TECHNICAL NOTE

Coupling Decoupling Networks (CDNs) for EMC Conducted Immunity Testing

Comprehensive Guide with Real-Life Application Examples

Per IEC/EN 61000-4-6 Conducted RF Immunity Standard

Featuring Com-Power Corporation CDN Product Solutions

January 2026

1. Introduction to Coupling Decoupling Networks

A Coupling Decoupling Network (CDN) is an essential device used in conducted RF immunity testing per IEC 61000-4-6. The CDN enables controlled injection of disturbance signals into power, communication, and data lines connected to the Equipment Under Test (EUT).

CDNs are the **preferred injection method** because they provide the lowest uncertainty of applied EMI stress and best decoupling of auxiliary equipment.

1.1 Primary Functions

1. **Coupling:** Transfers RF energy from test generator to EUT, simulating real-world EMI.
2. **Decoupling:** Prevents RF from affecting power source or auxiliary equipment.

2. Theory of CDN Operation

CDNs consist of passive components—resistors, capacitors, and inductors. The design ensures 150Ω common-mode impedance at the EUT port, representing typical cable impedance when excited by RF fields.

2.1 The 150Ω Common-Mode Impedance

IEC 61000-4-6 specifies 150Ω ± 20Ω common-mode impedance, established by 100Ω internal resistors combined with the 50Ω RF source impedance.

Table 1: CDN Circuit Elements

Component	Function	Specification
100Ω Resistors	Establish 150Ω CM impedance	100Ω + 50Ω = 150Ω
Coupling Capacitors	Couple RF to EUT lines	Low Z at RF frequencies
Decoupling Chokes	Block RF to AE port	≥280 µH at 150 kHz

3. IEC 61000-4-6 Test Requirements

The standard defines test methodology for conducted RF immunity from 150 kHz to 80 MHz (extendable to 230 MHz). Test signal is 80% AM modulated with 1 kHz sine wave.

Table 2: IEC 61000-4-6 Test Levels

Level	Voltage (V) e.m.f.	Typical Application
1	1 V RMS	Residential, commercial
2	3 V RMS	Industrial environment
3	10 V RMS	Heavy industrial, near transmitters

4. CDN Categories and Selection Guide

Com-Power offers four CDN categories for all conducted immunity testing needs:

Series	IEC Designation	Cable Type	Application
M-Series	CDN-Mxx	Unshielded power	AC/DC power lines
S-Series	CDN-Sxx	Shielded/Coaxial	USB, coax, STP
T-Series	CDN-Txx	Unshielded balanced	Ethernet, telecom
AF-Series	CDN-AFxx	Unshielded unbalanced	I/O, sensor lines

5. Power Series (M-Series) CDNs

Product Link: https://www.com-power.com/products/cdns/power-series

The M-Series CDNs are designed for AC or DC power supply lines. They inject common-mode disturbances to each conductor and decouple signals to protect building mains.

5.1 Model Specifications

Model	Lines	Current	Frequency	Application
CDN-M125E	1	25 A	150 kHz – 230 MHz	PE line only
CDN-M225E	2	25 A	150 kHz – 230 MHz	DC power, L+N
CDN-M2100	2	100 A	150 kHz – 230 MHz	High-current DC
CDN-M325E	3	25 A	150 kHz – 230 MHz	Single-phase L+N+PE
CDN-M350E	3	50 A	150 kHz – 230 MHz	High-power 1-phase
CDN-M525E	5	25 A	150 kHz – 230 MHz	3-phase 3L+N+PE

Table 3: Com-Power M-Series CDN Specifications

5.2 Real-Life Use Cases

Use Case 1: Medical Patient Monitor (Single-Phase AC)

Application: Hospital patient monitoring system requiring IEC 61000-4-6 testing for CE marking and IEC 60601-1-2 compliance. Device operates on 120V/240V AC single-phase with L+N+PE connections.

CDN Selection: CDN-M325E (3-line, 25A) – Handles Line, Neutral, and Protective Earth with adequate current capacity for medical equipment (typically 2-10A).

