

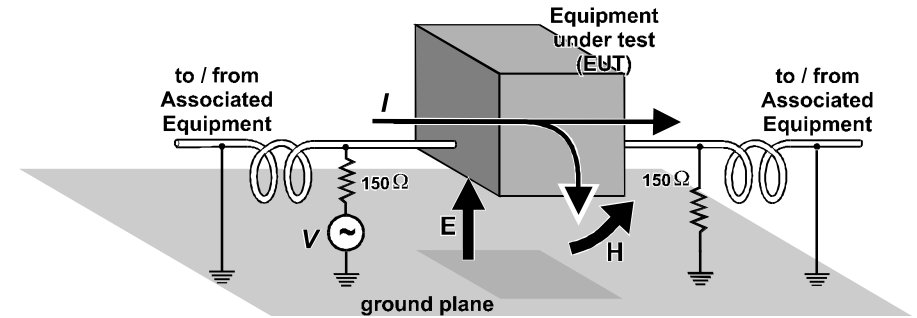
Type x46xx Versatile Coupling/Decoupling Network

User's Manual



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Overview

The Coupling/Decoupling Network or CDN is sometimes called an impedance stabilization network (ISN). It facilitates the testing of Electromagnetic Compatibility (EMC) by coupling interference directly to or from the cables associated with the Equipment under Test (EUT).

EN 61000-4-6 describes a method for *immunity* testing over the range 150KHz to 230MHz. This simulates radiated field testing by injecting interference onto the associated cables. There are two key benefits. The first is that testing does not require a calibrated test chamber and so costs much less and is more accessible to design modification. The second is that reproducibility is better because of the independence of room resonances and reduced sensitivity to the exact layout of the EUT and its cables.

A CDN network is fitted onto each of the cables connected to the EUT. One network is used to couple interference power into the EUT from an amplifier, whilst any others decouple the EUT from its environment and establish the desired 150ohm common-mode cable impedance. The EUT is supported above a ground plane to control the electric and magnetic fields applied during the test.

EN55022 includes limits and methods of measurement cable-borne *emissions* over the frequency range from 150KHz to 30MHz and, whilst recommending the use of the CDNs in EN 61000-4-6, sets out further possibilities including more specific coverage of tele-communication ports. Versatile CDNs from Richard Marshall Limited embody many new user-friendly features that improve accuracy and reduce cost, whilst retaining compatibility with both standards.

46 Series Features

The 46 series is *versatile*. Each member may be set up for use with a variety of shielded or unshielded cables and so replaces several of the basic networks given as examples in appendix D of EN 61000-4-6. This considerably reduces the stock of CDNs required to accommodate varied test situations and so overcomes the most widely recognised problem with the test method. This breakthrough has been achieved by the use of specially-designed internal components and links in the input and output connectors. Two family variants are available as follows;

The “Standard” S46xx variant combines the versatility described above with 100% compliance to the most strict application of the procedures in EN61000-4-6. The generator source impedance forms a part of the EUT interface impedance, giving rise to the requirement for the traditional power attenuator and pre-test calibration procedure described in EN 61000-4-6 using a pair of impedance adaptors such as our type 46ZZ.

The “Enhanced” E46xx variant offers built-in voltage monitoring that makes it independent of the generator source impedance. This improves accuracy and traceability by allowing continuous and direct calibration without need of off-line checks. It frees voltage and frequency calibration from dependence on the characteristics of specific cable, attenuator and amplifier parameters. Thanks to the voltage monitor the E46xx has no need of a defined rf power source impedance, avoiding the power attenuator required in other systems to stabilize this impedance. This gives an immediate saving of cost and complexity whilst leading to a reduced power requirement for the drive amplifier that can further reduce system cost. Immunity tests to the severe “Class A” level of 10volts with 80% superimposed amplitude modulation require an amplifier of only 5watts nominal rating.

