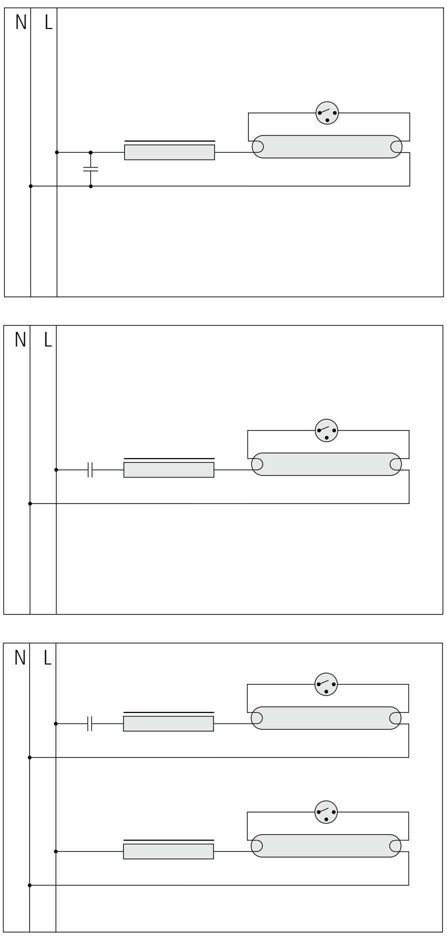
Circuit diagrams for fluorescent lamps. Compensating circuit: power factor correction by a capacitor in parallel (above).

Capacitive circuit: power factor is over-compensated by a series capacitor (centre).

Twin-start circuit: combination of a non-compensated and an over-compensated circuit (below).



same time allowing an instant restart after power failure.

2.4.1.7 High-pressure sodium lamps

High-pressure sodium lamps are operated on inductive ballasts. An ignition device is required due to their high ignition voltage.

Some double-ended lamps do allow an instant restrike when the lamps are still warm. As with metal halide lamps, a special ignitor is necessary for these lamps to handle the required high ignition voltages and the installation must be designed to take these voltages. Electronic ballasts are also available for high-pressure sodium lamps.

2.4.2 Compensation and wiring of discharge lamps

Inductive ballasts produce a certain amount of idle current due to the phase shift of the voltage with respect to the current – they have a power factor (cos φ) substantially below 1. Since idle current loads the mains, power supply companies require the idle current to be compensated – i.e. to a power factor to approach unity – in the case of large-scale lighting installations. Compensation is effected by means of capacitors, which balance the phase shift caused by the reactance. It is possible to compensate individual luminaires, groups of luminaires or an entire installation. Compensation is not necessary in the case of electronic ballasts, as they effectively have a unity power factor.

Fluorescent lamps that are run on inductive ballasts can be compensated via capacitors that are connected in parallel to or in series with the ballast.

If a compensating capacitor is connected in series with the ballast, we talk about a capacitive circuit. The power factor in this case is well above unity and so this type of circuit is referred to as an over-compensated circuit. Circuits of this kind allow a second lamp with a non-compensated ballast to be operated at the same time. Such circuits are known as twin-start circuits. The advantage of a twin-start circuit is that both lamps are out-of-phase. This means that stroboscopic or flickering effects at workplaces with rotating machine parts, for example, are avoided. Sequential connection of the lamps to a three-phase supply network will also minimize these effects.

Ballasts without compensating capacitors are referred to as *inductive circuits.* Compensation can be effected in this case using a parallel capacitor.

With a suitably designed ballast it is possible to operate two fluorescent lamps in series; this type of circuit is known as a *tandem circuit.*

2.4.3 Radio interference suppression and limiting other interference

Discharge lamps and the control gear they require may give rise to various disturbance factors in both the supply network and their environment.