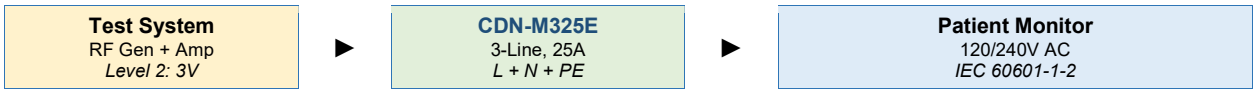

Figure 1: Medical Device Test Setup

Test Criteria: Monitor for alarm false triggers, display artifacts, SpO2/ECG waveform corruption, and communication failures. Medical standard requires Level 2 (3V) for healthcare facilities, Level 3 (10V) near MRI/electrocautery.

Use Case 2: Industrial VFD (Three-Phase AC)

Application: 15kW Variable Frequency Drive for motor control must comply with IEC 61000-6-2 for factory environments with welding equipment and two-way radios.

CDN Selection: CDN-M525E (5-line, 25A) – Accommodates full three-phase power (3L+N+PE).

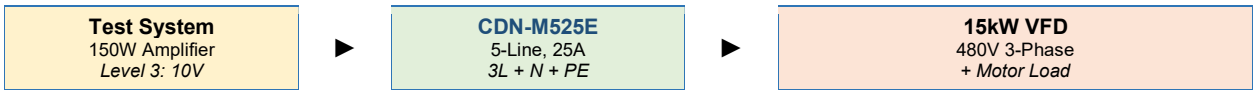

Figure 2: Three-Phase VFD Test Setup

Test Criteria: Monitor for motor speed fluctuations, fieldbus communication errors, fault codes, and unexpected trips. Industrial standards require Level 3 (10V) immunity.

Use Case 3: EV Charging Station (High-Current DC)

Application: Level 2 EV charging station with 80A DC output requires testing per SAE J1113-21 and IEC 61851-21-2 for deployment in parking structures with RF exposure from cellular equipment.

CDN Selection: CDN-M2100 (2-line, 100A) – For high-current DC output to vehicle battery.

Test Criteria: Monitor CAN bus/ISO 15118 communication integrity, charge current stability, safety interlock functionality, and ground fault detection. EVSE requires 10V immunity.

6. Screened Series (S-Series) CDNs

Product Link: https://www.com-power.com/products/cdns/screened-series

S-Series CDNs are for shielded cables, coaxial lines, and screened data cables. Signal couples to the **cable shield** (not individual conductors), making them independent of conductor count. Several models function as both CDN and ISN.

6.1 Model Specifications

Model	Interface	Frequency	Application
CDN-C50E	50Ω Coax (N-type)	150 kHz – 230 MHz	RF equipment (CDN/ISN)
CDN-C75E	75Ω Coax (F-type)	150 kHz – 230 MHz	Video, CATV (CDN/ISN)
CDN-T8SE	Shielded RJ45	150 kHz – 230 MHz	STP Ethernet (CDN/ISN)
CDN-USB-AE	USB Type A	150 kHz – 230 MHz	USB 2.0 host ports
CDN-USB-BE	USB Type B	150 kHz – 230 MHz	USB 2.0 device ports

Table 4: Com-Power S-Series CDN Specifications

6.2 Real-Life Use Cases

Use Case 1: Broadcast Video Encoder (75Ω Coaxial)

Application: Professional HD-SDI video encoder for TV stations with high-power transmitters. Must comply with EN 55032 (emissions) and EN 55035 (immunity).

CDN Selection: CDN-C75E – For 75Ω coaxial cables. BNC-to-F adapters may be required. Also functions as ISN for CISPR 32 emissions testing.

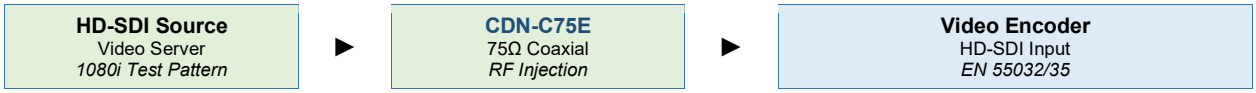

Figure 3: Broadcast Video Equipment Test Setup

Test Criteria: Monitor for video artifacts (sparkles, dropouts, color shifts), audio sync issues, encoder lockup. HD-SDI at 1.5 Gbps is sensitive to impedance mismatches.

