Fundamentals
M7
MAINTENANCE PRACTICES

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M7.4
Avionic General Test Equipment

EASA Part-66
CAT B1

Training Manual

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M7 MAINTENANCE PRACTICES

M7.4 AVIONIC GENERAL TEST EQUIPMENT

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OPERATION, FUNCTION AND USE OF AVIONIC GENERAL TEST EQUIPMENT

Introduction

To ensure the safety of aircrafts, aviation authorities issue regulations concerning the construction of aircrafts and their systems.

These regulations contain detailed specifications regarding the functionality and the accuracy of avionic systems.

In order to check these specifications, corresponding test equipment has been developed.

In accordance with the regulations of the aviation authorities, experts who check the avionic systems must be trained in the use of this test equipment.

This book presents several test devices as example. Not every device can be discussed here due to the wide variety of test equipment on the market. Still, their main functions are generally comparable due to the regulatory specifications.

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Measuring high currents

Basics

Measuring high currents is difficult in the practice since it is a “flow measurement“. Thus the measurement device must be connected in series in the electric circuit for this measurement.

For high currents such as in generator lines, the measurement device must be dimensioned accordingly high to withstand the loads.

This problem can be handled by using a current clamp meter. These devices measure the current flow indirectly by measuring the magnetic field caused by the current flow. The magnetic field strength increases proportionally to the current flow.

There are two measurement methods:

- The classic method through measuring with a coil
- Measuring with a hall effect sensor

With the classic method, only alternating currents can be measured. With the hall effect sensor, it is also possible to measure direct currents.

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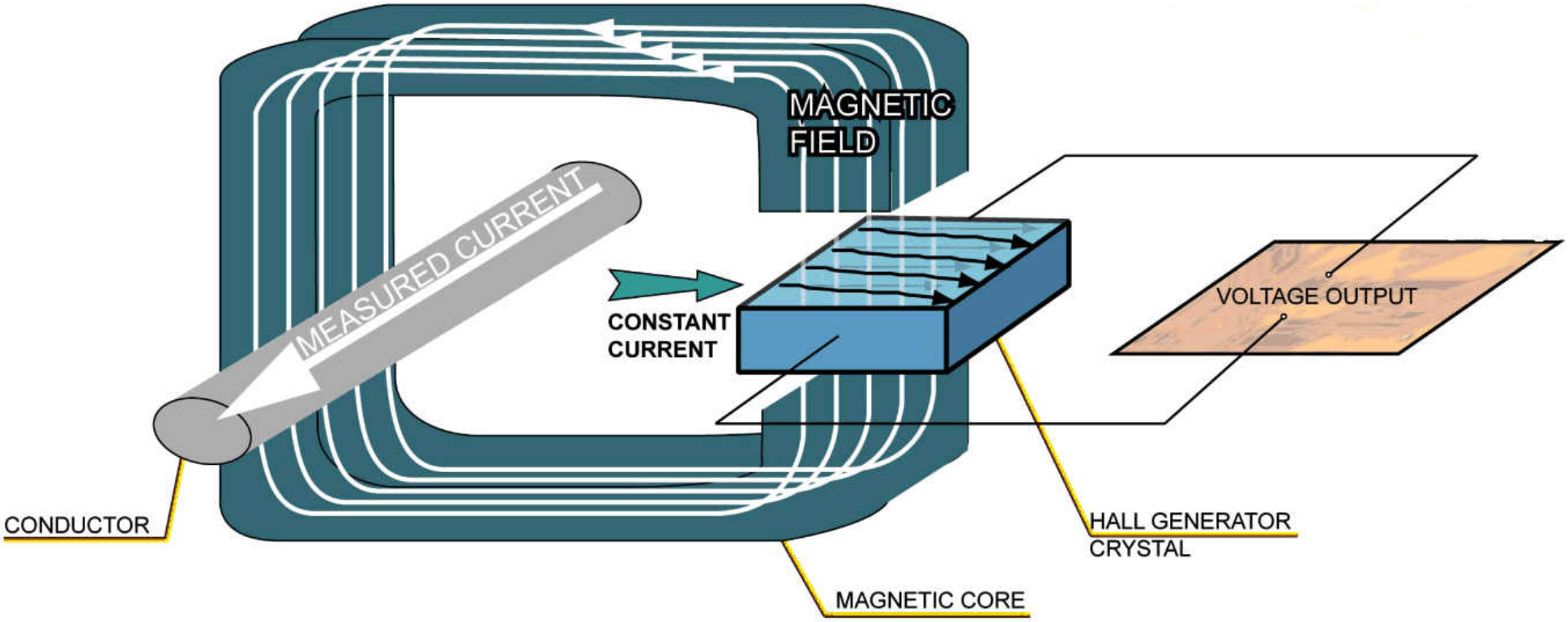


Figure 1 Hall-sensor

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Current Clamp Meter

For the different fields of application, different current clamp meters were developed

- for very high currents with corresponding large clamp
- milliammeter for small currents in lines that cannot be disconnected



Figure 2 Ampere Clamp Meter

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Figure 3 Milliampere Clamp Meter

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Measuring the electrical resistance

Basics

The conductor material in the aircraft wiring can break due to vibration or through frequent bending (doors/panels). As a result, the wiring system will no longer function.

In order to locate such a failure, a measuring device capable of measuring resistance is used. A so–called multimeter is generally used for this purpose. The resistance to be measured can range up to 1 kilo–ohm.

Breaks in the conductor often present themselves as so–called loose contacts. To verify these failures, an analogue measuring device is recommended while simultaneously “shaking“ the line.

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Figure 4 Multimeter Digital / Analogue

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To be able to check the electrical resistance, an electric circuit must be produced. This can be realized by either using the ground of the aircraft or with the help of an extension line.

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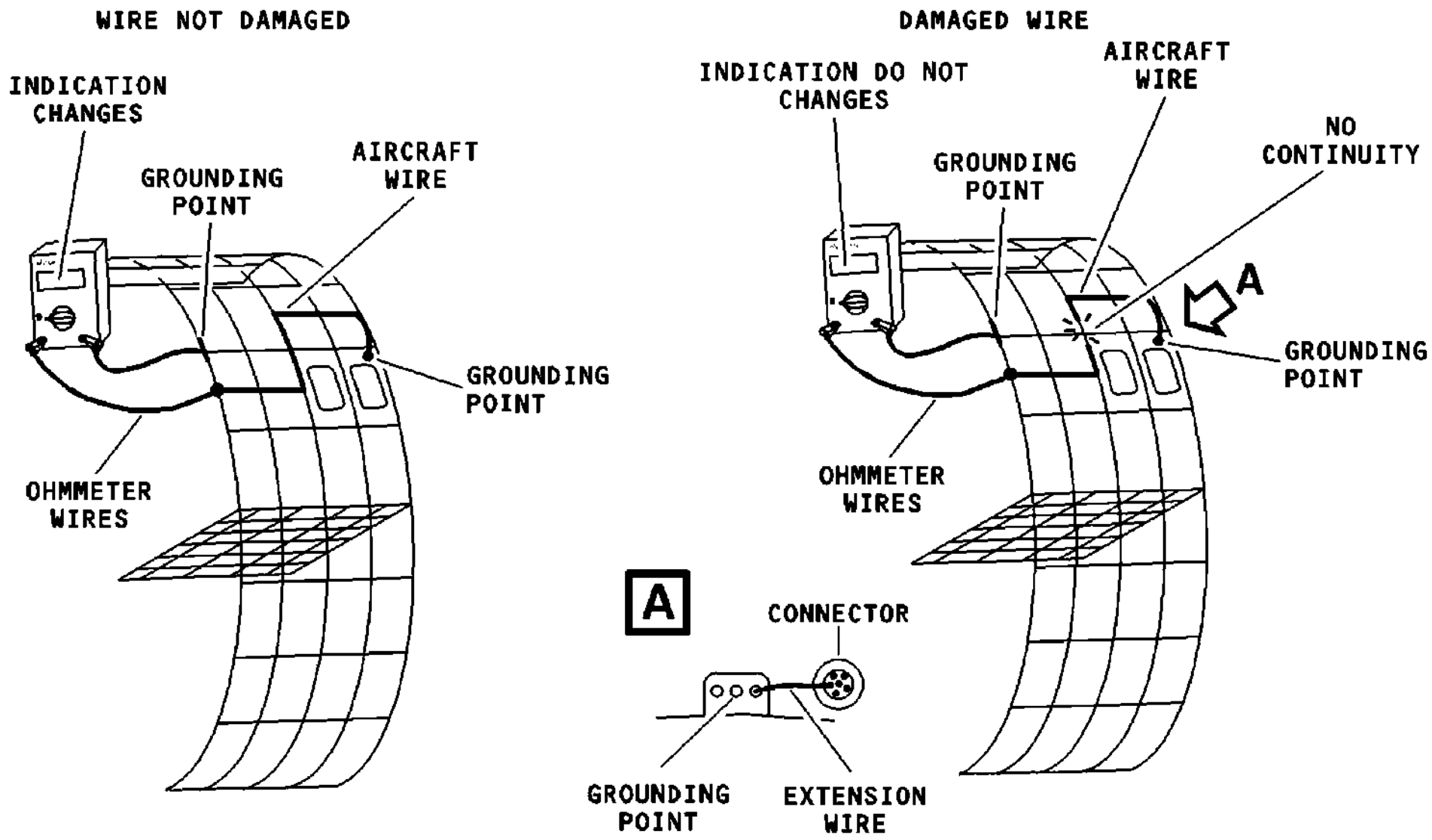


Figure 5 Measurement via Ground

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Measuring with extension line

