Pearson BTEC Levels 4 Higher Nationals in Engineering (RQF)

Unit 31: Electrical Systems and Fault Finding

Unit Workbook 1

in a series of 4 for this unit

Learning Outcome 1

Electrical Distribution Systems

Contents

INTRODUCTION 2
Operating principles 4
  Three-phase distribution methods and connections 4
  Single-phase distribution methods and connections 6
  Earthing system connections 7
    TT System 8
    TN-C System 8
    TN-S System 9
    TN-C-S System 9
    IT System 10
Transformer constructional features 11
  Construction 11
  Applications 12
  Step Up Transformers 12
  Step Down Transformers 12
  Isolating Transformers 13
  Shell Type Transformers 13
  Core Type Transformers 14
  Windings 15
  Connections 16
  Transformer Efficiency 18
  Electrical Circuit Symbols 19
  Electrical Layout Diagrams 20
Fault finding techniques and test equipment 21
  Input/Output 21
  Half Split 21
  Meters 21
  Insulation Testers 23
  Typical Faults 23

INTRODUCTION

LO1: Investigate the constructional features and applications of electrical distribution systems

Operating principles:

Three-phase, single-phase distribution methods and connections

Earthing system connections

Transformer constructional features:

Construction, application, characteristics of transformers such as step up/down, isolating, shell and core, windings, connections, efficiency

Electrical circuit symbols and layout diagrams

Fault finding techniques and test equipment:

