# OPERATING MANUAL

# POWER LINE

# COUPLING DECOUPLING NETWORK

# P/N: FCC-801-M2/M3-16A

# 150 kHz - 230 MHz


**Fischer Custom Communications Inc.**

**700307 P/N: FCC-801-M2/M3-16A Rev. E** **03/2019**

# ***SAFETY PRECAUTIONS***

Our objective is to maintain or improve standards of health, safety and welfare for persons at work, to protect others against risks to health, safety and welfare.

*To the best of current knowledge, there is no risk or safety where Fischer Custom Communications Inc. equipment is installed and operated properly, provided it has been properly maintained.*

*Precautions have been taken during the design and manufacture of this equipment to reduce the risks involved. When repairing or maintaining the equipment, a certain degree of risk must always be present, particularly under fault conditions. The list below has been prepared to draw attention to general risks envisaged; further information is available from Fischer Custom Communications, Inc. at any time.*

1) **ELECTRIC SHOCK**
   Beware mains voltage and induced aerial voltages; ensure metal chassis is properly grounded to earth.

2) **PHYSICAL STRAIN**
   Obtain assistance if heavy unit is to be lifted or moved.

3) **EXPLOSIONS AND IMPLOSION**
   Capacitors and resistors may explode if subjected to excessive voltage or voltage of incorrect polarity, and toxic materials may be released.

4) **BURN**
   Resistors and power transistor, terminals, (for example), may get hot. Avoid contact with these elements.

5) **RECYCLING OF FAULT COMPONENTS and/or ASSEMBLIES**
   Electronic components and assemblies may contain hazardous substances.

**Please refer to your local or state E-Waste recycling regulations, EU WEEE regulations, or other country recycling regulations.**

## ADDITIONAL SAFETY PRECAUTIONS

Prior to the connection of RF power or mains power conductors to the CDN, the CDN must be securely fastened to the earth ground plane. The proper grounding of the CDN prevents the following:

- Potential high leakage currents from presenting a hazard to personnel.
- Proper grounding of the CDN ensures the low impedance required for accurate immunity measurements. Provisions for securing the base plate to the ground plane have been provided in the form of U-shaped holes in the base plate. These U-shaped holes can be used to bolt the base plate directly to the ground plane. In order to verify that the CDN has achieved proper grounding a measurement of the resistance between the CDN grounding base plate and the ground plane is recommended. An indicated resistance value of 10 milliohms or less is necessary.

Electrically connect all test equipment and equipment under test to the load side of the CDN before connecting the line side of the CDN to the mains power.

All line side power conductors shall be attached to the line side / AE side of the CDN before the power conductor is connected to the mains.

The RF amplifier / RF test generator is then connected to the RF input port of the CDN.
After all of the above is completed, the line power conductors can be connected to the power mains using a suitable safety approved power plug.

The ground line / ground prong of the plug must make electrical connection first.

# WARNING

## HIGH LEAKAGE CURRENT

**Earth Connection Essential**
**Before Connecting Supply**

# CAUTION

## ELECTRIC HAZARD EXISTS

**Make All Connections**
**Before Applying Power**

# Warning

# Un-energized connect and disconnect of input and output power connections only!

During the testing personnel shall not come in contact with any exposed test leads or terminals.

When testing is complete:

- De-energize the amplifier.
- Disconnect the mains power line connection before disconnecting the power conductors leading to and from the CDN and the EUT.

## DESCRIPTION

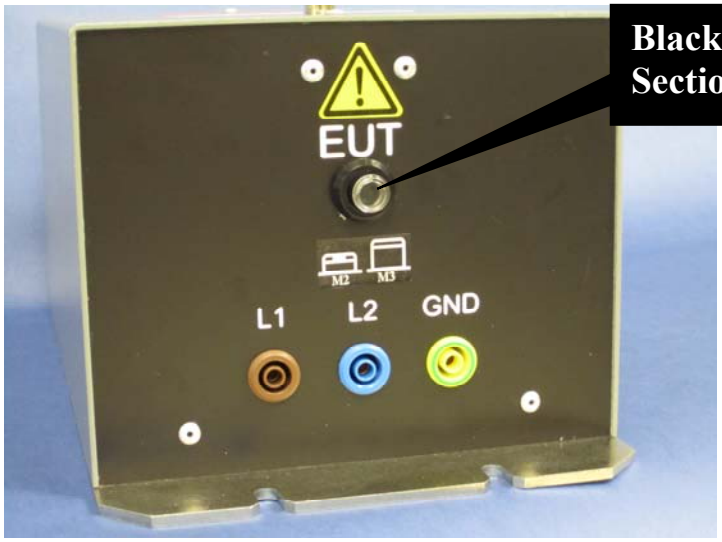
### 1.0 PURPOSE

The M2 section of the FCC-801-M2/M3-16A is used to couple RF CW and modulated voltages into equipment in accordance with IEC 61000-4-6. The equipment under test can have two wires and no more than 250 volt (DC-60 Hz) line to line power mains. The circuit wires shall be connected to the EUT phase(s) and neutral or protected earth connections. Insertion of this CDN shall not unduly influence the input power functions of EUT. Immunity measurements shall be carried out over 150 kHz to 230 MHz.

The M3 section of the FCC-801-M2/M3-16A is used to couple RF CW and modulated voltages into equipment in accordance with IEC 61000-4-6. The equipment under test can have three wires and no more than 250 volt (50-60 Hz) line to line power mains. The circuit wires shall be connected to the EUT phase(s) and neutral or protected earth connections. Insertion of this CDN shall not unduly influence the input power functions of EUT. Immunity measurements shall be carried out over 150 kHz to 230 MHz.

The FCC-801-M2/M3-16A CDN is equipped with a push button switch on the EUT side of the CDN. This switch is used to configure the FCC-801-M2/M3-16A between the M2 and M3 Coupling sections. When the switch is pushed in and showing green the device is set to couple the RF disturbance to the **M2** section on **L1 and L2**. When the Switch is out and black the device is set to couple the RF disturbance to the **M3** section on the **ground line (GND), L1 and L2**.


**M2 Switch Position**




**M3 Switch Position**

## 2.0 ELECTRICAL CHARACTERISTICS

### 2.1 SCHEMATIC

The schematic of the M2 section of the FCC-801-M2/M3-16A CDN is shown in Figure 1and the M3 section in figure 2. All components and characteristics are in compliance with IEC 61000-4-6 annex D.

### 2.2 COMMON MODE EUT TERMINAL IMPEDANCE

The construction and layout of the CDN is designed to ensure that the RF injected voltage is directed toward the EUT and isolates any auxiliary equipment (AE) input power or power mains from the injected RF voltage. This is to ensure that any demonstration of circuit abnormal operation or malfunction has been created by a known amount of RF injected voltage on the EUT. This isolates the AE and reduces problems due to an AE malfunction caused by the injected RF voltage. To ensure that this action occurs, the EUT common mode terminal impedance Zce is required to be in compliance with Table 3 of IEC 61000-4-6.This impedance is shown in Figure 2. Zce values must meet the requirement when the CDN AE or input power terminals are open or short circuited to ground. Verification measurement test setups of the Zce values are as shown in Figure 3 and Figure 4. It is important to note that the IEC 61000-4-6, paragraph 6.3 identifies Zce as the common mode EUT port impedance. A typical measured value of Zce for this CDN is show in Figure 6 & 7.