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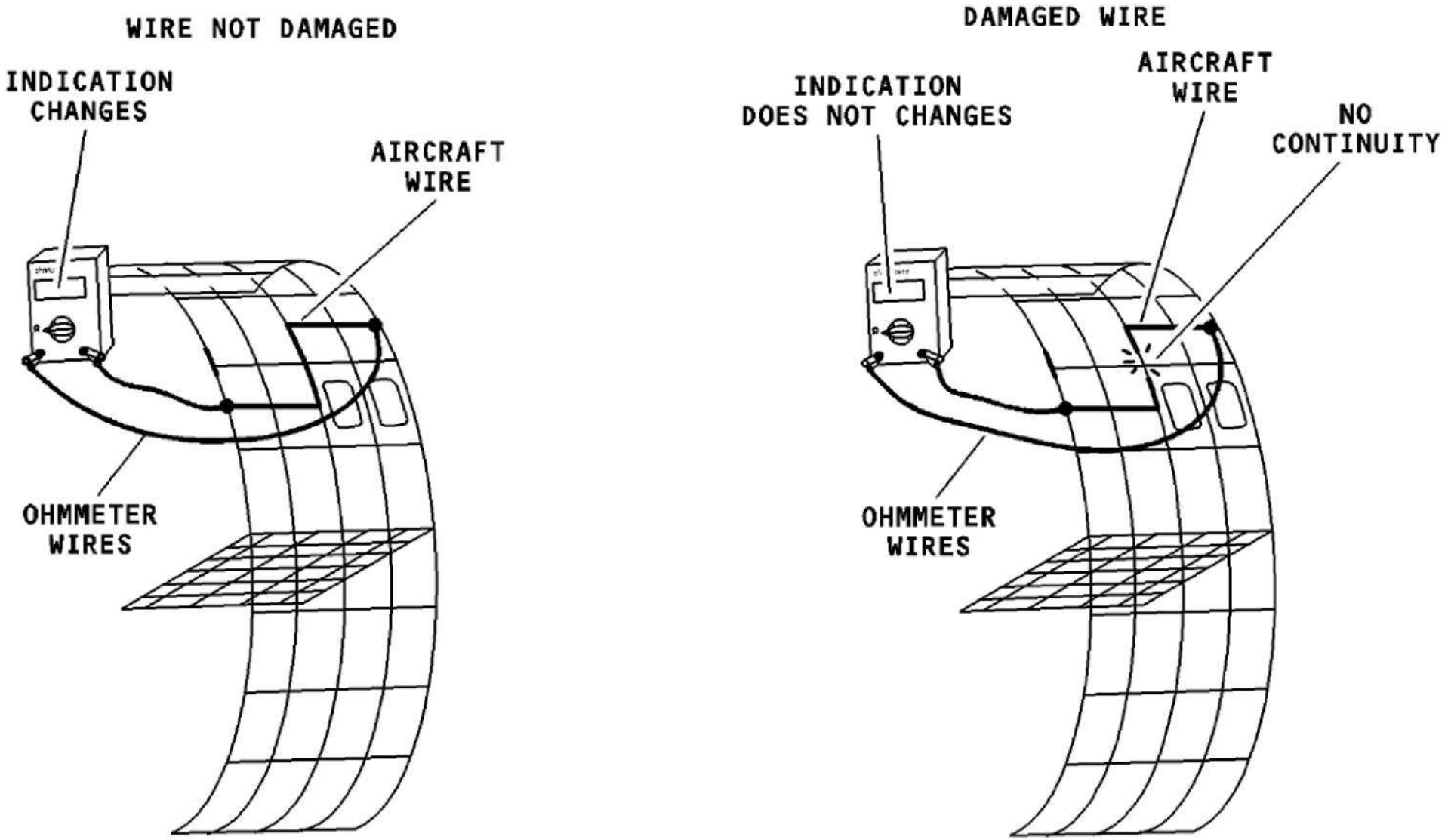


Figure 6 Measurement with Extension Line

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Measuring high-ohm resistance (insulation measurement)

Basics

Aircraft wires are protected by an insulation to prevent that a connection is set up between the conductors among themselves and between the conductors and the ground potential.

This insulation may partially or completely lose its functionality through environmental influences (humidity, ultraviolet radiation, coldness, heat, etc.) as well as through chemicals existing in aircrafts (oils, grease, hydraulic fluids, fluids used in lavatories, etc.).

Mechanical influences (abrasions) may also affect the insulation.

To check the quality of the insulation, insulation measurements are performed.

For these measurements, a voltage higher than the rated voltage is used – similar to the pressure test of a pipe line with an increased pressure value.

The measurement can be performed between two wires as well as between a wire and ground.

ATTENTION: Insulation measurement devices use potential values of up to 1000 volts. Therefore all devices, engines, sensors, etc. must be disconnected from the wire prior to the measurement.

ATTENTION: Take extreme care when performing insulation measurements on semi–conductor continuous loop fire detection systems since they will be destroyed through excessive measuring voltages!

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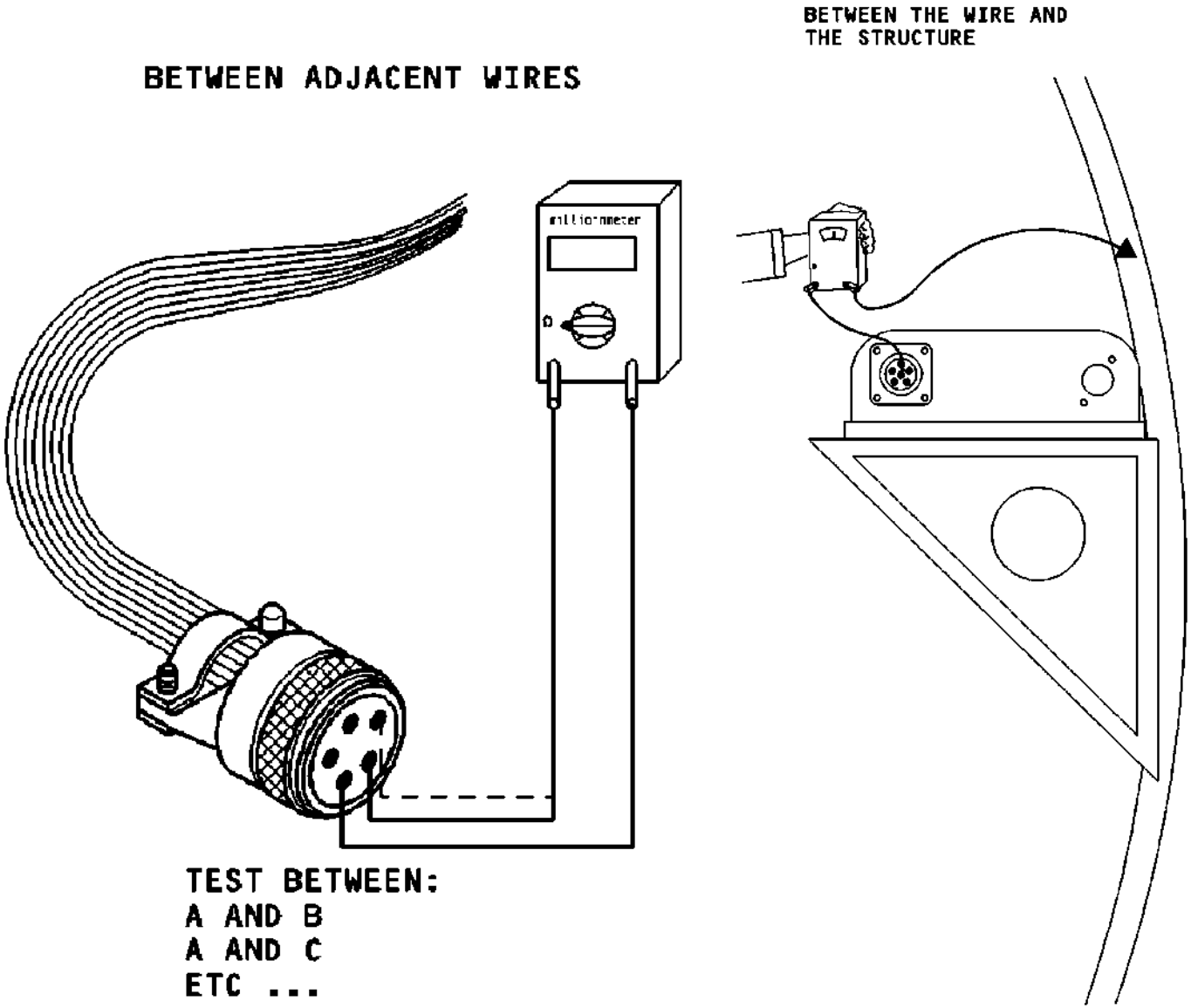


Figure 7 Isolation Check

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Insulation Measurement Devices

The insulation measurement is performed with special insulation testers or with multimeters with an integrated insulation test function.

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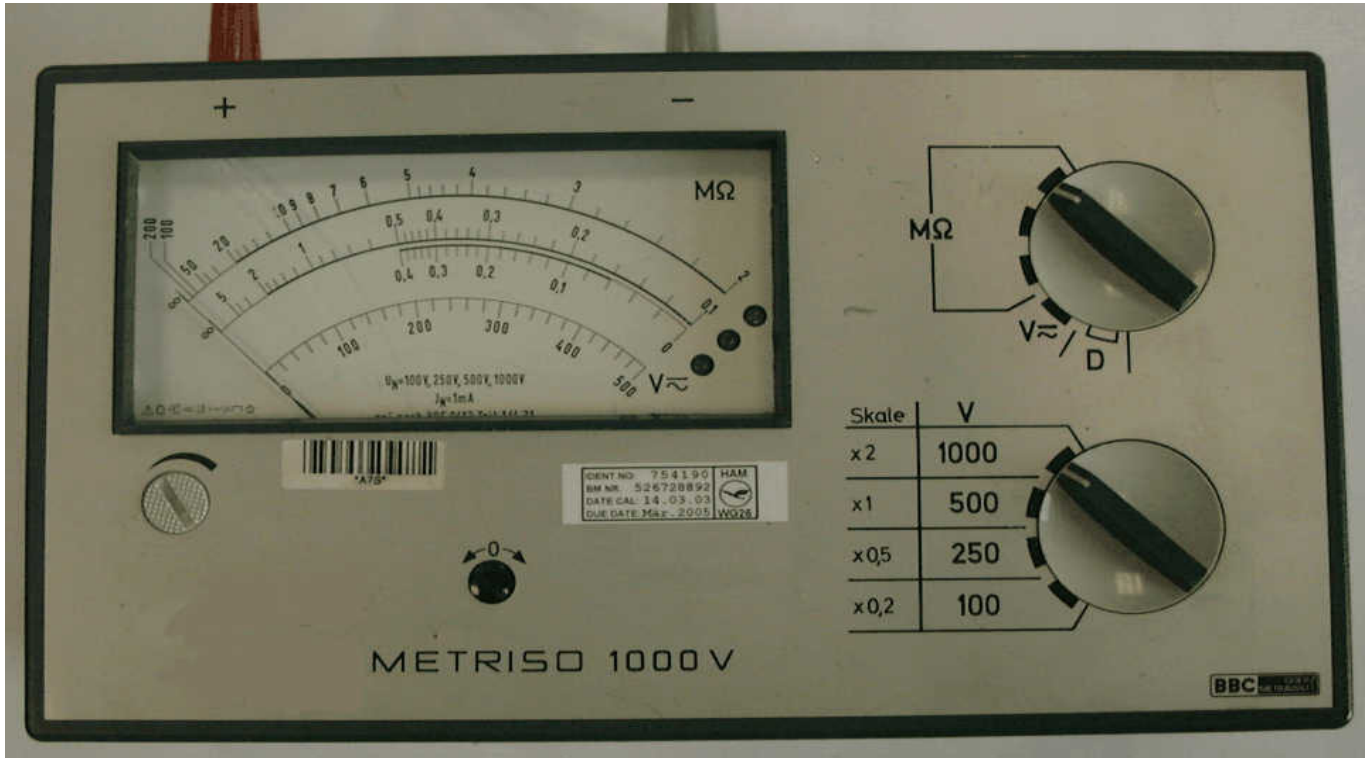


Figure 8 Isolation Tester

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Measuring low-ohm connections (Bondings/Groundings)

Basics

A lot of connections in aircrafts serve the purpose of introducing electricity into the structure (groundings) or which connect large conductive parts of the structure with one another (bondings).

