CALIBRATION OF LOOP ANTENNAS

There are at least four different methods of calibrating shielded loop antennas. The method described here is the spaced loop technique where a loop is used as a transmitting antenna spaced a known distance from the loop being calibrated. The particular instructions given below apply specifically to the calibration of the Solar Electronics loop sensor used for RE01 magnetic field emission tests (MIL-STD-461A).

BASIC CONCEPT:

The test setup is shown in Figure 1. The transmitting loop in this case is a loop antenna normally used in making RS01 magnetic field susceptibility tests. A specific r.f. current is established in the transmitting loop, measured with a series resistor and a voltmeter. At a given distance away, the field intensity generated by the current in the loop can be calculated. In the setup shown, for a distance of 13.25" (33.57 cm) from the center of the transmitting loop to the upper edge of the loop winding inside the shield of the RE01 loop, the field intensity is calculated to be 177.83 volts-per-meter when a current of one ampere is flowing in the transmitting loop.

SETUP DETAILS:

Since the dimension is critical, it is important to recognize that the 13.25" (33.57 cm) is not the distance between the edges of the loops, but is from the center of the RS01 loop winding to the center of the upper edge of the RE01 loop winding. These end points are not readily determined because the center of the RS01 loop winding is inside a piece of plastic and the upper edge of the RE01 loop winding is covered by the metal shield. Figure 2 shows a dimension of 10.65" (27 cm) between the faces of the loops when the 13.25" (33.57 cm) dimension is established at the theoretical points.

In setting up this dimension, take care to maintain the loops on the same axis and to orient them to face each other in a parallel fashion. A non-metallic fixture should be used to maintain the proper physical conditions. The setup should be arranged so that no metallic objects are in the vicinity of the loop antennas. (A metal object sometimes not considered is the presence of electrical conduit underneath the test bench.) The signal generator and the EMI meter should be at opposite ends of the setup so that the EMI meter is not receiving the signal by some other path than by way of the RE01 loop.

ELECTRICAL DETAILS:

It is not possible to obtain one ampere of r.f. current in the transmitting loop over the range of 30 Hz to 30 KHz with an ordinary signal generator. Figure 1 shows a power sweep generator being used to deliver the required current level.

When the physical dimension is maintained and the current through the loop is adjusted at each test frequency, the voltage received by the RE01 loop is measured with the EMI meter. In most test locations there are strong magnetic fields at the power frequency and its harmonics. It is desirable to avoid these frequencies by using a very narrow bandwidth in the EMI meter. A simple check on the validity of the received level would be to disconnect the signal generator from the transmitting loop. If the received signal is still present, the signal is arriving at the RE01 loop from some other source.

DETERMINING LOOP FACTORS:

It is desirable to obtain the correction factor for the loop in decibels, since the limits of RE01 are in terms of decibels above a picoTesla. For this reason it is convenient to measure the received voltage in dB above (or below) one microvolt.

The field intensity in this setup is 177.83 volts-per-meter (165 dB/μV/meter) which equates to 115.5 dB/pT. The measured level at each frequency in dB/μV is subtracted from 165 to obtain the correction factor for field intensity in decibels with reference to one micro-volt-per-meter (dB/μV/m). The measured level is subtracted from 115.5 to obtain the correction factor for field intensity in decibels with reference to one picoTesla (dB/pT).

As an example, assume that EMI meter reading is 82 dB/μV at 10 KHz. Subtracting 82 from the 165 reference yields 83, the factor for field intensity in dB/μV/m. At this frequency, the 83 dB factor must be added to the EMI meter reading to obtain the final answer in dB/μV/m.

For answers in volts-per-meter

Reference	165
EMI meter reading	− 82

Field Intensity: 83 db/μV/m

When the answer is to be in dB/pT, derive the factor by subtracting the 82 dB in this example from 115.5 to yield a correction factor (in dB) of 33.5.

For answers in Teslas

Reference	115.5
EMI meter reading	− 82.0

Field Intensity: 33.5 dB/pT

When using the RE01 loop in the RE01 test, add the 33.5 correction to the EMI meter reading (in dB) to obtain the field intensity expressed in dB/pT.

