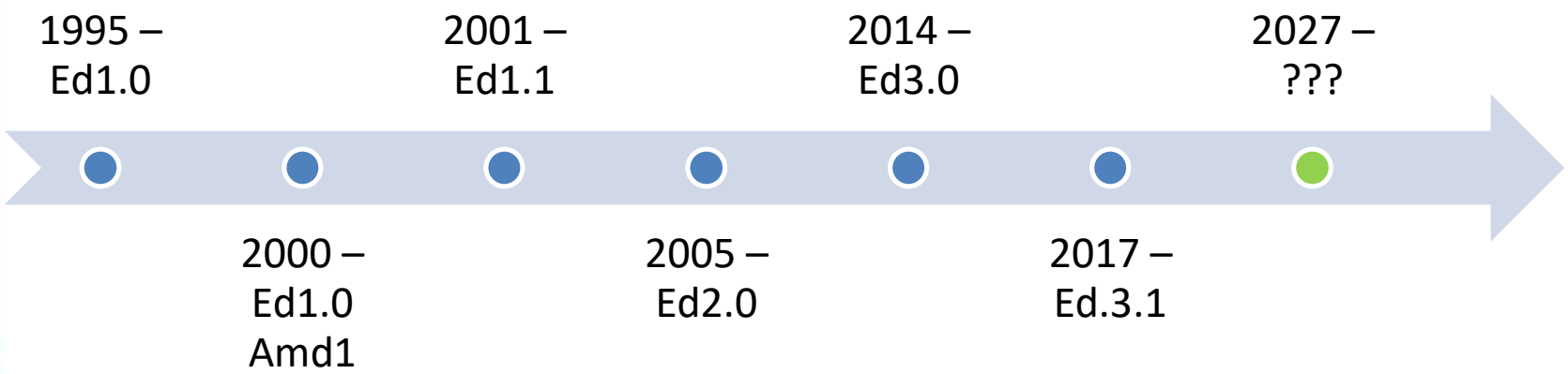
# IEC 61000-4-5

Electromagnetic compatibility (EMC) - Part 4-5
Testing and measurement techniques
Surge immunity test

SINCE 1952 VOLTA® S.p.A.

Competenza
ed entusiasmo per
soluzioni tecniche

# Timeline


1995 – Ed1.0
2000 – Ed1.0 Amd1
2001 – Ed1.1
2005 – Ed2.0
2014 – Ed3.0
2017 – Ed.3.1
2027 – ???

# Campo di applicazione

- Requisiti di immunità, procedure di prova e di taratura per componenti elettronici soggetti a impulsi mono direzionali causati da impulsi derivanti da transitori di commutazione e da fulminazioni nelle apparecchiature.

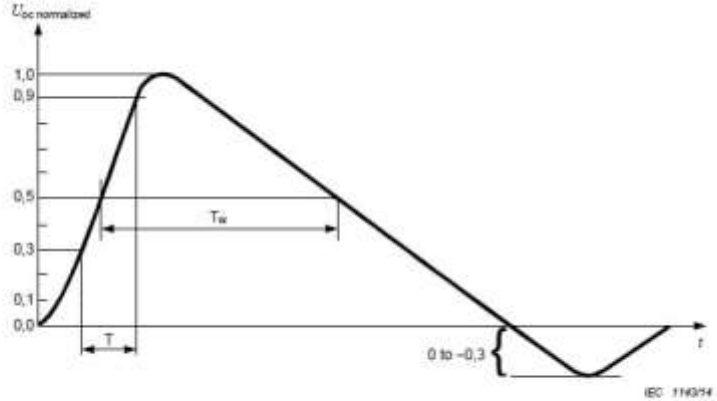
# Tipologia

- La norma fa riferimento ad immunità delle apparecchiature elettriche ed elettroniche sottoposte a fulminazioni sulle porte di alimentazione, di segnale, di controllo e di terra.
- Simula i disturbi causati dalla commutazione di carichi importanti, da guasti di sistema e fulminazioni.

# Ultimi cambiamenti

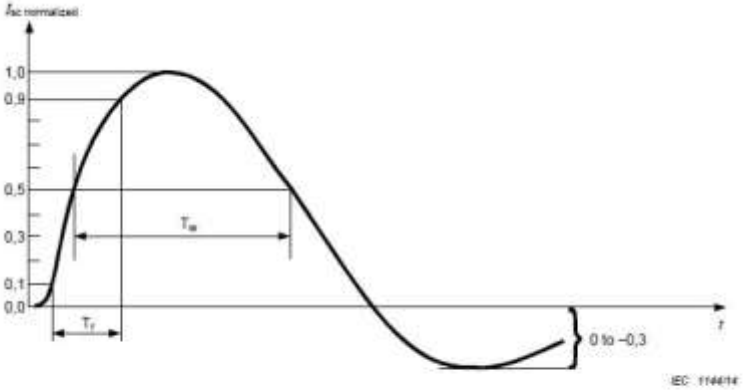
- Annex in sostituzione di par. 6.2 su surge telecom
- Annex sulla modellizzazione delle forme d’onda
- Annex sull’incertezza di misura
- Annex sul metodo di taratura
- Annex su CDN sopra 200 A
- Annex per prove di DC-DC converters

# La forma d'onda




Front time: $T_1 = 1{,}67 \times T = 1{,}2\ \mu s \pm 30\ \%$
Duration: $T_d = T_w = 50\ \mu s \pm 20\ \%$

NOTE The value 1,67 is the reciprocal of the difference between the 0,9 and 0,3 thresholds.

