AEROSPACE INFORMATION REPORT

AIR6236™	REV. A

Issued 2015-12
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Reaffirmed 2022-06

Superseding AIR6236

In-House Verification of EMI Test Equipment

RATIONALE

The only change to this revision is within the Rationale as follows: MIL-STD-461 no longer requires the routine calibration of many types of EMI test equipment. This AIR provides the EMI test facility with procedures that can be performed in-house using their own EMI test equipment to check that the devices no longer requiring calibration nevertheless are performing properly to manufacturer's specifications. These procedures can be performed to check that the transducer factors entered into EMI test software haven't changed, or in the case where a MIL-STD-461 measurement system integrity check indicates a problem, they serve as a quick check of the transducer's integrity.

AIR6236A has been reaffirmed to comply with the SAE Five-Year Review policy.

INTRODUCTION

MIL-STD-461G does not require certain types of test equipment to be periodically calibrated in a traceable manner. This aerospace information report provides guidance on how to self-check such devices, using equipment commonly found in EMI test facilities. The purpose is not to calibrate these devices, but to check that they have not varied significantly from manufacturer's specifications.

1. SCOPE

This AIR provides guidance to the EMI test facility on how to check performance of the following types of EMI test equipment:

Current probe
Line Impedance Stabilization Network (LISN)
Directional coupler
Attenuator
Cable loss
Low noise preamplifier
Rod antenna base
Passive antennas

All performance checks can be performed without software. A computer may be required to generate an electronic or hard copy of data. This is not to say that custom software might not be helpful; just that the procedures documented herein specifically eschew the necessity of automated operation.

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https://www.sae.org/standards/content/AIR6236A/

1.1 Purpose

The purpose of this AIR is not to reproduce the procedures used by an accredited calibration facility, but rather to provide simple and accurate methods available using only test equipment found in an EMI test facility. For simplicity, all set-ups are shown using a network analyzer, but a spectrum analyzer or EMI receiver with built-in tracking generator may be used in lieu of a network analyzer, and if that isn't available, a separate signal generator may replace the tracking generator. The effects of these substitutions are discussed in Section 4. Measurement methods offered herein are not exclusive, but found to work well with a minimum of complexity.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 U.S. Government Publications

Copies of these documents are available online at http://quicksearch.dla.mil.

MIL-STD-461

3. PERFORMANCE CHECKS

3.1 Current Probe

Various models of current probes based on transformer action are used from frequencies as low as 1 Hz to at least 1 GHz. All these probes may be calibrated as per Figure 1.

In Figure 1, the network analyzer source drives a current through the calibration fixture, which the current probe senses. The attenuator values (excepting the 10 dB pad on the input side of the calibration fixture) are so chosen that the ratio of the current probe output (T-port) to the reference (R) input is directly the transfer impedance in dB Ohms, with no data reduction required. They also perform impedance matching functions reducing vswr-related errors at higher frequencies. The 10 dB pad is solely for impedance matching and vswr-reducing, and need not be included if unnecessary, typically at audio frequencies where extra signal level into the calibration fixture is required. Its value does not affect the transfer impedance calculation.

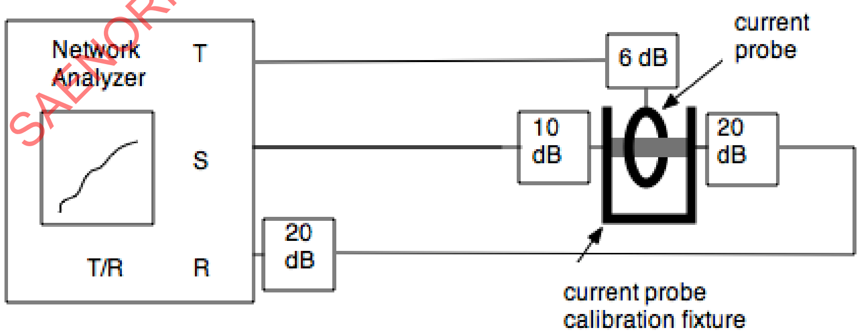

Figure 1 - Current probe calibration - T/R ratio is the transfer impedance in dB ohms

At radio frequencies where there is plenty of dynamic range, the source setting should be set 10 dB below maximum in order to place 10 dB of impedance matching attenuation between the source and coaxial transmission line. Also at radio frequencies where loss in the coaxial cable becomes appreciable, the length and type of coaxial connection between current probe output and "T" port and between the 20 dB pads on the output of the calibration fixture and the "R" input must be the same.