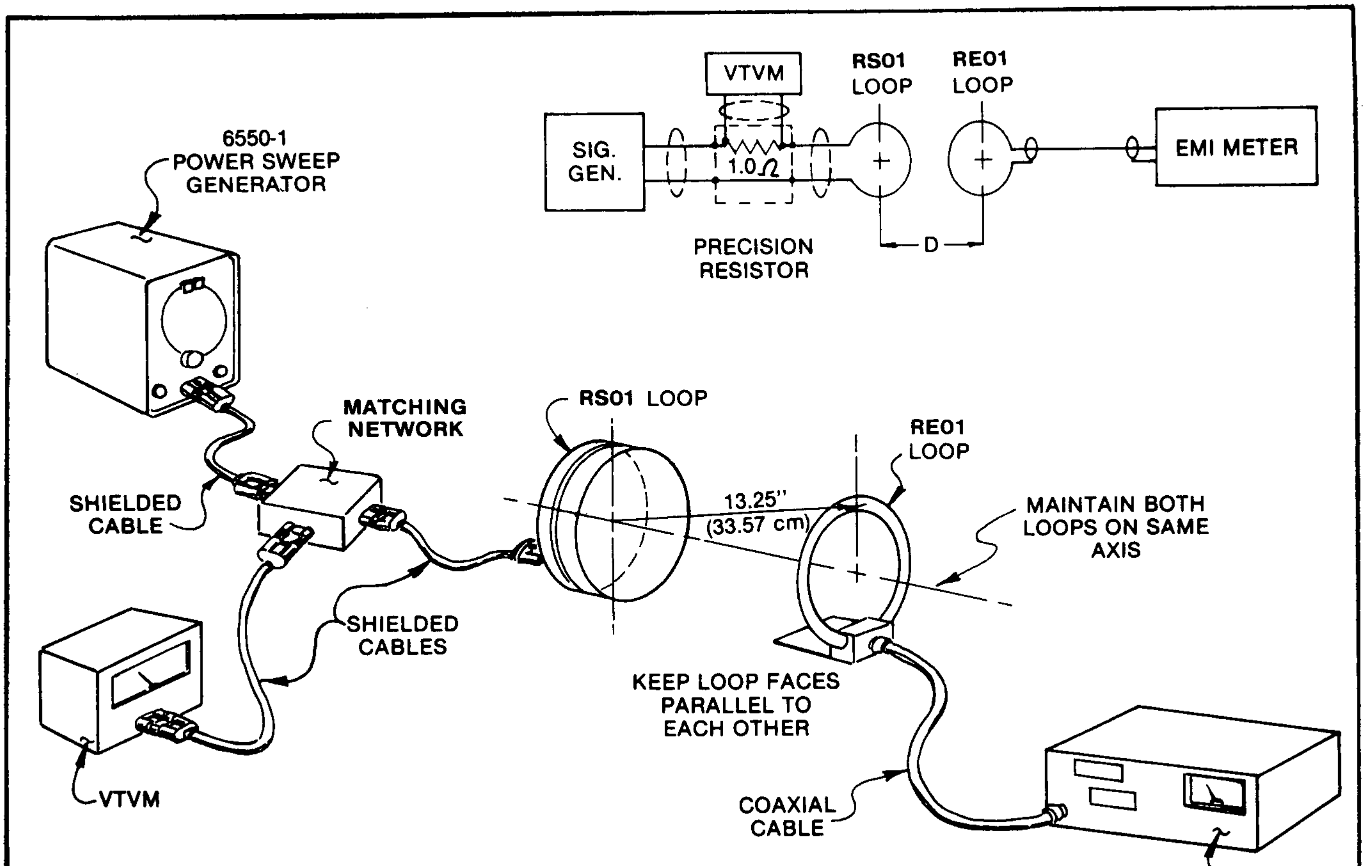

FIG. 1 BASIC TEST SET UP

CONVERSION TO OTHER TERMS:

To convert μV/m to picoTeslas, multiply by 3.33×10^{-3}.
To convert pT to μV/m, multiply by 3×10^{2}.
To convert dB/μV/m to dB/pT, subtract 49.5 dB.
To convert dB/pT to dB/μV/m, add 49.5 dB.

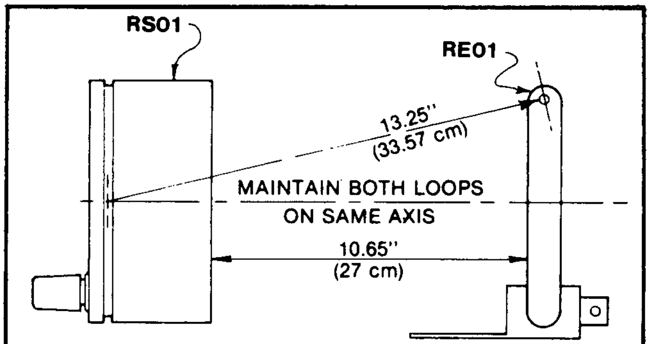

FIG. 2 PHYSICAL PLACEMENT OF LOOPS

REFERENCE INFORMATION:

The following expressions may be used in checking the accuracy of this test method and may be used in obtaining values for testing loop antennas of other types.

$$E = (47.15\ N\ d^2\ I) / D^3$$

Where: E = electric field intensity in volts-per-meter at the center of the receiving loop.
N = number of turns in the transmitting loop.
d = diameter of transmitting loop, in meters.
I = r.f. current flowing in the transmitting loop, in amperes.
D = distance from center of transmitting loop to periphery of receiving loop winding, in meters.

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