



DESIGN OF ELECTRICAL INSTALLATIONS

Commercial Installation Alteration

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Contents

Section A.....	2
Section B.....	6
Section C	10
References.....	13
Bibliography	13

Section A

1. The level of illumination within the sales office is to be upgraded by substituting the single 1500mm 58W luminaires with twin lamp fittings of the same dimensions and lamp rating.

Explain the possible effects the change will have upon the rating of the circuit cables and protective devices.

When changing a single 58W luminaire to a twin 58W lamp fitting, it is important to consider the conductor cross-sectional area supplying luminaires and the fuse rating in the distribution board. This is because there will be greater current consumption and the wiring and protective devices need to accommodate this. Current consumption can spike when lights are turned on, known as inrush current. Inrush current is an instantaneous high input current drawn by an inductive electrical load when it is energised. This can be up to six times the normal operating current of the equipment but it only lasts for a very short period of time, as shown in figure 1.

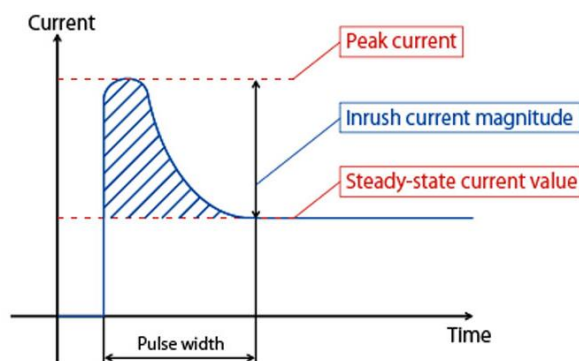


Figure 1 - Inrush Current

The original luminaire current demand is approximately 3.5A, as shown in equation 1. However, with the six luminaires within the sales office being upgraded to a twin light fitting the current will be increased to approximately 5A, as shown in equation 2. The lighting circuit protective device is a BS3036 rewirable fuse. The existing protective device will be rated at 5A. Because of the increase in demand, it will be necessary to upgrade the rating of the protective device to avoid nuisance tripping caused by the additional inrush current. An alternative method would be to calculate the fuse size using equation 3, which suggests larger capacity fuse or miniature circuit breaker should be used.

$$\text{Power (W)} = \text{Current (I)} \times \text{Voltage (V)}$$

$$\text{Therefore, Current (I)} = \frac{\text{Power (W)}}{\text{Voltage (V)}} = \frac{58}{230} = 252.17 \text{ mA}$$

$$\text{Current drawn from original 14 luminaires} = 252.17 \times 10^{-3} \times 14 = 3.53 \text{ A}$$

Equation 1 - Original Current Drawn From Luminaires

$$\text{Current drawn from upgraded luminaires} = 252.17 \times 10^{-3} \times 20 = 5.04 \text{ A}$$

Equation 2 – Upgraded Luminaire Current Draw

$$\text{Fuse Rating} = \frac{\text{Power (W)}}{\text{Voltage (V)}} \times 1.25 = \frac{58 \times 20}{230} \times 1.25 = 6.3 \text{ A}$$

Equation 3 - Fuse Rating Calculation

It is likely that the lighting circuit wiring is 1.00mm² twin and earth cable. The current-carrying capacity for this cable is 10.5 A. This is reinforced by (BS7671:2018. Table 4D5, P.409). This shows that the wiring is suitable for the addition of twin lamp fittings.

2. The partition is to be relocated between the sales manager's office and the manager's secretary's office.
 - a. Identify the ramifications in terms of electrical work.

There are numerous ramifications that need to be considered when relocating the partition between the sales manager's office and the manager's secretary's office. To relocate the partition, both the manager and the secretary will need to temporarily move from their offices for the works to be carried out efficiently. This is because the electrical sockets will need to be powered down, resulting in no power in these two rooms for electrical equipment. This will make it difficult for the manager and secretary to operate. Therefore, they will need to temporarily relocate into another office that has power or anywhere that they can carry out their daily work activities from.

- b. Explain what would be required between the various trades/ contractors working in such a small area.

A work scope will be made up for the electrical jobs that will need to be carried out at the office suite. This will coincide with tasks that are being performed by the other trades that are carrying out the work of relocating the partition. This work scope will be divided into two sections; first and second fix. However, before the first fix can take place the existing cables feeding the sockets in the sales manager's office and the manager's secretary's office will need to be pulled back up into the ceiling and terminated into a junction box. This will require identifying the ring final circuit that is feeding the sockets in the partition wall, isolating them at the distribution board and then testing for dead with a voltage tester and proving unit locally at each of the sockets. Once this is carried out, the cables can be removed from the two sockets either side of the partition and pulled up into the ceiling and terminated into a junction box. The first fix can then be carried out for the partition.