These connections must be of high quality to prevent a possible resistance and the formation of corrosion on these areas.

In order to check the quality of these connections, their resistance value must be checked.

However, the standard measurement method via the ohmmeter/multimeter two−wire measurement is not suitable in this case due to the very low resistance values to be measured. The resistance values of the measurement line and of the interface to the resistance to be measured highly influence the measurement current compared to the influence of the resistance to be measured. That way no suitable result can be obtained.

For that reason, the Kelvin measurement method, also called four−wire measurement, was developed. Here, two test leads supply a specific current which flows through the connection to be measured. Two further test leads measure the voltage drop directly on the resistance to be measured. The resistance value is then determined through the two values of the supplied current and the measured voltage drop.

One advantage of this measurement method is that the measurement device locates faulty transitions to the resistance to be measured by detecting that the measurement current does not flow. The fact that the voltage drop is measured instead of the flowing current is another advantage since the resistance of the measurement lines no longer influences the result.

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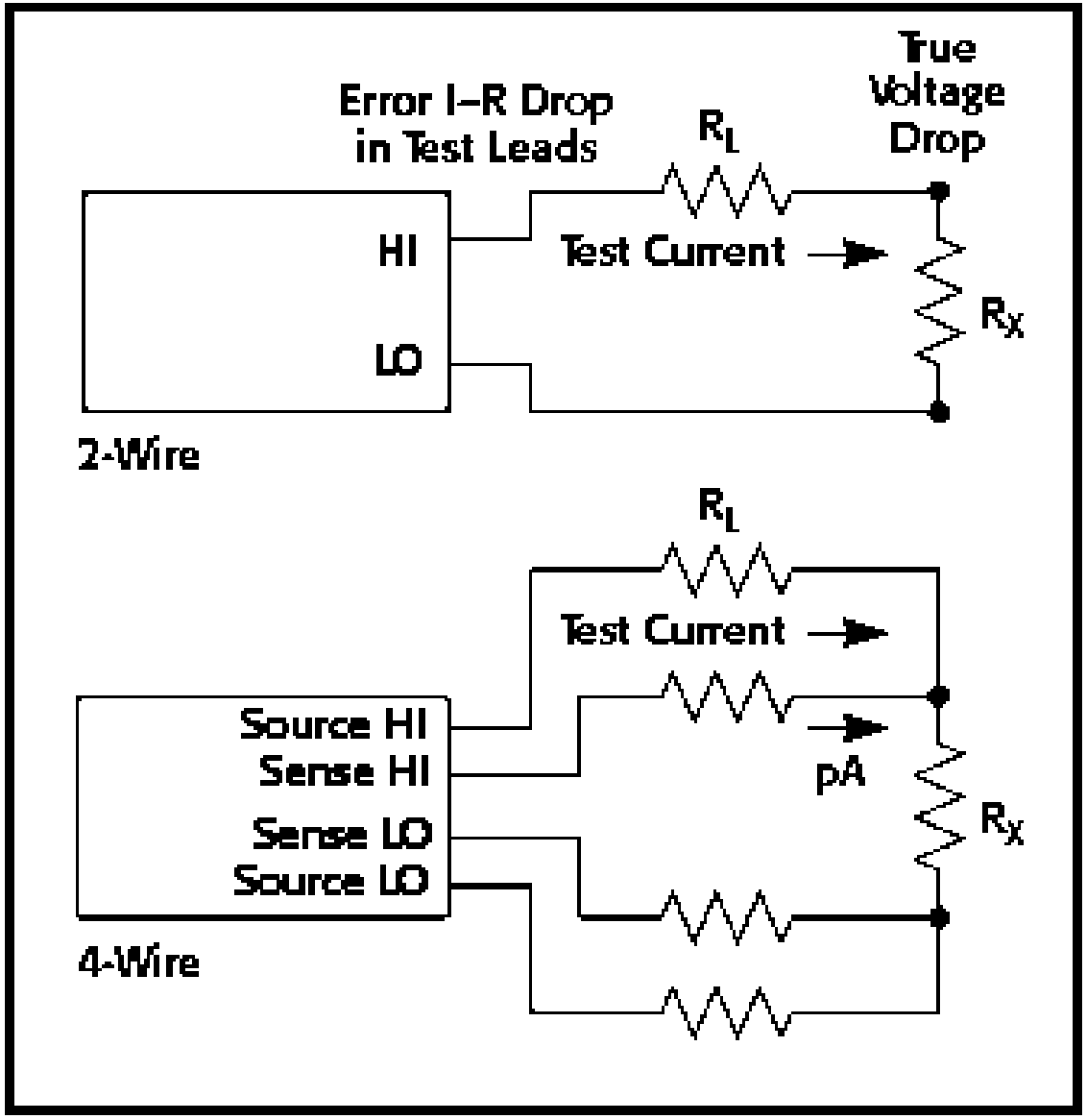


Figure 9 Principle of 2–Wire/4–Wire Metering

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Measurement Devices for Bondings/Groundings

For low resistance measurements, special measurement devices are used. One of these devices is the bonding meter. By now the bonding measurement has been integrated in multimeters as special function by manufacturers for measurement devices.

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Figure 10 Bondingmeter

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Bonding Meter for High Measurement Currents

To increase the measurement quality, the measurement current can be increased. This method is used by aircraft manufacturers in a way that a minimum measurement current is necessary for specific measurements. This, on the other hand, puts specific requirements on the measurement devices since the provision of the measurement current requires a corresponding stable current supply in the device. Therefore individual measurement devices are required for these special measurements. Those devices can supply measurement currents of up to 10 ampere.

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Figure 11 High Current Bondingmeter

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Operating the Bonding Meter

With the four–wire measurement, it is important that the voltage test leads are closer to the resistance to be measured than the current–supplying test leads.

In addition, with combined test handles, the voltage test leads are to be labeled with “P“ for potential or with “+“, and the current test leads with “C“ for current. When using the Metrahit 27 I, the two longer test spikes measure the voltage.

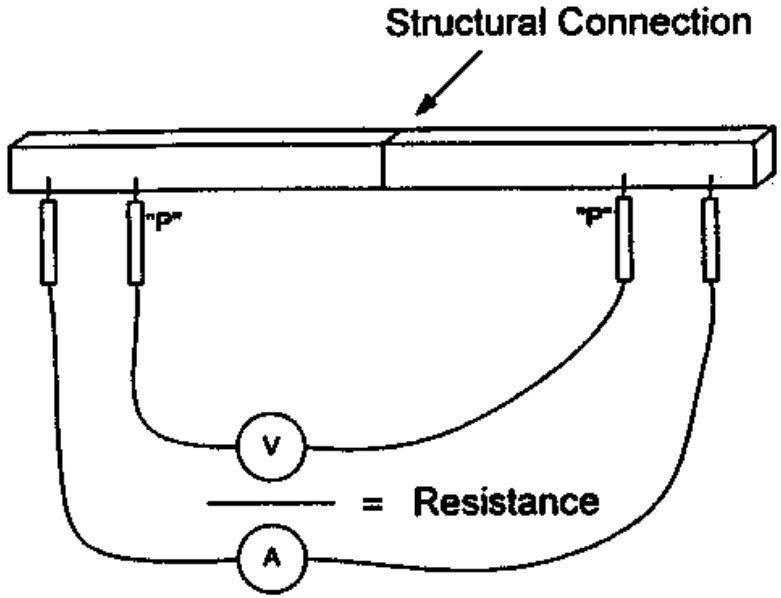


Figure 12 Bonding Metering

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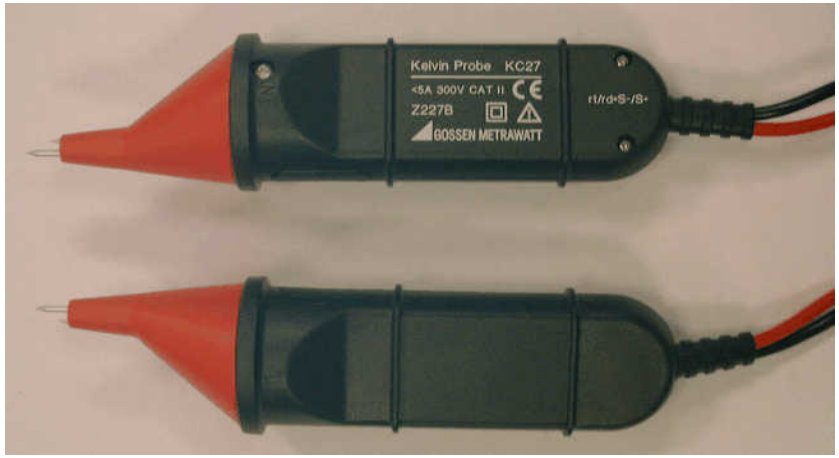




Figure 13 Test Leads

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Based on the minimum measurement current, the bonding meter can detect whether the test leads properly come in to contact with the resistance to be measured or not. If this is not the case, the device displays an error message. This message may be different depending on the type of device.

The T 477 W indicates the faulty contact via flashing decimal points on the display. The Metrahit 47 I on the other hand, shows the flashing message “LEADS OPEN“.

If this error message occurs, the connections of the measurement line must be checked and possibly remaining paint layers, oxide films, or similar, have to be removed. Only when no error messages are displayed, realistic results can be obtained.

NOTE: After the measurement it is necessary to protect the bare test points against corrosion again.

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Figure 14 „LEADS OPEN“ Indication

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Reflectometer measurement

Coaxial Cable Measurement via Reflectometer

For detecting and locating defects in coaxial cables or twisted wire pair cables, an impulse reflectometry tester (time domain reflectometry TDR) can be used.

This tester sends an impulse into the cable to be measured. Any defect in this cable will cause the impulse energy to be partially reflected back to the tester. This reflected impulse is then compared to the output impulse regarding the phasing, time shift and amplitude. This comparison then determines the distance to the defect and provides indicators for the type of defect.