This enhanced variant is particularly recommended as providing the highest performance at the lowest system cost for pre-compliance and production testing. The E46xx versions are supplied complete with the manufacturers calibration curves, but if desired they may be checked on-site using 46ZZ impedance adaptors.

Cautions

Any power supplies passing through a CDN should be fused at or below the current specified for that CDN.

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If the network is used with an Equipment Under Test (EUT) that *sources* a voltage, this voltage might be touched on the pins of the VCDN’s Associated Equipment (AE) connector if this were un-mated with the EUT switched on. Take care to avoid this.

If used with voltages above 50Vac or 75Vdc **there must be an effective safety earth connection** to at least one of the earth terminal brackets and to the AE cable shield and/or earth wire if appropriate.

Whilst it is itself passive, use of this item may lead to the emission of radio frequencies. Therefore it must only be used by EMC specialists within a controlled test environment.

Function and References

This network is intended for EMC immunity testing according to EN 61000-4-6 or ENV 50141, which is called up by EN50082-2, and for emission testing according to EN55022 and CISPR15 (CIS/F/434/FDIS). Reference should be made to these documents for general advice on test set-up, test method, and test limits. Read this manual in conjunction with the circuit diagram and Connection Scheme Drawing supplied.

Application Notes

User circuit: Isolation is provided between the EUT and the AE by the high series impedance of the special common-mode choke assembly L1,L2. When used with **shielded cables** the shield is earthed at the AE-side connector.

When used with **unshielded cables** a low-impedance to ground is provided at this point by the shunt decoupling of capacitors C1 to C25, which are installed according to product variant and wired to the active cable cores by links in the AE cable connector shell - see the “Connection scheme” drawing. If the user circuit carries high frequencies then the shunt capacitance of the capacitors provided may be unacceptable. In this case the links to them in the AE connection socket may be omitted with some increase in the emission level from the AE cable that may be reduced if desired by using shielded cable here. In the case of x46ST6 and x46M3 additional capacitors C26 and C27 are provided to reduce cable-borne emission at low test frequencies (say, 150KHz to 1.5MHz). Note that R1 & R2 provide safety discharge paths for these capacitors.

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With user cables operating **at radio frequencies or high data rates** the possibility of reflections due to any discontinuity of differential-mode characteristic impedance may need to be considered. If necessary this should be minimised by making up special I/O cables to match the system specification. There remains the cable within the VCDN, which has an electrical length of about 1metre, and so may have a significant effect at and above the frequency at which it becomes a quarter-wavelength long, ie 75MHz. Any such problem may be alleviated by adding an attenuator - preferably a "minimum loss" attenuator to match the two impedances concerned - within each of the I/O connectors to the VCDN.

Injection: The rf power input is provided with the correct source impedance for injection onto the EUT cable by 6, 8, or 24 resistors R40-R63 in parallel. In the case of a "Standard" network S46xx this parallel impedance is 100 ohms, leaving 50 ohms to be provided by a precision attenuator between the CDN and the associated power amplifier, as is shown in EN 61000-4-6.

In the case of an "Enhanced" network E46xx this parallel impedance is set to 150ohms because the voltage applied to the network is being monitored locally; In this respect the network differs from those shown in EN 61000-4-6 where the 50ohm source resistance has to be allowed for in series with the network which consequently contributes only 100ohms of the source impedance.

Capacitors C40 to C63 according to population prevent the injection network from upsetting dc potentials within the AE-EUT cable.

If the EUT cable is shielded then injection is onto the shield. For unshielded cables injection may be by resistors to each of the cable cores as described in EN 61000-4-6, or by transformer action as described in EN55022. The details of the connections are shown in the "Connection scheme" drawing.

In the case of an "Enhanced" network E46xx R7 to R10 limit the standing-wave ratio on the line from the power amplifier. They do not provide a perfect match since this would be wasteful of power. The rectifier D1 and its associated components provide a high-impedance monitor output, allowing the test engineer to maintain a precisely repeatable injection voltage source. C30 and C31 prevent any dc component of the rf source from upsetting the monitor calibration. R15 should avoid damage to the monitor if the rf power is briefly connected to it by mistake!.

