(4) Potential troubleshooting issue: As shown in the image on the right of figure 15-2A, continuity across a loose connection may have good continuity and no-load voltage measurements (not pictured). These readings would falsely indicate a good connection.

(5) Corrective action: Tighten terminal lug per NA01-1A-505-1 WP 019 00. Replace defective hardware or terminal boards as necessary.

k. Guidance on symptoms, causes, faults, how to identify, and the corrective action to take to resolve discrepancies that are caused by improper terminal lug stack-ups are as follows:

(1) Common fault: High-resistance, large current draws, overheating, erroneous system Operation.

(2) Common causes**:** Improper installation, improper hardware.

(3) How to identify: Visual inspection or voltage drop measurement.

(4) Potential troubleshooting issue: Similar to the condition shown on figure 15-2A, the continuity across an improperly stacked terminal lug may have good continuity and no-load voltage measurements (not pictured). These readings would falsely indicate a good connection.

(5) Corrective action: Verify correct stack-up and tighten per NA01-1A-505-1 WP 013 00.

l. Guidance on symptoms, causes, faults, how to identify, and the corrective action to take to resolve discrepancies that are caused by over-bent or flexed terminal lugs (see figure 15-3) are as follows:

(1) Common fault/symptoms: Excessive current draw/overheating, high-resistance, erroneous system operation.

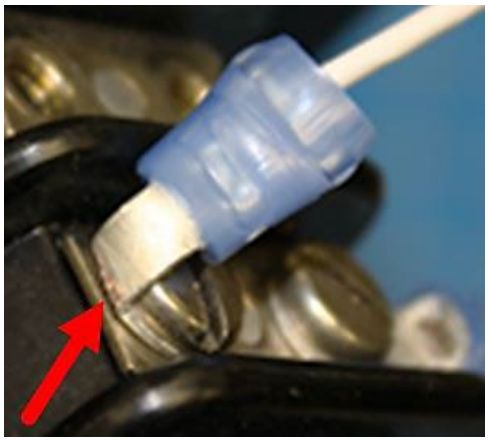
(2) Common causes**:** Improper installation, improper hardware.

(3) How to identify: If severe enough, may have high resistance readings, visual inspection, or voltage drop measurement.

(4) Potential troubleshooting issue: Similar to the condition shown in figure 15-2A, the continuity across an excessively bent terminal lug may have good continuity and no-load voltage measurements (not pictured). These readings would falsely indicate a good connection.

(5) Corrective Action: Inspect for over-bent terminal lug, replace lug as necessary per NAVAIR 01-1A-505-1 WP 013 00.

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Visible crack (red arrow) created by overflexing or flexing and unflexing more than once.

FIGURE 15-3. Over-bent/flexed terminal lug.

4. Detailed troubleshooting guidelines.

a. A voltage drop measurement will effectively identify nearly all high-resistance conditions because the measurement is made while the circuit is normally energized. It is important that the conductor of the circuit under test be accessible while fully connected to the circuit.

b. A voltage drop measurement will measure the voltage that is being 'used up' in the part of the circuit that is in between the meter leads. The process for making these measurements is as follows:

(1) Review system schematic to determine if AC or DC voltage is used in the circuit.

NOTE

Most voltage drops are in the mili-vol (mV) range. When testing DC circuits, if the reading is 0.0 VDC, set DMM to mVDC setting and retest. There is no mVAC setting on the DMM.

(2) Configure DMM for voltage measurements per guideline 7.

(3) The test points are:

a. A point on the terminal lug tongue prior to mounting post and hardware (see figure 15-4 blue arrow), and;

b. A point on the component that the terminal lug is mounted to and is in close proximity to the terminal lug. The idea is to read through all parts of the terminal lug connection (figure 15-4 green arrow).

(4) Perform voltage measurements.