To obtain an accurate distance measurement, it has to be considered that waves move at different speeds depending on the material they are in.

The relation of the propagation speed to the speed of light is indicated as “velocity factor“ (e.g. air = 0.99; Teflon = 0.7; polyethylene = 0.66). The velocity factor is usually stated by the cable manufacturer.

The tester primarily consists of an impulse generator which is connected to an oscilloscope.





Figure 15 Reflectometry Tester

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TIME DOMAIN REFLECTOMETER

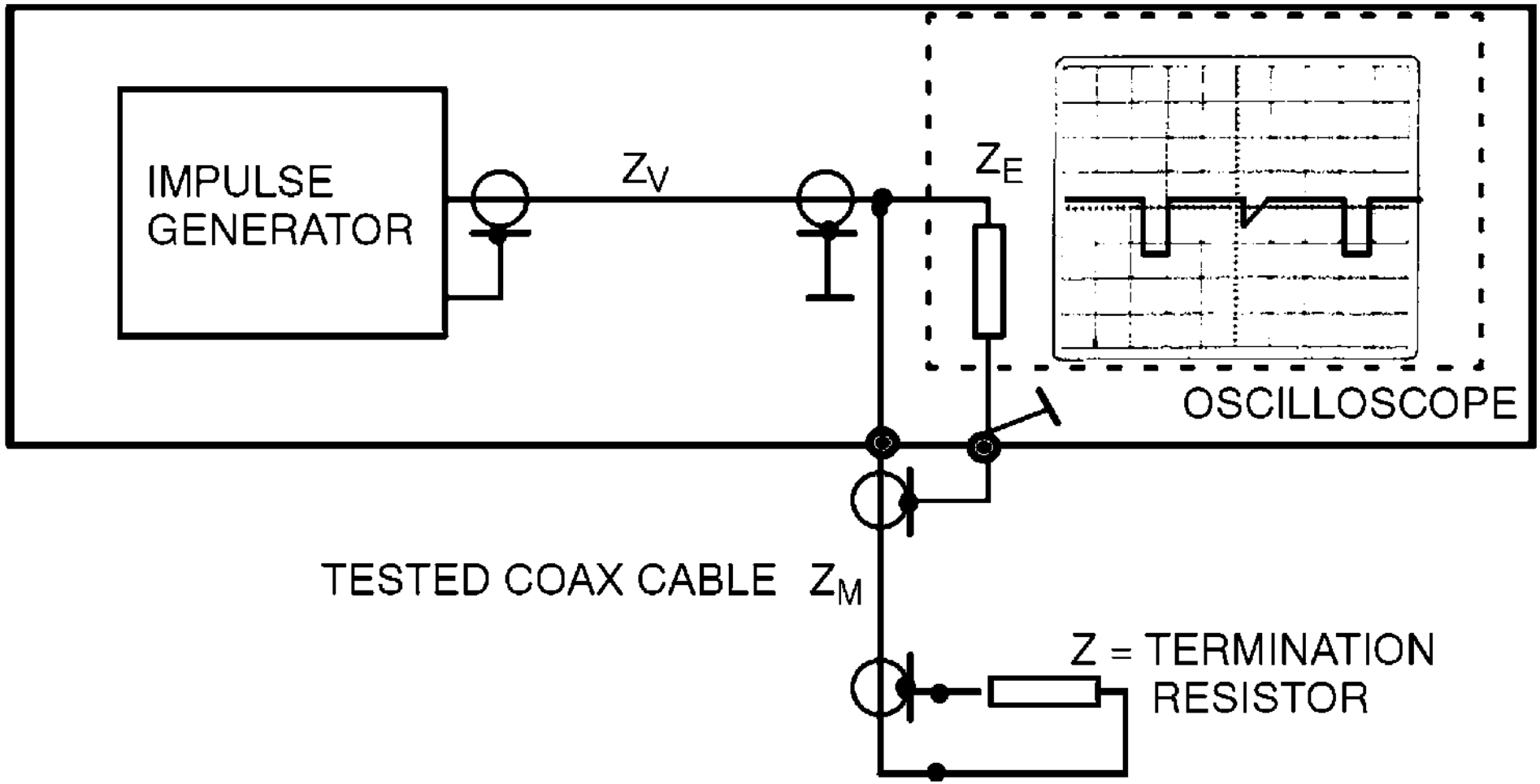


Figure 16 Reflectometry Circuit

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Error Pattern

Different errors in the measured lines cause different characteristic patterns.

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The type of reflected impulse provides information on the respective defect. A faultless line with correct terminating resistance will not cause any reflections.

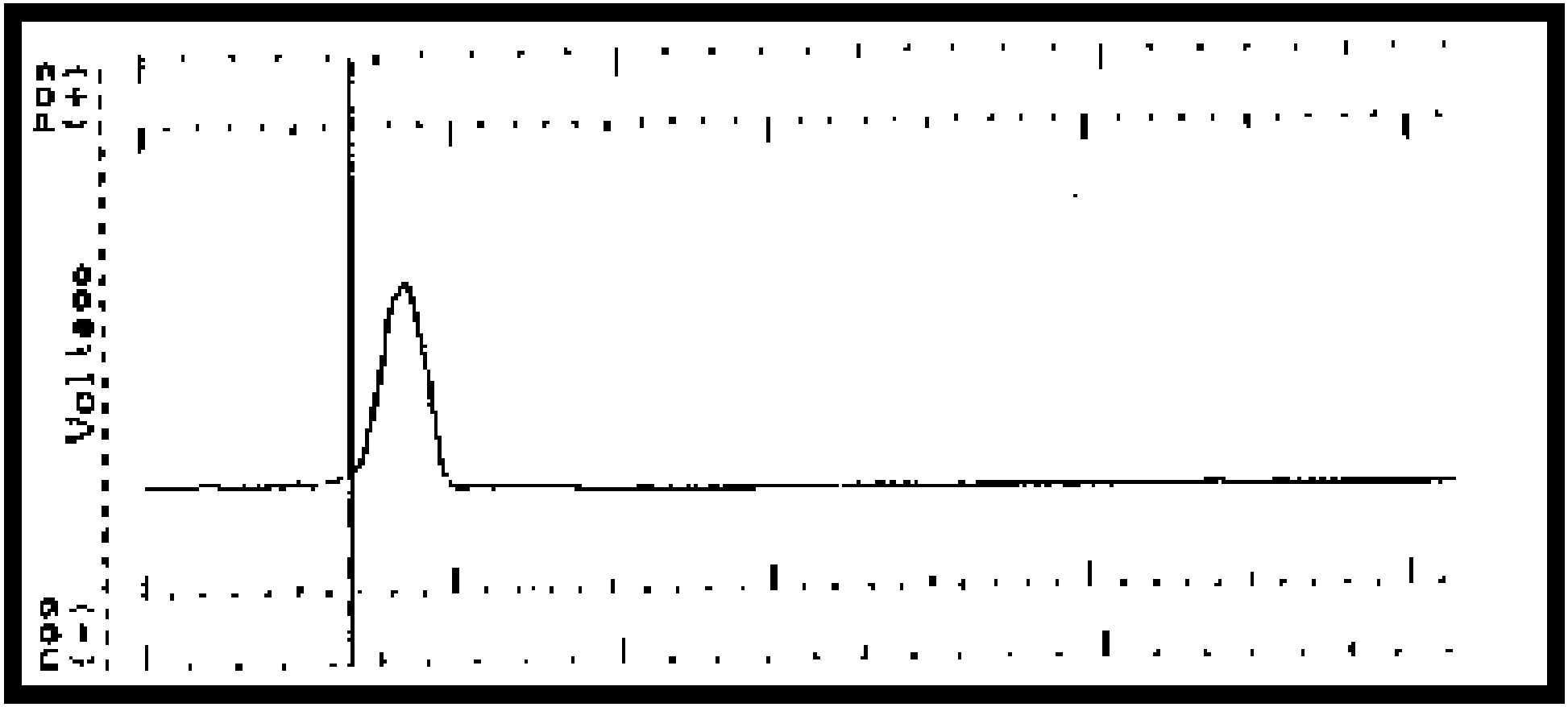


Figure 17 Faultless Wire

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A reflection with the same polarity as the input impulse indicates an open line,
i.e. a completely open line.

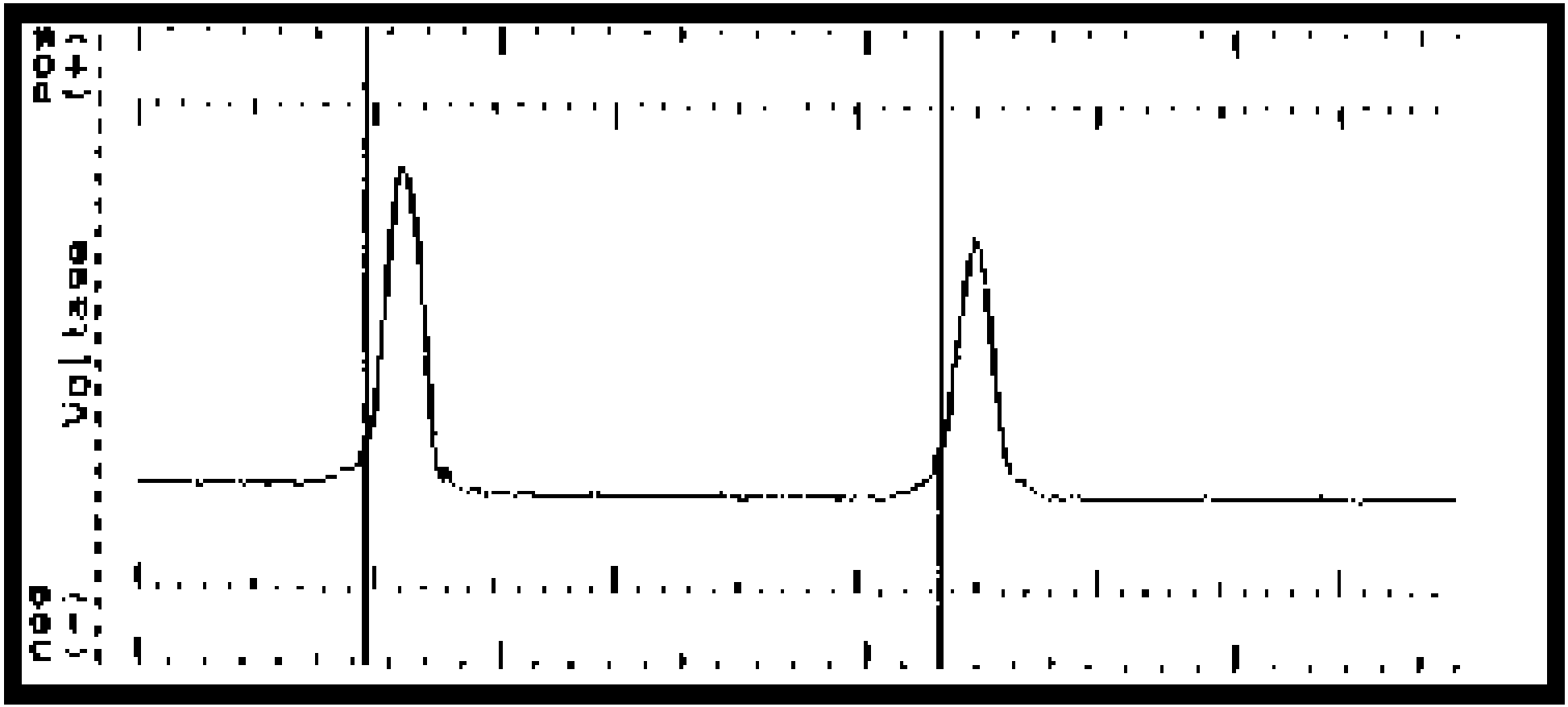


Figure 18 Open Wire

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With a short circuit in the line, a negative impulse is reflected.