The monitor output should only be connected to a load of at least 1Megohm and with not more than 500pF of capacitance if it is to maintain calibration and follow 1KHz modulation accurately. In use, the rf power should be adjusted to obtain the desired monitor output by reference to the calibration chart. A portable digital voltmeter can be used for this purpose. If the injected power is modulated then the monitor output will follow this modulation. If the DVM is average-sensitive (as most low-cost items are) then it will continue to indicate the carrier level. An oscilloscope may be substituted to inspect the modulation envelope or measure the peak voltage.

Application Adaptation

The network is customised by the use of suitably-wired connectors as shown in the appropriate application drawings.

It should be noted that the connection layouts of the connection cables are such that initial setup of the EUT does not need the CDN to be in place: the AE side and EUT side connectors may be directly plugged together. They may be secured with elastic bands, or with "Dtype Couplers" available from Farnell Electronic Components as 150-763.

Users may construct further connecting cables from scratch using D-type connectors with dimpled shells. Alternatively, Richard Marshall Limited will design and supply.

The connector sets may be identified by the label colour and function code. Most cable sets are compatible with more than one type of CDN:

CDN code	x46ST6	x46ST8	x46T24	x46S25	x46M3
Cable set					
S1	√	√			
S6	√	√			
S8		√			
S25				√	
T6	√				
T8		√			
T24			√		
M2	√ 3 amp	√ 1amp			√
M3	√ 2 amp				√

It is also possible for the user to parallel the cores of the standard cables to allow use with fewer circuits. For unshielded cables where resistive coupling is used all conductors must be used and the number of parallel elements must be the same for each conductor - eg a T8 cable set may be used for T4 and T2 but not for T3. Note that this reduces the characteristic impedance of each pair: In the case of high-speed data circuits this may need to be avoided, or its effects minimised by adding a series attenuator. In the case of shielded cable sets any number of the cores provided may be used and the remainder connected to the shield.

Whilst BS EN 61000-4-6 allows the Network-to-EUT cable to be up to 30cm long, it is recommended that this cable be cut to the minimum allowed, that is 10cm, if it is desired to maximise the reproducibility of tests at higher frequencies. *If this is done, useful tests may be performed at up to 500MHz using E46xx CDNs.*

“Connection scheme” drawings for *decoupling* are identical to those provided for couplers. When the S46xx is used for this purpose a 50ohm load should replace the rf input at the BNC socket. *However, a short-circuit should be applied at this point if an E46xx is used for decoupling.*

Earthing: The brackets provided project slightly to provide a direct connection to the ground-plane. A good connection is important for safety, for accuracy and for minimum emission from the AE cable, so ensure that contact surfaces are kept clean. Preferably screw the VCDN brackets to the groundplane, or use the sprung retainers supplied with the 46GP. When used at dangerous voltages provide an additional **cabled** ground connection to a VCDN bracket.

Emission Testing

CISPR15 allows the usual 30cm cable between CDN and EUT. However EN55022 requires an 80cm cable here. Appropriate extension cables may be made by the user or are available from RML.

Allowing for tolerances S46xx CDNs have an effective series resistance of 105ohms. For emission testing readings into 50 ohms should be corrected by adding a 10dB voltage division factor as described in para. 9.5.2 e) of CISPR22 or Figure B2 of CISPR15.

E46xx CDNs require the use of a type 22L Emission Receiver Adaptor. The receiver correction to be applied is given in the 22L documentation.