The first fix will include the removal of the original partition wall and then building a new partition in the designated place. The electricians are then able to connect in the new cables into the junction box and run in new cables to the new socket locations. This will include drilling through noggins to run the cables through and installing noggins to fix the socket back-boxes to. The bottom of the socket must be 450mm from the finished floor level. The other trades people are then able to carry out their work.

The second fix would include connecting into the sockets and then carrying out a series of tests for the ring final circuit. The circuit can then be powered up and the offices can be re-inhabited once the other trades have carried out their work.

c. Identify how (b) above, would be achieved.

The removal of the original partition and installation of the new partition would require good communication between all trades people. This is because certain trades need to allocate themselves times to carry out tasks and what needs to be carried out by other trades for the job to progress. It is important to consider how long each task will take so that other trades can carry out work elsewhere to avoid congestion whilst working in the office. For example, whilst the builders/ carpenters are carrying out the installation of the partition, the electricians can be changing the single luminaires to a twin luminaire. However, this could also interfere with office personnel so it may be more efficient for the work to be done out of hours or within a lunch break across a few separate days. This would minimise disruption with the staff and/or customers in the sales office. Therefore, other trades could carry out work offsite to minimise congestion at the offices.

The use of Gantt charts and flow charts could be used to help with the planning of the work, which would include timescales and provide a visual representation of the work involved.

3. List the factors to be considered when calculating the costs of:

a. Upgrading of fluorescent luminaires.

When upgrading the 1500mm 58W single luminaire to a twin luminaire, it is first important to consider the costs of the following:

- Light Fittings
- Labour
- Downtime

The choice of light fitting is an important consideration because they can cost from £20 to £40, so by replacing the six light fittings in the sales office it can cost approximately £180. Figure 2 is an example of the type of light fitting that could be used.

The screenshot shows the TLC Electrical Supplies website. The main product is a 'Thorn HF Pop Pack 5ft Twin 58w Fluorescent Fitting with Tubes'. The product is described as 'The only one called "Pop Pack", the original fluorescent batten with HF High Frequency control gear'. It lists several features: Tool-less, clip-on cover plate for quick installation; Can be surface or suspension mounted; Twist-lock lampholders for reliable electrical contact; Batten: rolled steel section in pre-coated high reflectivity white paint; Lampholder assembly: tough white polycarbonate; Slim spine with durable corrosion resistant finish; Adjustable twin lampholder enables optimum lighting performance to be selected; Four-way terminal block with capacity for 2 x 2.5mm² cables; Angled terminal block for easy wiring; Power factor correction. Dimensions: Height: 64mm, Width: 125mm, Length: 1500mm.

Product Code	Description	Price (inc VAT)	Quantity
TN PP258HF	5ft Twin 58w HF Fluorescent Fitting with Tubes (Fragile)	EACH £38.28 10+ £34.22	1 Add

Figure 2 - Twin Fluorescent Light Fitting, TLC Direct

The time spent on changing the light fittings needs to be kept to a minimum to reduce the labour cost and the disruption to the sales office. This is because the sales office lighting will all be fed from the same electrical supply. This supply will need to be isolated to change the light fittings. When considering these factors, it is unrealistic and dangerous for staff to continue to work in there whilst there is limited lighting. This can result in a decrease in sales and work productivity. Therefore, it will be more efficient for the work to take place outside of normal working hours or it could be carried out at lunchtimes across a few days.

The work involved should take approximately 30 minutes per light, which is three hours to carry out the work in the sales office. This will cost approximately £100 in labour but there may be additional costs if difficulties arise.

The cost of power consumption for the sales office will also increase as there are twice the amount of fluorescent tubes. An alternative option would be to use LED fittings which produce an equivalent light output but at a lower wattage. They cost a similar price to that of the fluorescent fitting but are also cheaper to run as they are a lower wattage.

