Grid Solutions

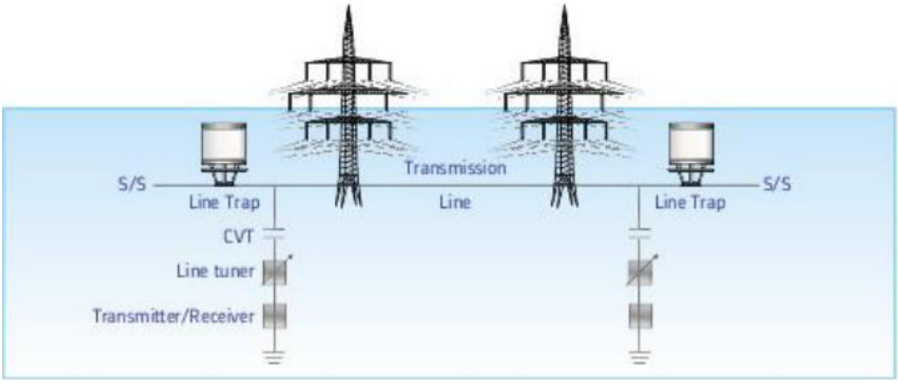
LINE TRAPS

Air Core, Dry Type Up To 800 Kv

At Grid Solutions at GE Vernova, the engineers have extensive experience in designing and supplying line traps for system voltages up to 800 kV, and the company has supplied customers all over the world for more than 35 years.

Light Weight Makes Mounting Flexible

Line traps are used in transmission and distribution networks around the world. Line traps are a key component in PLC (Power Line Carrier) systems used for remote control signals, voice communication, remote metering and control between substations in the electrical T&D network.



GE VERNOVA

Performance

- Up to 800 kV
- Can operate within the 30 kHz to 500 kHz frequency range

Characteristics

- Air core, dry type
- Outdoor use
- Compliance with IEC, ANSI or equivalent standard
- Mounting flexibility : vertical on top of Capacitor Voltage Transformer (CVT), vertical on top of insulator columns, horizontal or suspension.

Customer Benefits

- High short-circuit withstand capability
- Light weight
- Mounting flexibility
- Excellent cooling
- Extremely reliable tuning devices
- Self-resonance frequency greater than 500 kHz
- Maintenance-free design

Your partner in line traps

High voltage transmission lines are also used for transmitting carrier signals between 30 kHz and 500 kHz for remote control, voice communication, remote metering & protection, and so forth, and are often referred to as Power Line Carrier (PLC) systems.

Line traps prevent transmission of these high frequency signals to unwanted directions without loss of energy at power frequency. Line traps are series-connected to the transmission lines, and are designed to withstand the rated power frequency current and the shortcircuit current to which the lines are subjected.

Construction

Main coil

The main coil carries the rated current of the transmission line and is designed to withstand the maximum short-circuit current. To achieve reliable connections, all components carrying rated current are welded.

The construction of the line traps is made with well-proved techniques and materials.

Two winding technologies are used:

- OSD: Open Style Design
- MCD: Multi-wire Cable Design (Encapsulated)

OSD Design

The winding consists of high mechanical strength aluminum profiles of rectangular cross section. Depending on the current, one or more profiles are connected in parallel. Each turn is separated by fiberglass- reinforced spacers. The winding is held together by aluminum cross arms at the top and bottom end of the main coil, and one or more fiberglass tie rods.

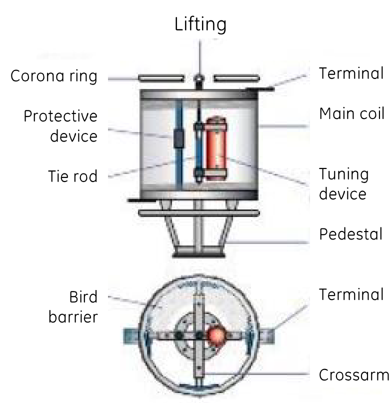


Fig. 1: Line trap main components

MCD Design

Its winding utilises insulated aluminium cables, connected in parallel. These conductors are mechanically immobilised and encapsulated in epoxy impregnated fiberglass filaments forming cylinders. Depending on the rated current and rated inductance, one or more of these cylinders are connected in parallel between aluminium crossarms. The individual cylinders are separated by fiberglass spacers which form the cooling ducts.

Extremely Reliable Tuning Devices

This key sub-component of a line trap is mounted inside the main coil on the central tie rod. It is easily accessible and exchangeable. It can be replaced without removing the line trap from the line.

