

Bulk Current Injection Probes

MANUAL



95236-1

95242-1

95252-1



ETS-Lindgren L.P. reserves the right to make changes to any products herein to improve functioning, design, or for any other reason. Nothing contained herein shall constitute ETS-Lindgren L.P. assuming any liability whatsoever arising out of the application or use of any product or circuit described herein. ETS-Lindgren L.P. does not convey any license under its patent rights or the rights of others.

© Copyright 2005 by ETS-Lindgren L.P. All Rights Reserved.
No part of this document may be copied by any means
without written permission from ETS-Lindgren L.P.

E-MAIL & INTERNET

Support@ets-lindgren.com
<http://www.ets-lindgren.com>

USA

1301 Arrow Point Dr., Cedar Park, TX 78613
P.O. Box 80589, Austin, TX 78708-0589
Phone 512.531.6400
Fax 512.531.6500

FINLAND

Euroshield OY
Mekaanikontie 1
27510, Eura, Finland
Phone + 358.2.838.3300
Fax + 358.2.865.1233

JAPAN

4-2-6, Kohinata
Bunkyo-ku
Tokyo 112-0006
JAPAN
Phone + 81 3 3813 7100
Fax + 81 3 3813 8068

CHINA

1917-1918 Xue Zhixuan Building
No 16 Xue Qing Road
Haidian District
Beijing Postcode: 100083
CHINA
Phone + 86 010 82755304
Fax + 86 010 82755307

Table of Contents

INTRODUCTION.....	1
APPLICATION.....	2
CONDUCTED SUSCEPTIBILITY	2
TEST SETUP APPARATUS.....	4
CONDUCTED EMISSION.....	7
TRANSFER IMPEDANCE (Z_T).....	7
INSERTION LOSS.....	10
EQUIPMENT.....	10
PROCEDURE	11
PRECAUTIONARY MEASURES.....	12
SPECIFICATIONS.....	13
SUPPORTING EQUIPMENT.....	16
MAINTENANCE.....	17
WARRANTY STATEMENT	18

INTRODUCTION

The ETS-Lindgren Bulk Current Injection Probe series is used to inject RF current into conductors and cables of electrical and electronic equipment undergoing susceptibility testing.

The Bulk Current Injection Probe provides a means of applying a controlled RF stress level to an instrument under test (IUT) through interconnecting cables or power cables without requiring a direct connection to the conductor(s) of interest. The models in this series are simply clamped around the test conductor which then becomes a one turn secondary winding, with the current probe forming the core and primary winding of an RF transformer. RF energy can be injected onto single and multi-conductor cables, grounding and bonding straps, outer conductors of shielding conduits and coaxial cables, etc.

The bulk current injection probe series is especially designed to provide minimum insertion loss over the following frequency ranges:

Model Number	Frequency Range	Useful Range
95236-1	0.1 to 10 MHz	0.01 to 100 MHz
95242-1	2 to 400 MHz	2 to 400 MHz
95252-1	450 to 900 MHz	20 to 1000 MHz

Table 1

Because of the high efficiency design, the injection probes can also be used as very sensitive sensors.

APPLICATION

The principal use of the bulk current injection probe is for inducing relatively large RF currents into the signal and power circuits of equipment under test for conducted susceptibility. A secondary application would be to use the same probe in a more familiar role as a sensor for measuring weak conducted RF currents.

CONDUCTED SUSCEPTIBILITY

Conducted susceptibility testing is intended to insure that RF signals, when coupled on to interconnecting cables and power supply lines of an IUT, will not cause malfunction or degradation of performance. In addition, this testing can provide an amplitude vs. frequency malfunction signature for the system which, when compared with the levels of current on the cables in a typical operating environment, can assist in the determination of adequate safety margins.