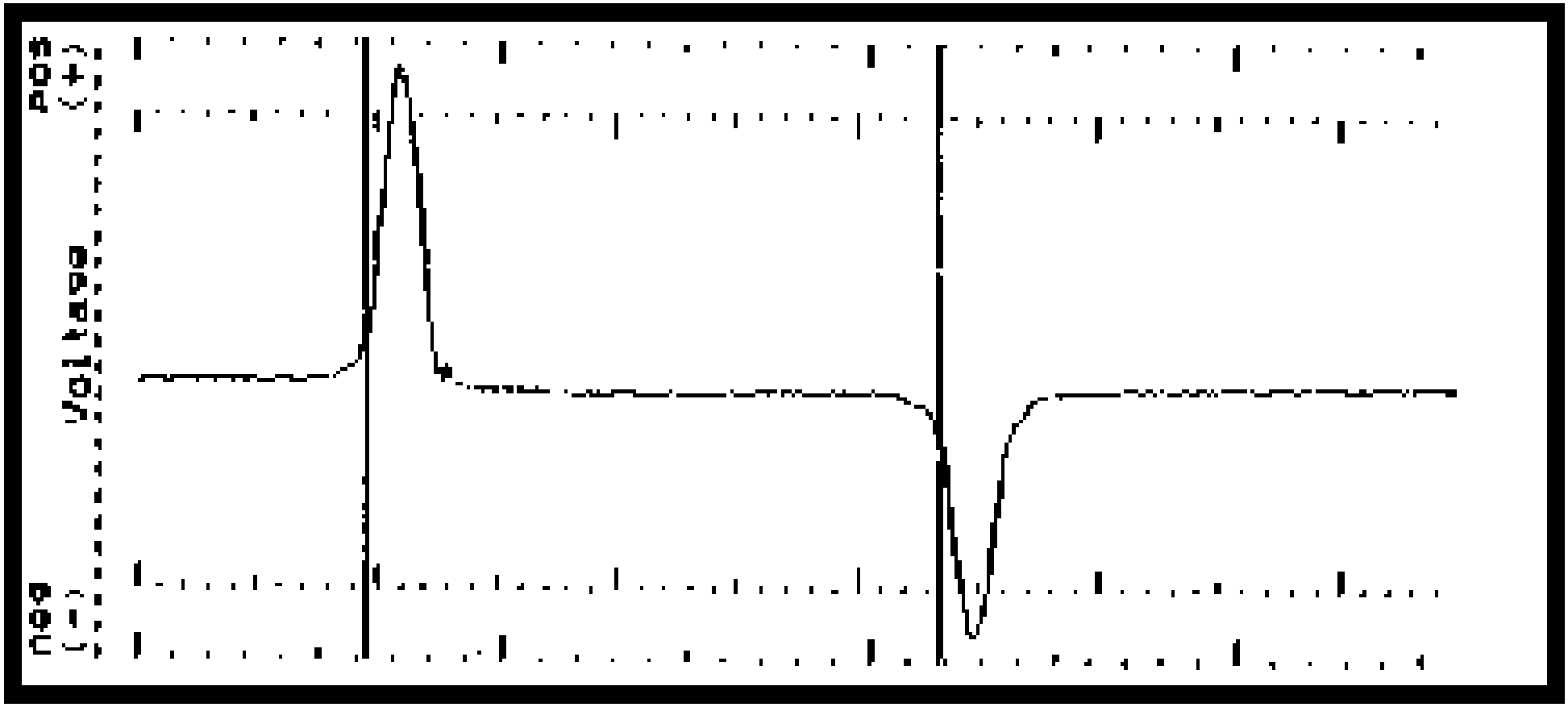


Figure 19 Shortened Wire

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Air Data System

Air Data System Specifications

In the FAR 25.1325 as well as in the FAR 43 Appendix E, the Federal Aviation Administration prescribes the following specifications for air data systems:

- Static System:
  - Leak test: The static system is to be evaluated with regard to the maximum possible differential pressure. Afterwards, the generated vacuum is enclosed in the system. The indicated altitude must not change of more than 2% or 100 feet within one minute; the highest deviation applies.
  - Accuracy: By means of test equipment, the system is set to the pressure altitudes corresponding to Table 1 shown below. The value can then be read off after a rest period of between one and ten minutes. The tolerances shall not be exceeded.
  - Additionally, hysteresis, after effect, friction and case leak tests in accordance with the tables stated below must be passed to receive an airworthiness certificate.
- Pitot System:
  - The system error shall not deviate by more than 3% of the calibrated airspeed or by 5 knots of the actual airspeed, depending on which value is higher.

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Table I

Altitude	Equivalent pressure (inches of mercury)	Tolerance ±(feet)
−1,000	31.018	20
0	29.921	20
500	29.385	20
1,000	28.856	20
1,500	28.335	25
2,000	27.821	30
3,000	26.817	30
4,000	25.842	35
6,000	23.978	40
8,000	22.225	60
10,000	20.577	80
12,000	19.029	90
14,000	17.577	100
16,000	16.216	110
18,000	14.942	120
20,000	13.750	130
22,000	12.636	140
25,000	11.104	155
30,000	8.885	180
35,000	7.041	205
40,000	5.538	230
45,000	4.355	255
50,000	3.425	280

Table II—Test Tolerances

Test	Tolerance (feet)
Case Leak Test	±100
Hysteresis Test:	
First Test Point (50 percent of maximum altitude)	75
Second Test Point (40 percent of maximum altitude)	75
After Effect Test	30

Table III—Friction

Altitude (feet)	Tolerance (feet)
1,000	±70
2,000	70
3,000	70
5,000	70
10,000	80
15,000	90
20,000	100
25,000	120
30,000	140
35,000	160
40,000	180
50,000	250

Table IV—Pressure-Altitude Difference

Pressure (inches of Hg)	Altitude difference (feet)
28.10	−1,727
28.50	−1,340
29.00	−863
29.50	−392
29.92	0
30.50	+531
30.90	+893
30.99	+974

Figure 20 Test specifications

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Air Data Tester

To test the air data systems of aircrafts, modern computer−controlled air data testers with multi−functional equipment are used nowadays. That way, many different aircraft types can be inspected with one tester.

These tester allow for a variety of different test functions:

- Generation of pressure/vacuum
- Automatic leak check
- Controlled ventilation of the system
- Altitude/air speed specification
- Static/dynamic/overall pressure specification
- Altitude/air speed rates specification
- Mach number specification
- Generation of EPR pressures

The tester of the company DMA Marchiori is presented in the following as example.

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Figure 21 Air Data Test Set

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Operating the Air Data Test Set

When connecting the test set to the sensors of the aircraft, the highest possible tightness needs to be ensured since even small leaks already significantly influence the low test pressures.

In order to connect the test set, special adaptor kits for the respective aircraft type have to be used.

ATTENTION: Before connecting test equipment to heated sensors in the aircraft, the heating must be switched off. Otherwise, equipment as well as sensors can be irreparably damaged.

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Figure 22 Air Data Test Connection Set

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The test method must proceed in such a way that the connected pressure capsules will not be damaged. Especially differential pressure capsules can be destroyed when incorrect pressure is applied.

ATTENTION: Mnemonic phrase: Without speed, the plane cannot gain height! So generate pitot pressure first and reduce the static pressure afterwards!

Changes in the altitude data as well as the speed data may influence the aircraft.

ATTENTION: When specific speed values are reached, aircraft–internal systems are capable of changing the position of the control surfaces and lift–generating flaps (flap load relief, autoslat, etc.). The safety precautions in the maintenance manual must be considered!