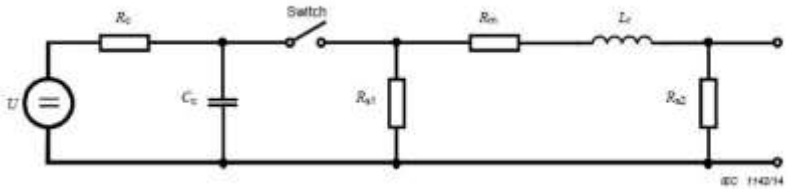



Front time: $T_1 = 1{,}25 \times T_r = 8\ \mu s \pm 20\ \%$
Duration: $T_d = 1{,}18 \times T_w = 20\ \mu s \pm 20\ \%$

NOTE 1 The value 1,25 is the reciprocal of the difference between the 0,9 and 0,1 thresholds.

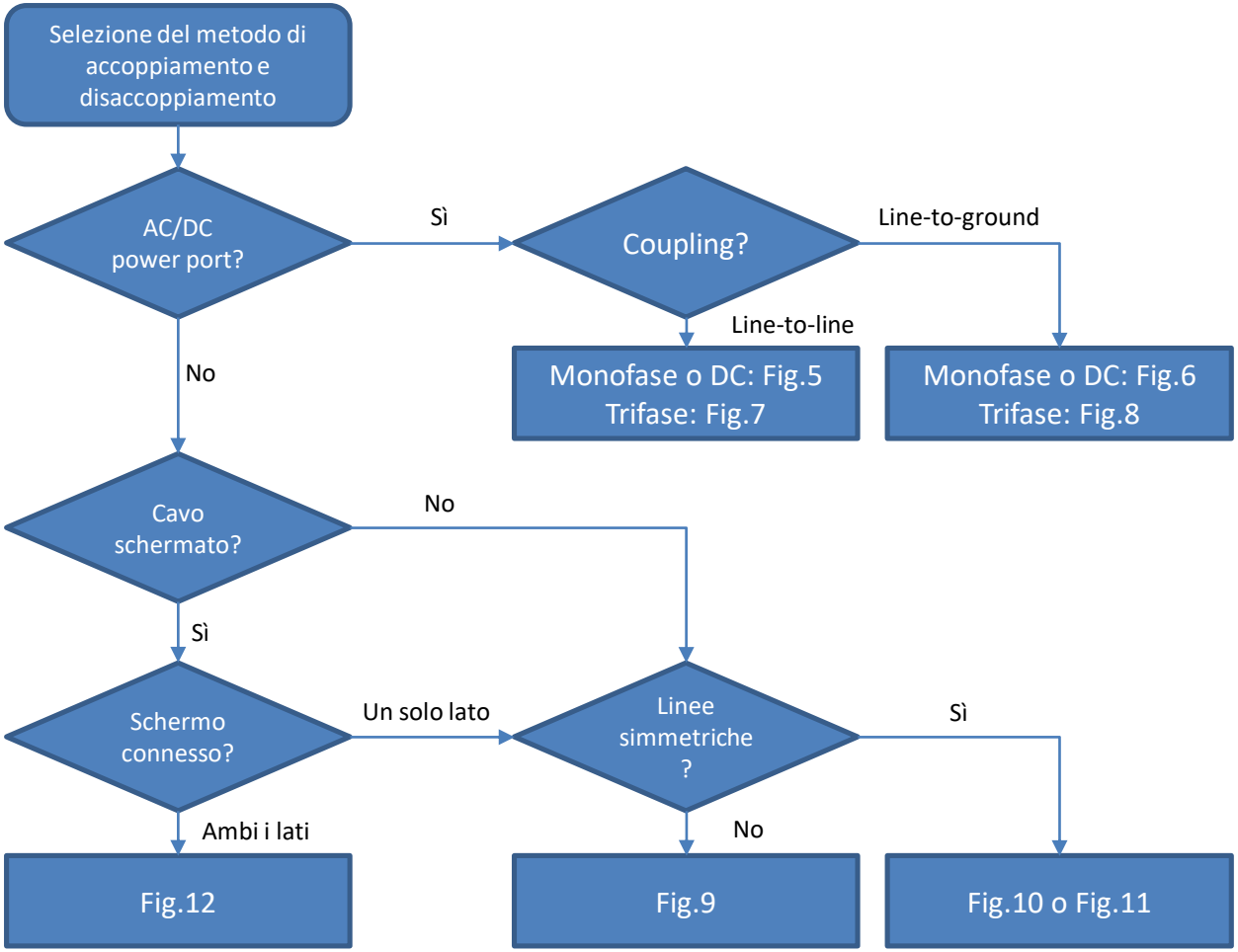
NOTE 2 The value 1,18 is derived from empirical data.