Input/output, half split

Meters, insulation testers

Typical faults found

Operating principles

Three-phase distribution methods and connections

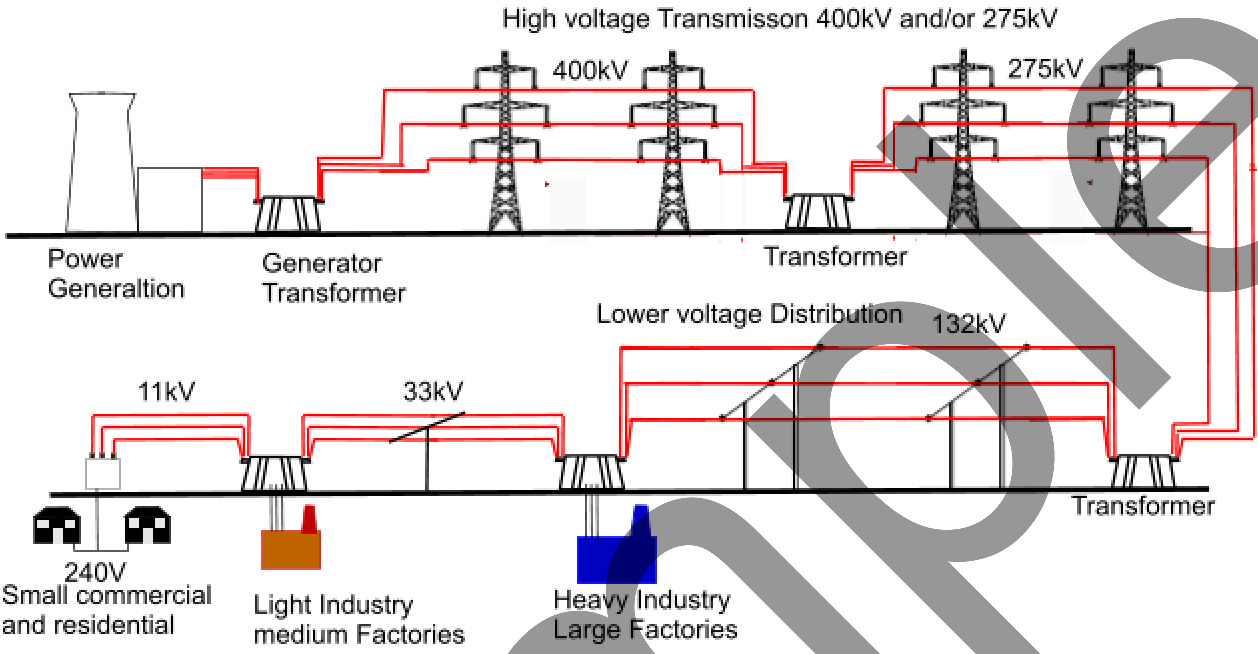

Figure 1 *UK electrical power distribution from source to consumer*

The source of electrical supply is, mainly, at a large power station. The common fuels used can be coal, nuclear, gas or oil. Other sources of supply are renewable in nature; bio-mass, hydro-electric, tidal, wind or solar.

At the power station, the fuel generates energy which turns turbines. These turbines generate 33kV of electricity. The voltage from each turbine is presented to switches, and a transformer. The switches are commonly oil filled (cooling) cylindrical tanks, one tank for each of the three phases. Each tank has an input and an output, and the switch is immersed in the oil beneath. The output from the switch is presented to a step-up transformer, also oil cooled, which transforms the input voltage on its primary to 400kV (sometimes 275kV) at its secondary winding, as per figure 1.

The three 400kV phases are then carried on cables suspended from large pylons. These cables tend to have a steel core surrounded by aluminium and are suspended from the pylon arms by large insulators. Further on, we see more localised distribution, where the 400kV is presented to a step-down transformer which produces 132kV. This 132kV is either presented to heavy industrial factories, or stepped down further, via another transformer, to 33kV. This 33kV is presented to light industrial factories or stepped down further to 11kV. The 11kV can be presented to light commercial industry, or to local sub-stations. The sub-stations convert the 11kV, via a transformer, to 230/240 volts between each phase and neutral (assuming a star/wye arrangement for the three phases (see figure 2 and figure 3).