### 2.3 ATTENUATION

The other important characteristic of this CDN is its attenuation. IEC 61000-4-6 does not specify any values for attenuation however; it is beneficial to keep it as small as possible. The attenuation magnitude is the parameter that controls the amount of power that is lost between the coaxial input terminals of the CDN and the EUT terminals of the CDN. This parameter is related to coupling factor which is described in paragraph 2.4 of this document.

#### 2.3.1 MEASUREMENT OF ATTENUATION

IEC 61000-4-6 specifies that Passive Impedance adapters (150-50Ω) shall be incorporated into the method of measuring attenuation. These adapters are also incorporated in the test setup to measure the injected immunity levels, and are basically a 100Ω series resistance. The Passive Impedance adapters are shown in Figures 7d and 7e of IEC 61000-4-6. The attenuation factor is useful in predicting the amount of input voltage (power) required from a 50Ω generator to generate the required immunity voltage. A typical measured value of attenuation / insertion loss for this CDN is shown in Figure 8 & 9.

### 2.4 COUPLING FACTOR

CDN coupling factor is defined as the open circuit voltage obtained at the EUT (common mode) connector divided by the open circuit voltage obtained at the input power connector. A CDN containing a 100 Ω series resistor, which is the case for this CDN, has a value of 0 dB. The coupling factor is not specified, but it is desirable to be kept to a minimum value. This explanation is provided as background on discussions contained in IEC 61000-4-6. The coupling factor of a typical FCC-801-M2/M3-16A is shown in Figure 10 & 11. The coupling factor is approximately 10 dB less than the attenuation factor.

## 3.0 SETTING IMMUNITY LEVELS

In order to establish the correct test setup and immunity levels of injected RF voltages, the following procedure is to be followed. The test set-up for this is shown in Figure 12, which is the same as IEC 61000-4-6, Figure 8C.

**A.** It requires two Passive Impedance adapters (150-50 Ω), one for the EUT terminals and the other for the AE terminals.
- Connect a Passive Impedance adapter to the EUT terminals via a shorting adapter.
- Connect the other Passive Impedance adapter to the AE terminals via a shorting adapter.
- Connect a 50 Ω load to the type-N port of the AE Passive Impedance adapter.
- These Passive Impedance adapters are provided in the Adapter Kit model number: FCC-801-150-50-CDN.

**B.** Connect a suitable 50 Ω RF spectrum analyzer to the Type-N port of the EUT Passive Impedance adapter.

**C.** Connect a RF test generator to the RF input connector of the CDN.

**D.** The first step is to establish the correct setting of the unmodulated test level.
- Therefore, the test generator shall be set for CW without modulation.

**E.** In order to inject the proper CW signal level, the 50 Ω spectrum analyzer shall measure the following magnitudes for each category of immunity.

| | |
|---|---|
| Level 1 | 0.167 RMS. |
| Level 2 | 0.5 RMS. |
| Level 3 | 1.67 RMS. |

**Note:** The above levels have been established by dividing the open circuit specification magnitude by 6. The factor of 6 comes about due to the following:
- The levels in Table 1 of IEC 61000-4-6 are specified as open circuit values.
- The loaded 150 Ω impedance level is one-half the open circuit value.
- The 50 Ω spectrum analyzer measures one-third of the 150 Ω value.

This is how the one-sixth factor enters into the calculation.

**F.** The next step is to activate the 1 kHz sine wave modulator and, modulate the previously set CW for 80% modulation, which is verified using the spectrum analyzer.

## 4.0 EXPECTED AMPLIFIER POWER

The CW amplifier power required to generate the maximum level is expected to be no more than 10 watts. This wattage takes into account a realistic maximum 10 to 16 dB attenuation value of the CDN over its 150 kHz - 230 MHz frequency range, and the loss of forward amplifier power due to the 3:1 VSWR created by the CDN and the Passive Impedance adapter. If the amplifier can deliver forward power into a load having 150 Ω impedance, the CW power required will vary from about 0.6 watt at 150 kHz to 2.4 watts at 230 MHz. If added attenuation is required to reduce the VSWR, it should be no more than 6 dB which would increase the maximum CW power to 9.6 watts. The added power during modulation is supplied by the modulator.

## 4.1 CDN POWER RATING

The power rating on the label of the CDN refers to the total internal power dissipation capability of the CDN. The CDN power rating does not refer to the power of the amplifier used to generate the conducted disturbance signal coupled through the CDN. However, worst case scenarios involving the amplifier and loads on the EUT port of the CDN were taken into account when setting the CDN power rating.

For example, consider the IEC 61000-4-6 Edition 3.0 open circuit ($U_0$) voltage test level which corresponds to the open circuit voltage of the amplifier which had a 50 ohm source impedance ( any attenuation between the amplifier output and the CDN is ignored). The worst case (although unlikely) scenario would be for the load at the EUT port of the CDN being a short circuit as this would result in the maximum current flow through the CDN. For a 30 volt $U_0$ (CW, un-modulated) at the amplifier, the total current flowing through the CDN (which looks like a 100 ohms series resistance) would be 30 volts/(50Ω+100Ω) = 0.2 amps. This 0.2 amps, which will divide up between the internal CDN resistors, is used to set the power rating of these resistors.

Edition 4.0 of IEC 61000-4-6 has added a measurement (section 6.4.2) wherein the $U_0$ cited above is increased by 5.1dB to verify acceptable amplifier linearity. For the 30 volt case cited above, increasing by 5.1 dB results in a voltage of 54 volts. However, for this measurement, Edition 4.0 requires 150 ohms be placed on the EUT port of the CDN (series 100 ohms plus the 50 ohms of the measuring equipment). So the open circuit voltage of the amplifier (54 volts) sees a load of its own 50 ohms source impedance, the 100 ohms of the CDN and the 150 ohms on the EUT port. The amplifier current flowing through the CDN is therefore 54V/(50Ω+100Ω+150Ω) = 0.18 amps. This is less than the 0.2 amps cited above and used to set the power rating of the CDN resistors. So the CDN is capable of being used for this new Edition 4.0 measurement.

The CDN power rating discussed above is based on the un-modulated rms CW voltage and is therefore average power. Under 80% modulation, as shown in IEC 61000-4-6 Ed 4.0, the rms voltage goes up by about 12% with an associated increase in average power. The power rating of the CDN has been selected to handle this increase in dissipated power resulting from 80% modulation.

Note that this CDN power rating is different from the power rating required of the amplifier. The amplifier power rating needs to take into account the peak voltage the amplifier is required to generate under maximum modulation and the presence of any attenuator between the amplifier and the CDN.