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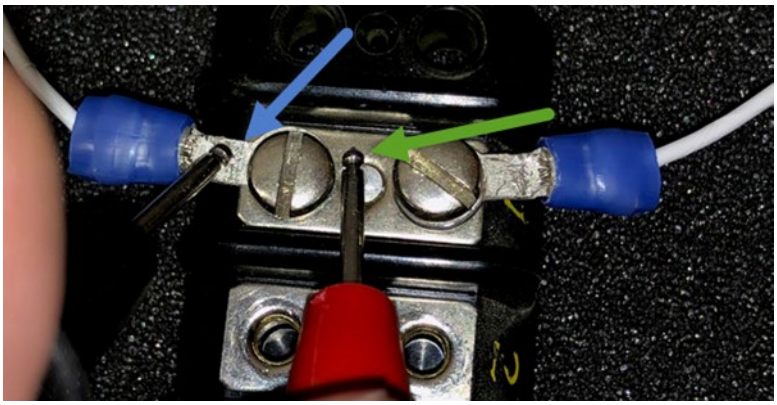


FIGURE 15-4. DMM meter lead placement to measure the voltage drop at a terminal lug connection.

NOTE

Measurements of 1.0 - 5.0 mV are above ideal but may not be the cause of a fault. If no obvious fault is identified, additional inspections of voltage drop measurements greater than 1.0 mV may be required. The effect of an excessive voltage drop is circuit dependent. An electrical motor may be able to operate as normal with 1.0 V (1000 mV) loss or excessive voltage drop, but a 10 - 20 mV loss may render a digital signal inoperable.

(5) Record and analyze measurements. Voltage drops should be less than 1.0 mV.

(6) If greater than 1.0 mV and the terminal lug connection is suspected to be the cause of the fault, inspect terminal lug connection for:

a. Obvious signs of damage, e.g., cracks, gouges, etc.

b. Proper terminal lug stack-up.

c. Contaminants in between all mating surfaces associated with the connection. Performing surface cleaning and preparation procedures will remove any oxidation or contaminants not visible to the naked eye.

d. Refer to NAVAIR 01-1A-505-1 WP 013 and WP 026 00-for disassembly, cleaning, and reassembly.

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GUIDELINE 16

TROUBLESHOOTING OF INTERMITTENT EWIS DISCREPANCIES

1. Purpose. This guideline provides guidance in troubleshooting intermittent EWIS discrepancies.

2. Applicable documents.

NAVAIR 01-1A-505-1	Installation and Repair Practices, Aircraft Electric and Electronic Wiring
NAVAIR 01-1A-505-1 WP 010 00	Harness Installation
NAVAIR 01-1A-505-1 WP 029 02	EWIS Test Methods

3. General troubleshooting guidelines.

a. Intermittent discrepancies are some of the most difficult faults to isolate because standard EWIS SE cannot detect discrepancies when the system is operating properly.

b. An intermittent EWIS fault may exist if one or more of the following conditions apply:

(1) The reported symptom cannot be duplicated, and system operation appears to be properly functioning.

(2) No fault is detected while troubleshooting.

(3) The malfunction persists after exhausting other recommended troubleshooting techniques.

CAUTION

Reduce or limit the amount of force applied to the harness during flex testing. Excessive pressure/force may compromise the integrity of the wire harness/cable being tested.

c. If the symptoms reported are associated with an airframe maneuver (e.g., during a hard right bank, etc.) or vibration (e.g., gunfire, etc.), any flexing of the wiring under test should attempt to mirror the reported force and direction or vibration conditions. For detailed guidance on the flex test method, see paragraph 4 of this guideline.

d. The DMM continuity check can indicate the presence of a fault where shorts, opens or certain high-resistance occur for 250 microseconds or longer. Because of this response rate, the continuity check is the ideal DMM setting when performing the flex test method (see section 4 of this guideline). When a short is detected, the audible beep will activate. When an open or high-resistance (see guideline 11 for more information) is detected, the audible beep will stop.

e. If the flex test method fails to identify a fault, the test may not have adequately simulated the forces required to detect the fault, or the short or open lasts less than 250 microseconds. Specialized intermittent diagnostic equipment (such as the Wire Intermittent Fault Tester

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(WIFT)) may be required. Refer to NAVAIR 01-1A-505-1 WP 029 02 or contact the platform CEA for additional troubleshooting resources.

f. Common external forces that influence intermittent EWIS discrepancies:

(1) External force or vibration (e.g., during 10-degree bank indicator became inoperable, etc.).

(2) Operational time (e.g., system failure after a 2-hour flight, etc.).

(3) Operational temperatures (e.g., during high-power turns, system indication became erroneous, etc.).