# Il fenomeno

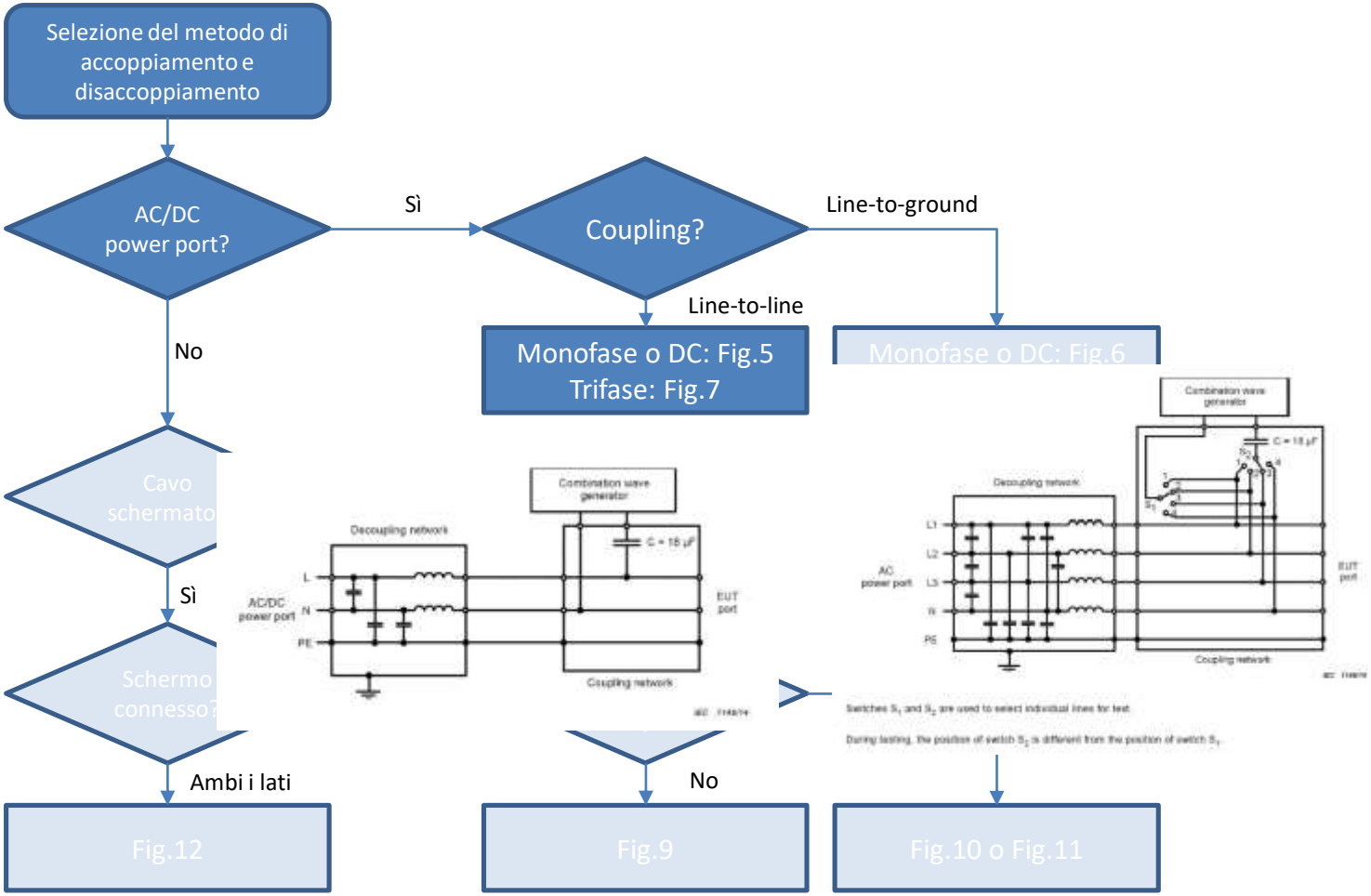



- Par. 6.2.1
  - Open circuit front time: 1.2 μs
  - Open circuit voltage duration: 50 μs
  - Short circuit front time: 8 μs
  - Short circuit current duration: 20 μs

