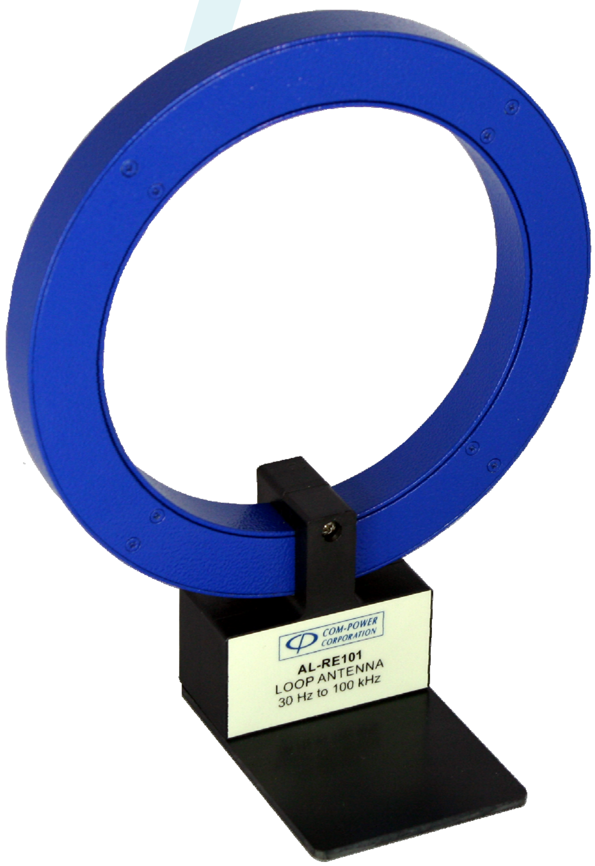
INSTRUCTION MANUAL
for
LOOP ANTENNA
Model: **AL-RE101**



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1.0 Introduction

This manual includes descriptions of product features; product specifications, safety precautions, operational instructions, antenna theory, measurement guidelines, warranty and product maintenance information.

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2.0 Products Available from Com-Power

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Line Impedance Stabilization Networks (LISN)

Antenna Masts

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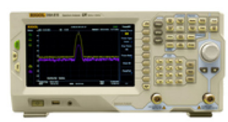
Power Amplifiers



Spectrum Analyzers

Surge Generators

Transient Limiters

Turntables

Antenna Tripods

Telecom Test Systems

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3.0 Product Information

3.1 Incoming Inspection

Please check the contents of the shipment against the package inventory in section 3.2 to ensure that you have received all applicable items.

3.2 Package Inventory

STANDARD ITEMS:

- **AL-RE101 Loop Antenna**
- **Calibration Data and Certificate**

3.3 Product Features

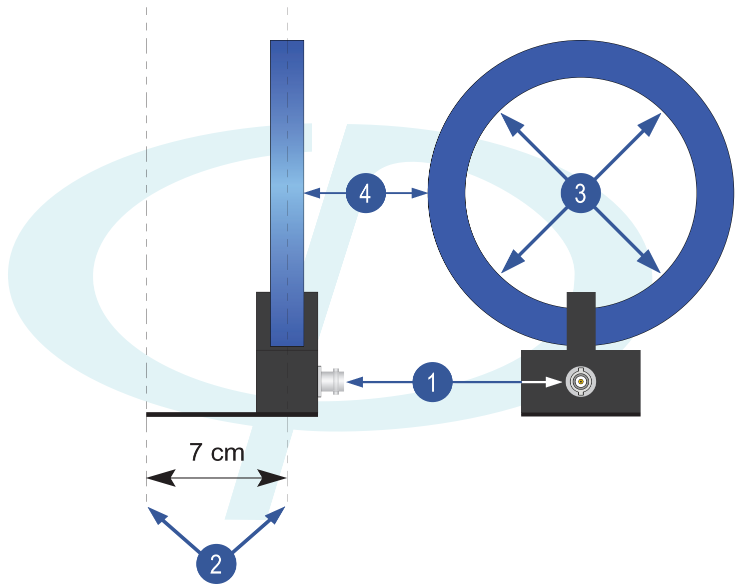

FIGURE 1 - *AL-RE101 Features*

1. **Antenna Output Port**
   Coaxial BNC port for connection to input port of measuring instrumentation.
2. **7 cm Spacing**
   The 7 cm spacing required for MIL-STD 461, RE101 is achieved when the front edge of the plexi-glass bottom plate of the antenna assembly is positioned perpendicularly against the EUT surface.
3. **Loop Coil**
   Contained within the electrostatic shield is the loop coil consisting of 36 turns of 41 gauge, 7-strand Litz wire.
4. **Electrostatic Shield**
   The powder coated metallic structure housing the loop coil serves as the electrostatic shield for the loop.