Use Case 2: Industrial Label Printer (USB Interface)

Application: Thermal barcode printer for warehouse use with USB connection. Must operate reliably with nearby handheld RF scanners and wireless access points. EN 55032/35 compliance.

CDN Selection: CDN-USB-BE (Type B device port on printer) + CDN-USB-AE (Type A host port on PC).

Figure 4: USB Printer Test Setup

Test Criteria: Monitor for USB enumeration failures, print job corruption, communication timeouts, device disconnection. Verify barcode scan quality after test.

7. Telecom Series (T-Series) CDNs

Product Link: https://www.com-power.com/products/cdns/telecom-series

T-Series CDNs are for **unshielded balanced lines**, including Ethernet, telecommunications, and twisted-pair data. They're specific to the number of balanced pairs.

7.1 Model Specifications

Model	Lines/Pairs	Connector	Frequency	Application
CDN-T2E	2 / 1 pair	RJ11	150 kHz – 230 MHz	Telecom, POTS
CDN-T4E	4 / 2 pairs	RJ45	150 kHz – 230 MHz	10/100 Mbps
CDN-T8E	8 / 4 pairs	RJ45	150 kHz – 230 MHz	Gigabit Ethernet

Table 5: Com-Power T-Series CDN Specifications

7.2 Real-Life Use Cases

Use Case 1: VoIP Phone (Gigabit Ethernet with PoE)

Application: Enterprise VoIP desktop phone with Gigabit Ethernet and 802.3at PoE (25.5W) for office buildings with extensive wireless infrastructure. EN 55032/35 compliance.

CDN Selection: CDN-T8E (8 lines / 4 pairs) – Required for Gigabit Ethernet which uses all four twisted pairs. Handles PoE power delivery.

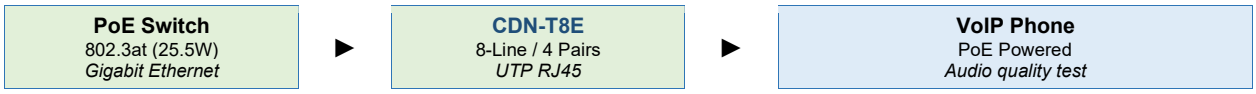

Figure 5: VoIP Phone with PoE Test Setup

Test Criteria: Monitor audio quality (clicks, dropouts, echo), display artifacts, call setup failures, PoE negotiation. Use VoIP metrics (MOS score, jitter, packet loss). Level 2 (3V) for commercial.

Use Case 2: DSL Modem (Telecom Line)

Application: VDSL2 residential gateway with RJ11 telecom connection. EN 55032/35 and telecom immunity requirements for homes with cordless phones and Wi-Fi routers.

CDN Selection: CDN-T2E (2 lines / 1 pair) – For RJ11 telecom line using single balanced pair (tip and ring).

Figure 6: DSL Modem Test Setup

Test Criteria: Monitor for DSL sync loss, speed degradation, CRC errors, FEC corrections, connection drops. VDSL2 extends to 30 MHz and may interact with upper-frequency immunity signals.

Use Case 3: IP Security Camera (10/100 Mbps PoE)

Application: PoE IP camera for outdoor installation near radio transmitters. Uses 10/100 Mbps Ethernet with 802.3af PoE (15.4W).

CDN Selection: CDN-T4E (4 lines / 2 pairs) – 10/100 Mbps uses only pairs 1-2 and 3-6. Supports 802.3af PoE on data pairs.

Test Criteria: Monitor video stream for artifacts, frame drops, latency spikes. Check camera reboot, focus motor, IR illuminator. Outdoor cameras require Level 3 (10V) immunity.

8. AF Series CDNs

Product Link: https://www.com-power.com/products/cdns/af-series

AF Series CDNs are for **unscreened, unbalanced cables** carrying low current signals. They feature 2mm shrouded banana socket connections for I/O lines, sensors, and control cables.