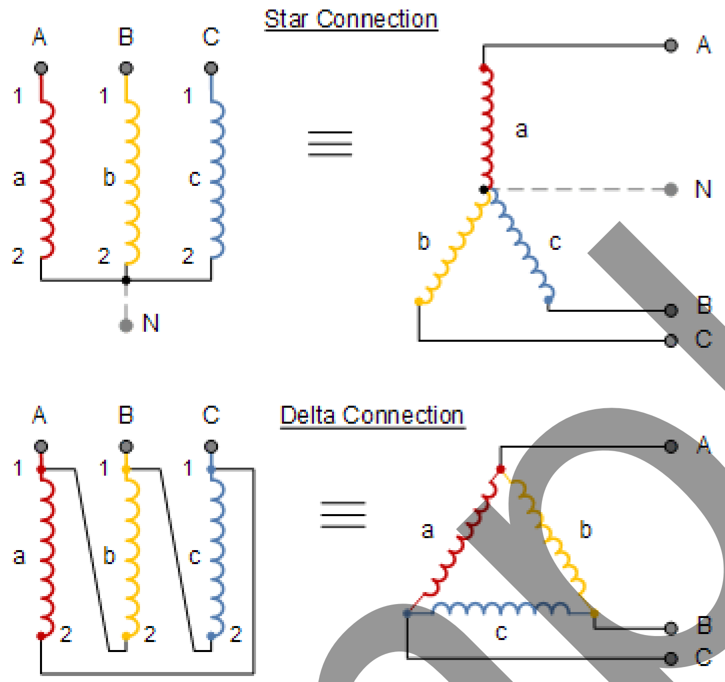

Figure 2 *Star and Delta connections for a three-phase system*

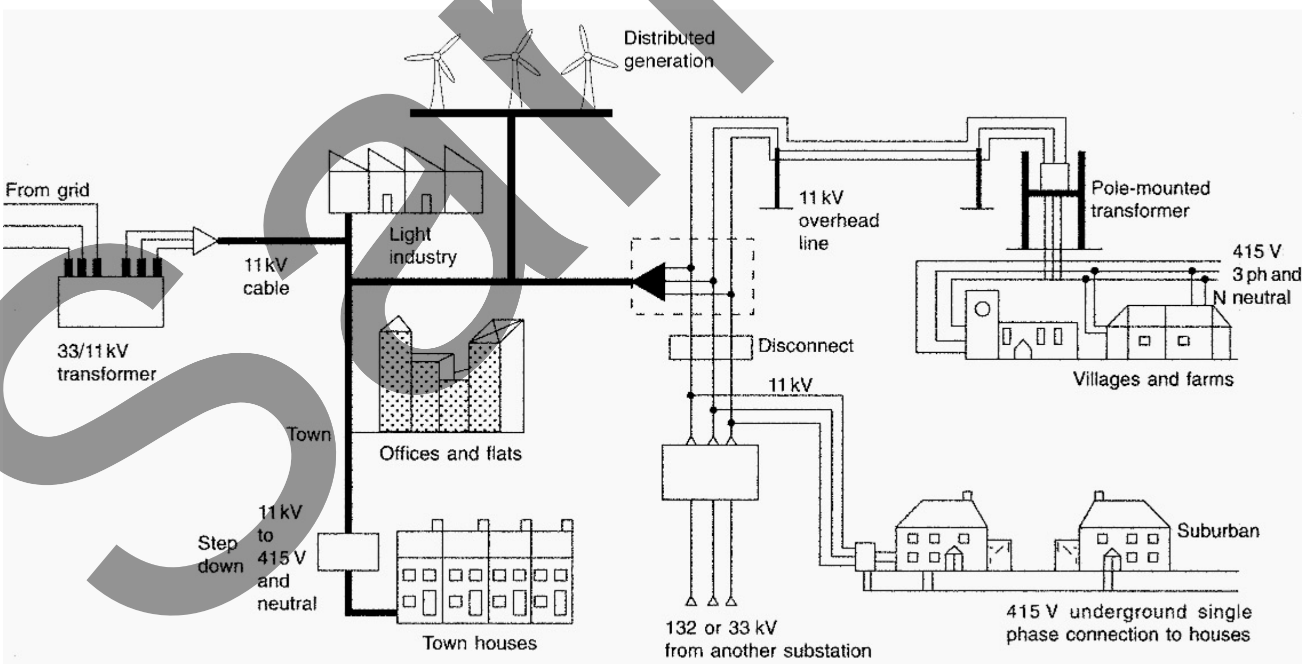

Figure 3 *A closer view of the localised end of the electricity distribution network*

An example of a three-phase transformer is shown in figure 4.