3.4 Product Specifications

Frequency Range	**30 Hz to 100 kHz** *(usable range: 10 Hz to 1 MHz)*
Standard(s)	**MIL-STD-461, RE101**
Loop Diameter (outside)	**13.3 cm** (5.24 in.)
Number of Turns ***(N)***	**36 Turns**
Wire Type	**7 Strand, 41 AWG Litz Wire**
Loop Shielding	**Electrostatic Shield**
Resistance of Loop Coil ***(Rc)***	**10Ω** *(nominal)*
Inductance of Loop Coil ***(L)***	**340 μH** *(nominal)*
Connector	**Coaxial BNC** *(female)*
Weight	**0.84 lbs.** *(0.38 kg)*
Operating Temperature	**40°F to 104°F** *(5°C to 40°C)*

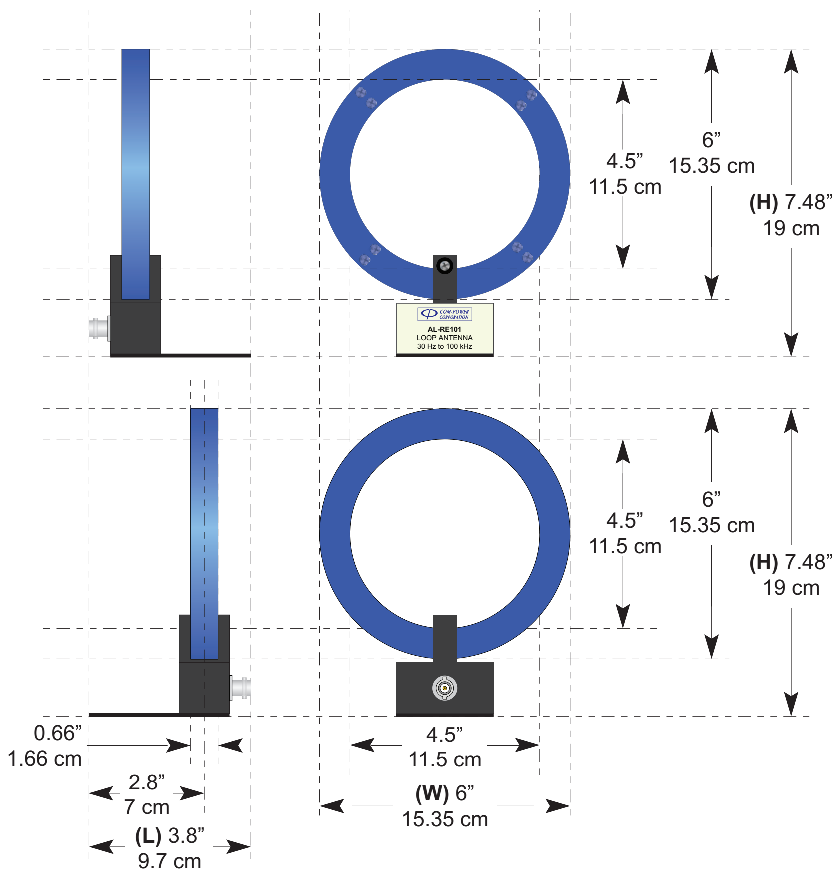

FIGURE 2 - *AL-RE101 Loop Antenna Dimensions*

4.0 Using Your AL-RE101 Loop Antenna

The AL-RE101 Loop Antenna should be connected directly to the input port of the measuring instrument(s). Follow the procedures described in the applicable standard for the test(s) to be performed.

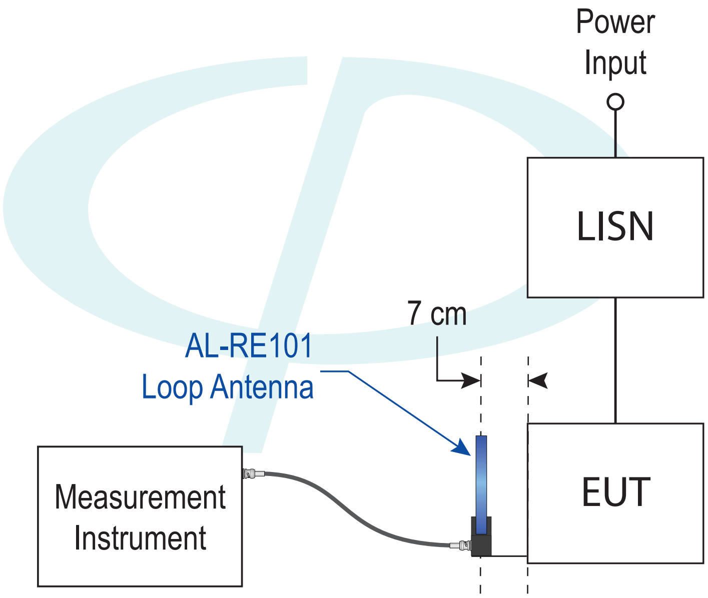

FIGURE 3 - *Typical Test Arrangement*

Generally, the AL-RE101 Loop Antenna is intended to be positioned at a 7 cm distance from the Equipment Under Test (EUT). Due to the small size of the loop coil, its close proximity to the EUT, and also depending on the size of the EUT, the magnetic field pick-up of the AL-RE101 Loop Antenna may be sensitive to small movements over the surfaces of the EUT.