The screenshot shows the BLT Direct website. The top navigation bar includes links for Home, LEDs, Tubes, Ballasts, Halogens, Energy Saving, CFLs, Incandescents, Discharge, Light Fittings, Brands, and More. The main product page is for a 'V-Tac 5 Foot LED Batten 50W Daylight 6400K (6000lm) with Samsung Chip (125W Alternative)'. The product image shows a long, thin LED batten. Key specifications listed are 6000 Lumens, 240 Volts, and 50W. The price is £21.02, with a 56% discount from the RRP of £47.87. The product has a QuickFind number 50553 and a Part No. 669. It has 5 stars from 26 customer reviews. The page also features a 'Product Summary' section with icons for Actual Wattage (50 W), Beam Angle (110 Degree), Colour Daylight (860/865), Colour Temp (6400 K), Equivalent Wattage (125 W), IP Rating (IP20), and Length (1500 mm). On the right side, there are customer reviews from Elizabeth Neal and Philip Hargreaves, both giving 5 stars.

Figure 3 – LED Batten Alternative, BLT Direct

b. Removal and replacement of outlets within the partition.

The removal of the original socket outlets in the partition will require an electrician to isolate the supply and then remove the sockets from the ring final circuit, and then use a junction box to make the circuit safe. The approximate cost of a 30A junction box is £1.50 and an electrician's hourly rate is approximately £30 per hour.

Following the relocation of the partition, the electrician can then install two new double sockets. The cost of a metal back box and a double socket is approximately £4.00, so for both rooms it will cost approximately £8.00. As the partition is being relocated, additional cable will be required. This cable will be 2.5mm² Flat Twin and Earth, which costs approximately £1.10 per metre. The location of the new partition is not known so it is not possible to gauge how much cable is required and which will also effect the time spent carrying out the job.

Section B

4. Due to the electrical loading for this building, the supplier's equipment has current transformers (CT's) fitted as part of the metering arrangement. With the aid of a sketch, show how such CT's would be fitted and connected.

Current transformers (CT) are used to reduce high currents to a level that they can be monitored using a standard ammeter. CT's produce an output signal that is proportional to the current flowing through the conductor that the CT core is situated around. The CT output is a ratio of the primary current flow. For example, a CT with a ratio of 100:5 would produce a 5A output when there is a 100A primary current flowing. The ammeter scale would correspond with this ratio by having a range of 0-100A but the full scale deflection input would be 5A. Therefore, the metering equipment would replace the ammeter in figure 4 and needs to be compatible with the CT ratio.

The primary side windings of the CT has only one or two turns, whereas the secondary side windings has a large number of coil turns. When installing the CT, the current needs to flow from the P1 to the P2 side of the CT. There are two terminals to connect onto, labelled S1 and S2. These terminals are to be connected into the meter as inputs. It is common practice for the secondary winding of the CT to be earthed at the S2 connection. This reduces the chances of a potential difference being generated at different points of the current transformer. As there is a three-phase supply feeding the office suite, there will need to be three separate CT's to monitor each phase.

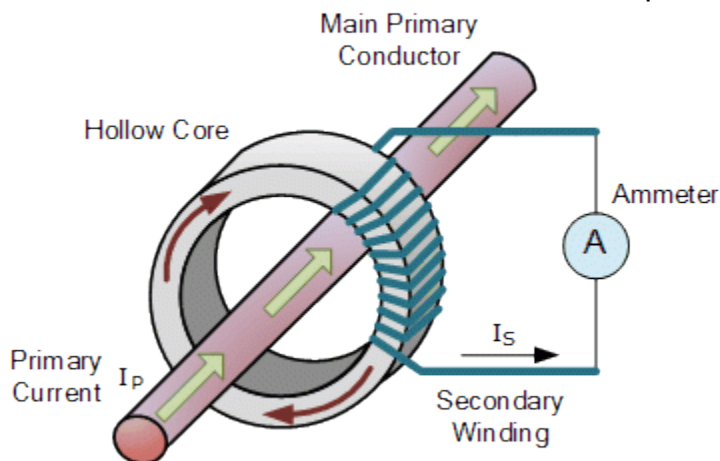


Figure 4 - Current Transformer Configuration, Electronics Tutorials

5. Upon completion of the alterations and additions to the electrical installation, the work will have to be inspected and tested following which it must be certified.

Describe the:

- a. Testing that will need to be carried out

There are several tests that need to be carried out upon completion and prior to energisation for the alterations and additions to the installation, to include the following:

- Continuity of Protective Conductors
- Continuity of Ring Final Circuit Conductors
- Insulation Resistance
- Polarity.