# Scelta dell’accoppiamento



# Scelta dell’accoppiamento



# Scelta dell’accoppiamento

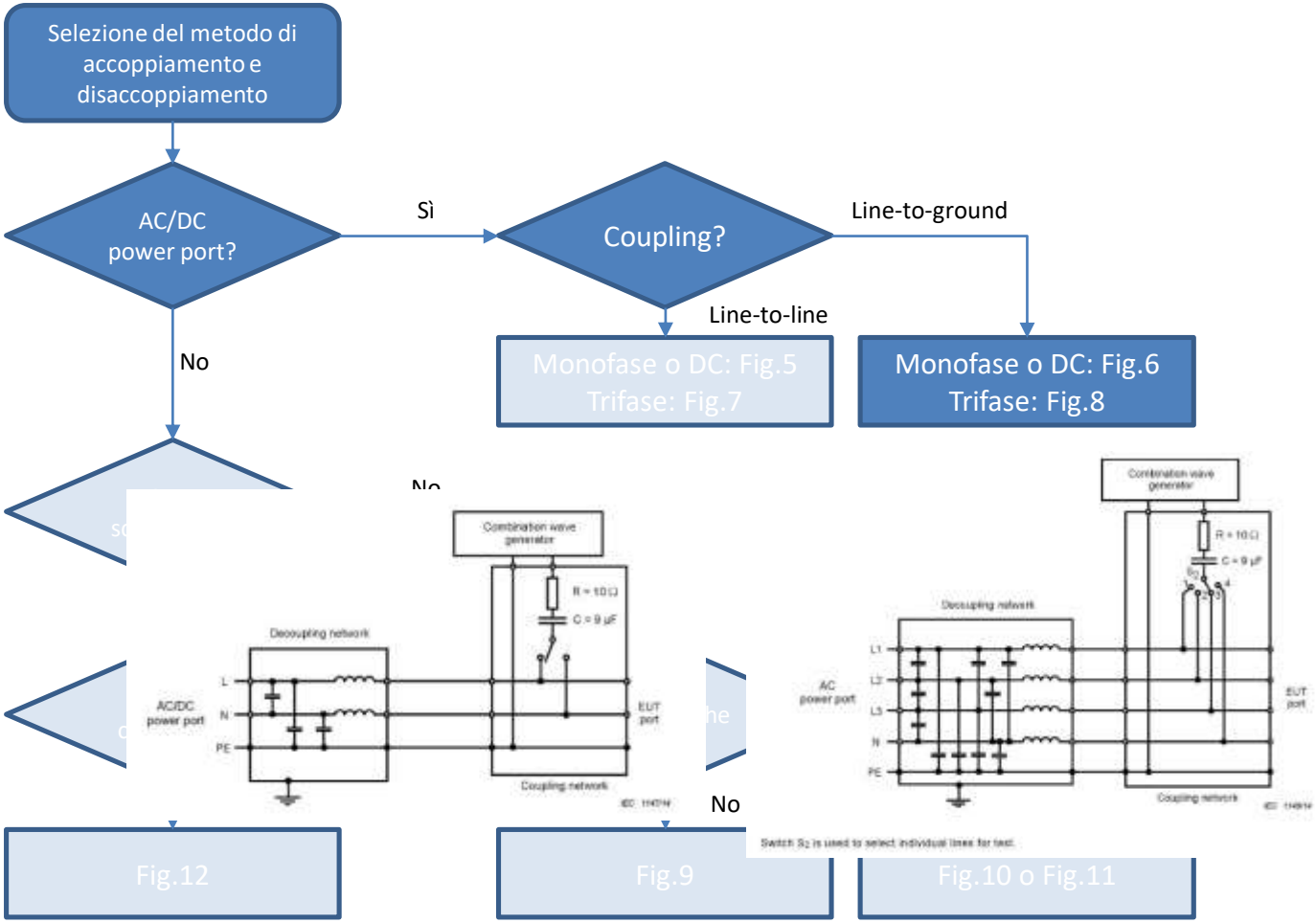


**Table 4 – Voltage waveform specification at the EUT port of the CDN**

| Surge voltage parameters under open-circuit conditions [a, b] | Coupling impedance | |
|---|---|---|
| | 18 µF (line-to-line) | 9 µF + 10 Ω (line-to-ground) |
| Peak voltage | | |
| Current rating ≤ 16 A | Set voltage +10 %/-10 % | Set voltage +10 %/-10 % |
| 16 A < current rating ≤ 32 A | Set voltage +10 %/-10 % | Set voltage +10 %/-10 % |
| 32 A < current rating ≤ 63 A | Set voltage +10 %/-10 % | Set voltage +10 %/-15 % |
| 63 A < current rating ≤ 125 A | Set voltage +10 %/-10 % | Set voltage +10 %/- 20 % |
| 125 A < current rating ≤ 200 A | Set voltage +10 %/-10 % | Set voltage +10 %/- 25 % |
| Front time | 1,2 µs ± 30 % | 1,2 µs ± 30 % |
| Duration | | |
| Current rating ≤ 16 A | 50 µs +10 µs/-10 µs | 50 µs +10 µs/-25 µs |
| 16 A < current rating ≤ 32 A | 50 µs +10 µs/-15 µs | 50 µs +10 µs/-30 µs |
| 32 A < current rating ≤ 63 A | 50 µs +10 µs/-20 µs | 50 µs +10 µs/-35 µs |
| 63 A < current rating ≤ 125 A | 50 µs +10 µs/-25 µs | 50 µs +10 µs/-40 µs |
| 125 A < current rating ≤ 200 A | 50 µs +10 µs/-30 µs | 50 µs +10 µs/-45 µs |

NOTE The current rating in Table 4 is the CDN rating.

[a] The measurement of the surge voltage parameters shall be performed with the a.c./d.c. power port of the CDN open-circuit.

[b] The values shown in this table are for a CWG with ideal values. In case the CWG generates parameter values close to the tolerances, the additional tolerances of the CDN may generate values out of tolerances for the CWG-CDN combination.