Therefore, as described in MIL-STD-461, the antenna position should be slowly scanned over the face of the EUT and around the connectors, in order to find the point(s) of maximum radiation.

4.1 Antenna Conversion Factors

Your AL-RE101 Loop Antenna is provided with two sets of antenna conversion factors. The input impedance of your measuring instrument determines which factor to use, as described below.

The 50 ohm antenna conversion factors are the most commonly applied. These are to be used when the AL-RE101 Loop Antenna is connected to a measuring instrument having a nominal input impedance of 50 ohms. These factors are provided over the frequency range of 10 Hz to 1 MHz, as shown in *Figure 4*. To find the factors for frequencies between those listed on the table, see section 4.1.1.

The 100 kΩ factors are used when the AL-RE101 Loop Antenna is connected to a measuring instrument with a high input impedance (greater than approximately 500 ohms). These factors are provided over the truncated frequency range of 10 Hz to 50 kHz, also as shown in *Figure 4*. The antenna should generally not be used above 50 kHz without a 50 ohm termination.

Antenna Type		**Loop Antenna**
Model		**AL-RE101**
FREQUENCY	**ANTENNA CONVERSION FACTORS**	
(kHz)	**100 kΩ** *[dBpT/μV]*	**50Ω** *[dBpT/μV]*
0.01	90.1	91.6
0.02	84.1	85.7
0.03	80.5	82.1
0.05	76.1	77.7
0.1	70.1	71.7
0.2	64	65.6
0.3	60.6	62.2
0.5	56.1	57.7
1	50.1	51.7
2	44.1	45.7
3	40.5	42.2
5	36.1	37.8
10	30.1	32.2
20	24.1	27.4
30	20.5	25.4
50	16.2	23.9
100		23
200		22.8
300		22.7
500		22.7
1000		22.7

FIGURE 4 - *Antenna Conversion Factors*

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The antenna conversion factor (in dBpT/µV units) is to be added to the measured value (in dBµV) to obtain the corrected magnetic field strength value, or flux density (in dBpT).

$$\text{Measured Value (in dB}\mu\text{V)} + \text{Antenna Conversion Factor (in dBpT/}\mu\text{V)} = \text{Magnetic Field Strength (in dBpT)} \quad \textbf{EQUATION (1)}$$

EXAMPLE CALCULATION #1:

An EUT emission is identified at a frequency of ***500 Hz***, with a measured value of ***40 dBµV***, or ***100 µV*** on a measurement instrument having a nominal input impedance of 50Ω.

Using the table shown in Figure 4, the 50Ω antenna conversion factor at 500 Hz is 57.7 dBpT/µV; therefore:

$$\underset{\text{dB}\mu\text{V}}{40.0} + \underset{\text{dBpT/}\mu\text{V}}{57.7} = \underset{\text{dBpT}}{97.7}$$

The magnetic field strength, or flux density, is 97.7 dBpT.

4.1.1 Interpolation of Antenna Conversion Factors

In order to find the antenna conversion factor **(ACF)** for frequencies between those listed in the table, *Equation (2)* may be used for interpolation:

$$ACF_X = ACF_1 + (ACF_2 - ACF_1)\left(\frac{\log(f_X / f_1)}{\log(f_2 / f_1)}\right) \quad \textbf{EQUATION (2)}$$

where:

- ACF_X = *unknown antenna conversion factor at* f_X
- ACF_1 = *antenna correction factor at* f_1
- ACF_2 = *antenna correction factor at* f_2
- f_X = *frequency at which antenna conversion factor is desired*
- f_1 = *frequency just below* f_X
- f_2 = *frequency just above* f_X

EXAMPLE CALCULATION #2:

In this example, the 50 ohm antenna conversion factor at **60 Hz** is calculated. Using the *Figure 4* table, the following values are known:

Frequency		Antenna Conversion Factor (50Ω)	
f_1	50 Hz	ACF_1	77.7 dBpT/µV
f_2	100 Hz	ACF_2	71.7 dBpT/µV

Using *Equation (2)*, the antenna conversion factor at 60 Hz is calculated as ACF_X:

$$ACF_X = 77.7 + (71.7 - 77.7)\left(\frac{\log(60/50)}{\log(100/50)}\right) \text{ dBpT/µV}$$

$$ACF_X = \mathbf{76.1} \text{ dBpT/µV}$$

5.0 Antenna Theory

This section details the theoretical operation of the AL-RE101 loop antenna. *Equation (3)* through *Equation (7)* define the relationship between the average magnetic field strength (or magnetic flux density) within the area of the loop coil and the voltage present at the antenna terminals, in order to determine the antenna conversion factors. These equations consider the physical and electrical characteristics for the antenna, as shown in the following pages.