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Confidence test

In case of doubt remove the lid and check visually for over-heating of resistors. Note that the lid is keyed so that it may only be replaced in the position in which the label reads correctly. *For the enhanced variant check that the impedance at the rf input socket is 170ohms +/- 5%. and that the impedance at the monitor socket is that of a diode (anode to common).*

Calibration

Since the CDN is characterised with an output impedance of 150ohms, calibration requires an impedance adaptor as defined in EN 61000-4-6 Fig7e. This adaptor is itself calibrated in a test of a back-to-back pair: Such a pair, with BNC connectors and a universal interface connector for x46xx series CDNs, can be supplied by Richard Marshall Limited as product code 46ZZ. In the case of the “Standard” variant calibration depends not only on the CDN but also on the power amplifier and/or power measuring device, on the power attenuator, and on the cables connecting these items. Careful configuration management is required, and calibration must be carried out whenever one of these items is changed. The method is described in EN61000-4-6 paragraph 6.4.

The calibration of “Enhanced” CDNs is independent of the ancillary rf items, and need only be checked annually or after suspected misuse. The 46ZZ adaptors and a reference 50ohm rf voltmeter are then required, or the VCDN may be returned to the manufacture.

Safety Testing

Note that the 46Mx CDNs **only** should be subjected to high-current earth-bond tests. Such tests should be applied between the AE and EUT cable earth wires. A separate test may be performed between the CDN earth brackets and the CDN’s D-type connector shells, but do not perform a high-current test between the **cable** earth wire and the CDN metal parts, since these parts are linked only for functional purposes.

Waste Electrical and Electronic Equipment Directive

Please ensure that this product is ultimately disposed of in an environmentally-friendly way. If in the EC, take care to conform to the local implementation of the WEEE Directive

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Series 46 VCDN Specification

Injection/receiver circuit:

EUT rf common-mode impedance: $150\Omega \pm 20\Omega$ from 0.15 to 26MHz.
 $150\Omega + 60 - 45\Omega$ from 26 to 230MHz.

For E46xx the whole of this impedance is provided within the CDN: For S46xx the CDN provides 100 ohms and relies on the rf source to provide the remainder.

Rf input/output: BNC socket. Maximum continuous input power 3 watts (50 Ω equivalent).

“High power” versions accept 27 watts (50 Ω equivalent) for 30 volts emf modulated testing and impulses up to 1KV.

For E46xx only: VSWR < 2.5:1 referred to 50W.

*Monitor output (E46xx only): BNC socket. Frequency dc to >2KHz.
Load $\geq 1M\Omega$*

Nominally 1volt dc per volt rms rf carrier or modulation.

User circuit:

As required by EN 61000-4-6 the basic injection impedance of 150 Ω in series with 30nF is applied directly to any cable shield (in the x46S25 and certain configurations of the x46ST6 and x46ST8) and cannot then affect the working circuit.

With unshielded cables proportionately higher-impedance injection components are connected to each core as in EN61000-4-6. For example, these amount to 450 Ω in series with 10nF from each conductor of a 3-wire mains circuit in E46M3 or a suitably-configured E46ST6, and 3,600 Ω in series with 1.2nF across each of six unshielded balanced pairs configured within an E46T24.

Alternatively, this direct connection to the cores of unshielded cables may be avoided by using x46ST6 or x46ST8 or x46S25 in the transformer-coupled configuration of EN55022 figure D3.