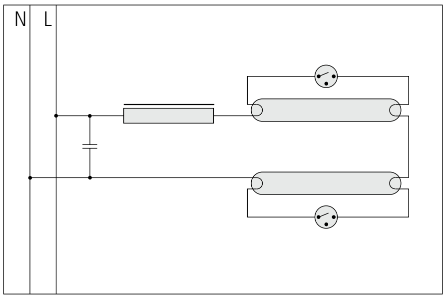
This consists primarily of radio interference, which is caused by ignition devices and by the discharge lamp itself. Radio interference can be suppressed by the use of suitably rated radio-interference capacitors.

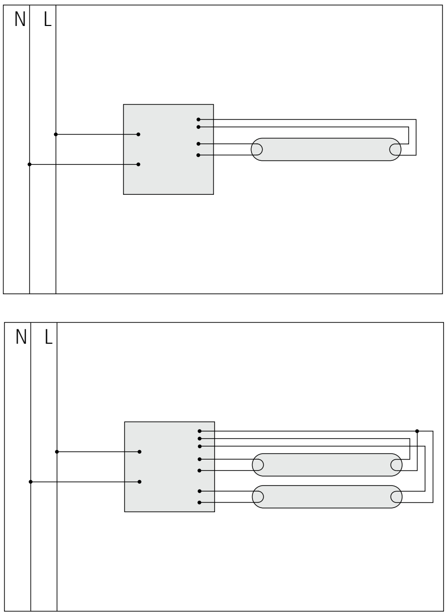
Depending on their application control gear and luminaires must meet certain minimum requirements with regard to radio interference (in Germany, Limiting Value Category B, VDE 0875, for example) and bear the seal of approval. Retroactive effects on the supply network due to harmonic oscillations have to be below stated minimum values (VDE 0712).

In the hospital environment, for example, the operation of ECG and EEG equipment may suffer interference from electric and magnetic fields induced by lighting installations – particularly by cabling, ballasts and transformers. For this reason there are special regulations (VDE 0107) for electrical installations in doctors' practices, hospitals and similar environments.

Audio frequency energy control devices such as those that control night storage heaters and street lighting systems may cause interference from ballasts with parallel compensation. To avoid interference of this kind specially designed inductive ballasts can be wired in series with the compensating capacitors.

Fluorescent lamp circuits. Tandem circuit: operation of two lamps connected in series to one ballast (parallel compensation).





Circuit diagrams for fluorescent lamps. Operation on an electronic ballast: starter and compensating capacitor are not required. Single lamp (above) and twin-lamp circuit (below).

2.4.4 Transformers for low-voltage installations

In addition to ballasts and ignition devices for discharge lamps low-voltage installations also require transformers as part of their control gear.

The low voltage required for such installations, generally below 42 V (mostly 6, 12 or 24 V) is taken from the mains voltage using transformers. Transformers may be an integral part of the luminaire or may be installed separately and supply one or more luminaires.

Transformers form an interface between mains voltage and low voltage, for which certain safety regulations apply. To guarantee that a low-voltage installation is never subject to mains voltage, in the case of technical faults, in Germany for example, safety transformers compliant with VDE 0551 must be used.

If transformers are mounted on inflammable surfaces, they are required – as are luminaires – to bear an additional ▽ or ▽ ▽ symbol. These transformers contain a thermal protection switch, which ensures that they do not overheat.

Transformers for low-voltage installations must have fuses that can handle primary voltage (230 V). Slow-blow fuses are used for this, as currents up to 20 times above the rated current can occur when the lamp is switched on.

It must be noted that significant voltage drops may occur in the connecting cables when dealing with low-voltage installations. This is due to the high current values that occur with low voltages. This can be compensated for, if appropriate cable diameters are used and the connections are kept short; many transformers have both primary and secondary voltage tapping devices, which means that in the case of longer connection cables, excessive voltage drop can be avoided.

Electronic transformers are comparable to electronic ballasts from the point of view of their properties and functions: in particular, the way they operate at high frequencies, the fact that they are smaller and lighter, and that they allow low power loss. Electronic transformers supply voltage that is to a large extent independent of the load. They are therefore suitable for handling small partial loads.
As with electronic ballasts, d.c. operation for emergency lighting is also possible. Electronic transformers are also more expensive than conventional transformers.