



# Usage of Bonding Meters in Aviation

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## Abstract

This paper is about bonding meters, their principles, specifications and usage of bonding meters in aviation. The bonding meter is essentially a milliohm meter. It is used for measuring small values of resistance. The word "bonding" means that conductive parts of aircraft are bonded together by a conductive connection. The bonding meter tests, if the conductive connections are really conductive. This paper is, in its essence, a study how to use bonding meter and its usage. The usage is focused on the aviation. The first part of the paper describes bonding meter's purpose and its specifications. There are several types of the bonding meters and every type has different specifications. The next part describes bonding meter's usage, its application and measuring principles. The bonding meters can be used by different ways so it is good to explain the most used principles. The last part of this paper summarizes all mentioned knowledge and shows authors opinion to a development of the bonding measurements.

## Keywords

Bonding meter — Bonding meters in aviation — Milliohm meter — Usage of bonding meter

## 1. Introduction

A bonding meter (Fig. 1) is a measuring instrument that use digital techniques to measure and display small values of resistance. It helps to identify the integrity of electrical connections. The bonding meters are used to measure very small resistances. The range of the bonding meter is in milliohms ( $m\Omega$ ). Milliohm is a unit of measure that equals to  $10^{-3}$  ohm ( $\Omega$ ). Resistances that are smaller than  $0.2\ m\Omega$  can usually be measured with reduced accuracy [1]. The electrical resistance of an electrical conductor represents the difficulty of passing an electric current through that conductor. The resistance of an object is defined as the ratio of voltage across it to current through it.

All the conductive aircraft components must have a minimal electrical resistance to prevent damage that could be caused by a residual current in the aircraft system or for instance by lightning strikes. All these aircraft components are electrically connected together. These components are measured by bonding meter. These things can be included in the word "components": screening, ground straps, screw connections and pipes including connections.

Bonding meters is one of the devices that use a four-wire Kelvin probe system. The Kelvin probe system passes a test current through the probe so that the voltage is sensed by the centre pin. This method eliminates contact resistance and minimizes the possibility of errors caused by the resistance of the leads [2].



**Figure 1.** T477W bonding meter [1]



**Figure 2.** Damage caused by a bond failure [4]

## 2. Bonding Meters Specifications

This section may be divided by subheadings. It should provide a concise and precise description of e.g. the experimental results, their interpretation as well as the experimental conclusions that can be drawn.

Milliohm meters (or bonding meters) carry specifications for [3]:

- Bandwidth
- Sampling rate
- Maximum channels
- Operating temperature
- Display type
- Display digits

Bandwidth is the frequency range for the measured AC current or voltage. A sampling is the conversion of a digital signal to an analogue signal. The sampling frequency or sampling rate is the average number of samples obtained in one second. Maximum channels is the total number of channels for the device.

An operating temperature is the temperature at which the milliohms meter operates. A display type: There are two display types. Ty types are analogue and digital. Analogue devices usually display values with a needle and digital devices have an electronic display with numbers.

Display digits: The milliohm meters usually display digits in range from 3 to 7 or more. There are devices that can even display a half-digit [3].

## 3. Bonding Meters Usage

Every aircraft needs a reliable ground circuit. This circuit is important for the safety of the aircraft. Ground circuits are created through a range of bonding elements including structural bonds and brackets, ground straps, cable shields and connector back shells. Integrated grounding

circuit needs to be secure. In modern aircrafts, whose structures are made from composite materials, aircraft OEMs cannot rely on metallic fuselages to carry voltage transients and stray currents anymore. So the bonding is necessary.

An ineffective ground circuit can be caused by incorrect assembly, material defect at manufacture or degradation of material and joints. So these circuits must be controlled. The controls are done by the bonding meters.

There is a list of the damaging effects that influence the aircraft. The bonding helps to prevent the damaging [4]:

- Stray Currents (Fig. 2): They are caused by faulty equipment. These currents can be dangerous for personnel, passengers and aircraft itself, if they are not diverted safely.
- Lightning Strike: They can cause currents to pass through the aircraft fuselage to the wiring looms and aircraft systems. These currents can damage or potentially destroy electrical systems and must be routed effectively to ground.
- High Intensity Radiated Fields (HIFR): They are fields that are generated by radio frequency emissions. These emissions compose from many different radiated fields such as high power radio signals and radar and particularly military radar. These fields can cause voltage transients that can result in damage or malfunction of critical systems.

There are three testing areas that can be tested with bonding meter [4]:

- Bond test: This test is used to measure the electrical resistance between two metallic elements. This test is used by injecting known current that flows from one element to the other. Then measures the volt drop that is lost during the flow. The resulting

resistance is then calculated by Ohms law. This test is typically used to test resistance between a bracket and structure.

- Loop test (Fig. 3): In this test, several metallic elements and equipment are connected together into a loop of parallel resistance paths. The loop test is used by using current clamp to inject current into the loop. The flowing current is known and combined with known voltage feedback from internal power source. The bonding meter automatically carries out a phase corrections to calculate loop resistance. The loop is typically made of cable shields and bonding straps.
- Joint test: This test used to measure the group loop that is made up of a number of elements. The joint test makes use of the joint resistance between these elements to determine the total loop resistance. If the resistance is high, it is likely because a single joint is being loose or damaged. The loop clamps inject a known current through the ground loop and bonding meter then calculate the volt drop. After phase correction and calculating, the joint resistance is reported by the bonding meter.