All components are chosen to ensure exceptional operating reliability and a long service life.

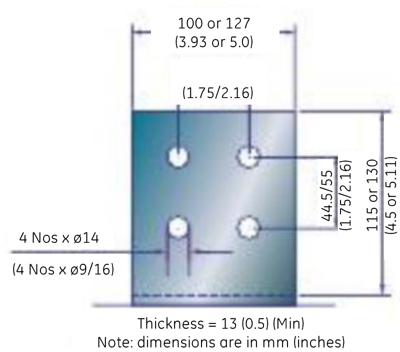


Fig. 2A: Terminals details

The tuning device can be factory fixed or field adjustable, designed for single-frequency, double-frequency or wide-band tuning. In addition, the tuning device can be furnished for use in line traps of other manufacturers.

All components are encapsulated in a triple weather-protection housing resistant to ever-changing environmental conditions and mechanical shocks.

The temperature coefficients of the tuning device elements are chosen to yield a very high degree of tuning consistency.

Protective Device

The protective device is connected across the main coil and the tuning device to prevent the line trap from being damaged by transient overvoltages. Its ratings are chosen to respond to high transient overvoltages, but it will not operate as a result of the power frequency voltage developed across the line trap by the rated short-circuit, nor will it remain in operation after the response to a transient overvoltage developed across the line trap by the rated short-circuit.

Gapless (or gapped) metal-oxide (ZnO) or gapped silicon carbide (SiC) types are used depending on the line trap characteristics.

Mounting

Suspension Mounting

All line traps are equipped with a lifting lug, which is bolted directly to the central tie rod. For this type of mounting, an eyebolt is similarly added to the bottom cross arm to anchor the line trap and prevent swaying. Two, three or four-point suspension can be provided upon request.

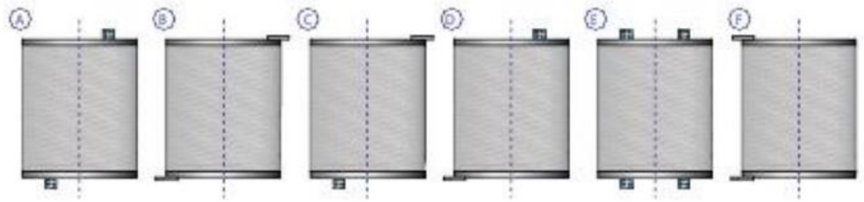


Fig. 2B: Terminals arrangements

Pedestal Mounting

Vertical mounting

For this type of mounting, the line traps feature an aluminum pedestal. The pedestals have adequate height to prevent excessive heating of the post insulator or coupling capacitor voltage transformer (CCVT) fittings due to the magnetic field of the main coil.

Small or medium sized line traps can be mounted directly on a single post insulator or CCVT by using a pedestal (vertical pedestal).

The number of columns and other mounting details of the vertical pedestal type can be adapted to meet customer requirements.

Horizontal mounting

Given that the open style winding offers an equally effective cooling property in the horizontal position as in the vertical, the line traps are adequate for operation in the horizontal position. The line traps are furnished with two or four aluminium pedestals mountable on base flanges with eight 18 mm (11/16") diameter holes to fit 127 mm (5") or 178 m (7") BCD's or other patterns upon request.

Terminals

The line traps are supplied with 4-hole NEMA flat pad aluminium terminals (refer to fig. 2A for details). For copper connectors, tin-plated copper adapter plates are provided. Other hole patterns are available upon request.

The number of terminals and cross-section depend on the rated current of the line trap (refer to fig. 2B for typical terminal arrangements).

Mechanical Strength of Terminal

Permissible static line pull in longitudinal direction: 2940N.

Permissible static bending load applied in the centre of the terminal: 2450N.

Nameplates

Aluminium or stainless steel nameplates are supplied.

Bird Barriers

Bird barriers prevent the intrusion of birds into the main coil. The bird barriers consist of a temperature and UV resistant fiberglass reinforced plastic grid with square-shaped 15×15 mm openings. The bird barrier does not adversely affect the cooling of the line trap.

Surface Finish

The surface is first cleaned by sandblasting. A finishing coat of alkyd-enamel to a minimum thickness of 30 m (1.2 mils) in Munsell N6.5 (ANSI 70) grey is applied. Special customer requirements can be accommodated.

Thermal Strength

The line traps are designed for temperature Class F (155 °C) according to IEC 353 (1989) and Insulation Temperature Index of 155 °C according to ANSI C93.3-1981.