**Table 5 – Current waveform specification at the EUT port of the CDN**

| Surge current parameters under short-circuit conditions [a] | Coupling impedance | |
|---|---|---|
| | 18 µF (line-to-line) | 9 µF + 10 Ω (line-to-ground) [b] |
| Front time | $T_d = 1,25 \times T_r = 8$ µs ± 20 % | $T_d = 1,25 \times T_r = 2,5$ µs ± 30 % |
| Duration | $T_d = 1,18 \times T_w = 20$ µs ± 20 % | $T_d = 1,04 \times T_w = 25$ µs ± 30 % |

[a] The measurement of the surge current parameters shall be performed with the a.c./d.c. power port of the CDN open-circuit.

[b] The value 1,04 is derived from empirical data.

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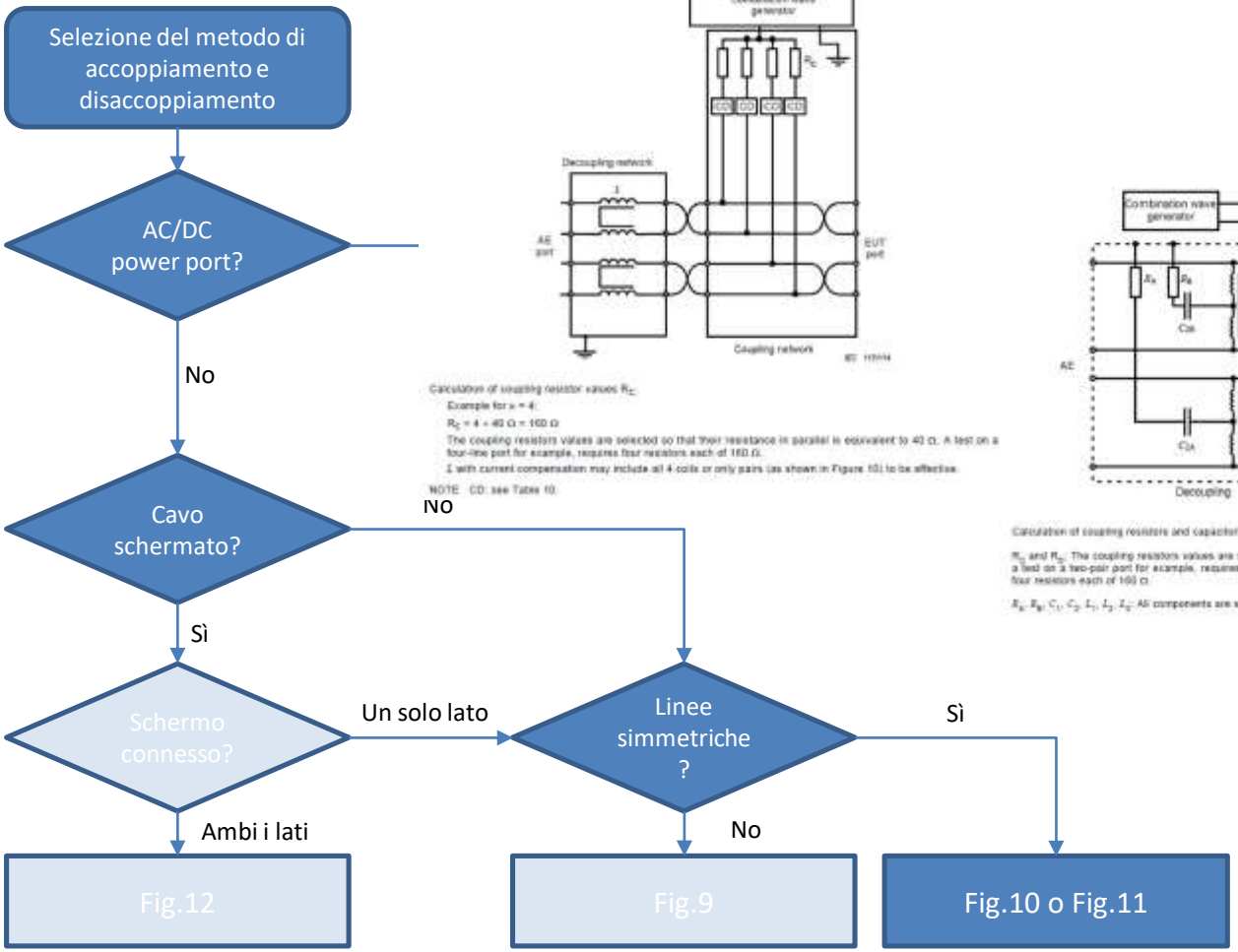
# Scelta dell’accoppiamento







Calculation of coupling resistor values $R_C$:

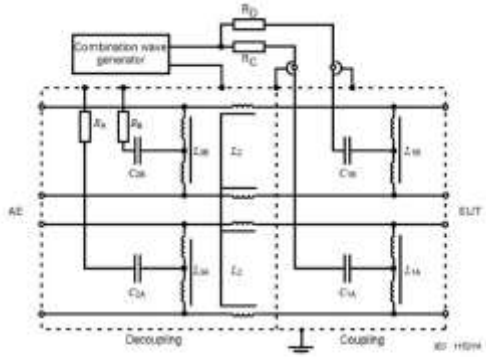
Example for $n = 4$:

$R_C = 4 \times 40\ \Omega = 160\ \Omega$

The coupling resistors values are selected so that their resistance in parallel is equivalent to 40 Ω. A test on a four-line port for example, requires four resistors each of 160 Ω.