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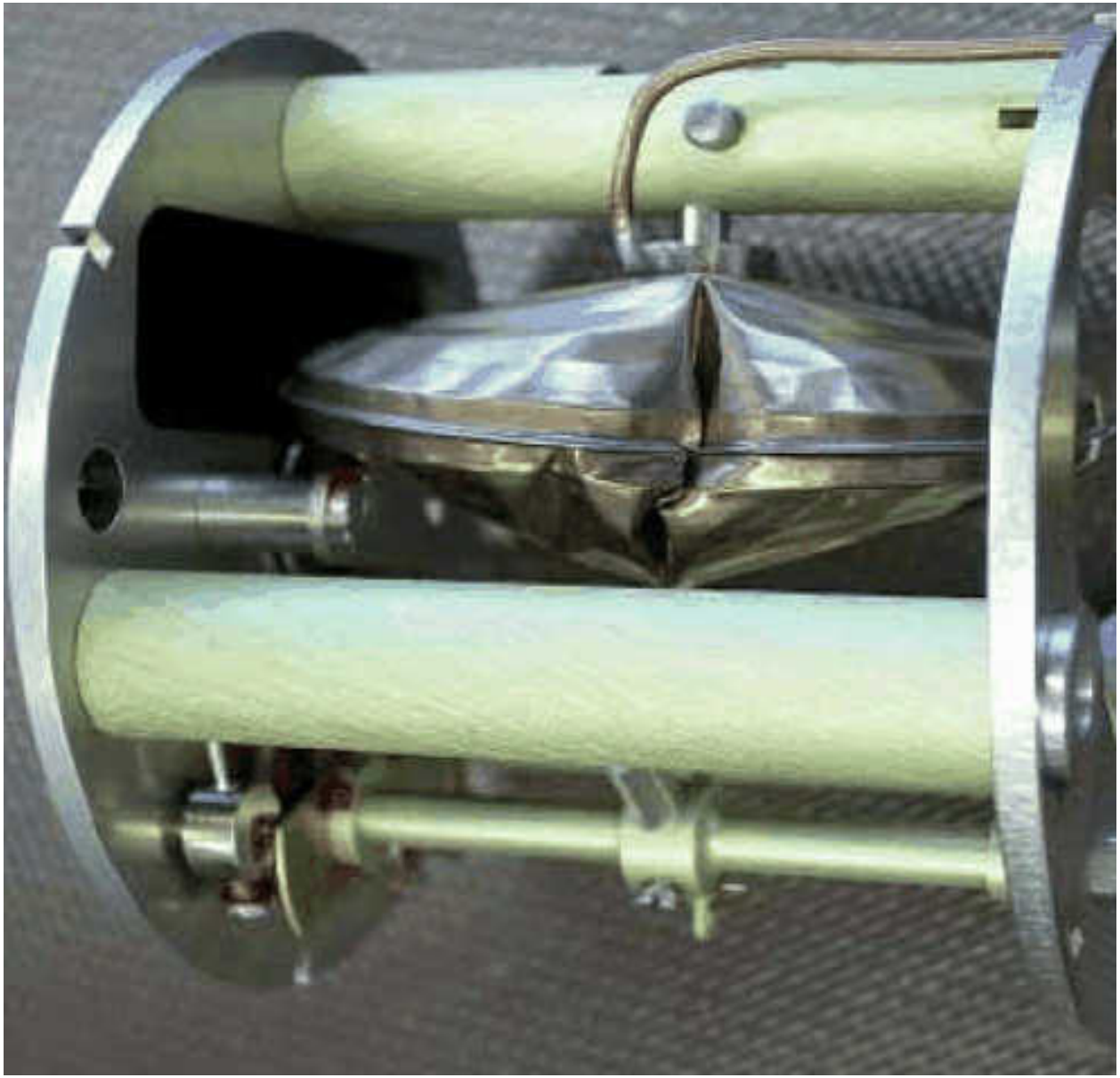


Figure 23 Destroyed Pressure Capsule

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The air data test sets of the company DMA are operated with a corresponding remote control in most cases. For the different application purposes, different remote controls were developed.

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Figure 24 Air Data Test Set Remote Controls

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The air data tester can be operated in different modes:

- Control Mode: Pressure and vacuum are generated and maintained.
- Measure Mode: The UUT (unit under test) is isolated and the pressure measuring part of the air data set is active only.
- Vent Mode: In the vent mode, the pitot and static systems are driven on ambient pressure in a controlled manner.
- Leak Mode: The connected system is inspected by an automatic leak test.
- Limits Mode: In the limits mode, the current limits of all functions can be changed.

After connecting the test sets, the individual data to be achieved is set. Afterwards, the test set automatically runs through the set test sequence. Protective circuits in the test set prevent the damaging of the pressure capsules in the aircraft through the incorrect application of pressure.

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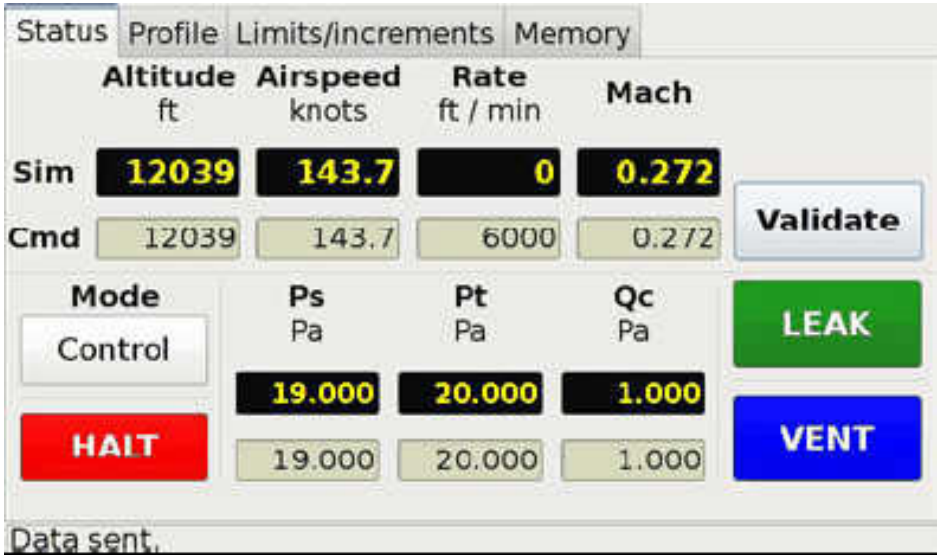


Figure 25 Air Data Test Set Screens

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Standby Compass Calibration

Specifications

In accordance with the FAR 25.1327 construction regulations, a standby compass shall not deviate by more than 10 degrees on each heading. To ensure this, the standby compass must be calibrated and compensated. This is realized by means of a so−called ¿compass swing¿ on an authorized compensating disc or a tool designed for that purpose, such as the standby compass calibrator.

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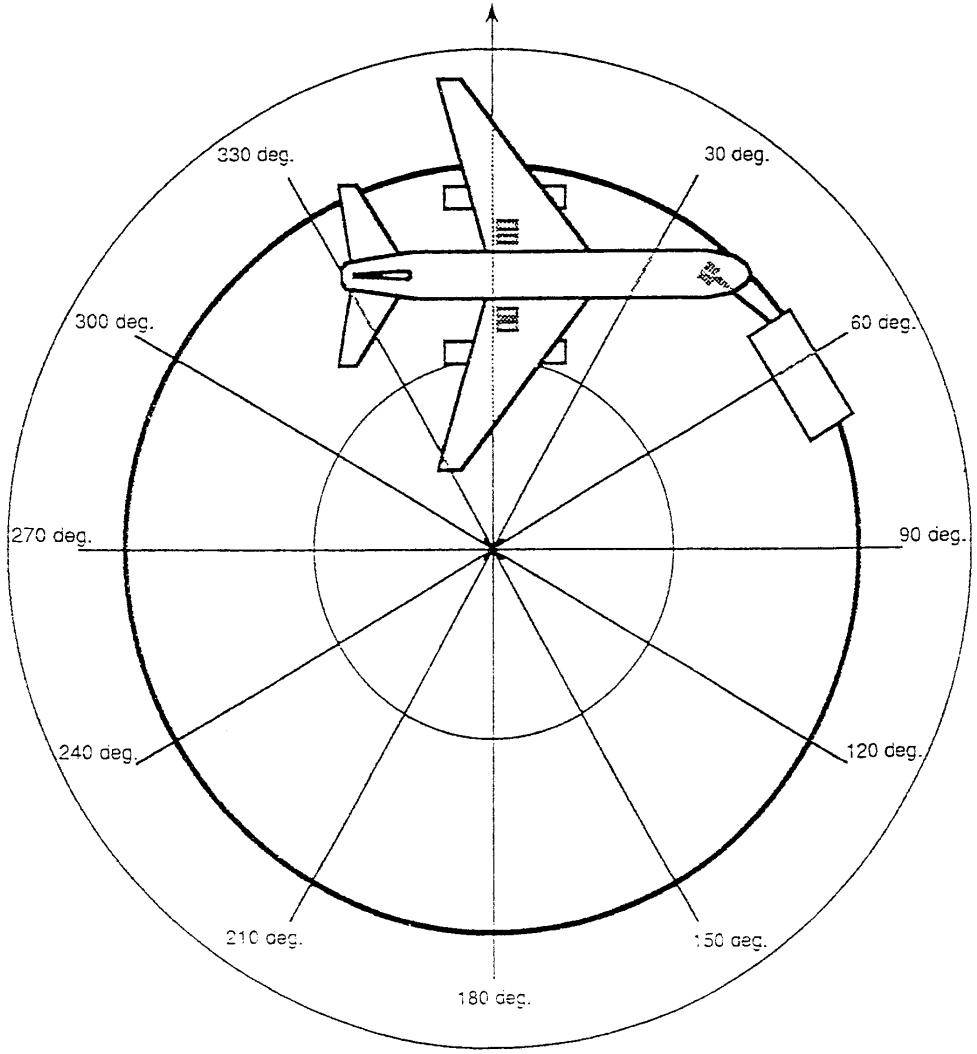


Figure 26 Compass Swing

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Standby Compass Calibrator

Since it is not always possible to set up a compensating disc or to have one available, the standby compass calibrator was developed. With two adjustable magnets, this tool neutralizes the magnetic field existing at the place to be compensated and replaces the field with an artificially produced magnetic field through two pivoted magnets. By that, only the interferences caused by the aircraft influence the compass. These interferences are then compensated by adjusting the compensating magnets in the compass.

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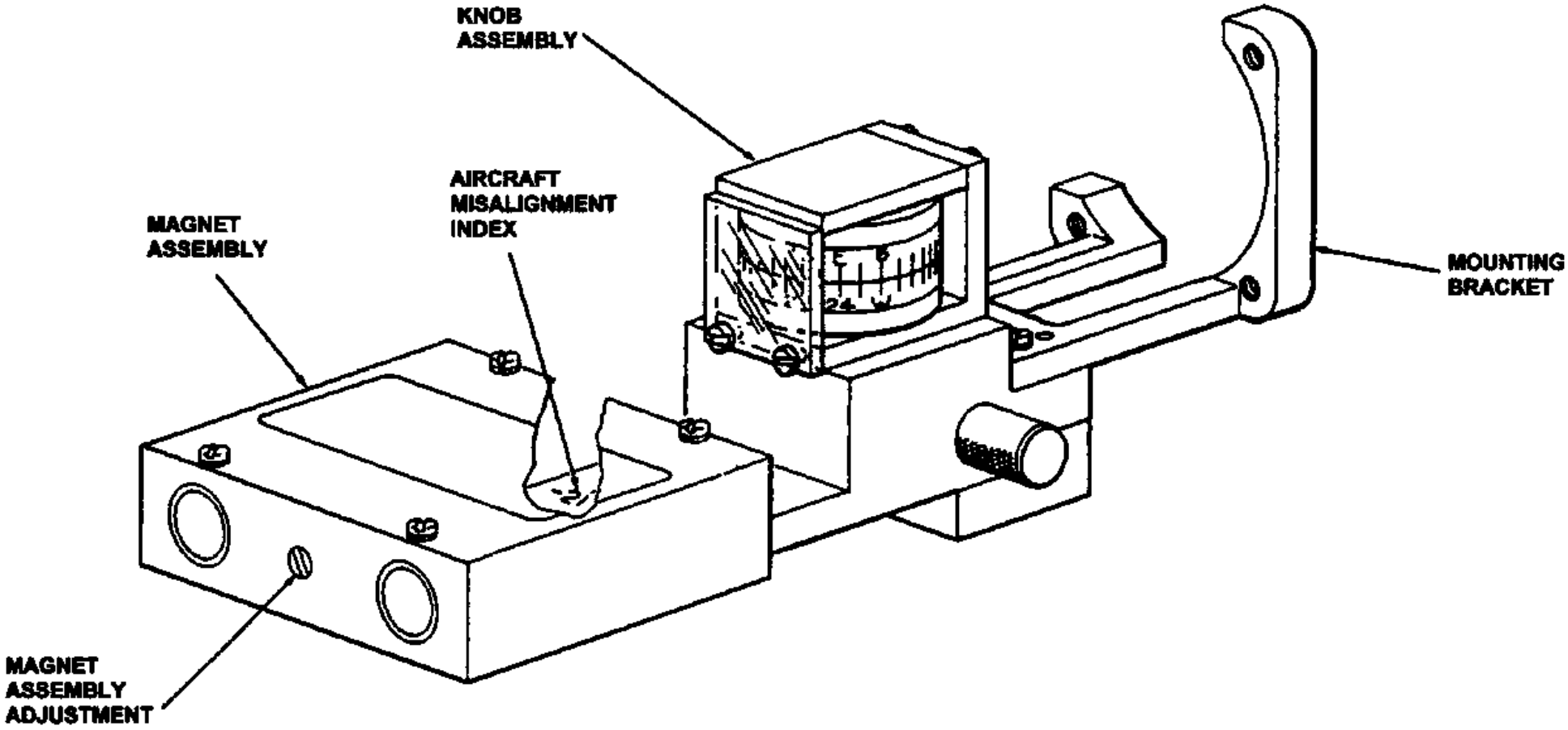