These standards allow a temperature rise of 115 °C (measured by the resistance method) and a maximum temperature rise of 135 °C (hot spot) above the mean ambient temperature.

Nevertheless, the line traps are designed to display an average temperature rise of only 80 °C at rated current at a power frequency of 50 Hz. This makes it possible to use the same line trap on 60 Hz networks at a continuous ambient temperature of 45 °C.

Accessories

In addition to the standard design consisting of a main coil, a tuning device and a protective device, the following accessories are available upon request:

- Line connectors (aluminium or bi-metal), for direct connection of the high voltage conductor
- Corona rings are usually not required for system voltages up to 245 kV, given that no special corona discharge requirement is imposed.

Tests

The following routine (production) tests are applicable:

Testing

The routine testing program for the line traps is performed with a measuring system specifically developed for this purpose.

Frequency response curves can be plotted for the resistive component, impedance, blocking attenuation or tapping loss according to the user- defined settings.

Type (Design) Tests

The most common type (design) tests are: temperature rise, measurement of radio influence voltage (RIV) and short-circuit.

Numerous type tests have been performed at recognized laboratories around the world, such as KEMA (Holland), CESI (Italy), CEPEL (Brazil), CPRI (India), among others. Type test reports are available upon request.

IEC

- Measurement of rated inductance of the main coil (at 100 kHz)
- Measurement of power frequency inductance of the main coil (at 100 Hz)
- Power-frequency dielectric withstand test on tuning device
- Measurement of blocking impedance or blocking resistance or tapping loss or tapping loss based on the blocking resistance

ANSI

- Measurement of main coil true inductance (at 100 Hz and 100 kHz)
- Sparkover test of auxiliary protective devices
- Measurement of blocking impedance
- Measurement of tuning device component values
- Power-frequency dielectric withstand test on tuning device

Line Trap According To IEC Standard

I (A)	STANDARD	ISC (kA) / 1s	ISC (kApeak)			L (mH)			
400	IEC I	10	25.5	0.1	0.2	0.32	0.5	1.0	2.0
	IEC II	16	41	0.1	0.2	0.32	0.5	1.0	2.0
630	IEC I	16	41	0.1	0.2	0.32	0.5	1.0	2.0
	IEC II	20	51	0.1	0.2	0.32	0.5	1.0	2.0
800	IEC I	20	51	0.1	0.2	0.32	0.5	1.0	2.0
	IEC II	25	64	0.1	0.2	0.32	0.5	1.0	2.0
1250	IEC I	31.5	80.5	0.1	0.2	0.32	0.5	1.0	2.0
	IEC II	40	102	0.1	0.2	0.32	0.5	1.0	2.0
1600	IEC I	40	102	0.1	0.2	0.32	0.5	1.0	2.0
	IEC II	50	127.5	0.1	0.2	0.32	0.5	1.0	2.0
2000	IEC I	40	102	0.1	0.2	0.32	0.5	1.0	2.0
	IEC II	50	127.5	0.1	0.2	0.32	0.5	1.0	2.0
2500	IEC I	40	102	0.1	0.2	0.32	0.5	1.0	2.0
	IEC II	50	127.5	0.1	0.2	0.32	0.5	1.0	2.0
3150	IEC I	40	102	0.1	0.2	0.32	0.5	1.0	2.0
	IEC II	50	127.5	0.1	0.2	0.32	0.5	1.0	2.0
4000	IEC I	63	161	0.1	0.2	0.32	0.5	1.0	2.0
	IEC II	80	204	0.1	0.2	0.32	0.5	1.0	2.0

** Shaded ratings not available with OSD.*

Line Traps According to ANSI Standard

I (A)	STANDARD	ISC (kA) / 2s	ISC (kApeak)	L (mH)
400	ANSI	15	38.3	0.265
800	ANSI	20	51	0.265
1200	ANSI	36	91.8	0.265
1600	ANSI	44	112	0.265
2000	ANSI	63	161	0.265
3000	ANSI	63	161	0.265
4000	ANSI	80	204	0.265
5000	ANSI	80	204	0.265

Other ratings can be designed upon request.

High frequency characteristics

The frequencies normally used for high frequency carrier transmission range from 30 kHz to 500 kHz. The purpose of the line trap is to block specific frequency bands within this frequency range.

Certain characteristic values such as impedance or resistive component of the impedance must remain above a given minimum value within a specified bandwidth.

Resistive Component

The main component of the high-frequency characteristics of a line trap is the resistive part of the impedance, also called the resistive impedance. This value is inherent to the line trap. In contrast, attenuation or tapping loss values always represent a comparison.