TYPICAL TEST SETUP

Typical conducted susceptibility tests require that all power and interconnecting cables be tested by subjecting them to the required current or voltage levels, while monitoring the applied current using a current probe. Usually, a reference level calibration is performed using a calibration jig with a specified impedance. This reference curve is then replayed to expose the IUT to a controlled stress level, while a current probe is used to insure that a low impedance IUT is not overstressed.

Note: Some tests may allow the reference calibration to be performed at a lower level and then scaled up to the required power level when applied to the IUT.

Entire cables or cable bundles may be tested, or each line may be broken out and tested individually. Some standards may also require simultaneous injection onto multiple cable bundles using several injection probes. Absorbing clamps may be required to isolate peripheral equipment from the IUT, and insure that only the IUT is exposed to the required stress level. Refer to the pertinent test standard for more specific details.

TEST SETUP APPARATUS

The following equipment may be needed to set up the test environment:

- **Current Injection Probes:**

- 95236-1 (0.1 to 10 MHz)

- 95242-1 (2 to 400 MHz)

- 95252-1 (400 to 1000 MHz)

- **Calibration Jig 95241-1**

- For the current injection probes. When using the Model 95252-1 the Model 95251-1 Calibration Jig is recommended. It is the same as the Model 95241-1 Jig listed above except that it has been modified to provide better high frequency characteristics for the Model 95252-1 injection probe.

- **Current Monitoring Probes**

- **Signal Source/Generator**

- **Power amplifier(s)**

- The power amplifier should be capable of supplying the full rated power into the current injection probes (which have a high VSWR) with a low harmonic content.