Σ with current compensation may include all 4 coils or only pairs (as shown in Figure 10) to be effective.

NOTE CD: see Table 10.

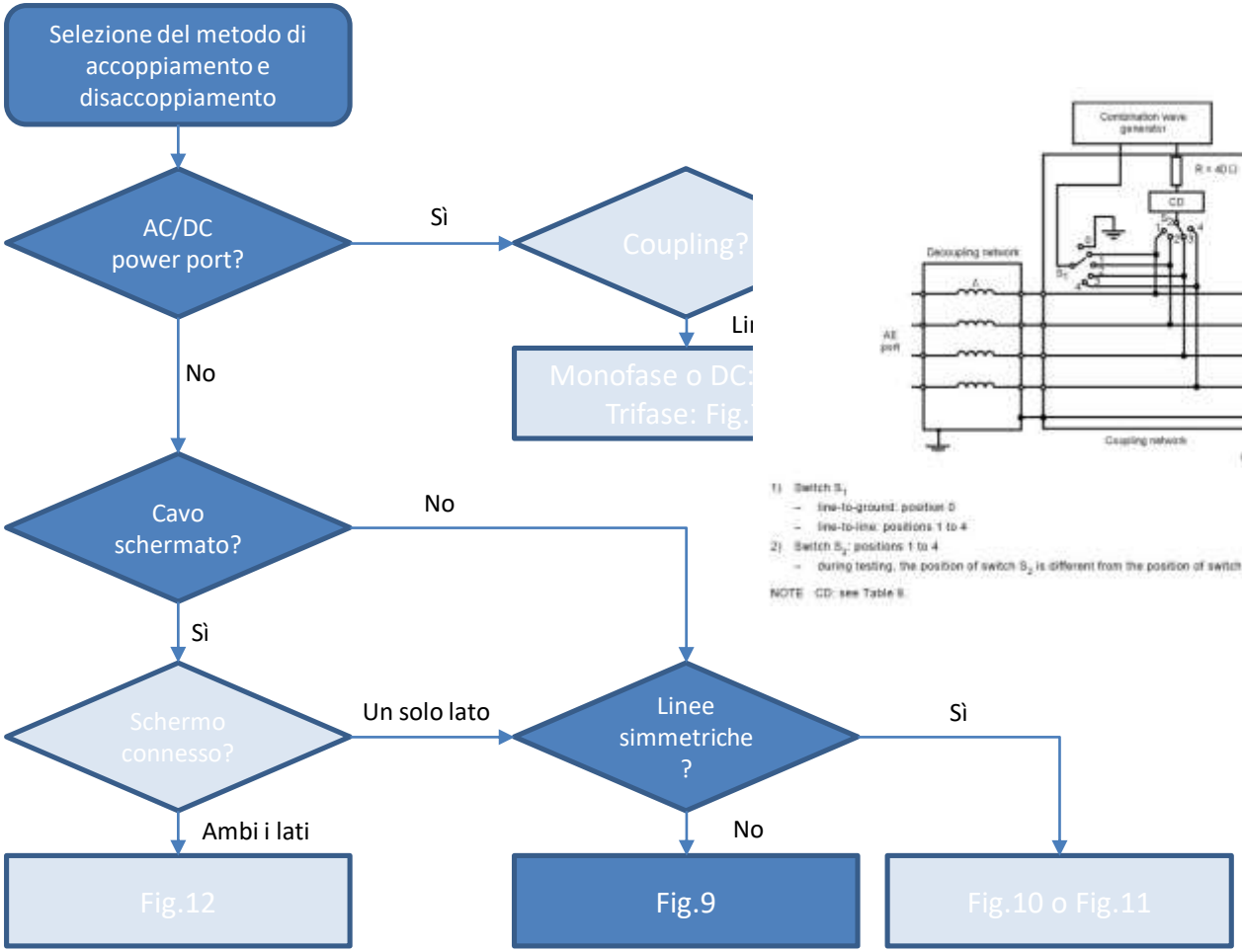


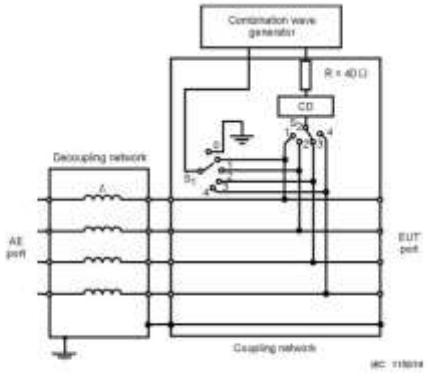

Calculation of coupling resistors and capacitors values:

$R_D$ and $R_C$: The coupling resistors values are selected so that their resistance in parallel is equivalent to 40 Ω. So, a test on a two-pair port for example, requires two resistors each of 80 Ω, and a test on a four-pair port, requires four resistors each of 160 Ω.