(4) Moisture (e.g., the system failed after aircraft wash, etc.).

g. Many intermittent faults are inaccurately identified as intermittent because resistance measurements, no-load voltage measurements, or continuity checks do not detect a wiring fault. If the WRA/LRU is suspected good, there may be a high-resistance condition that is undetectable to the DMM.

h. Low-voltage signal circuits are more susceptible to ‘intermittent’ faults because even the slightest impedance can cause significant circuit discrepancies. Pay particular attention to subtle disparities in measurements or inspections when troubleshooting signal circuits or systems that are not tolerable to impedance changes (e.g., high-speed data, etc.).

i. Coax cables and high-speed data cables are highly susceptible to EMI if their shield layout is damaged or disturbed. Zip-ties and over-tightened spot ties can cause disruptions in the shield layout, making the cable susceptible to EMI or disturbances in the electrical path (reflection or dielectric impedance).

j. These conditions can be especially difficult to troubleshoot because, in most cases, the DMM stimulus current has a significantly lower current draw than during normal operation.

k. When continuity checks, resistance measurements, and no-load voltage measurements do not detect a wiring fault, and the WRA/LRU is suspected good, there may be a high-resistance condition that is undetectable to the DMM. Physical inspection may be the only or most effective method in identifying these conditions. Additionally, if subtle differences were noted during previous resistance readings, pay particular attention to components in those segments. The following conditions may be undetectable or difficult to identify when using the DMM alone:

(1) A break where the conductor is not fully severed.

(2). A break where vibration or other moving forces influence/disrupt its conductivity,

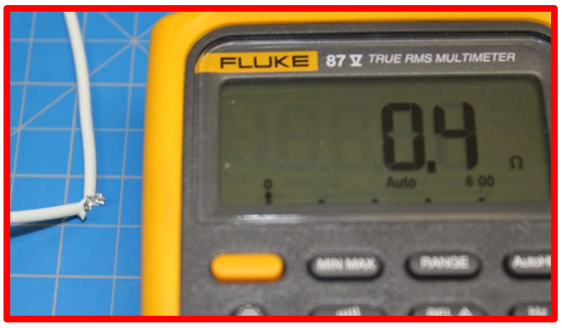
(3) A break where temperature influences its conductivity.

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(4) Misaligned pin making minimal contact with the socket.

(5) Corrosion.

l. Many intermittent faults are inaccurately identified as ‘intermittent’ because the type of fault exceeds the capabilities of the SE being used. For example, if the impedance of the conductor is not enough to disrupt the DMM stimulus current (less than 50 milliamps), the measured resistance will be normal. A no-load voltage measurement presents the same issue because the circuit under test does not have current flowing. As shown on figures 16-1 and 16-2, the partially broken wire measured a 250 mV drop at 5 amps (100+ times greater than the <2mV recorded before damage was induced) even though it measured 0.4 ohms of resistance.

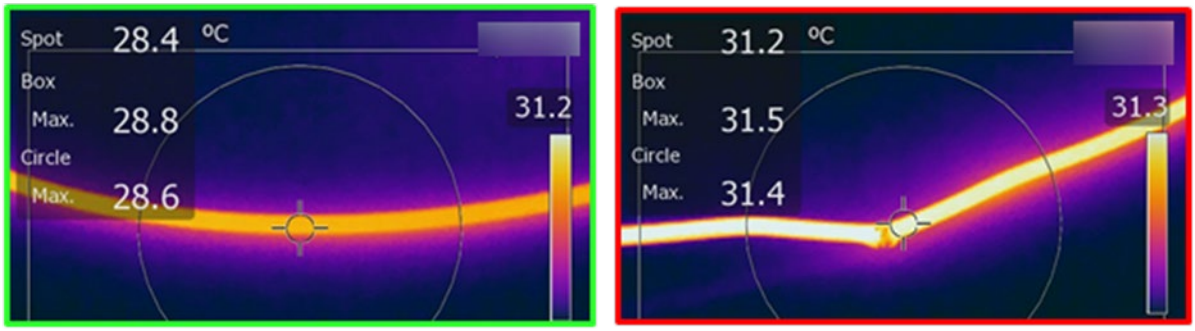


DMM measurements/tests of a partial conductor break:

- Continuity - Good
- Resistance - 0.4 ohms
- Voltage (no load) - normal
- Voltage drop - 250 mV @ 5 amps

FIGURE 16-1. Partially broken conductor with “good” resistance measurement.