- **Spectrum analyzer or measuring receivers**

- **Directional coupler**

- **RF Voltmeter(s)**

- **RF Absorbing Clamp**

- **RF Attenuator**

- **RF Loads**

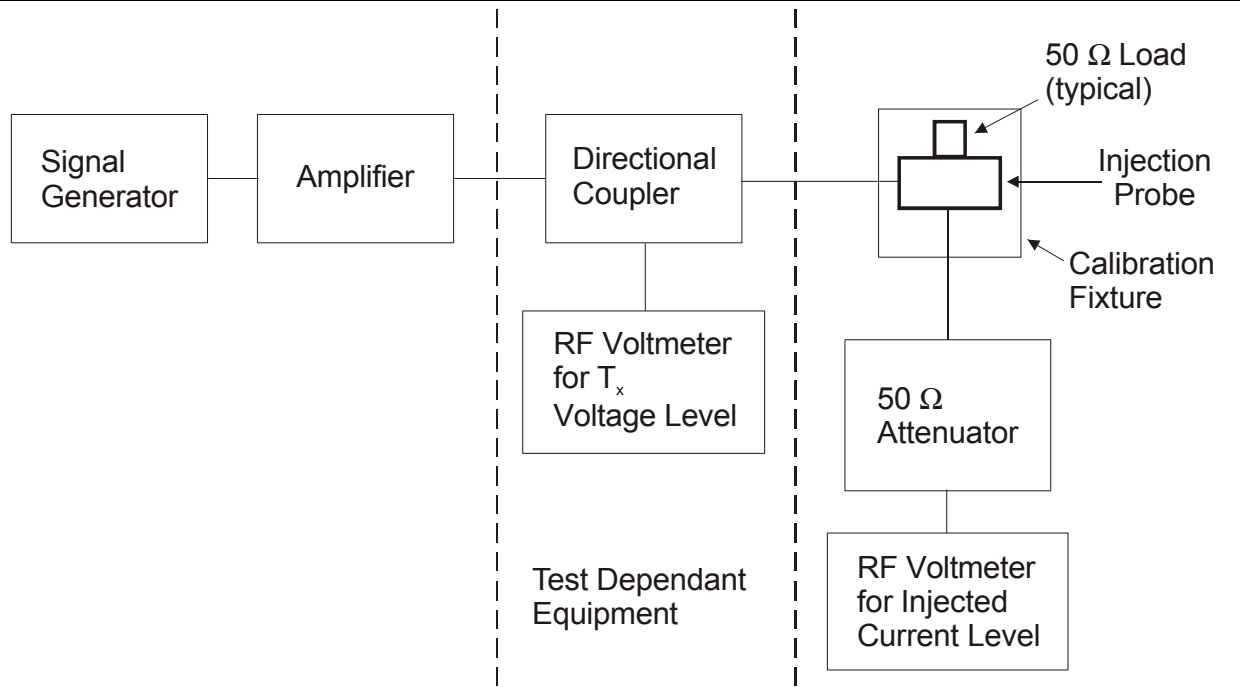


Figure 1—Sample Conducted Susceptibility Calibration Setup

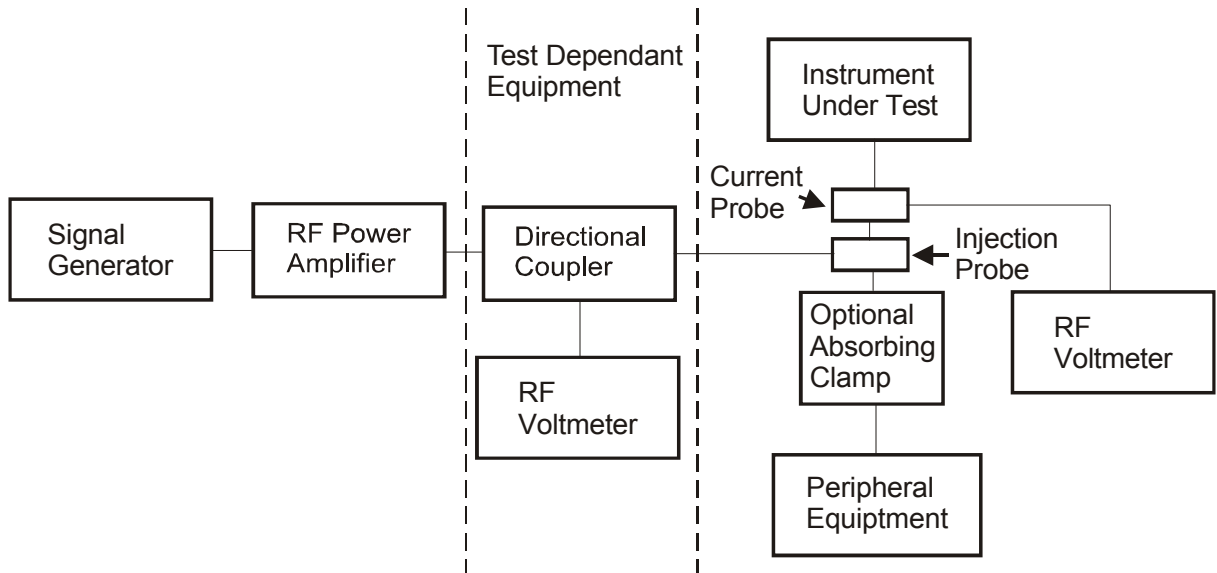


Figure 2—Sample Conducted Susceptibility Test Setup

CONDUCTED EMISSION

TRANSFER IMPEDANCE (Z_T)

The current injection probe may also be used as a sensor for measuring conducted emission. The RF current (I_P in microamperes) in the conductor under test is determined from the measuring receiver reading of the probe output (in microvolts (E_S)) divided by the probe transfer impedance (Z_T in ohms).

$$I_P = E_S / Z_T$$

Or in dB,

$$I_P(\text{dBmA}) = E_S(\text{dBmV}) - Z_T(\text{dB})$$

The transfer impedance is determined by passing a known RF current (I_P) through the primary test conductor and noting the voltage (E_S) developed across a 50 Ohm load on the probe output.

$$Z_T = E_S / I_P$$

Calibration Jig 95241-1 may be used for this determination. Typical transfer impedance values for the Model 95242-1 Probe when used as a sensor are:

Frequency (MHz)	Z_T (W)
2	7
4	14
6	21
8	26
10	30
15	35
20	37
30	38
40	39
50	39.5
60	40
80	41
100	41
140	42
180	42
220	43
260	43
300	43
320	43.5
340	43.6
360	44
380	42.5
400	39
420	32
440	25
460	17

Table 2

High sensitivity and minimal core gap indicate that the current probe should be used only on signal lines where heavy currents are not encountered. Heavy currents may affect measurement accuracy should current probe core saturation occur.