$R_A$, $R_B$, $C_1$, $C_2$, $L_1$, $L_2$, $L_3$: All components are selected so that the specified impulse parameters are met.

# Scelta dell’accoppiamento



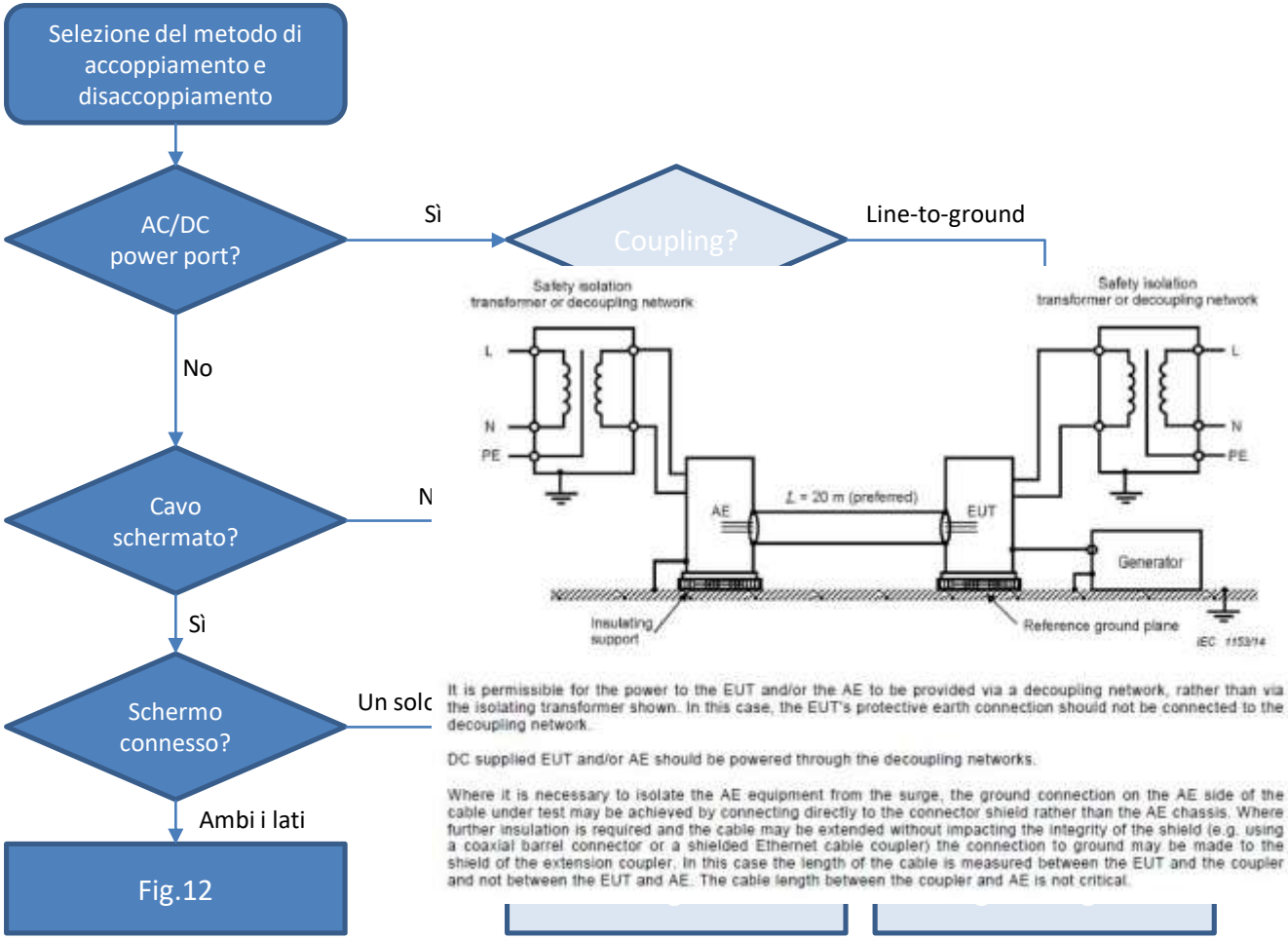




1) Switch $S_1$
- line-to-ground: position 0
- line-to-line: positions 1 to 4

2) Switch $S_2$: positions 1 to 4
- during testing, the position of switch $S_2$ is different from the position of switch $S_1$

NOTE CD: see Table 8.

# Scelta dell’accoppiamento



# Compact NX5

- Dalla Tab.4 abbiamo capito che le CDN possono coprire al massimo due range di correnti da < 16 A fino a 200 A
- Con **Compact NX5** e **Coupling NX5 trifase** si può ottenere una CDN che commuta per potere coprire continuativamente il range necessario di correnti nominali del provino

# Taratura

- 6.2.3 – Calibration of the generator
  - The characteristics of the generator shall be measured through an external capacitor in series with the output, both under open-circuit […] and short-circuit conditions at the same set voltage.
  - All performance characteristics stated in 6.2.2 […] shall be met at the output of the generator.