The testing for the continuity of the protective conductors and the ring final circuit conductors is carried out using a three step test, which is as follows:

- Carry out an end-to-end resistance test on the line, neutral and earth. All readings should be $\leq 0.05\Omega$, which proves that there is no open circuit.
- The line and neutral cores of the outgoing and returning circuit are cross-connected together at the distribution board, as shown in figure 5. The resistance is then measured at each of the ring socket outlets and the same value should be measured.
- The line and earth cores of the outgoing and returning circuit are cross-connected together in the distribution board to carry out an $(R1+R2)$ test, as shown in figure 6. The resistance is then measured at each of the ring socket outlets and the same values should all be measured, and the highest reading should be recorded.

This test will also confirm that the circuit polarity is correct.

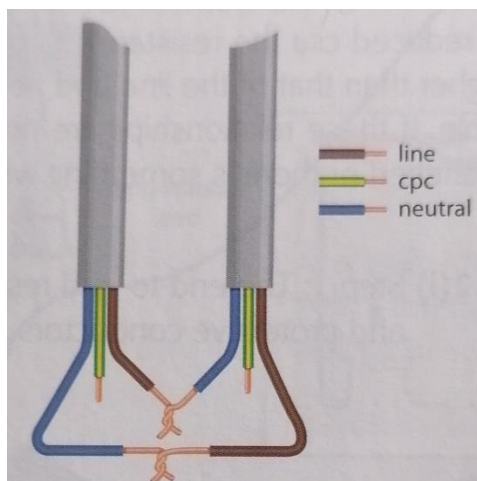


Figure 5 – Line and Neutral Cross-Connected,
BS7671:2018 IET Guidance Note 3

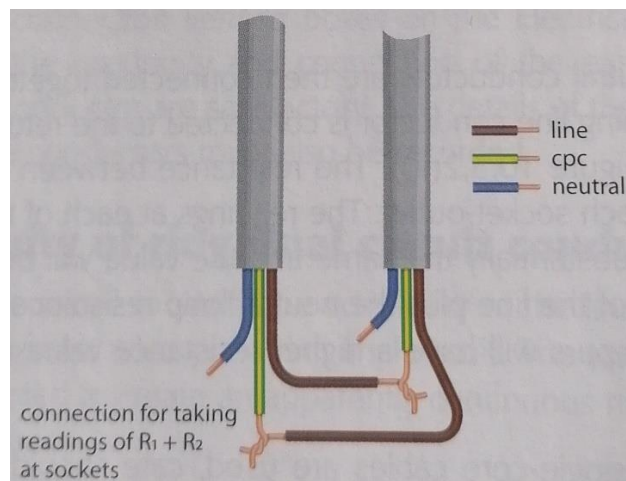


Figure 5 – Line and Neutral Cross-Connected,
BS7671:2018 IET Guidance Note 3

An insulation resistance (IR) test used to find a potential fault within an electrical installation. Locke (2008, p.196) reinforces this by stating 'the tests show faults or shorts as well as low insulation' resistance. To carry out the IR test on the ring final circuit, all electrical appliances connected into the ring final circuits' original socket outlets need to be removed. A 500V DC test voltage can be applied to the ring final circuit between the following:

- Line – Neutral
- Line – CPC (Earth)
- Neutral – CPC (Earth).

The results can then be recorded and no value should be less than 1MΩ and further investigation should be carried out if it is between 1-2MΩ, which is supported by BS7671:2018. Table 64, p.409).

Earth fault loop impedance (Z_s) is described by BS7671:2018, p.409) as 'The impedance of an earth fault current loop starting and ending at the point of earth fault'. An earth fault loop impedance test is carried out to find the value of the external impedance (Z_e), which can then be added to the ($R1+R2$) value. The test instrument is connected between line and earth with all circuits off or the main switch in the off position. The earth must be disconnected and then reconnected following the testing. The earth fault loop impedance can then be calculated using $Z_s = Z_e + (R1+R2)$.

b. Standards to which the test equipment and leads must comply

The test equipment must comply with the BSEN61010 Safety requirements for electrical equipment for measurement, control, and laboratory use. The test equipment leads must comply with the Health and Safety Executive Guidance Note GS38. This is supported by (BS7671:2018, p.8) in Section 1.1 Safety, parts (iii) and (iv).

c. State the certification forms which must be completed

An electrical installation certificate should be completed following the installation and testing of the alterations and modifications at the office suite.

d. Person who should receive the completed forms

The person who should receive the completed form should be the person who has ordered the work, such as the manager or property owner.