Typical transfer impedance values for the Model 95252-1 when used as a sensor are:

Frequency (MHz)	Z_T (Ω)
400	25
450	16
500	20
550	22
600	22
650	20
700	19
750	18
800	15
850	11
900	8
950	5.7
1000	3.7

Table 3

INSERTION LOSS

Insertion loss of the 94242-1 Bulk Current Injection Probe may be measured at low signal levels. ETS-Lindgren offers this measurement as a calibration service, please contact our calibration department for more information.

EQUIPMENT

Signal Generator (50 Ohms)	2 to 400 MHz	400 to 1000 MHz
RF Voltmeter (50 Ohms)	2 to 400 MHz	400 to 1000 MHz
Calibration Jig	95241-1	95251-1
50 Ohm Termination	VSWR <1.2	VSWR <1.2
Bulk Injection Current Probe	95242-1	95252-1

Table 4

PROCEDURE

1. Connect the signal generator output directly to the RF voltmeter input as show in Figure 3, indicated by the dashed line, using the same cables which connected the calibration jig and the injection probe under test. Tune to the test frequency and adjust the signal level for a reference of 0 dBm indication on the RF voltmeter.
2. Without changing control settings, connect the signal generator output to the bulk current injection probe input and connect the calibration jig connector to the RF voltmeter input.
3. Note the RF voltmeter output in dB. The difference between this reading and 0 dB is the insertion loss. In this measurement, the loss can not be less than 3 dB since half the injected power is absorbed by the 50 Ohm termination that is particularly loading (50%) the Calibration Jig.

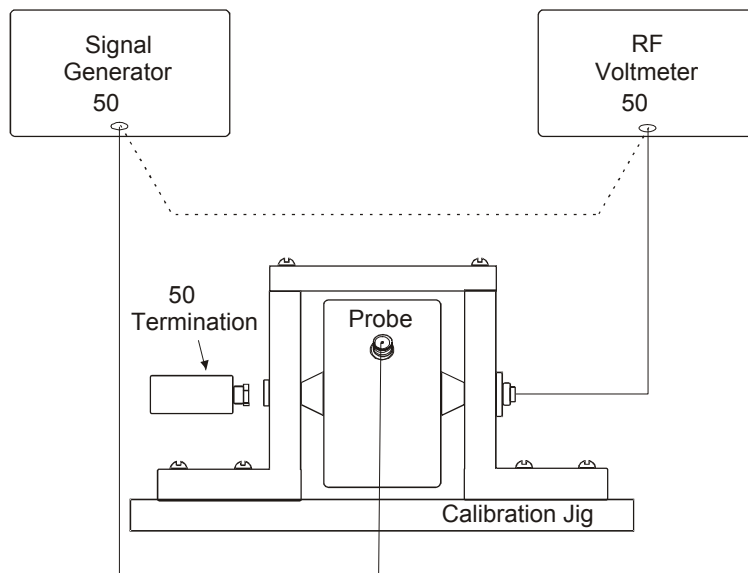


Figure 3—Typical Reference Calibration Setup

PRECAUTIONARY MEASURES

CAUTION: RF fields can be hazardous. Observe appropriate RF exposure limits.



When measuring conductors that are not insulated, use extreme care when installing the current probe and taking measurements. If possible, de-energize the test sample during assembly and disassembly of the setup. Also, arrange to center the test conductor in the current probe window for additional voltage breakdown protection.