The main advantage and reason for using the resistive component, as a basis for evaluation is the fact that this value indicates the lowest line trap impedance under any operating condition, including the presence of a full or partial series resonance. If a sufficient high ohmic component is attained, the problem of series resonance is eliminated in carrier transmissions. The possibility of excluding the occurrence of series resonance is of particular importance. In its tuned frequency range, each line trap has inductive and capacitive components. Each reactive component of the line trap impedance can be compensated by the corresponding component of the substation or of the network impedance. The series connection of the two impedances then forms a series resonant circuit whose inherent frequency can be any carrier frequency. In this case, and in the lack of a sufficient resistive component of the line trap impedance, almost the entire high-frequency energy is discharged, a phenomenon which will have adverse effects on carrier transmissions. To prevent this occurrence, the line traps are delivered with suitable tuning devices so that the line trap impedance will always include the necessary resistive component in each specified frequency range.

Attenuation Modes

The evaluation of line traps based on tapping loss and blocking attenuation must be mentioned. This involves a comparison of the line trap impedance at a specific frequency with the impedance of the network as viewed from the line trap installation site.

Depending on the standards applied, the line impedance (characteristic impedance) is assumed to be between 300 and 600 ohms (400 ohms in the case of phase-to-ground coupling and 600 ohms for phase-to-phase coupling), providing a uniform basis for comparison purposes. The tapping (insertion) loss, At, and the blocking attenuation, Ab, are distinct parameters to measure the line trap efficiency. Both values are derived from a voltage ration and are expressed either in nepers or in decibels and can be obtained from the following formulas:

$$A_t = \ln\left|1+\frac{Z_L}{2Z}\right|_{(Np)} \text{ and } A_b = \ln\left|1+\frac{Z}{Z_1}\right|_{(Np)}$$

Where:

A_t= tapping loss

Z_L= line impedance **(W)**

Z= line trap impedance **(W)**

A_b= blocking attenuation

Z_1= network impedance (normally 400 **W** for single-phase coupling and 300 **W** for two-phase coupling)

1 Np = 8.7 dB

Horizontal pedestal line trap with corona ring

High-Frequency Characteristics Of The Main Coil

When using Grid Solutions line traps, it is possible to exchange a tuning device in the event of a frequency range alteration without removing the main coil from the line.

Line Traps With Single-Frequency Tuning

When a capacitor is connected in parallel to a relatively low inductance, the result is a resonant circuit with a high impedance at the resonance frequency. The circuit has a very selective operating bandwidth.

This tuning device offers a very low resistive component of the impedance at the bandwidth limits but in turn, delivers a very high blocking impedance at the resonance frequency (sample of response curve shown in fig. 6 page 8).

The desired minimum resistive component of the impedance is obtained by damping the parallel resonant circuit, i.e. by adding a resistor in series with the tuning capacitor.

The minimum resistive component of the blocking impedance in the single-frequency tuning mode is obtained using the following formulas:

$$Rmin = k.\pi.L\frac{f_2.f_1}{f_2-f_1} \quad Zmin = \sqrt{2}.k.\pi.L\frac{f_2.f_1}{f_2-f_1}$$

fr (kHz)	Factor5k
20	0.75
25	0.76
30	0.77
35	0.78
40	0.79
50	0.82
60	0.85
70	0.87
80	0.88
90	0.89
≥ 100	0.90

$f_r = \sqrt{f_2 . f_1}$

f_1 = lower band limit

f_2 = upper band limit

where k is determined from the below table (intermediate values of fr can be interpolated):

Line Traps With Wide Band Tuning

At a same geometric mean (fr), the main coil provides twice the bandwidth of an equivalent single- frequency tuning device. The minimum resistive component occurs at the limits and in the centre of the blocked bandwidth (sample of response curve shown in fig. 7 page 8).

The minimum resistive component of the blocking impedance and the minimum impedance in the wide band tuning mode are obtained using the following formulas :

$$Rmin = k.2\pi.L \frac{f_2 . f_1}{f_2 - f_1}$$

$$Zmin = \sqrt{2}.k.2\pi.L \frac{f_2 . f_1}{f_2 - f_1}$$

where k is determined from the same table as for single-frequency tuning.

Note: Increased bandwidths can be obtained by use of a special wide band tuning circuit, as illustrated in fig. 8 page 8.

Line Traps For Double-Frequency Tuning

Double-frequency tuning devices can be used to block two non-adjacent frequencies (sample of response curve shown in fig. 9 page 8).