4. LISN

While there are several methods for measuring the LISN impedance specified in MIL-STD-461, none has the simplicity and ease of measuring the insertion loss the LISN presents to a 50 Ohm signal source. Insertion loss is the potential measured at the LISN port relative to at a 50 Ohm load. Above 1 MHz, where the 50 uH LISN approximates 50 Ohms, the insertion loss is 0 dB. At lower frequencies, insertion loss increases with decreasing frequency. Figure 2 shows the measurement set-up, and Figure 3 shows expected results, including error bars representing the MIL-STD-461 20% tolerance on LISN impedance. This method and limit account for the 0.25 uF blocking capacitor loss. Note that the upper tolerance above 1 MHz is strictly academic; there is no way the LISN impedance can be higher than 50 Ohms, so the insertion loss cannot exceed 0 dB. At frequencies where coaxial cable loss is significant, the type and length of the cables connecting to the "T" and "R" ports must be the same. The connection between splitter and LISN input power connector must be short enough to have no significant loss. Insertion loss is measured as the T/R ratio.

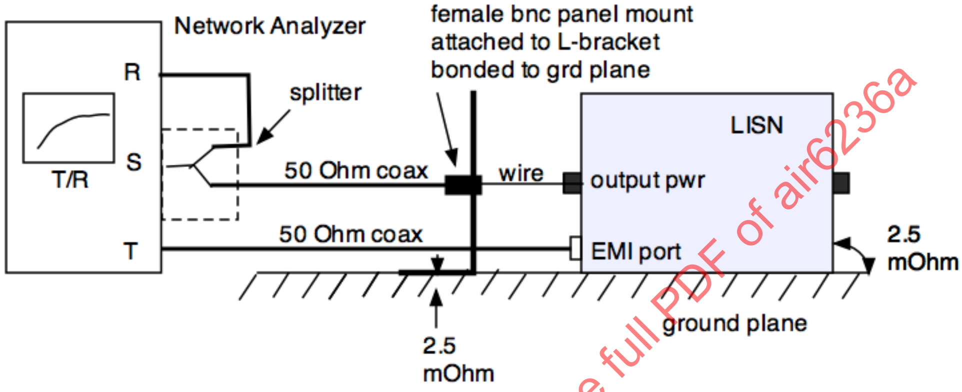

Figure 2 - LISN insertion loss measurement set-up

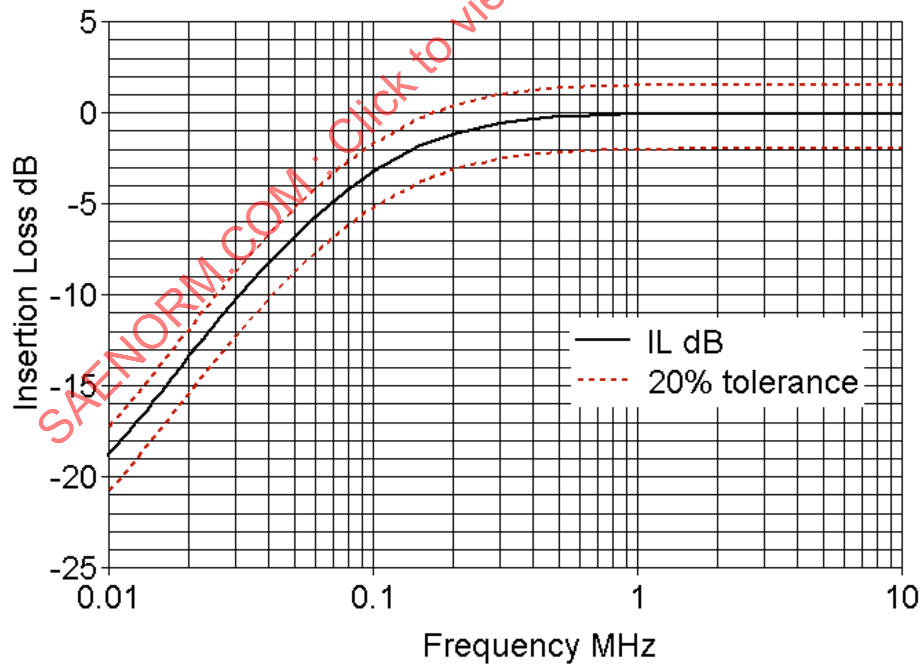

Figure 3 - MIL-STD-461 50 uH (upper curve) and 5 uH LISN insertion loss (lower curve), including losses in the 0.25 uF blocking capacitor with 50 uH curve

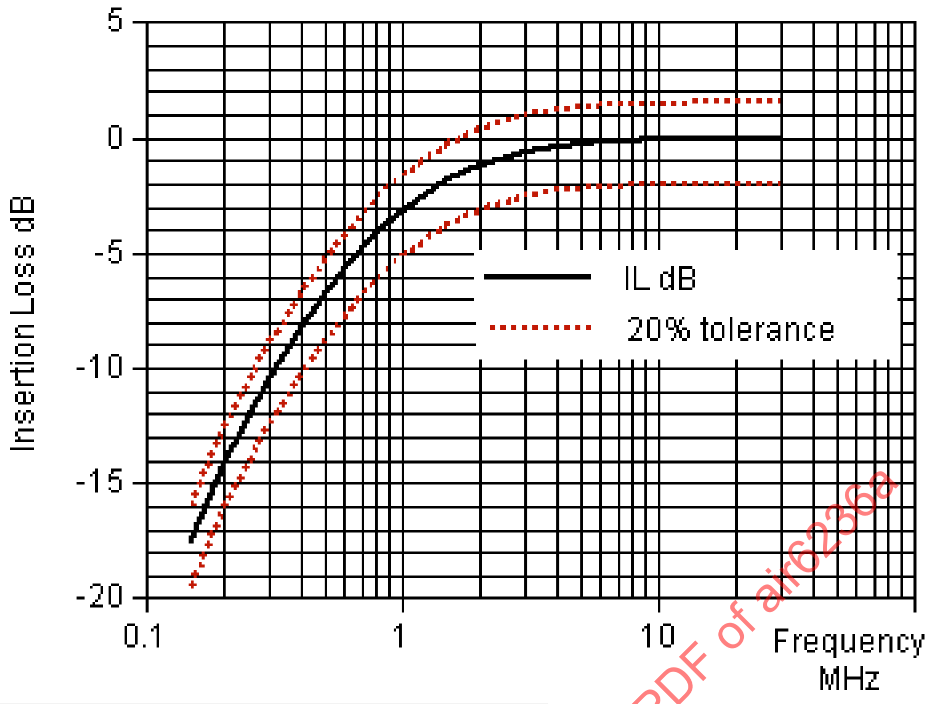

Figure 3 (continued) - MIL-STD-461 50 uH (upper curve) and 5 uH LISN insertion loss (lower curve), including losses in the 0.25 uF blocking capacitor with 50 uH curve

4.1 Directional Coupler

The forward power port coupling factor is used in some MIL-STD-461 measurements. This procedure measures that factor, as shown in Figure 4. The T/R ratio is the coupling port factor. At frequencies where coaxial cable loss is significant, the type and length of the cables connecting to the "T" and "R" ports must be the same.