## Accommodations and Environmental Conditions

The standard upper and lower limits of operation FCC-801-M2/M3-16A are:

| | | |
|---|---|---|
| Temperature: | Low – 17 °C | High – 29 °C |
| Humidity: | Low – 15 % | High – 80 % |

**** The recommended calibration interval for this unit is 1 year.**

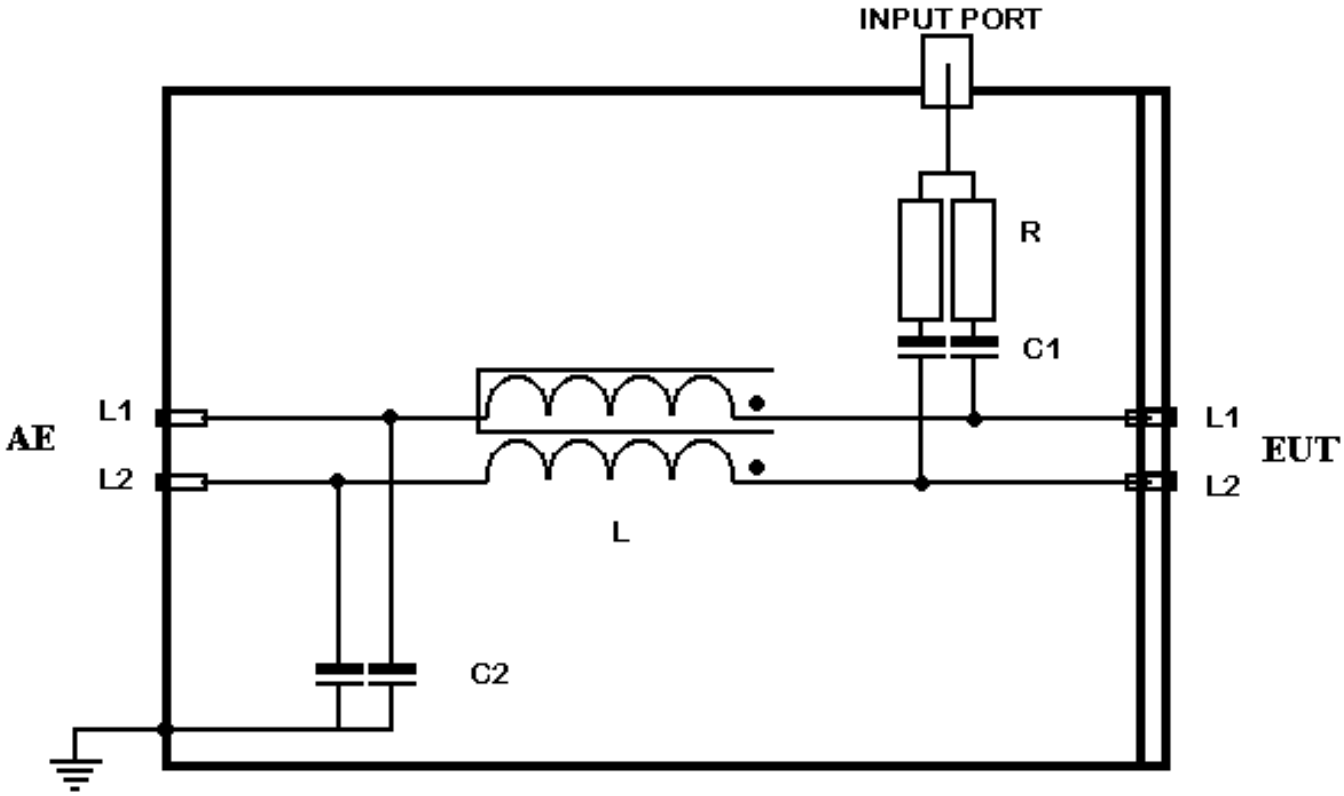



**Figure 1**

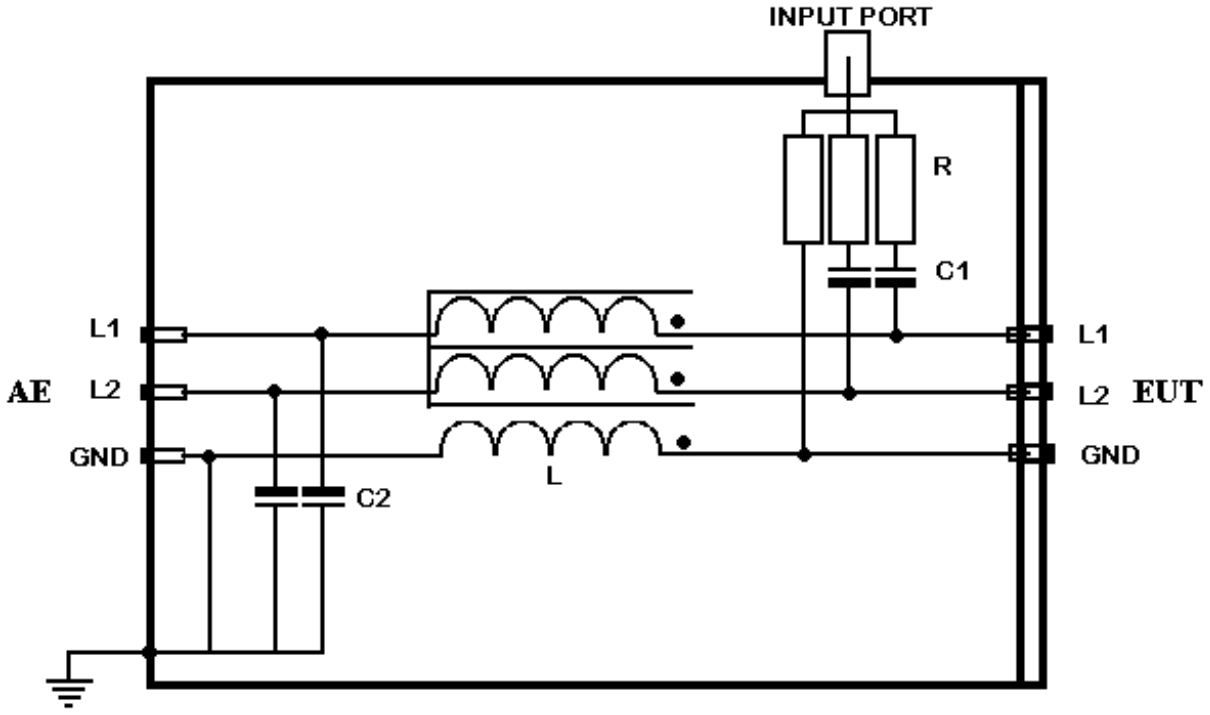
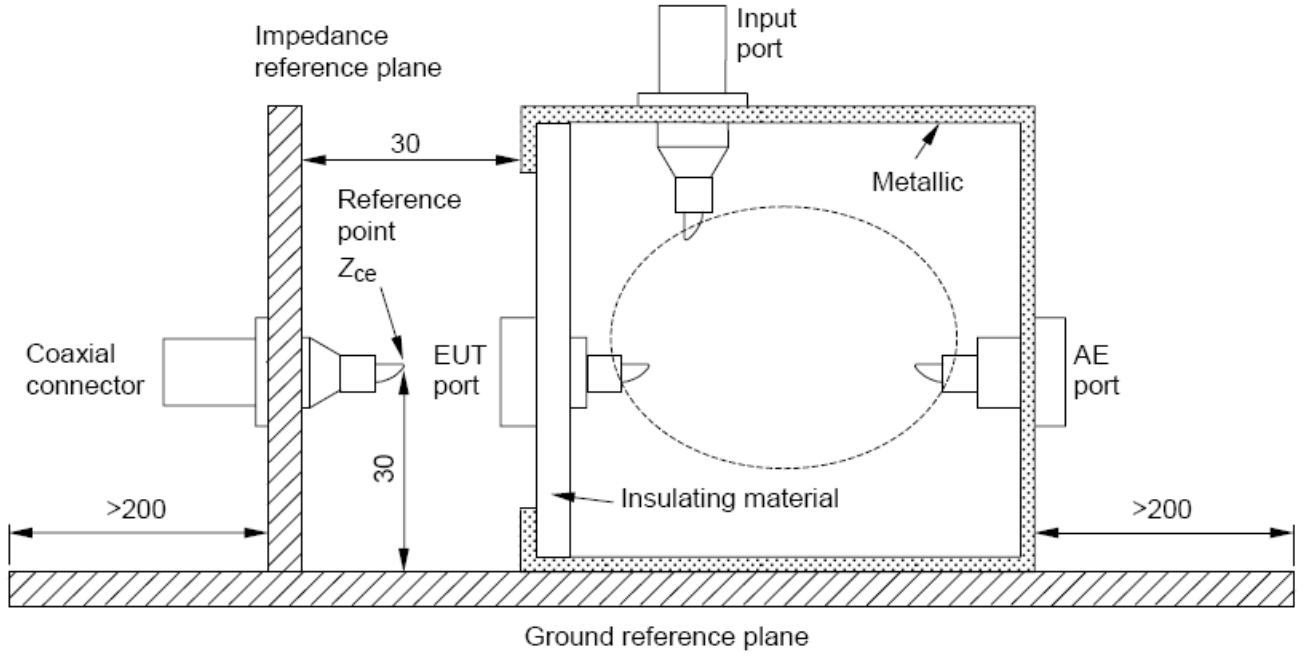