5.1 Open Circuit Antenna Terminal Voltage vs Flux Density

Equation (3) below defines the relationship between open circuit loop terminal voltage, number of turns in the coil, area of the coil, the frequency and the average flux density within the area of the coil:

$$e_{i(V)} = 2\pi N A f B_{(T)} \text{ (Volts)}$$

EQUATION (3)

where:

$e_{i(V)}$ = open-circuit loop terminal voltage (in Volts)
N = number of turns in loop coil = ***36 turns***
A = area of coil = ***0.0139 meters²***
= πr^2, where r = coil radius = 0.0665 meters
f = frequency (in Hz)
$B_{(T)}$ = magnetic flux density (in Tesla)

Equation (3) is resolved below by substituting the actual number of turns ***(N)*** and coil area ***(A)*** for the AL-RE101 Loop Antenna; and to provide the resultant quantity in microvolts (rather than volts).

$$e_{i(V)} = 2\pi N A f B_{(T)} \text{ (Volts)}$$

*substituting known constants (**number of turns** and **coil area**)...*

$$e_{i(V)} = 2\pi \times [36] \times [0.0139] \times f B_{(T)} \text{ (Volts)}$$

$$e_{i(V)} = [3.144] \times f B_{(T)} \text{ (Volts)}$$

*converting **Volt/Tesla** units to more convenient **µV/pT** units...*

$$e_{i(\mu V)} = 10^{-6} \times [3.144] \times f B_{(pT)} \text{ } (\mu V)$$

EQUATION (4)

where:

$e_{i(\mu V)}$ = open-circuit loop terminal voltage (in microvolts)
f = frequency (in Hz)
$B_{(pT)}$ = magnetic flux density (in picotesla)

EXAMPLE CALCULATION #3

In the following example, *Equation (4)* is solved for the magnetic flux density ***(B)*** assuming a frequency ***(ƒ)*** of ***500 Hz***, with the AL-RE101 Loop Antenna connected to a high impedance oscilloscope input. The measured amplitude ***(e_i)*** is ***120 µV, or 41.6 dBµV***.

$$e_{i(\mu V)} = 10^{-6} \times [3.144] \times f B_{(pT)} \ (\mu V)$$

as voltage is the known quantity, the formula is rearranged to solve for flux density...

$$B_{(pT)} = \frac{e_{i(\mu V)}}{10^{-6} \times [3.144] \times f} \ (pT)$$

*substituting known variables (**voltage** and **frequency**)...*

$$B_{(pT)} = \frac{[120]}{10^{-6} \times [3.144] \times [500]} \ (pT)$$

$$B_{(pT)} = 76{,}336 \text{ pT}$$

*converting **linear** result into **logarithmic** units...*

$$B_{(pT)} = 97.7 \text{ dBpT} \quad (20*\log[pT])$$

NOTE: The same result can be determined using Equation (1) and the 100 kΩ antenna conversion factor given in Figure 4.

EQUATION (1)

Measured Value (in dBµV)	+	Antenna Conversion Factor (in dBpT/µV)	=	Magnetic Field Strength (in dBpT)
[41.6] dBµV	+	[56.1] dBpT/µV	=	97.7 dBpT

5.2 Determination of Antenna Conversion Factors

The basic formulae for determining the antenna conversion factors for the antenna are given in *Equation (5)* and *Equation (6)*. Considered in these equations are the frequency and resistance, inductance, area and number of turns of the loop coil:

$$ACF = 20Log\left(\left|\frac{B_{(pT)}}{V_{L(\mu V)}}\right|\right) \ (dBpT/\mu V)$$ **EQUATION (5)**

$$\left|\frac{B_{(pT)}}{V_{L(\mu V)}}\right| = 10^6 \frac{\sqrt{\left(1+\frac{R_C}{R_L}\right)^2 + \left(\frac{2\pi f L}{R_L}\right)^2}}{2\pi f A N} \ [pT/\mu V]$$ **EQUATION (6)**

where:

ACF = antenna conversion factor (in pT/μV)
$B_{(pT)}$ = magnetic flux density (in pT)
$V_{L(\mu V)}$ = voltage across R_L (in μV)
R_C = loop coil resistance = **10Ω**
R_L = load resistance [or input impedance of measurement instrument] (in ohms)
f = frequency (in Hz)
L = loop coil inductance = **0.00034 H**
A = area of coil = **0.0139 meters²**
= πr^2, where r = coil radius = 0.0665 meters
N = number of turns in loop coil = **36 turns**

The derivation of *Equation (6)* is given in section 5.1.1.