Do not permit the un-insulated current probe connector and cable connectors to come in contact with the ground plane or other nearby conductors. This will prevent possible measurement error due to ground loops, and will avoid danger from high voltages.

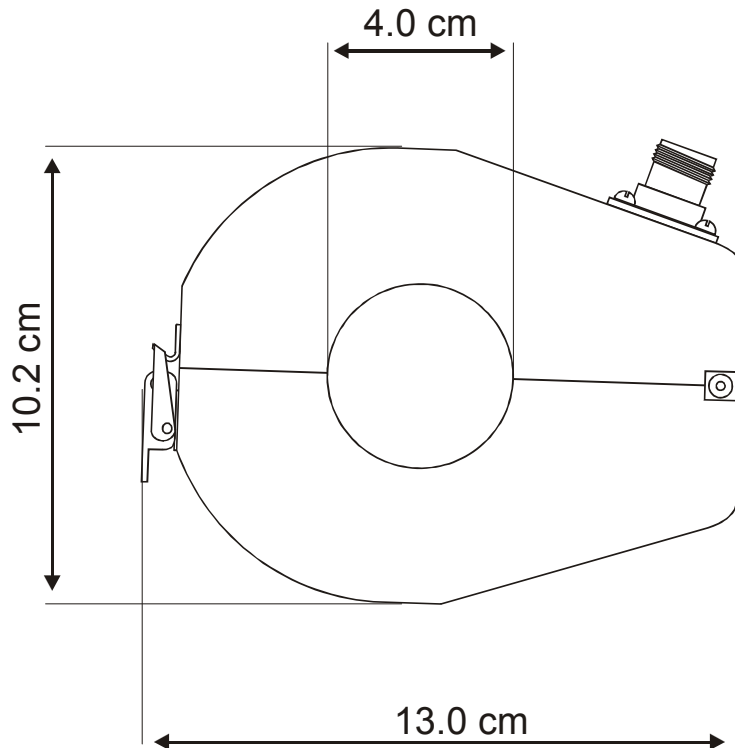
Ensure that the 50 Ohm load is capable of safely dissipating the incurred power. Should the load become disconnected, the developed voltage will be come much greater and may be very dangerous.

SPECIFICATIONS

PHYSICAL

Window Diameter	4.0 cm
	1.57 in
Outside Diameter	13.0 cm
	5.11 in
Width	6.0 cm
	2.36 in
Weight	(Model 95252-1 is 3.5 cm Wide)
	1.60 kg
	3.52 lbs
Output Connector	(Model 95252-1 weighs .90 kg)
	Type N
Input Impedance	50 Ω

Table 5



SERIES SPECIFIC ELECTRICAL SPECIFICATIONS

Electrical Specifications	95236-1	95242-1	95252-1
Frequency Range	10 kHz to 100 MHz	2 to 400 MHz	10 MHz to 1000 MHz
Maximum Input Power	100 W	200 W (See Note)	100 W
Maximum Input Current	20 Amperes	60 Amperes	25 Amperes
Maximum Core Temperature	80 degrees C	80 degrees C	80 degrees C
Recommended Maximum Temperature Rise	35 degrees C	35 degrees C	35 degrees C
Maximum Time for Continuous Rating at Full Power	30 minutes	30 minutes	15 minutes
Turns Ratio	1:2	1:1	1:1
Inductance	47 μ H, \pm 20%	0.8 μ H, \pm 20%	0.5 μ H, \pm 20%

Table 6

Note: The power limit of the 95236-1 probe is 100 W. Powers in excess of 75 W should be used with care to avoid excessive temperature in the equipment under test. Prolonged testing should be avoided, particularly if unattended.

Note: The power limit of the 95242-1 probe is 200 W. Powers in excess of 100 W should be used with care to avoid excessive temperature in the equipment under test. Prolonged testing should be avoided, particularly if unattended.