**Figure 2**

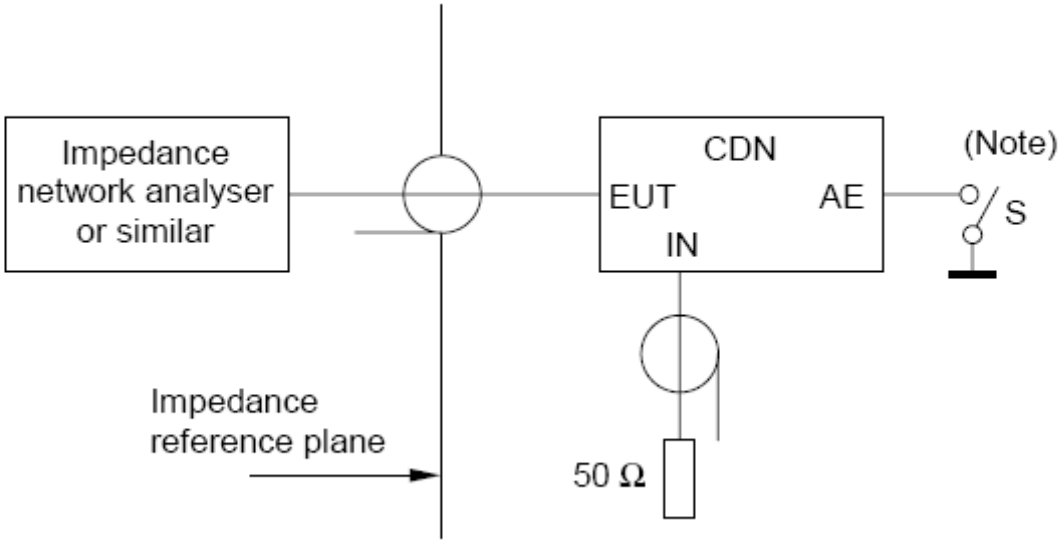
| | Frequency band | |
|---|---|---|
| **Parameter** | **0.15 MHz – 26 MHz** | **26 MHz – 80 MHz** |
| **$\|Z_{ce}\|$** | **150 Ω ± 20Ω** | **150 Ω + 60Ω -45Ω** |
| NOTE 1 Neither the augment of $Z_{ce}$ nor the decoupling factor between the EUT port and the AE port are specified separately. These factors are embodied in the requirement that the tolerance of $\|Z_{ce}\|$ shall be met with the AE port open or short – circuited to ground reference plane. | | |