In the formulae below, *Equation (6)* is reformulated to integrate the actual resistance ***(R$_C$)***, inductance ***(L)***, number of turns ***(N)*** and coil area ***(A)*** for the AL-RE101 Loop Antenna; in *Equation (7)*:

rearranging equation (6) to separate **2πL** *from* ***f***...

$$\left|\frac{B_{(pT)}}{V_{L(\mu V)}}\right| = 10^6 \frac{\sqrt{\left(1+\frac{R_C}{R_L}\right)^2 + (2\pi L)^2\left(\frac{f}{R_L}\right)^2}}{2\pi f A N} \ (pT/\mu V)$$

substituting known constants (coil resistance (R_C), coil inductance (L), number of turns (N) and coil area (A))...

$$\left|\frac{B_{(pT)}}{V_{L(\mu V)}}\right| = 10^6 \frac{\sqrt{\left(1+\frac{[10]}{R_L}\right)^2 + (2\pi \times [0.00034])^2\left(\frac{f}{R_L}\right)^2}}{2\pi \times f \times [0.0139] \times [36]} \ (pT/\mu V)$$

equation (7) is determined...

$$\left|\frac{B_{(pT)}}{V_{L(\mu V)}}\right| = 10^6 \frac{\sqrt{\left(1+\frac{[10]}{R_L}\right)^2 + [4.564 x 10^{-6}]\left(\frac{f}{R_L}\right)^2}}{f \times [3.144]} \ (pT/\mu V)$$ **EQUATION (7)**

EXAMPLE CALCULATION #4:

In the following example, the antenna conversion factor ***(ACF)*** is calculated using *Equation (5)* and *Equation (7)*. For the purposes of this example, the frequency ***(f)*** is assumed to be ***500 Hz***, and the measuring instrument termination or load resistance ***(R_L)*** is ***50 ohms***:

$$\left|\frac{B_{(pT)}}{V_{L(\mu V)}}\right| = 10^6 \frac{\sqrt{\left(1+\frac{[10]}{[50]}\right)^2 + [4.564\mathrm{x}10^{-6}]\left(\frac{[500]}{[50]}\right)^2}}{[500]\ \mathrm{x}\ [3.144]}\ (pT/\mu V)$$

$$\left|\frac{B_{(pT)}}{V_{L(\mu V)}}\right| = [763.5]\ (pT/\mu V)$$

$$ACF = 20Log\left(\left|\frac{B_{(pT)}}{V_{L(\mu V)}}\right|\right)\ (dBpT/\mu V)$$

$$ACF = 20Log([763.5])\ (dBpT/\mu V)$$

$$ACF = \mathbf{57.7\ dBpT/\mu V}$$

EXAMPLE CALCULATION #5:

In this example, *Equation (7)* is solved for magnetic flux density ***($B_{(pT)}$)*** assuming a frequency ***(f)*** of ***500 Hz***, with the AL-RE101 Loop Antenna connected directly to a spectrum analyzer having an input impedance ***(R_L)*** of **50 ohms**, which indicates a measured amplitude ***($V_{L(\mu V)}$)*** of ***100 µV***, or ***40 dBµV***:

$$\left|\frac{B_{(pT)}}{[100]}\right| = 10^6 \frac{\sqrt{\left(1+\frac{[10]}{[50]}\right)^2 + [4.564\mathrm{x}10^{-6}]\left(\frac{[500]}{[50]}\right)^2}}{[500]\ \mathrm{x}\ [3.144]}\ (pT/\mu V)$$

$$\frac{B_{(pT)}}{[100]} = [763.5]\ (pT/\mu V)$$

$$B_{(pT)} = [100]\ \mathrm{x}\ [763.5]\ (pT)$$

$$B_{(pT)} = \mathbf{76,350\ pT}$$

$$B_{(pT)} = \mathbf{97.7\ dBpT}\quad (20log[pT])$$

NOTE: For this example, the same result can be determined using Equation (1) and the 50Ω antenna conversion factor given in Figure 4.

Measured Value (in dBµV)	+	Antenna Conversion Factor (in dBpT/µV)	=	EQUATION (1) Magnetic Field Strength (in dBpT)
[40.0] dBµV	+	[57.7] dBpT/µV	=	97.7 dBpT

5.2.1 Derivation of Antenna Conversion Factor Equation

The formulae below demonstrates the derivation of *Equation (6)* for determination of the loop antenna conversion factors (ACF).

Equation (6a) was introduced earlier as *Equation (3)*. It is borrowed from basic magnetic loop theory, and establishes the relationship between the physical parameters of the loop antenna, the magnetic flux density present within the loop coil, and the open circuit voltage developed across the loop terminals.

$$e_{i(V)} = 2\pi N A f B_{(T)} \text{ (Volts)}$$

EQUATION (6a)

where:

- $e_{i(V)}$ = open-circuit loop terminal voltage (in Volts)
- N = number of turns in loop coil = **36 turns**
- A = area of coil = **0.0139 meters²**
  - = πr^2, where r = coil radius = 0.0665 meters
- f = frequency (in Hz)
- $B_{(T)}$ = magnetic flux density (in Tesla)