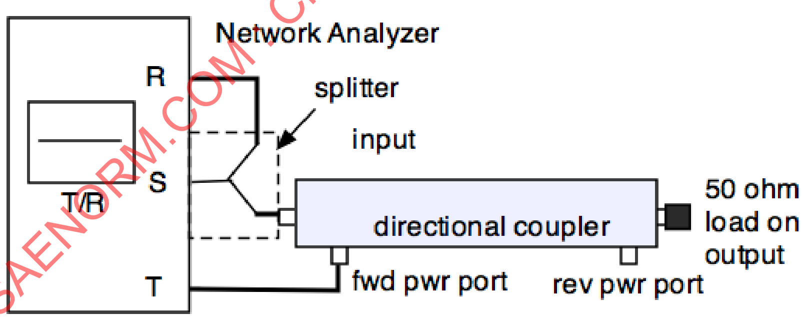

Figure 4 - Directional coupler forward power coupling factor measurement

Because return loss can be used to verify antenna performance (see 3.8), the following set-up and description explain how to characterize the reverse power port. Figure 5 is similar to Figure 4 and measures the reverse power port coupling factor. The T/R ratio is the reverse power coupling port factor. At frequencies where coaxial cable loss is significant, the type and length of the cables connecting to the "T" and "R" ports must be the same. Connection between splitter and directional coupler should be as short as possible, with negligible loss.

Figure 6 shows how to determine the limit on return loss measurement associated with a good match to 50 Ohms. The return loss so measured represents a minimum vswr value that can be ascertained using this method.

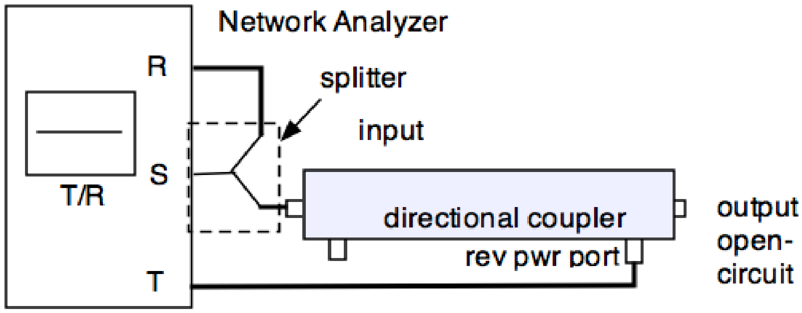

Figure 5 - Directional coupler reverse power coupling factor measurement

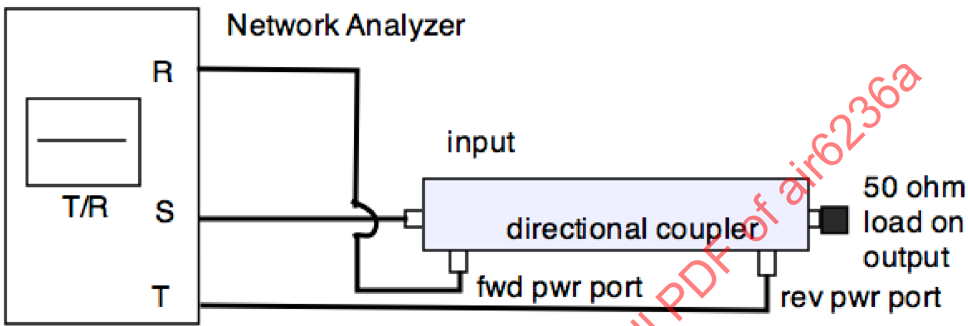

Figure 6 - Measurement to determine the minimum vswr that can be determined using the return loss method

4.2 Resistive Attenuator

Attenuators are used in a variety of tests, both emissions and susceptibility. This procedure measures attenuation, as shown in Figure 7. The T/R ratio represents the attenuation. At frequencies where coaxial cable loss is significant, the type and length of the cables connecting to the "T" and "R" ports must be the same. Connection between attenuator and splitter should be as short as possible, with negligible loss.