**Figure 3**




*Dimensions in millimetres*

**Figure 4**




**Note the Impedance Requirement shall be met with open and closed switch S**

**Figure 5**

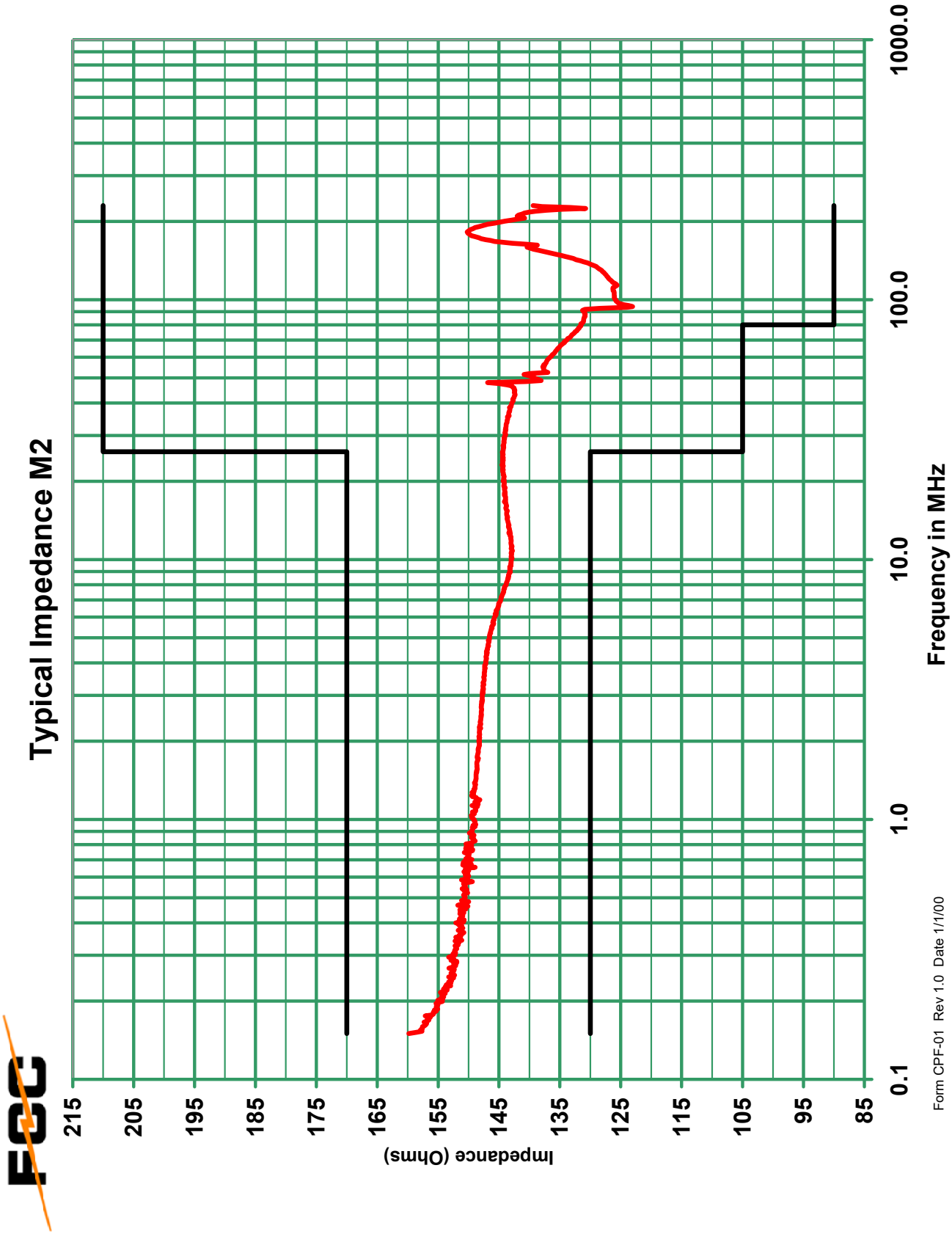



**Figure 6 M2**

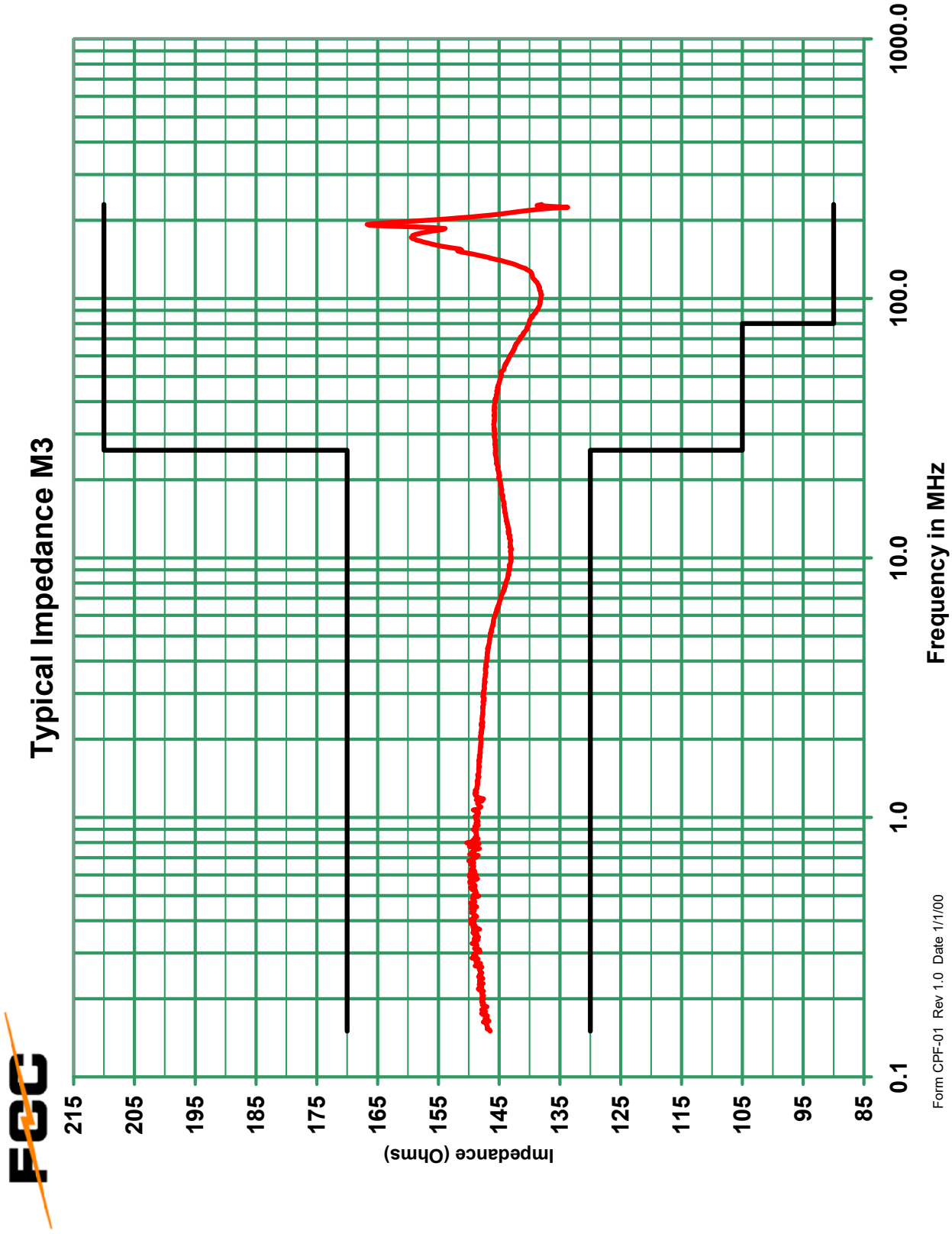



**Figure 7 M3**

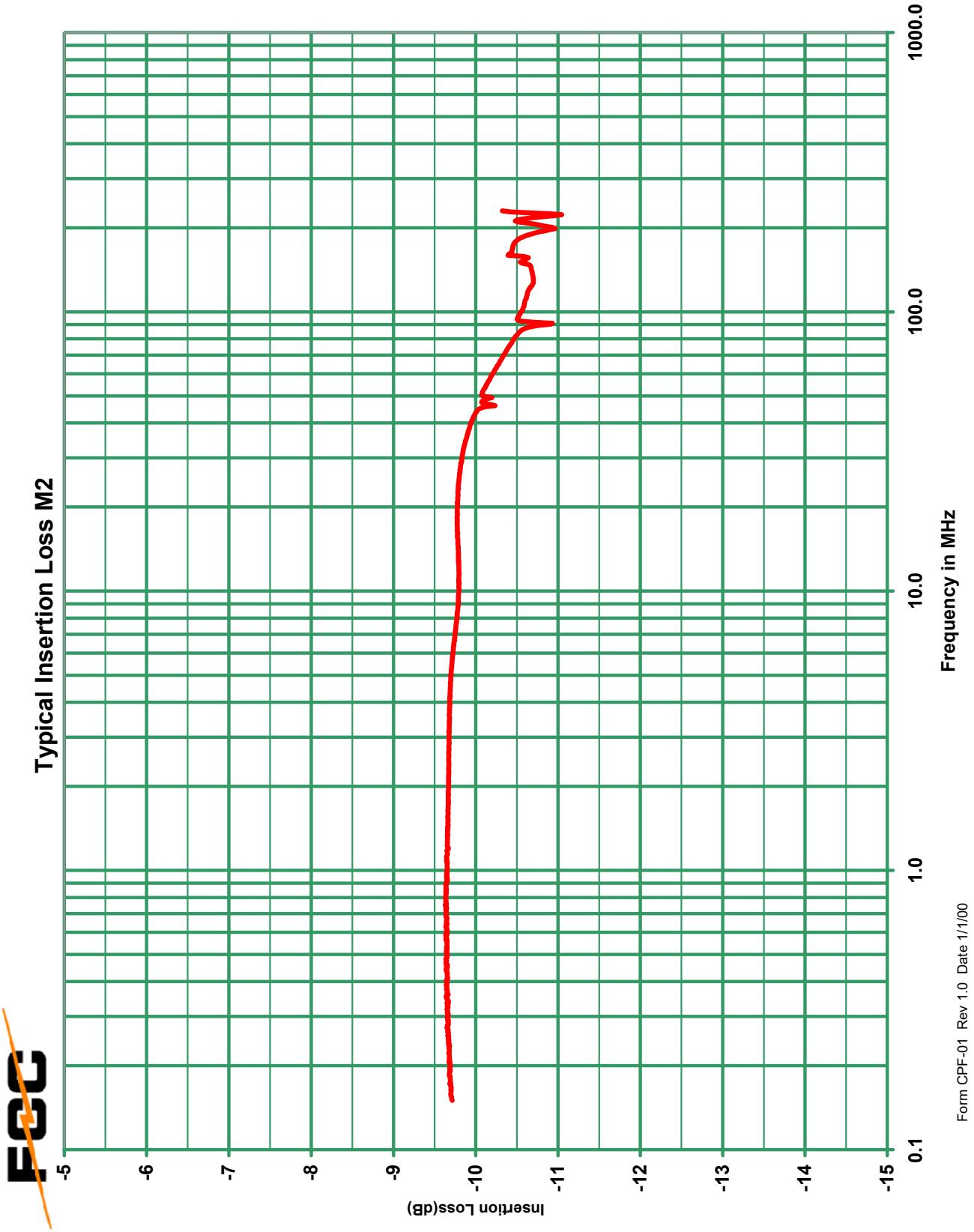