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The image on the left (green border) is a 12 AWG wire with no damage.
The image on the right (red border) is a 12 AWG wire with an 85-90% conductor severed in a localized spot. Resistance measurement of damaged wire was 0.5 ohms end-to-end, same as non-damaged wire.
The undetected resistance causes an excessive voltage drop when higher levels of current flow across the wire. The thermal image provides a visual representation of the fault.

FIGURE 16-2. Wire with no damage vs. partially severed wire.

m. Guidance on symptoms, causes, faults, how to identify, and the corrective action to take to resolve discrepancies that are caused by partially broken conductors are as follows:

(1) Common faults: Opens, large current draws, excessive heat, arcing, intermittent opens/shorts, burnt insulation.

(2) Common causes: Collateral damage (pinched in cable clamp, cut while removing safety wire, damaged during component removal, etc.).

(3) How to identify: Visual inspection. In limited circuits, TDR or voltage drop measurement.

4. Detailed troubleshooting guidelines.

a. The flex test method attempts to recreate the environmental effects when the discrepancy occurred. Flexing the harness may reveal the cause of a short or open fault by a change in resistance value being monitored during flexing. Limit the amount of force/pressure applied so as not to damage the item being tested. If testing for an intermittent open, the continuity beeper should continuously beep until a disruption in the circuit occurs (discontinuity).

WARNING

The flex test method cited below should only be performed in conjunction with resistance measurements or continuity testing with the DMM. Employing the flex test method with any other support equipment requires prior approval from your platform engineering support. Failure to comply with this requirement may result in damage to support equipment, damage to aircraft/components or electrical injury.

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NOTE

The continuity feature on the DMM provides a more immediate response (250 microseconds) compared to the resistance setting when the completed path is detected. This feature is beneficial in detecting intermittent shorts that only make partial contact or intermittent opens that create quick discontinuities.

b. To perform the flex test method, the following procedure should be used:

(1) Setup the DMM for continuity checks per guideline 7.

CAUTION

While flexing wire harnesses, do not exceed bend radiuses outlined in NAVAIR 01-1A-505-1, WP 010 00. Damage to wiring may occur.

NOTE

Ensure meter leads or accessories are securely attached to circuit test points. Any disruptions in the meter lead or accessory connections to the circuit under test will likely prevent the DMM from detecting continuity or provide false indications of discontinuities.

(2) Move and flex wire harness to simulate the conditions that caused the reported discrepancy.

(3) If continuity is detected (for troubleshooting shorts) or lost (for troubleshooting opens), inspect the surrounding applicable EWIS components for defects. Note the wire path under test, the change observed, and the location and direction of flex.

(4) Move the measuring meter leads to the next set of circuit test points to be evaluated.

(5) Perform the previous two steps on all wiring to be evaluated.

(6) If attempting to isolate an intermittent short circuit condition, it may be necessary to change the setup to include testing between the affected wire path and all of the other paths populated in a given connector, including the backshell and airframe ground or shield.

(7) Perform a visual inspection of applicable EWIS:

a. Wiring – look for any signs of damage (nicks, kinks, crushed spots, etc.). Zip-ties or over-tightened spot ties can cause significant disruptions to low-voltage signal wires.

b. Connectors - recessed pins, misaligned pins, loose grounds/shield terminations, corrosion, partially broken wire at crimp barrel, etc.

c. Terminal lugs - over-bent, cracked, corrosion, contaminant/sealant under terminal lug. See guideline 15 for additional test methods.

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(8) Depending on the level of disassembly allowed, gain access to the area where a disturbance was noted and correct any abnormal condition. If disassembly is not allowed, replace harness as required in accordance with applicable MIMS/Technical Manuals.

CONCLUDING MATERIAL

Custodians:
Army - CR
Navy - AS
Air Force - 85
DLA - CC

Review activities:
Air Force - 19, 184

Preparing activity:
Navy - AS

(Project 6145-2020-020)

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above by using the ASSIST Online database at https://assist.dla.mil.

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