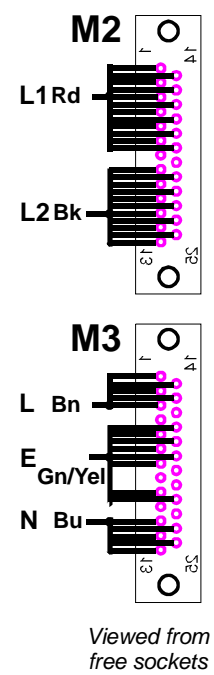
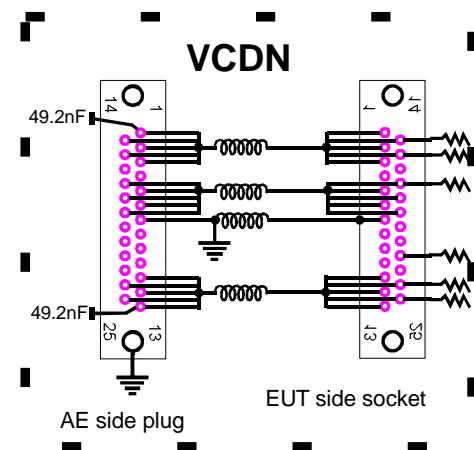
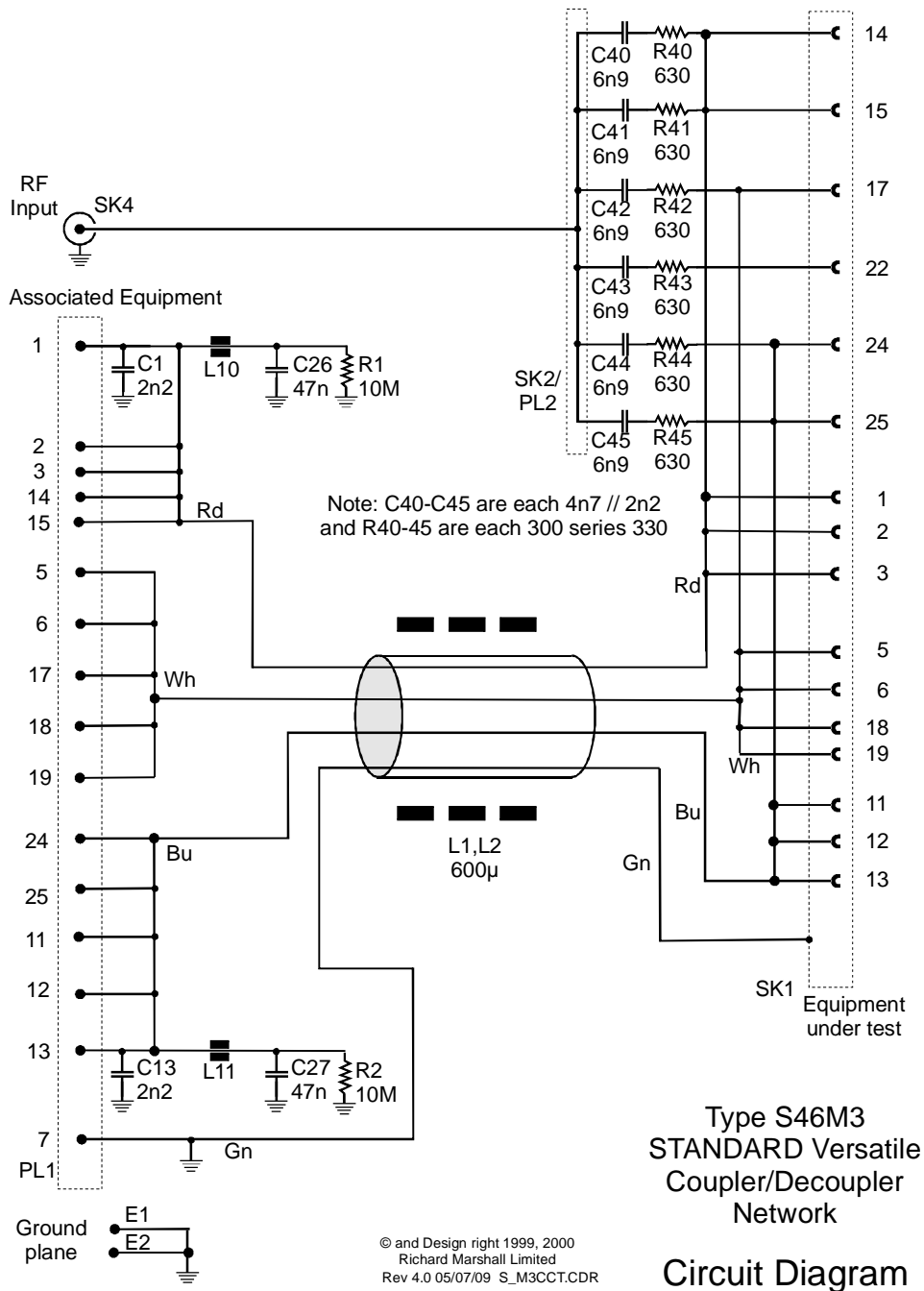
Connectors:	Input 25way D-type male. Output 25way D-type female.
Max volts:	250 Vac, except that the overvoltage capability of x46ST8 and x46S25 is limited and they should not be used on mains circuits. x46T24 is limited to 100 volts peak.
Max. current per core:	x46ST6 1A; x46ST8, x46S25 & x46T24 0.25A; x46M3 16A.
Max. unbalanced current per cable:	100mA peak or dc.
AE Filter capacitance:	x46ST6 nil or 220pF per core with 47nF available on 2 cores; x46ST8 nil or 47pF per core; x46S25 none required; x46T24 47pF per core; x46M3 49nF on L and N. All capacitors (except for x46T24) are safety rated.
Characteristic impedance:	50 Ω for the x46ST6, x46ST8 and x46S25 in S1 configuration.
Longitudinal conversion loss:	typically >60dB for x46ST8