**Figure 8 M2**

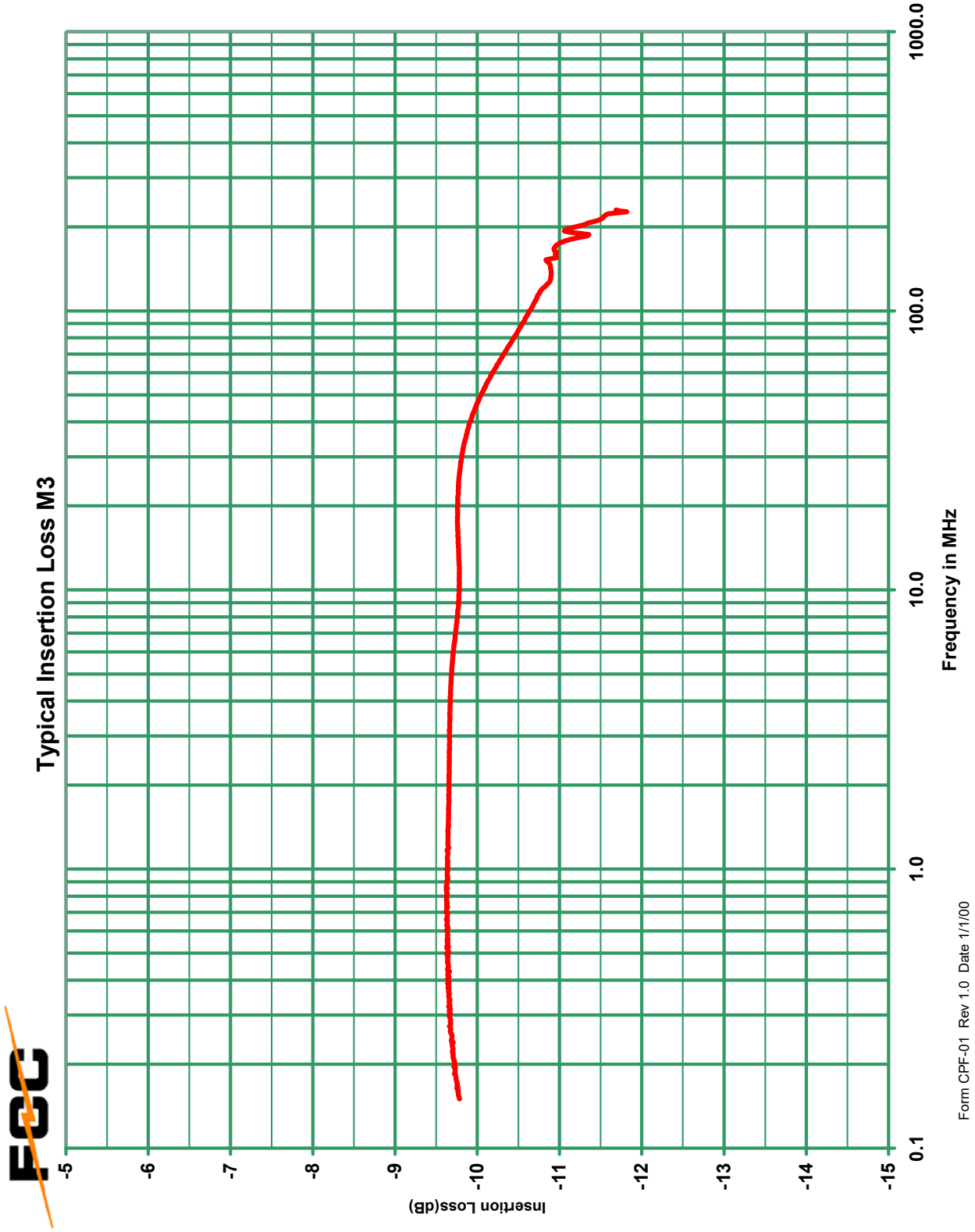



**Figure 9 M3**

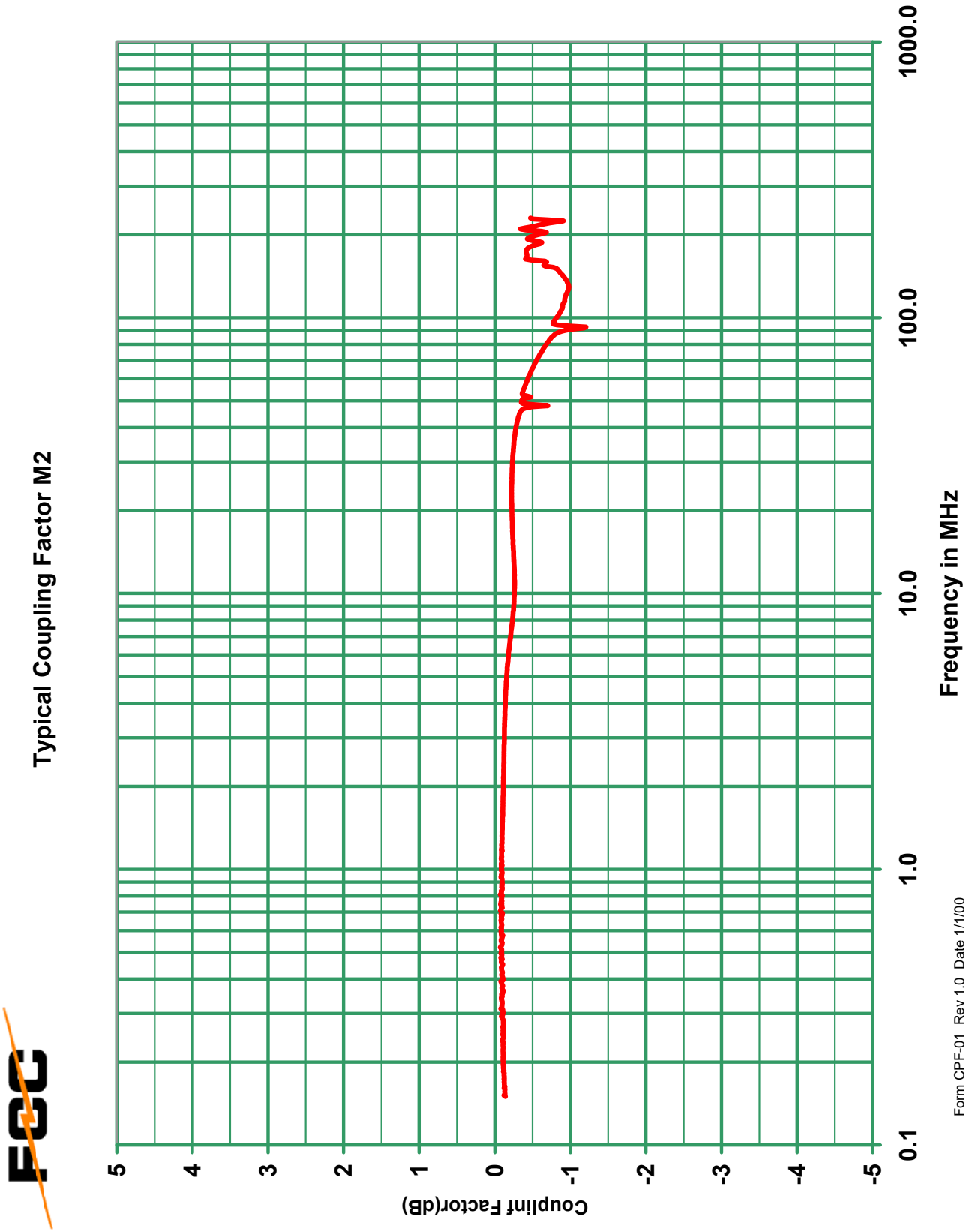



**Figure 10 M2**

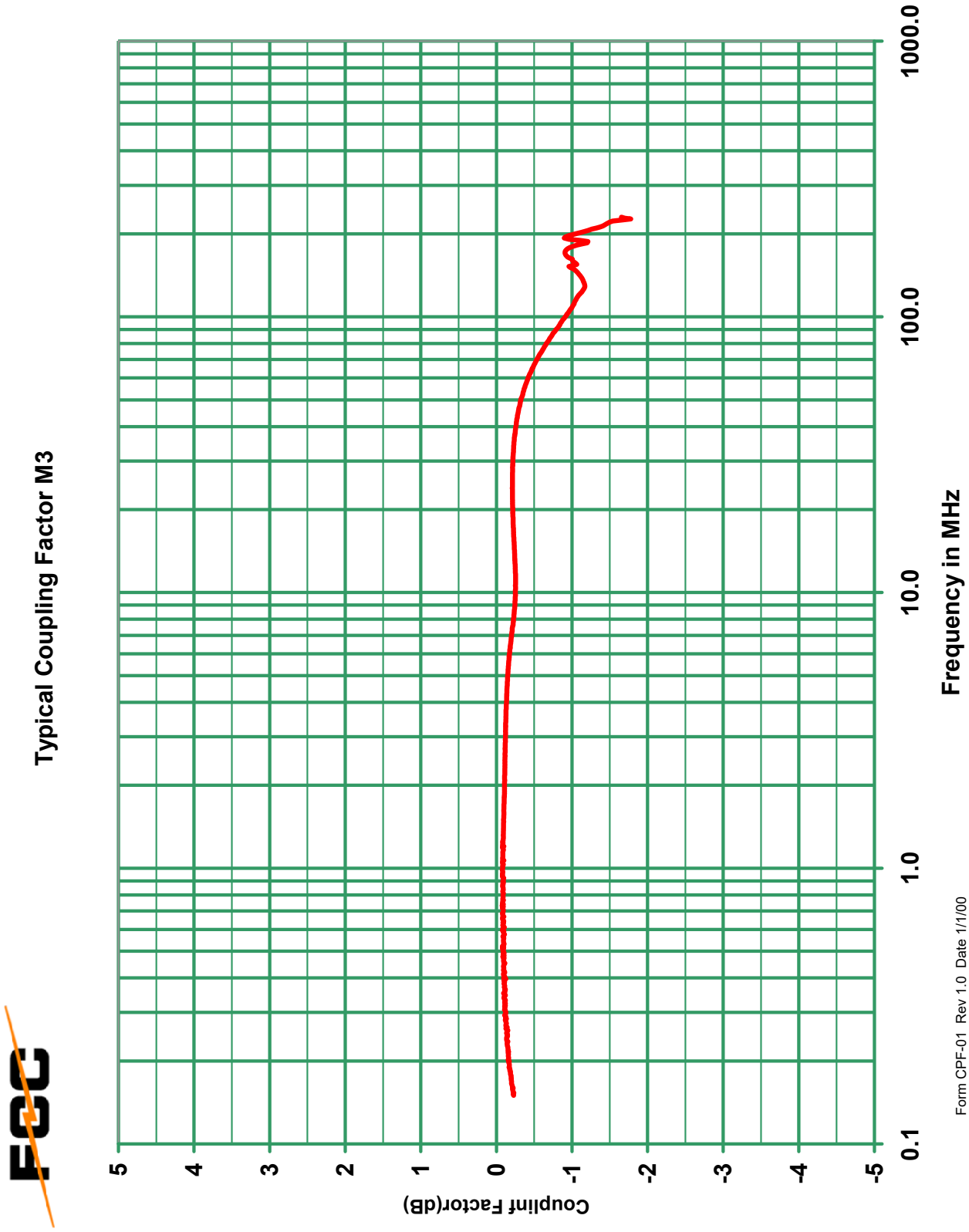
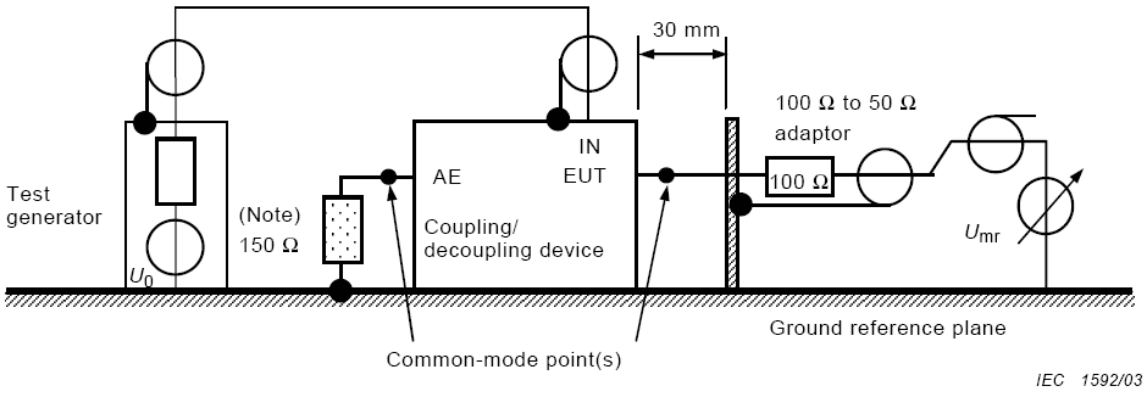



**Figure 11 M3**




Examples of coupling and decoupling devices:

– coupling/decoupling networks (CDNs);

– direct injection network (with decoupling);

– clamp injection device (EM clamp);

NOTE The 150 Ω loading, e.g. a 150 Ω to 50 Ω adapter terminated with a 50 Ω load, at the AE-port shall only be applied to unscreened cables (screened cables have their screens connected to the ground reference plane at the AE-side).