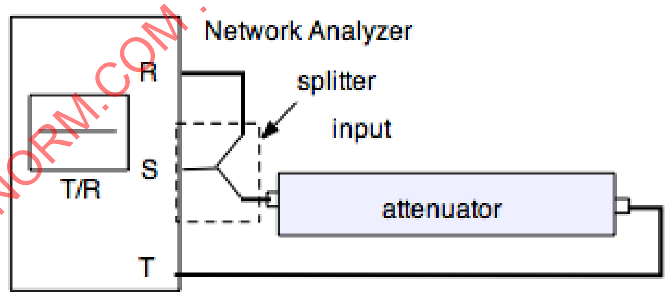

Figure 7 - Attenuator measurement

4.3 Cable Loss

Coaxial cables are used in all measurement set-ups. This procedure measures cable attenuation, as shown in Figures 8 and 9. The T/R ratio represents the attenuation. The type and length of the cables connecting to the "T" and "R" ports must be the same, and for this measurement they must be measured to be the same, as in Figure 8. Once these cables have been shown to be the same, or their differences accounted for, they may be used to measure the loss of the cable-under-test, as in Figure 9. Because small losses are measured, vswr can be a perturbing factor. Attenuation placed between the test and reference cable can minimize any impedance discontinuity effects.

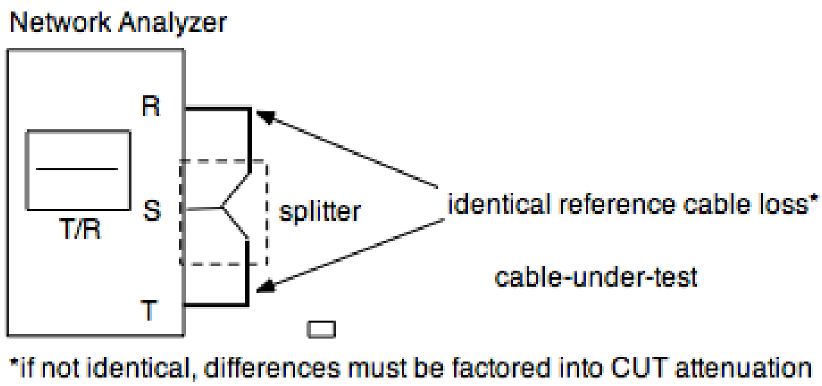

Figure 8 - Reference cable loss measurement

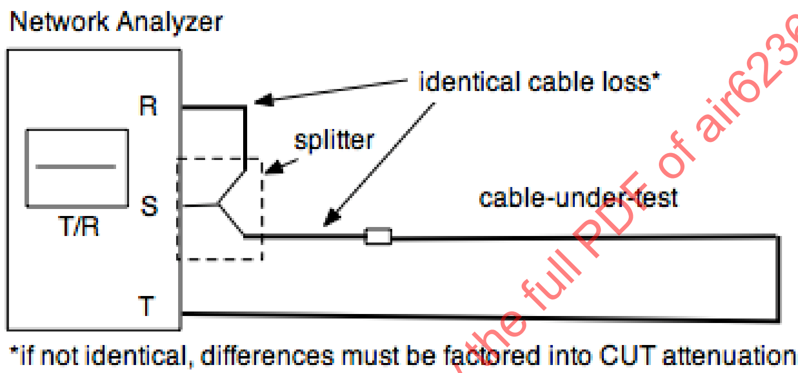

Figure 9 - Cable loss measurement

4.4 Low Noise Preamplifier Gain

Low noise pre-amplifiers are often employed to make sensitive measurements such as radiated emissions, where the noise figure performance of the spectrum analyzer or EMI receiver is in itself not good enough to measure to the required limit. This procedure measures the amplifier gain, which must be accounted for when reducing data measured using the preamplifier. Figure 10 shows the set-up. The T/R ratio represents the gain. Care must be taken to use a very low input so the amplified output is well below the 1 dB compression point of the preamplifier. This method can also be used to ascertain the 1 dB compression point, by repeatedly measuring the gain while increasing the input, until gain compression is realized. At frequencies where coaxial cable loss is significant, the type and length of the cables connecting to the "T" and "R" ports must be the same. The connection between the splitter and preamplifier should be as short as possible with negligible loss.