Field-Adjustable Tuning Devices

Field-adjustable tuning devices can be singlefrequency, double-frequency or wide-band tuned. This kind of tuning is considered when there is a need to modify the frequency range of the line trap after its installation on the site.

Vertical pedestal A line trap mounted on CCVT

Inquiry Check List

- Rated inductance
- Rated current
- Rated power frequency
- System voltage
- Rated short-circuit current
- Tuning device type
- Tuning range
- Minimum blocking impedance or resistance
- Mounting requirements
- Terminal arrangement
- Installation conditions (e.g. seismic requirements, wind speed, ambient temperature if over 45 °C, operating altitude if more than 1000 m (3300 ft) above sea level)

Vertical pedestal B line trap

Line traps

Air Core, Dry Type Up To 800 kV

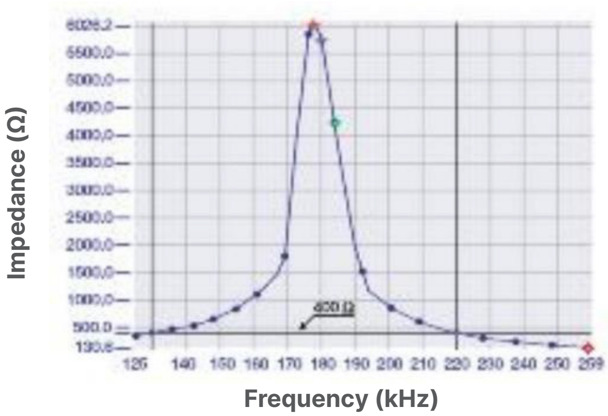


Fig. 6: Sample response curve of single-frequency tuning

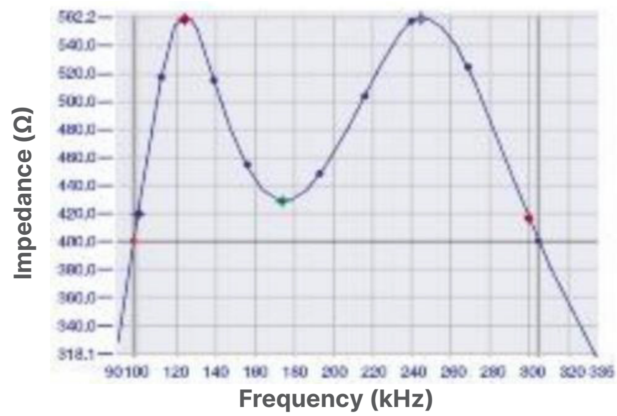


Fig. 7: Sample response curve of wide band tuning

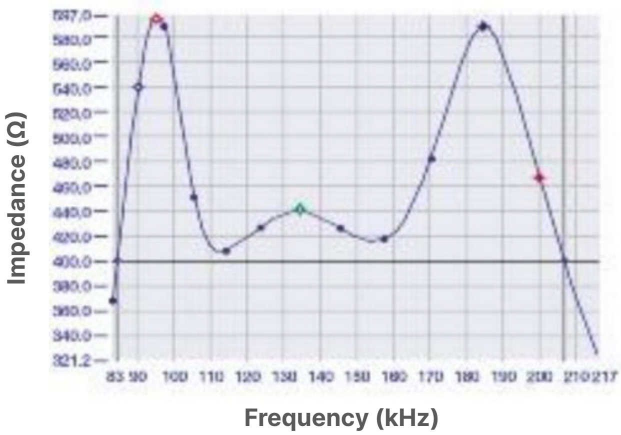


Fig. 8: Sample response curve of a special wide band tuning circuit

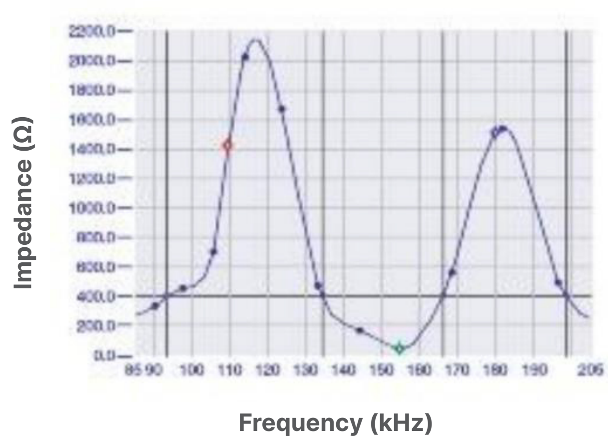


Fig. 9: Sample response curve of double-frequency tuning

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