During actual measurements, the antenna terminals are terminated by the input impedance of the measuring instrument **(R_L)**. The measured voltage **(V_L)** is proportional to the impedance of the loop coil **(R_C) + (jX_C)** and **(R_L)**. This relationship is demonstrated in *Equation (6b)*, and then rearranged in *Equation (6c)* and *Equation (6d)*.

$$\frac{e_{i(V)}}{R_L + R_C + jX_C} = \frac{V_{L(V)}}{R_L}$$

EQUATION (6b)

where:

- $e_{i(V)}$ = open-circuit loop terminal voltage (in Volts)
- R_L = load resistance [or input impedance of measurement instrument] (in ohms)
- R_C = loop coil resistance = **10Ω**
- jX_C = loop coil reactance ($2\pi f L$) (in ohms)
- L = inductance of the loop coil = **0.00034 H**
- $V_{L(V)}$ = voltage across R_L (in Volts)

$$\frac{e_{i(V)}}{V_{L(V)}} = 1 + \frac{R_C}{R_L} + j\frac{X_C}{R_L}$$

EQUATION (6c)

$$\left|\frac{e_{i(V)}}{V_{L(V)}}\right| = \sqrt{\left(1 + \frac{R_C}{R_L}\right)^2 + \left(\frac{X_C}{R_L}\right)^2}$$

EQUATION (6d)

In *Equation (6e)*, *Equation (6a)* is integrated to substitute for **(e_i)** in order to solve for **(|B/VL|)**

$$\left|\frac{B_{(T)}}{V_{L(V)}}\right| = \frac{\sqrt{\left(1+\frac{R_C}{R_L}\right)^2 + \left(\frac{X_C}{R_L}\right)^2}}{2\pi f A N} \quad \text{(Tesla per Volt [T/V])}$$

EQUATION (6e)

And finally, in *Equation (6f)*, we multiply by 10^6 in order to convert the units from Tesla/Volt into pT/µV.

$$\left|\frac{B_{(pT)}}{V_{L(\mu V)}}\right| = 10^6\,\frac{\sqrt{\left(1+\frac{R_C}{R_L}\right)^2 + \left(\frac{X_C}{R_L}\right)^2}}{2\pi f A N} \quad [pT/\mu V]$$

EQUATION (6f)

6.0 Calibration and Calibration Cycle

Your AL-RE101 Loop Antenna has been individually calibrated with NIST traceability, and the appropriate data and certificate has been provided. Periodic re-calibration of the AL-RE101 is recommended. Calibration intervals is left to your discretion, but should be chosen based on the frequency with which it is used, and/or as allowed for by your internal quality control system (if applicable). Com-Power offers NIST traceable calibration services. Recognized ISO 17025 accredited calibrations are also available.

6.1 Calibration Equipment

During calibration, the current flowing through the transmitting loop must be monitored. The current can be monitored by measuring the voltage drop across a 1 ohm resistor placed in series with the drive line to the transmit loop; or it can be monitored using a current probe placed around the drive line to the transmit loop.

Typical measurement setups for the respective calibration methods are illustrated in *Figure 5* and *Figure 6*.