Figure 4 *A three-phase transformer*

Single-phase distribution methods and connections

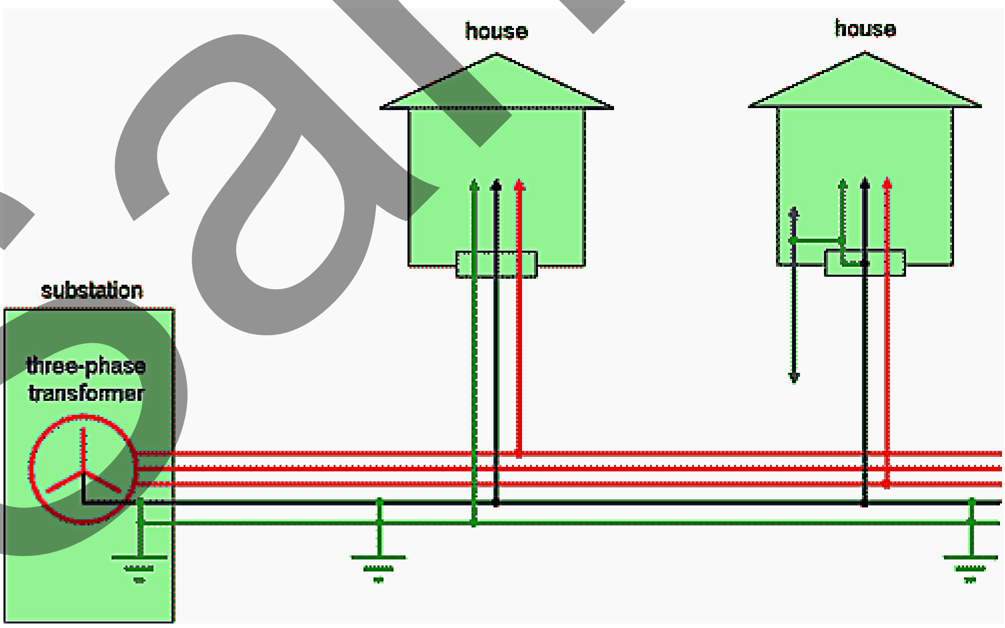

Figure 5 *Distribution of alternate phases to residential dwellings*

A residential dwelling normally has its electrical distribution arrangement in the form a Ring Circuit, as shown in figure 6.