#### 4. Application of Bonding Meters

The bonding meters is applied by connecting a probe to the input connector, turning the bonding meter on and then applying the probe to the object or bond that is measured (Fig. 4).

To ensure good electrical connections a coating or anodizing must first be penetrated or removed. The bonding meter will then display resulting resistance. The probe connections must be adequate. This ensure that the bonding meter display will be stable [5].

To connect the bonding meter to unknown resistance cables that consist of two current leads with regulated current output and two voltage sensing leads are used to pick up voltage across the unknown [6].

Because the sensed voltage is small and the current is alternating a small transformer effect exists between the

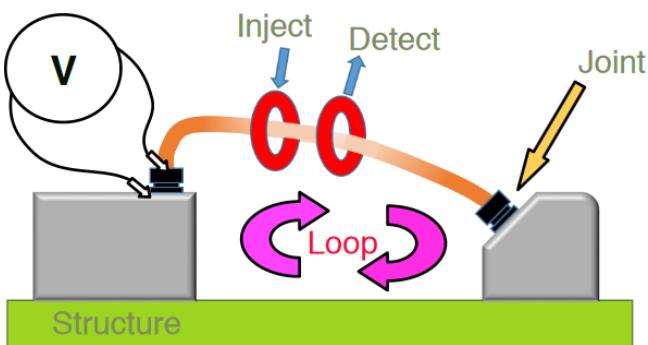


Figure 3. Bond testing structure [4]



Figure 4. Bond testing [4]

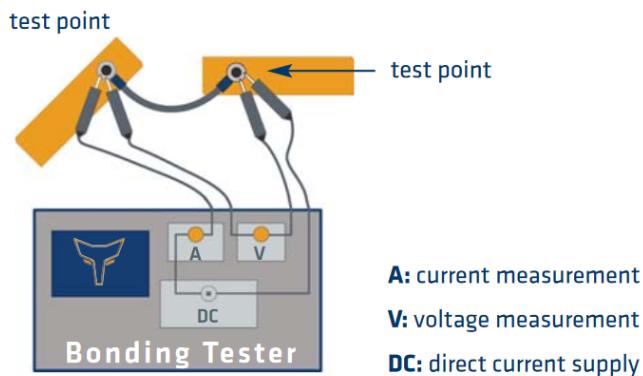
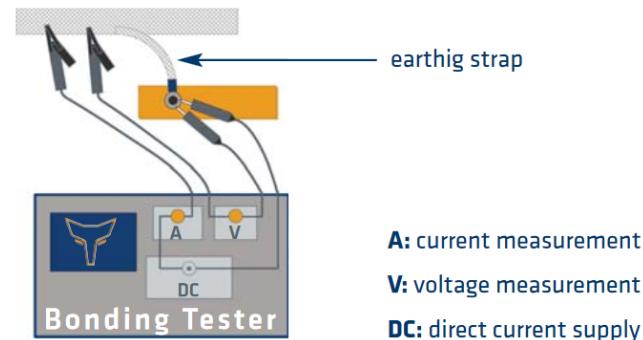
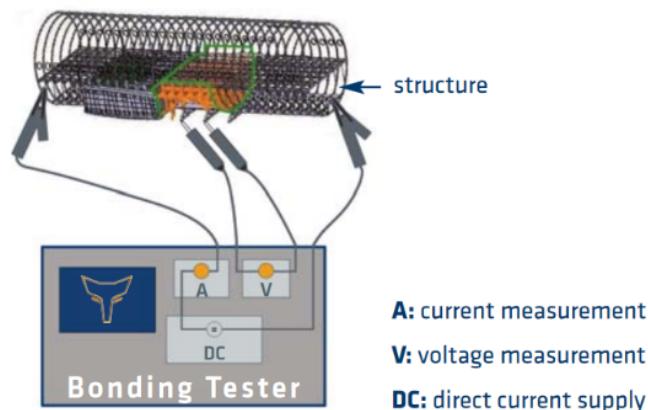
current and the voltage sensing leads. To minimize this effect the current and voltage sensing leads have to be separated. Therefore, care must be exercised in selection of the probes [1].

#### 5. Measuring Principles

The Kelvin system method is used by bonding meters. All transitions and cable resistances are compensated to ensure that all test results are correct. There are three ways how to apply and measure resistance using bonding meter. The ways is described by simple pictures. Figures 5, 6 and 7 describes point to point measurement, point to structure measurement and Return current measurement.

#### 6. Discussion

The measuring by bonding meters is a modern technology that is used in aviation. It can be assumed that this technology will stay there. And more, the scientists and technics will upgrade the devices and measuring methods too. But the authors think that the upgrading will be hard. It is because the current methods and devices are very good and they have been chosen because they are the best. And it is very difficult to upgrade the best thing. But everything develops and the area of bonging measuring will not stay behind.

**Figure 5.** Point to point measurement [2]**Figure 6.** Point to structure measurement [2]**Figure 7.** Return current measurement [2]

## 7. Conclusion

An effective ground circuit is essential in protecting modern aircrafts. Faulty ground circuit can result from incorrect assembly or material defect. There are many bonding points and ground circuits in the aircrafts. All of these elements need to be tested to ensure a low resistance path. For this purpose the bonding meters are used. The bonding testing is a not negligible part of a nondestructive testing in aviation and it will develop in the future.

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