**Figure 12**

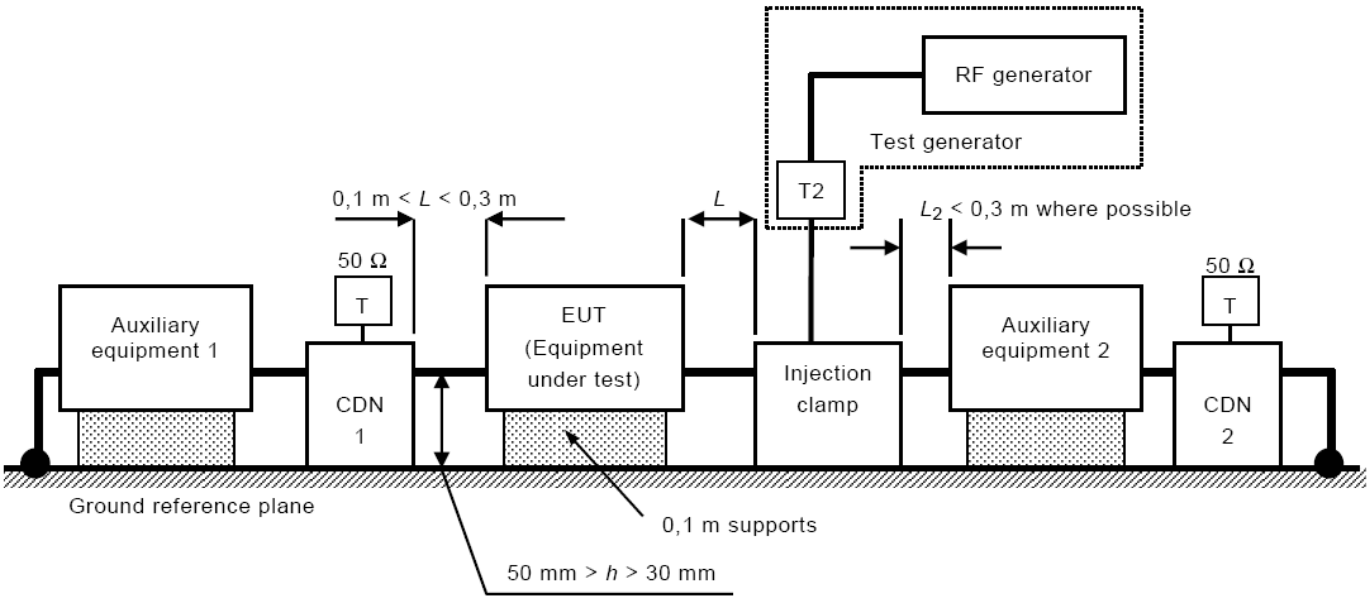
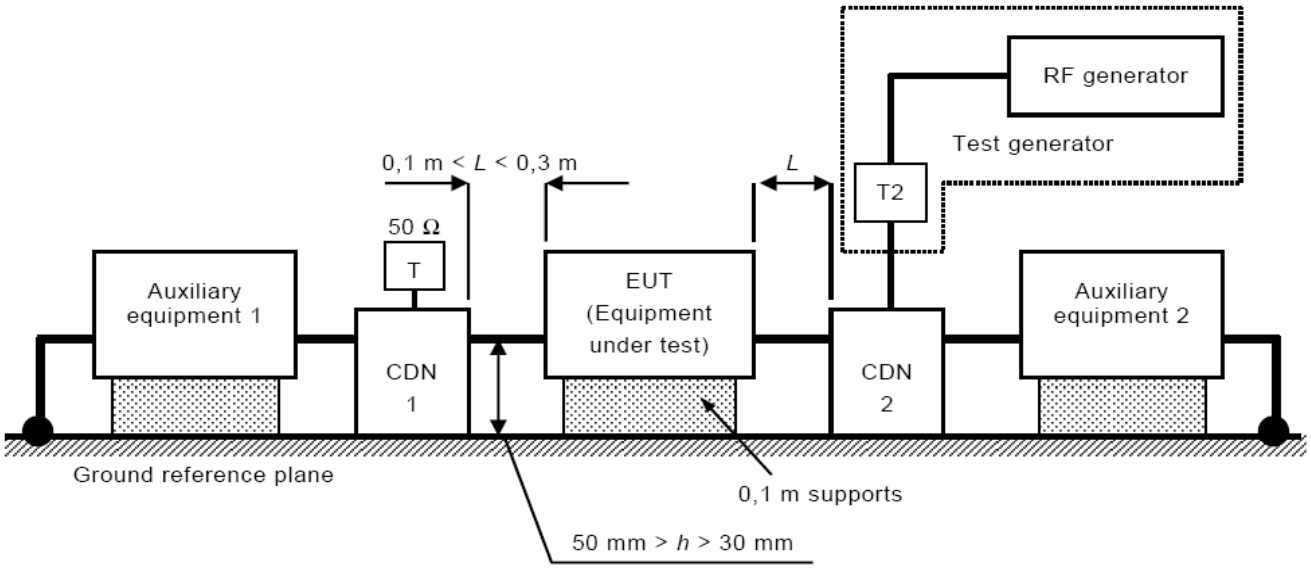



**Figure 13**




T : Termination 50 Ω
T2: Power attenuator (6 dB)
CDN: Coupling and decoupling network
Injection clamp: current clamp or EM clamp

**Figure 14**

## CDN SPECIFICATION

| | |
|---|---|
| **Frequency Range:** | **150 kHz -230 MHz.** |
| **Supply Lines:** | **3** |
| **Impedance:** | **Frequency dependent**<br>**150 KHz to 26 MHz 150Ω ± 20 Ω**<br>**26 MHz to 80 MHz 150Ω +60Ω -45Ω**<br>**Published IEC 61000-4-6, Tables 3**<br>**80 MHz to 230 MHz 150Ω +60Ω -60Ω**<br>**Published IEC 61000-4-6, Annex B Table B.1** |
| **Maximum Current:** | **16A** |
| **Maximum Voltage:** | **DC-60Hz**<br>**Line to Line 250V** |
| **Power Rating:** | **9 Watts Maximum** |
| **Line Input Connector:** | **4mm Multi-Contact Safety Socket Un-energized connect and disconnect of input and output power connections only!** |
| **Line Output Connector:** | **4mm Multi-Contact Safety Socket Un-energized connect and disconnect of input and output power connections only!** |
| **RF Disturbance Input Port:** | **50 Ω BNC** |
| **Dimensions:** | **22.9 X 15.2 X 12.7cm** (9 x 6 x 5in.) |
| **Weight:** | **1.82kg** (4 lbs.) |

## WARRANTY

LIMITED WARRANTY: The warranty period of mechanical and electrical components manufactured by Fischer is one (1) year from the date of shipment. Any defects in workmanship or material shall be corrected at no charge to the customer. Fischer, however, reserves the option to either repair or replace such defective equipment as specified below. Warranty is void if equipment repairs have been attempted by the Buyer. The warranty on the semiconductor components used by Fischer is limited to guarantees offered by the respective manufacturers of such items.

Subject to the preceding limitation and any additional limitations specified in the data sheet for the applicable Product, if the Product, which is the subject of this Limited Warranty, fails to conform to the above warranty during the Warranty Period, Fischer, at its option and sole discretion, will: (1) repair the Product; or (2) replace the Product with another product (where the replacement product is an equivalent product at the time a claim for warranty service is made to Fischer under this Limited Warranty; or (3) credit the then-current value of the Product (at the time a claim for warranty service is made to Fischer under this Limited Warranty) towards future purchases from Fischer. The Limited Warranty will extend to Product which is repaired or replaced for the balance of the applicable period of the original warranty or thirty (30) days from the date of return shipment from Fischer of a repair or replacement Product, whichever period is longer.

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