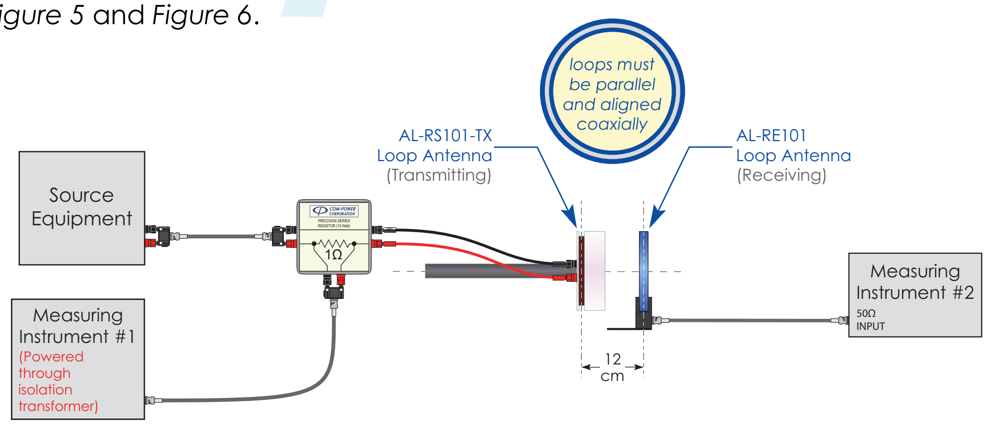

FIGURE 5 - *Typical Measurement Setup for Calibration (1Ω Resistor Method)*

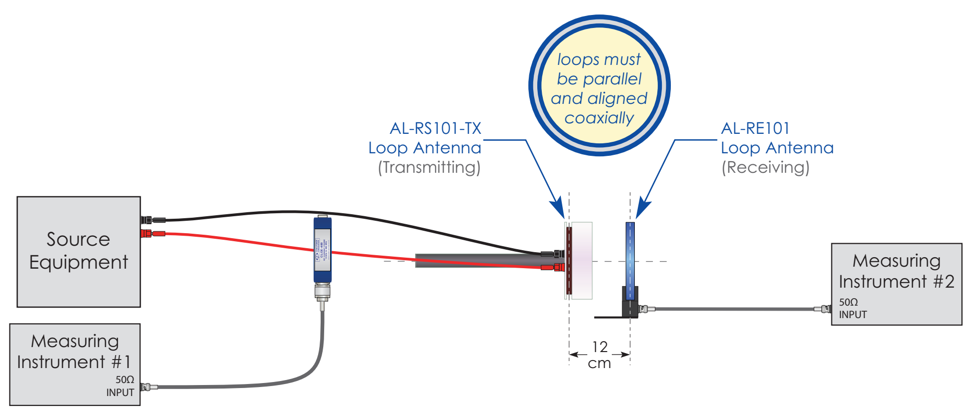

FIGURE 6 - *Typical Measurement Setup for Calibration (Current Probe Method)*

6.1.1 Source Equipment

The following subsections describe the type of equipment that will be needed in order to perform calibration of the AL-RE101 Loop Antenna.

As current flowing through the transmitting loop antenna is monitored during the calibration, the type of source equipment has no real restriction; only that it be able to supply the desired current.

It is desirable from an efficiency standpoint that the output impedance of the source be as low as possible. The greater the output impedance of the source, the greater the power required to generate the same current.

Some typical examples of signal sources are given below.

- Signal (or function) generator with a power amplifier, such as the Com-Power ARI-300K Audio Power Amplifier.
- Signal (or function) generator with power amplifier and output transformer.
- Signal (or function) generator with transformer
- Signal (or function) generator with current amplifier
- Power sweep generator
- Network analyzer
- Spectrum Analyzer with tracking generator

6.1.2 Measuring Instruments

Any properly functioning, calibrated measuring instrument, or combination of measuring instruments, having the proper input impedance and operational specifications/capabilities for the measurement functions for which it will be employed may be used for the calibration. Typical types of instruments include oscilloscopes, spectrum analyzers, EMI receivers, true rms volt meters, digital multimeters, etc.

6.1.3 Transmitting Loop Antenna

The Com-Power AL-RS101-TX Loop Antenna is the ideal antenna to use as the transmitting loop during the calibration. Other transmitting loops may also be used; however, the calibration-related calculations provided in section 6.2 apply only to calibrations performed using the AL-RS101-TX Loop Antenna.

6.1.4 Precision 1-ohm Series Resistor

This is a standard accessory provided with the Com-Power RS-101-TX Loop Antenna. The resistor must be a precision, 1% tolerance resistor with sufficient power rating.

6.1.5 RF Current Probe

Any properly functioning, calibrated current probe having appropriate operational specifications/capabilities for the measurement functions for which it will be employed may be used for the calibration.

6.2 Interpretation of Standards

Section 4.3.11.2 of the MIL-STD-461 documents states the following:

"Factors for test antennas shall be determined in accordance with SAE ARP958".

Section 6 of the SAE ARP958 Rev. D (1999-03) standard contains the calibration procedures, associated calculations and theoretical antenna conversion factor tables for the three (3) loop antennas specified by MIL-STD-461 for the RE101 and RS101 tests and related calibrations.

Below are (2) excerpts from the above-referenced ***SAE ARP958*** standard:

(1) " 6.1 Operating Theory:

This test method is not meant to experimentally determine the magnetic fields. In most cases, for a controlled situation like this, they can be more accurately calculated than measured. This method is to set up a standard by which it can be determined that the antennas are functioning correctly. Thus, a failure such as a cold solder joint, broken wire, etc. can be detected."

And, from section 6.2 (Calibration):

(2) " The loop antenna shall be considered to be calibrated when the levels have been compared to the values of Table 1 and found to be within ±2 dB of those values."

Based on the above, it could be interpreted that the purpose of calibration is NOT to determine the actual antenna conversion factors; but only to validate that the antenna is functioning correctly, and that the theoretical factors are to be used in practice.

Or, it could also be interpreted that the factors determined through calibration measurements are to be used in practice, as long as they are within ±2 dB of the theoretical factors.

Com-Power provides the AL-RE101 Loop Antenna individually calibrated as per the procedures described in the SAE ARP958 standard. The acceptance criteria employed dictates that the antenna conversion factors determined during the calibration shall be within ±2 dB of the calculated, theoretical factors.

Both sets of factors are provided; and it is left to the discretion of the user whether the theoretical, calculated factors, or the factors determined through calibration measurements are used in practice.

6.3 Calibration Methodology

The calibration of the AL-RE101 antenna is performed by generating a known magnetic field using the AL-RS101-TX Antenna, which is a 12 cm diameter loop antenna having 20 turns of 12 gauge enamel insulated wire. The calibration is performed with a separation distance of 12 cm between the perpendicular loop faces, with the centers of the loops aligned along the same axis, as shown in *Figure 5* and *Figure 6*.