Figure 27 Standby Compass Calibrator

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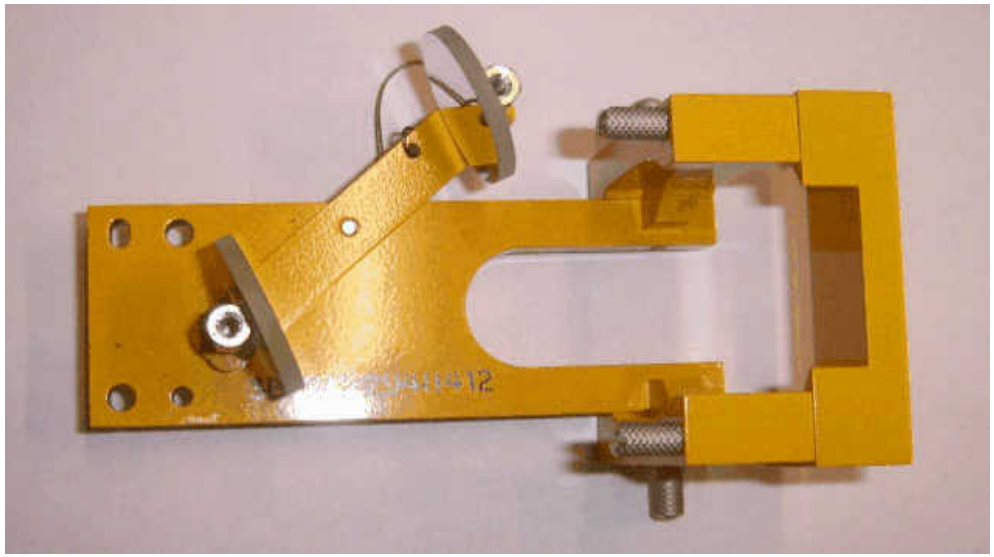
Handling the SCC

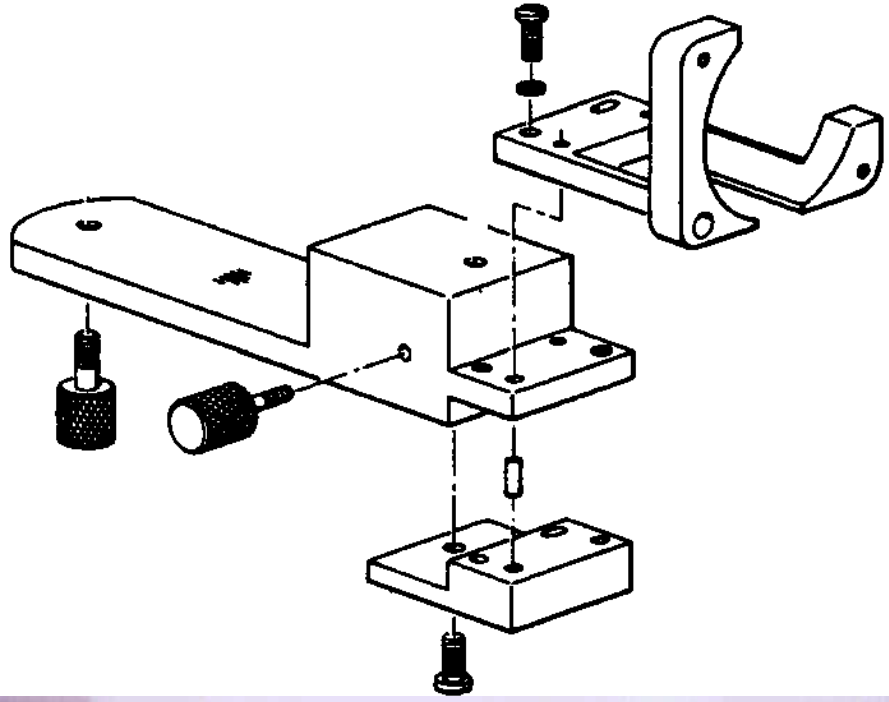
Adjusting to the Compass Type

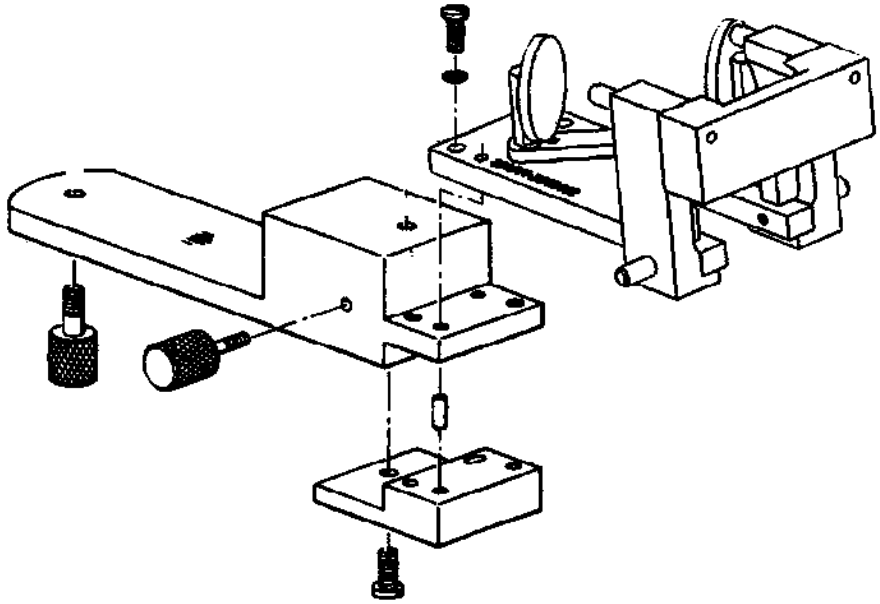
Depending on the compass type, the mounting for the installation of the SCC to the compass must be rearranged prior to the recalibration of the SCC.

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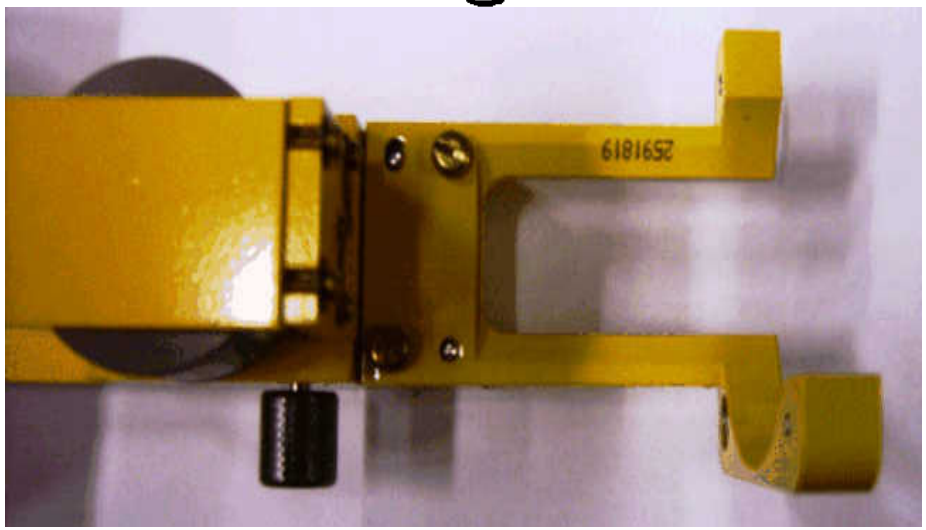


Figure 28 SCC Mounting

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Short description of the compensating method

The SCC is adjusted on the compensating location. Afterwards, the aircraft is aligned with its nose directly pointing to the north with a maximum accuracy of +/– 2 degree.