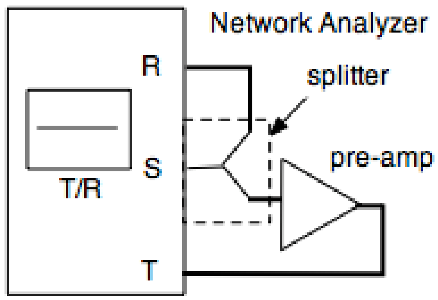

Figure 10 - Low noise preamplifier gain measurement

5. 41 INCH ROD ANTENNA BASE TRANSDUCER FACTOR MEASUREMENT

The base of a 41 inch rod antenna, whether active or passive, acts as an impedance matching device between the capacitive output impedance of the rod, and the 50 Ohm connection into the spectrum analyzer or EMI receiver. A capacitor simulating the rod output impedance must be used in series between the network analyzer 50 Ohm source output, and the point at which the rod antenna mates with the antenna base, as per MIL-STD-461F Figure RE102-8, and as depicted below in Figure 11. The rod antenna factor is the measured transducer factor (gain or loss) less 6 dB, to account for the half-meter effective height of the 41 inch rod. The ratio T/R represents the gain or loss of the rod antenna base. Care must be taken in case of an active rod antenna to select a sufficiently low source signal level in order to avoid overload of the preamplifier in the rod antenna base.

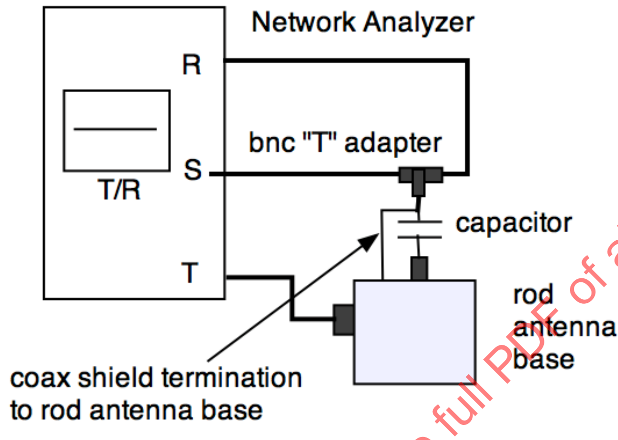

Figure 11 - 41 inch rod antenna base transducer factor measurement

5.1 VSWR Check of Antenna Matching Network

The most accurate check of an antenna's performance is its physical dimensions. If the radiating elements have not suffered damage, and the matching network between the 50 Ohm coaxial input to the radiating elements is also intact, antenna performance will be as advertised. While the radiating elements may be inspected visually, the matching network cannot, and its performance must be measured to ascertain integrity. While a simple device such as the small loop used for MIL-STD-461 test RE101 may be measured with an ohmmeter to verify continuity, more complex antennas such as the biconical and double ridge guide horns cannot be so checked. A check of their match to 50 Ohms in-band to their operating frequency band can verify that the matching network is not damaged. Such a check also checks any damage to coaxial connectors.

There are many ways to measure vswr, directly and indirectly. The vswr shown in Figure 12 was specifically chosen to use only equipment found in an EMI test facility.

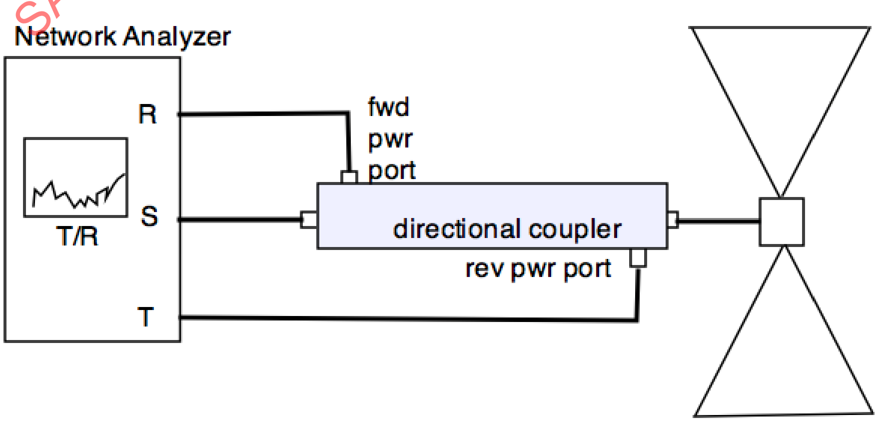

Figure 12 - Antenna vswr measurement