6. State the types and ranges of test instruments which will be used to test this electrical installation.

The test equipment used to carry out the testing of the electrical installation are as follows:

- Low Resistance Ohmmeter (0-20Ω)
- Insulation Resistance Tester (0-500MΩ)
- Phase-Earth Fault Loop Impedance Tester (0-2000Ω).

7. Describe the action to be taken in the event of the earth loop impedance test at the Visual Display Unit (VDU) switched socket outlet failing to meet the requirements of BS7671.

The earth fault loop impedance test is carried out to ensure that if an earth fault were to occur, the circuit protective conductor would be sufficiently large enough to carry the fault current. The fault current will take the path of least resistance to earth and therefore the resistance measured needs to be as low as possible to provide a clean path to earth. If the fault current was low and there was a high resistance to earth, the fault may go undetected and not operate the protective device and cause damage to the circuit.

In the event of the earth fault loop impedance at a switched socket outlet failing to meet the requirements of BS7671:2018, there are a few options that could be used. One option would be to install a Residual Current Device (RCD). RCDs are used to protect humans and animals from the risk of an electric shock by switching off the load in the event of an earth fault. They work by monitoring the current flowing in the line and neutral conductors in a circuit via a coil. If there is an imbalance between the conductors due to an earth fault, the coil will send a trip signal to a mechanism to disconnect the load.

Section C

8. Consider a way in which the entire lighting system in the factory area can be switched by the operation of one Key Switch located by the front door. Create a wiring diagram to illustrate the interconnection between the of control components within circuit.