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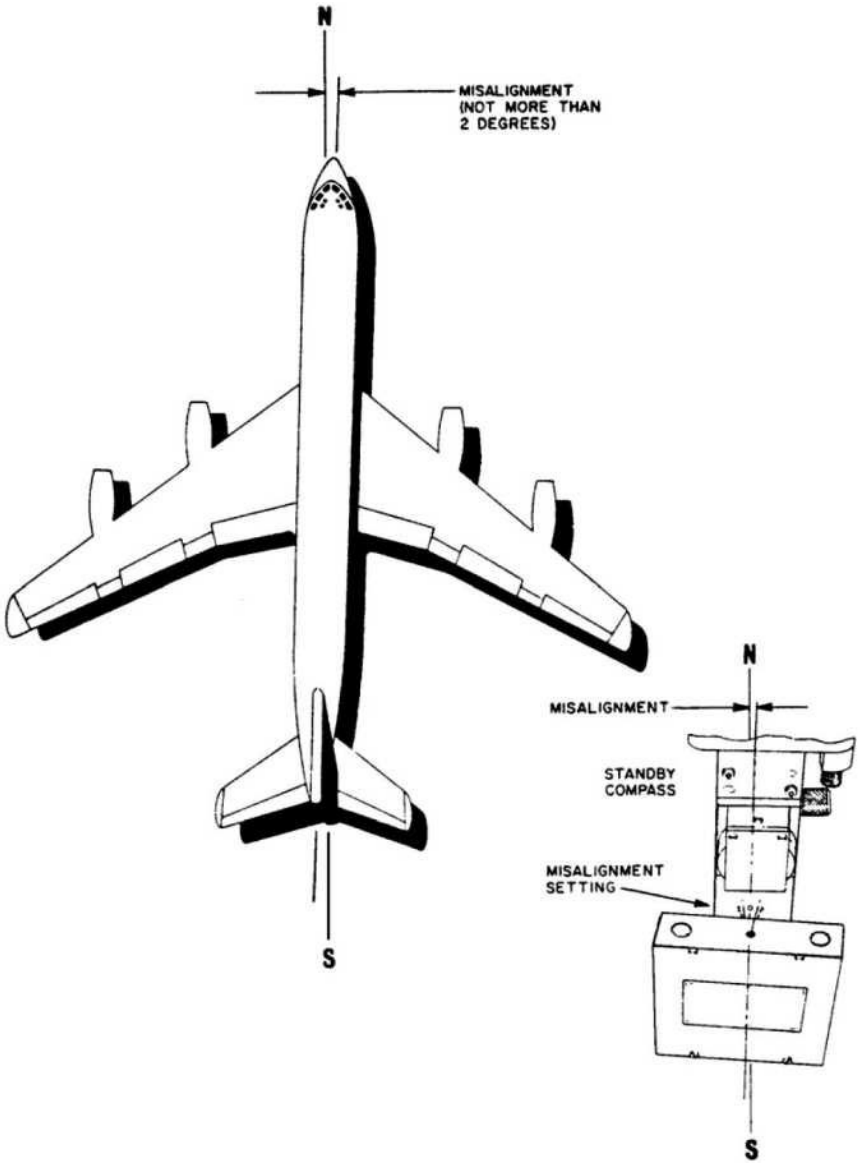


Figure 29 A/C on N-S Line

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Now the SCC is positioned on the standby compass. With the aid of the rotary magnets, the SCC sets the route for the compass. If the compass does not display the route with an accuracy of at least +/– 8 degrees, it must be readjusted with the compensating magnets in the compass.

NOTE: This example is from Airbus; other specifications may be valid for other manufacturers or maintenance organizations.

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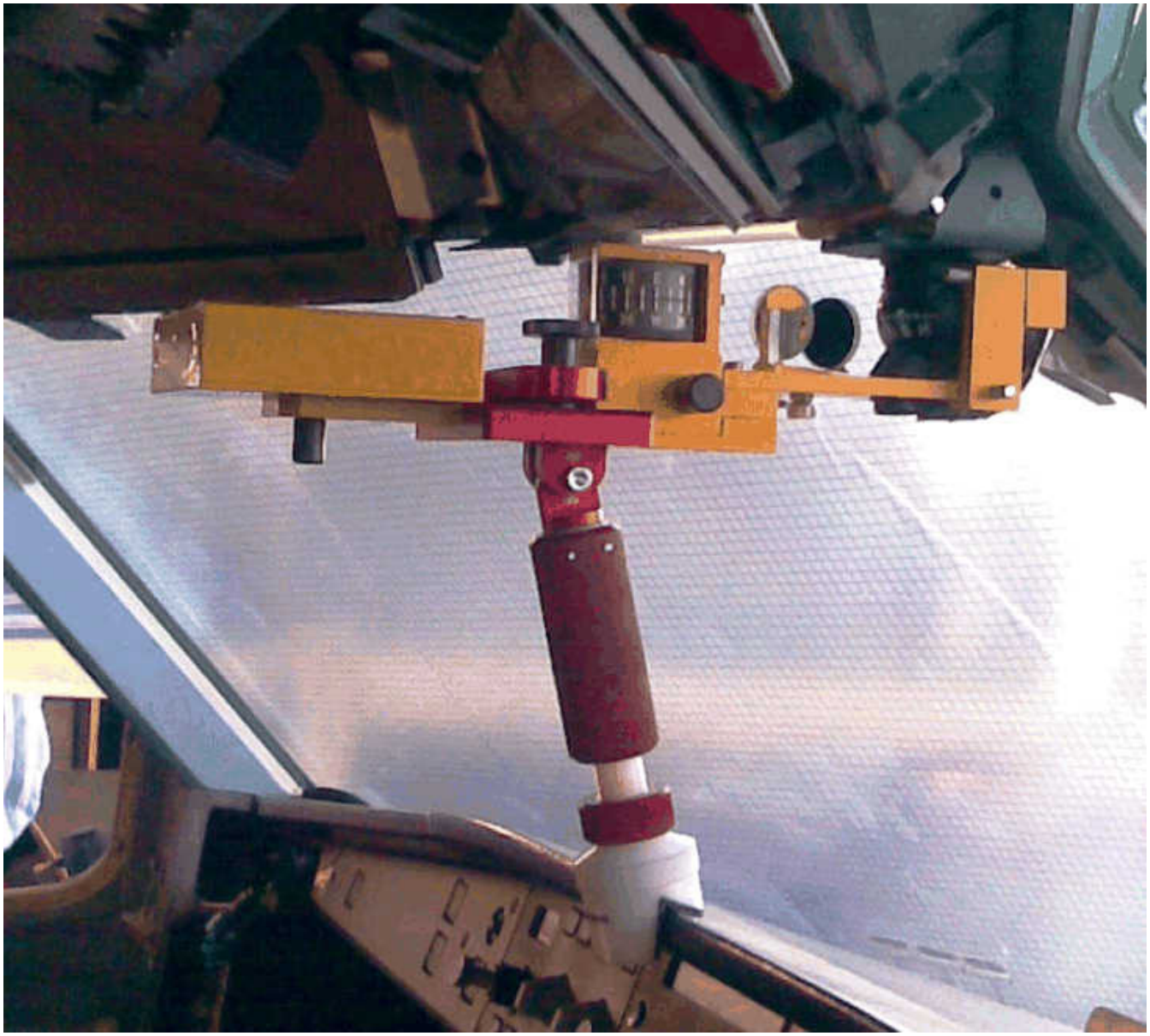


Figure 30 SCC on Compass

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Fuel Quantity System

Fuel Quantity Test Set PSR60–2R

The PSD60–2R Fuel Quantity Gauging System Test Set is a test device with which a complete functional test and a calibration on the fuel gauging system can be carried out in the built–in as well as the removed state.

The test set is capable of accurately measuring the capacity and the insulation resistance of the tank units, the compensator or of the whole system.

The test set can also simulate a capacity to cause an indication by the indicator.

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Figure 31 PSD60–2R

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Connecting the test set

The test set is connected with special test lines.

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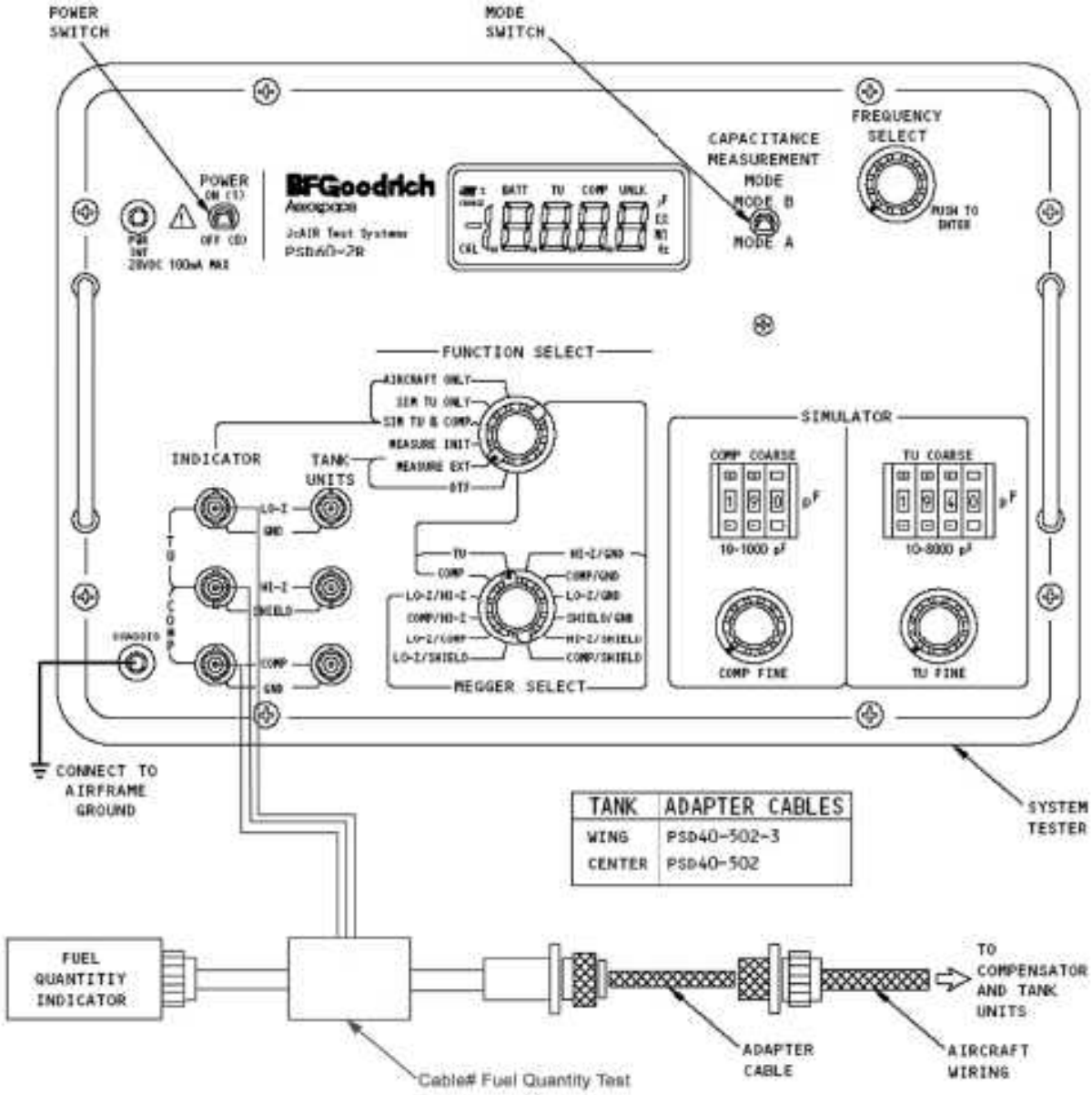


Figure 32 Connection FQIS - PSD60-2R

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