Dimensions: 115 x 90 x 80mm excluding connectors.

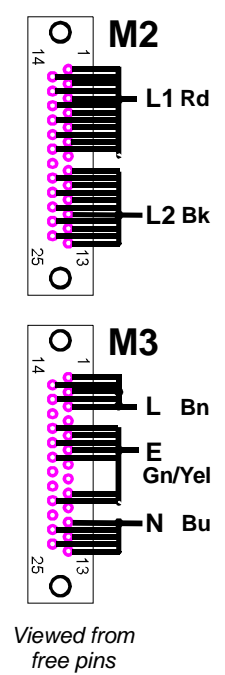
*In the search for improved quality this specification is subject to change.
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AE side cable & socket
Typical cable length 1.7m



EUT side cable & plug
Standard cable length 30cms

M2 as shown is also useable with the x46ST6, x46ST8, and x46T24 CDNs subject to their voltage and current limitations.

M3 as shown is also OK with x46ST6 CDN subject to its voltage and current limitations.

M1 may be implemented with either of the above by paralleling the leads.
NB: To avoid saturation low-frequency or dc current flow should be kept below 100mA peak.

**Connection Schemes
CDN Models x46M3**

Type 22L Emission Adaptor for E46xx Versatile CDNs

User's Manual

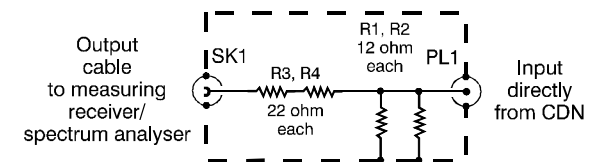
Overview

This adaptor matches the 50 ohm input of a measuring receiver or spectrum analyser to the rf port of ENHANCED VCDNs. No adaptor is required for the STANDARD versions. For details see the 46xx manual.

It may also be employed as the "Short-circuit termination" needed when using E46xx Networks as *decoupling* networks.

Description

The adaptor comprises an "L" section attenuator that adds minimally to the Enhanced CDN common-mode impedance of 150ohms whilst presenting a matched 50ohms to the measuring receiver or spectrum analyser. The combination of CDN and adaptor emulates the ISN shown in Figure D4 of EN55022.



Receiver correction Factor

The voltage presented to a matched 50ohm load is 34.3dB below that present on the EUT cable connected to the associated E46xx CDN. That is, 34.3 should be added to the receiver dB(μ V) reading before comparing the figure with the dB(μ V) limits given in tables 3 and 4 of EN55022.

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