Note: The power limit of the 95252-1 probe is 100 W. Powers in excess of 75 W should be used with care to avoid excessive temperature in the equipment under test. Prolonged testing should be avoided, particularly if unattended.

Bulk Injection Probe	Useful Range	Insertion Loss (Typical)	
		dB	Range
95236-1	10 kHz—100 MHz	<-15 dB -35 db \pm 3 dB	1 MHz-100 MHz @ 10 kHz
95242-1	2 MHz—400 MHz	<-15 dB	10 MHz – 400 MHz
95252-1	400 MHz—1 GHz	<-12 dB <-22 dB <-30 dB	400 MHz—700 MHz 750 MHz—900 MHz 950 MHz—1 GHz

Table 7

SUPPORTING EQUIPMENT

The following equipment is often required when using the Model 95242-1 to perform susceptibility tests.

Optional Injection Probe

The Model 93686-1 Current Probe with a 6.6 cm window diameter may be used as a bulk current injection probe over the frequency range 50 kHz to 2 MHz.

Model 95241-1 Calibration Jig

The Model 95241-1 Calibration Jig is used in equipment setup for measuring insertion loss of the current injection probe and is essential to equipment setup of some susceptibility test procedures.

Current Monitoring Probes

Suggested monitoring current probes are Models 91550-1 (10 kHz to 100 MHz) and 94111-1 (1 MHz to 1 GHz). Models 91550-1 and 94111-1 have a 1.25 inch (3.2 cm) window size and a transfer impedance of 0.5 to 6 ohms over the 50 kHz to 400 MHz frequency range.

Please consult the Sales Department for sizes and sensitivities of other current probes.

MAINTENANCE

To ensure reliable and repeatable long term performance annual recalibration of your current probe by ETS-Lindgren's experienced technicians is recommended. Our staff can recalibrate almost any type or brand of current probe. Please call to receive a Service Order Number prior to sending a current probe to us for calibration.

For more information about our calibration services or to place an order for current probe calibration visit our calibration website at www.ets-lindgren.com and follow the links.

WARRANTY STATEMENT

ETS-Lindgren, L.P., hereinafter referred to as the Seller, warrants that standard EMCO products are free from defect in materials and workmanship for a period of two (2) years from date of shipment. Standard EMCO Products include the following:

- ❖ Antennas, Loops, Horns
- ❖ GTEM cells, TEM cells, Helmholtz Coils
- ❖ LISNs, PLISNs, Rejection cavities & Networks
- ❖ Towers, Turntables, Tripods & Controllers
- ❖ Field Probes, Current Probes, Injection Probes

If the Buyer notifies the Seller of a defect within the warranty period, the Seller will, at the Seller's option, either repair and/or replace those products that prove to be defective.

There will be no charge for warranty services performed at the location the Seller designates. The Buyer must, however, prepay inbound shipping costs and any duties or taxes. The Seller will pay outbound shipping cost for a carrier of the Seller's choice, exclusive of any duties or taxes. If the Seller determines that warranty service can only be performed at the Buyer's location, the Buyer will not be charged for the Seller's travel related costs.

This warranty does not apply to:

- ❖ Normal wear and tear of materials
- ❖ Consumable items such as fuses, batteries, etc.
- ❖ Products that have been improperly installed, maintained or used
- ❖ Products which have been operated outside the specifications
- ❖ Products which have been modified without authorization
- ❖ Calibration of products, unless necessitated by defects

THIS WARRANTY IS EXCLUSIVE. NO OTHER WARRANTY, WRITTEN OR ORAL, IS EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE REMEDIES PROVIDED BY THIS WARRANTY ARE THE BUYER'S SOLE AND EXCLUSIVE REMEDIES. IN NO EVENT IS THE SELLER LIABLE FOR ANY DAMAGES WHATSOEVER, INCLUDING BUT NOT LIMITED TO, DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

Note: Please contact the Seller's sales department for a Return Materials Authorization (RMA) number before shipping equipment to us.