The current through the transmit loop is monitored in order to determine the magnetic field strength (flux density) that is present at a distance of 12 cm. This quantity is calculated using *Equation (F)* below:

$$B = \frac{\mu I N r^2}{2\,(r^2 + d^2)^{(3/2)}} \quad \text{(Tesla)}$$

EQUATION (8)

where:

- B = *magnetic flux density* (in Tesla)
- μ = *permeability of air* = $4\pi \times 10^{-7}$ H/m = $\mathbf{1.25664 \times 10^{-6}}$ H/m
- I = *current through loop coil* = **0.1** Amps
- N = *number of turns in loop coil* = **20** turns
- r = *radius of the loop coil* = **0.06** meters
- d = *separation distance between the Tx and Rx loops* = **0.12** meters

$$B = \frac{[1.25664 \times 10^{-6}] \times [0.1] \times [20] \times [0.06]^2}{2\,([0.06]^2 + [0.12]^2)^{(3/2)}} \quad \text{(Tesla)}$$

$$B = \frac{[1.25664 \times 10^{-6}] \times [0.1] \times [20] \times [0.0036]}{2\,([0.0036] + [0.0144])^{(3/2)}} \quad \text{(Tesla)}$$

$$B = \mathbf{1.873288 \times 10^{-6}} \text{ Tesla}$$

$$B = \mathbf{1{,}873{,}288} \text{ pT} \quad ([\text{Tesla}] \times 10^{12})$$

$$B = \mathbf{125.45} \text{ dBpT} \quad (20\text{Log}[\text{pT}])$$

So, under the above conditions, the measured value *(in dBμV)* on the measuring instrument connected to the AL-RE101 Loop Antenna, at any given frequency; plus the respective, appropriate antenna conversion factor *(based on the frequency and instrument input impedance)*, should be approximately equal to ***125.45 dBpT ±2 dB***. When the antenna meets this condition over the frequency band of operation, it is considered to be calibrated.

Measured Value *(in dBμV)* + **Antenna Conversion Factor** *(in dBpT/μV)* ≅ **125.45** dBpT (± 2 dB)

EXAMPLE CALCULATION #6:

In the following example, with the test arrangement illustrated in *Figure 5* or *Figure 6*, the measured value on the measuring instrument connected to the AL-RE101 Loop Antenna at ***30 Hz*** is ***43.35 dBµV***. The theoretical, 50 ohm antenna conversion factor for the AL-RE101 Loop Antenna (calculated using *Equation (5)* and *Equation (7)* and given in the table shown in *Figure 4* at ***30 Hz*** is ***82.1 dBpT/µV***.

$$\underset{dB\mu V}{43.35} + \underset{dBpT/\mu V}{82.1} = \underset{dBpT}{125.45} \cong 125.45 \text{ dBpT} \ (\pm 2 \text{ dB})$$

In this example, the measured magnetic field strength (flux density) is within 2 dB of actual; thereby validating the theoretical antenna factor of 82.1 dBpT/µV at 30 Hz.

Therefore; in this example, the antenna meets the calibration requirement at 30 Hz.

7.0 Warranty

Com-Power warrants to its Customers that the products it manufactures will be free from defects in materials and workmanship for a period of three (3) years. This warranty shall not apply to:

- Transport damages during shipment from your plant.
- Damages due to poor packaging.
- Products operated outside their specifications.
- Products Improperly maintained or modified.
- Consumable items such as fuses, power cords, cables, etc.
- Normal wear
- Calibration
- Products shipped outside the United States without the prior knowlege of Com-Power.

In addition, Com-Power shall not be obliged to provide service under this warranty to repair damage resulting from attempts to install, repair, service or modify the instrument by personnel other than Com-Power service representatives.

Under no circumstances does Com-Power recognize or assume liability for any loss, damage or expense arising, either directly or indirectly, from the use or handling of this product, or any inability to use this product separately or in combination with any other equipment.

When requesting warranty services, it is recommended that the original packaging material be used for shipping. Damage due to improper packaging will void warranty.

In the case of repair or complaint, Please visit our website www.com-power.com and fill out the RMA form (http://com-power.com/repairservicereq.asp). Our technical assistance personnel will contact you with an RMA number. The RMA number should be displayed in a prominent location on the packaging and on the product, along with a description of the problem, and your contact information.

8.0 Maintenance

This product contains no user serviceable parts. If the unit does not operate or needs calibration, please contact Com-Power Corporation. Any modifications or repairs performed on the unit by someone other than an authorized factory trained technician will void warranty.

The exterior surface may be cleaned with mild detergent and then be wiped with a dry, clean, lint-free cloth. Use care to avoid liquids or other foreign objects entering the chassis.

9.0 Typical Performance Data