8.1 Model Specifications

Model	Conductors	Connector	Frequency	Current
CDN-AF2E	2	2mm banana sockets	150 kHz – 230 MHz	0.5 A
CDN-AF4E	4	2mm banana sockets	150 kHz – 230 MHz	0.5 A
CDN-AF8E	8	2mm banana sockets	150 kHz – 230 MHz	0.5 A

Table 6: Com-Power AF Series CDN Specifications

8.2 Real-Life Use Cases

Use Case 1: Temperature Controller (Thermocouple Input)

Application: PID temperature controller for plastic injection molding with Type K thermocouple inputs. Operating in industrial environment with heating elements and VFDs. IEC 61000-6-2 compliance.

CDN Selection: CDN-AF2E (2 conductors) – For each thermocouple input (TC+ and TC-). 0.5A rating adequate for microamp-level thermocouple signals.

Figure 7: Temperature Controller Test Setup

Test Criteria: Monitor for temperature reading errors (spikes, offsets, noise), control output oscillation, alarm false triggers. Thermocouple millivolt signals are sensitive to CM interference. Level 3 (10V) required.

Use Case 2: 4-20mA Process Transmitter

Application: Pressure transmitter for oil/gas with 2-wire 4-20mA current loop output to DCS. Operating in hazardous location with radio communications. NAMUR NE 21 compliance.

CDN Selection: CDN-AF2E (2 conductors) – For 2-wire current loop (signal+ and signal-/common).

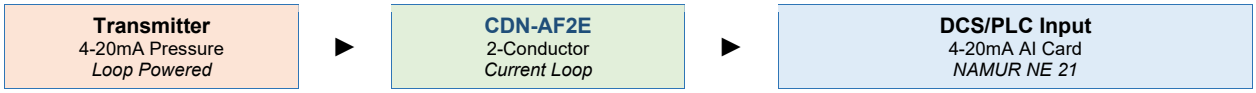

Figure 8: 4-20mA Current Loop Test Setup

Test Criteria: Monitor output current deviation (>1% of span unacceptable), measurement noise, HART communication errors. NAMUR NE 21 specifies Level 3 (10V) with strict accuracy requirements.

Use Case 3: Strain Gauge Signal Conditioner

Application: Signal conditioner for load cells in weighing system with 4-wire connection (Exc+, Exc-, Sig+, Sig-). OIML R76 compliance for legal-for-trade scales.

CDN Selection: CDN-AF4E (4 conductors) – Handles both excitation output and signal input of 4-wire strain gauge.

Test Criteria: Monitor weight reading instability, zero drift, non-linearity. Strain gauge signals (2-3 mV/V) are extremely sensitive to RF. Legal metrology has strict accuracy requirements.

9. Test Setup and Calibration

Proper calibration is essential for accurate testing. IEC 61000-4-6 specifies level-setting procedures using calibration adapters.

9.1 Required Accessories

- **150Ω to 50Ω Adapters (ADA-515-X):** Convert CDN impedance for measurement equipment
- **Shorting Adapters:** CDN-specific adapters that short EUT port for calibration
- **6 dB Attenuator:** Protects amplifier from reflected power

9.2 Calibration Voltage Relationship

Measured voltage at 150Ω to 50Ω adapter output = Open-circuit test voltage ÷ 6

Test Level	Open-Circuit (Uo)	Measured (Umr)
Level 1	1 V RMS	167 mV
Level 2	3 V RMS	500 mV
Level 3	10 V RMS	1.67 V

Table 7: Test Level Calibration Reference Values

10. References

10.1 International Standards

3. IEC 61000-4-6:2013, EMC Part 4-6: Immunity to conducted disturbances, induced by RF fields.
4. CISPR 16-1-2:2014, Coupling devices for conducted disturbance measurements.
5. CISPR 22/32, IT equipment radio disturbance characteristics.

10.2 Peer-Reviewed Publications

6. Sroka, J., "Practical approach to IEC 61000-4-6 testing," Semantic Scholar.
7. "Alternative conducted immunity testing with multiple CDNs," Semantic Scholar.
8. Joo et al., "Simulation-Based System-Level Conducted Susceptibility Testing," Electronics, MDPI, 2019.

10.3 Product Links

- Com-Power Power Series: com-power.com/products/cdns/power-series
- Com-Power Screened Series: com-power.com/products/cdns/screened-series
- Com-Power Telecom Series: com-power.com/products/cdns/telecom-series
- Com-Power AF Series: com-power.com/products/cdns/af-series
- IEC Webstore: webstore.iec.ch