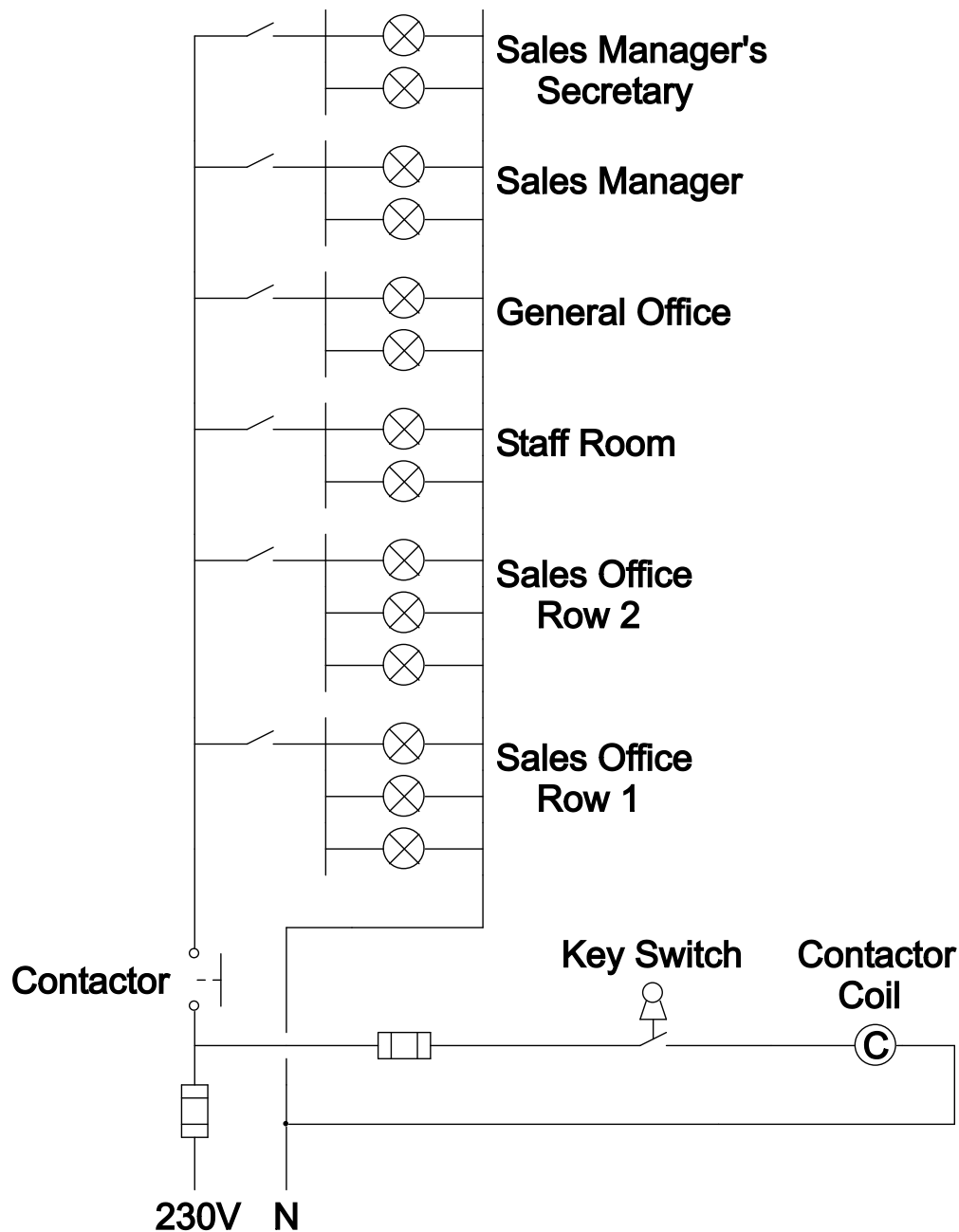


Figure 7 – Key Switch Controlling a Lighting Circuit

Figure 7 shows a potential method of a key switch being used to switch the lighting circuit. The contactor will be open circuit if the coil is de-energised and therefore, no lights will be able to be turned on. When the key switch is turned into the on position, the coil will be energised and the contactor will close. The individual switches in the rooms can then be used to turn the lights on or off. The contactor will need to have a

rated contact to be greater than that of the amperage flowing through the lighting circuit, which is approximately 5A.

9. State three possible causes of the non-operation of a fluorescent luminaire within the office area and suggest how you would rectify each.

There are a variety of reasons for the non-operation of a fluorescent luminaire. One potential reason is the failure of the tubes. Another potential cause of the non-operation of a fluorescent luminaire is that the power supply to the fitting has been lost, which would also cause the other luminaires supplied from the same circuit to be non-functioning. This can be resolved by first of all finding the reason for the supply to be off, and then fixing the issue. The circuit fuse can then be replaced with one that is of the same current rating. A potential cause for the supply to be lost is that the ballast has burnt out. There are two possible ways of rectifying this issue. One method would be to replace the whole fluorescent luminaire with a new fitting. The alternative option is to convert the fitting to an LED luminaire, which will require an LED tube of the same size as the fluorescent to be purchased and the internal wiring of the luminaire will need to be modified to power the LED tube. This is shown in figure 8.

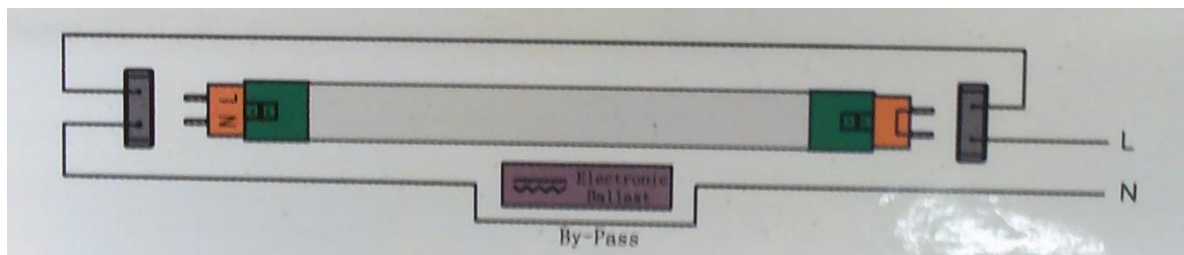


Figure 8 – Fluorescent to LED Conversion

10. State the implications of isolating the supply to the office once it has been occupied by the client.

Whilst carrying out the electrical works in the office, the electrical supply feeding the socket outlets and the fluorescent luminaires will need to be isolated. This can have a large impact on the day-to-day running of the business because there will be no power for electrical components such as computers. This can cause interruption within the business and must be avoided where possible as there will be a decrease in productivity and sales. If the lighting is turned off in the sales office, staff will be unable to use this room as it will be unsafe and potentially cause an accident.

To avoid all unnecessary work loss at the business, a suggestion could be made to carry out the work outside of normal working hours, such as on weekends or after hours. This would mean that the day-to-day running of the business would not be affected as much by the works. An alternative option that could be undertaken whilst carrying out the relocation of the partition is to provide each office with a temporary supply from an energised circuit. This would mean that personnel working in the two offices would be able to use electrical equipment. However, with the construction works being carried out within the same rooms they may be distracted. Therefore, the

decision will need to be carried out by the manager regarding how the work disruption will be managed.

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