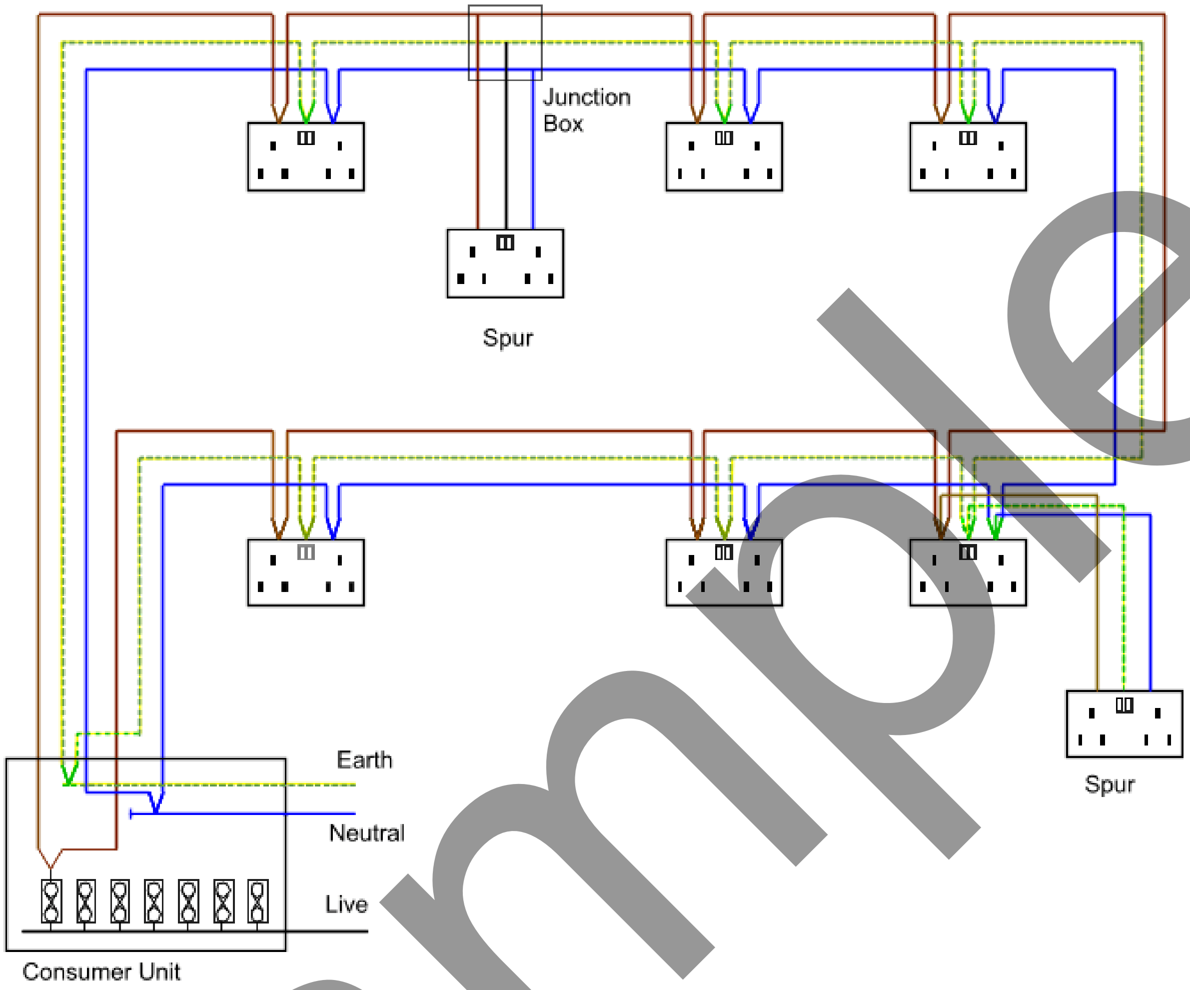

Figure 6 *A residential ring circuit*

The consumer unit (MCB) is protected by a 32A fuse, and the 230V supply is routed around the dwelling as shown.

Earthing system connections

Earthing systems can be classified by three schemes;

- TT System (earthed neutral)
- TN System (exposed conductors connected to neutral)
- IT System (impedance-earthed neutral)

TT System

Here the neutral is connected to earth at its source. All other exposed metallic parts are connected to a separate earth rod, which could possibly be connected to the source neutral. This arrangement is shown in figure 7.

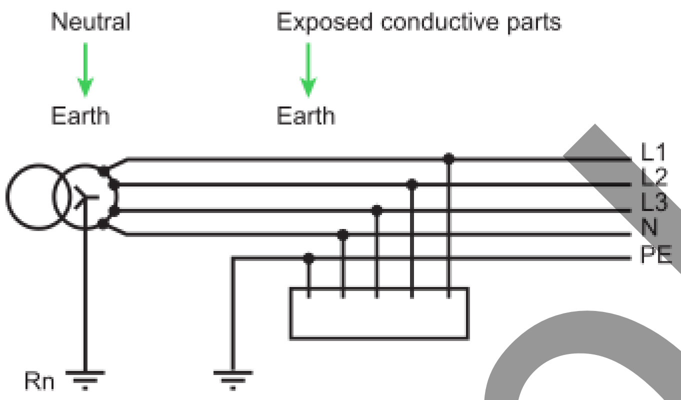

Figure 7 *The TT earthing scheme*

TN-C System

In this arrangement the neutral is used as a protective conductor, known as a PEN (Protective Earth and Neutral). The system is not allowed for portable devices, nor when the conductors have a cross-sectional area of less than 10mm^2. An equipotential environment is necessary here, so the system needs regularly distributed earth electrodes. The arrangement is shown in figure 8.

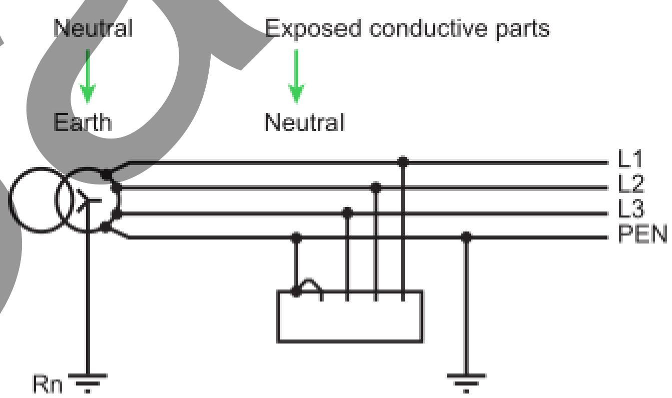

Figure 8 *The TN-C earthing scheme*