# Taratura

- 6.4 – Calibration of coupling / decoupling networks
  - […] The waveform parameters measured at the EUT port of the CDN are dependent upon the generator source and as such are only valid for the particular generator / CDN combination tested.

# Taratura

- 6.4.2 – Calibration of CDNs for AC/DC power port rated up to 200 A per line
  - All performance characteristics stated in 6.3.2 Tables 4, 5 and 6 shall be met at the output of the CDN with the AC/DC power port open circuit.

# Annex C (informativo)
# Note esplicative

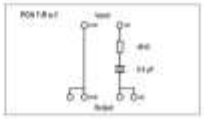
- L'impedenza da 2 Ω rappresenta l'impedenza della rete AC
- L'impedenza da 12 Ω rappresenta l'impedenza della rete AC tra alimentazione e terra
- L'impedenza da 42 Ω rappresenta l'impedenza tra «altre» linee e terra

# Reti di segnale DCD

# Applicazioni railway

**11.7.1. Railways application for 1-phase coupling with PCN 7-R s-1 as per EN 50121 standard**

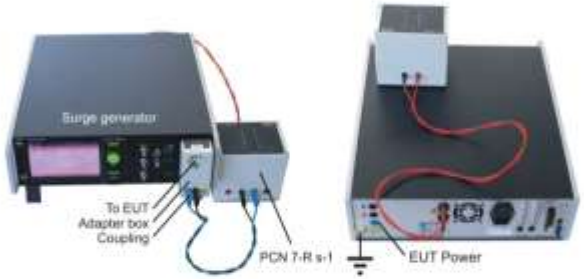
The PCN 7-R s-1 is a 1 - phase coupling network for manual coupling with an impedance of 42 Ω, 0.5 μF according EN 50121 standards
The decoupling network of the generator is used for decoupling the impulse.



**Application**

**Connections rearside:**
- HV cable red: HV generator - PCN 7-R s-1 Input HV
- HV cable black: COM generator - PCN 7-R s-1 Input COM
- Earth: Earth bolt generator - **to the system GND**

**Connections frontside**
Couplings: All couplings for surge pulses are realized with the connection from PCN 7-R s-1 Output to the adapter box connection coupling to the AC lines (L-N, L-PE, N-PE).




**Generator Setting**

Coupling: Select Internal HV – COM
Voltage setting: Set Surge voltage and repetition time and other required parameters

# Annex H (informativo) CDN sopra 200 A

- Verificare:
  - Se la prova di surge abbia senso
  - Se non si possa svolgere su sotto-assiemi della struttura
  - Se non si possa svolgere a potenza ridotta

# Annex H (informativo) CDN sopra 200 A

- Se non esistono CDN sul mercato:
  - Usare le figure 7 e 8
  - CDN di choke singolo o un cavo abbastanza lungo da fornire l'impedenza richiesta (1 m di cavo = 1 $\mu$H)

# Annex I (informativo) Problemi con DC-DC converter

- L'utilizzo di convertitori DC-DC al fine di minimizzare lo spreco di energia, porta ad una corrente di ingresso pulsata la cui frequenza può essere limitata dalla CDN, disegnata per lavorare a 50 Hz e 60 Hz.

# Annex I (informativo) Problemi con DC-DC converter

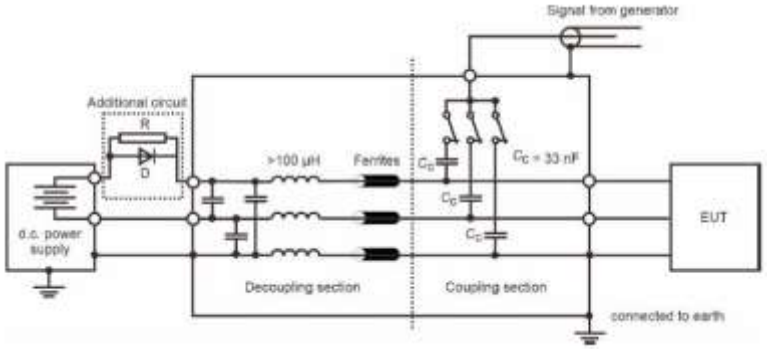
- Il passaggio a PWN (Pulsed Width Modulation) implica una forma d'onda in corrente complessa.
- L'induttanza di disaccoppiamento della CDN impedisce il passaggio di transizioni ad alta frequenze e riduce o azzera istantaneamente la tensione al provino.

# Annex I (informativo) Problemi con DC-DC converter

- La presenza di DC-DC converter implica anche un'induttanza aggiuntiva tra sorgente DC e converter che può causare oscillazioni e risonanze.
- Il margine di stabilità alle risonanze di un DC-DC converter in combinazione con la CDN non è conosciuto a priori dal laboratorio di prova.

# Annex I (informativo) Problemi con DC-DC converter

- Soluzioni:
  - Cambio di sorgente
  - Utilizzo di batterie
  - Inserimento di circuito serie di resistenza e diodo in parallelo
  - Utilizzo di CDN sovradimensionata (induttanza minore)



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