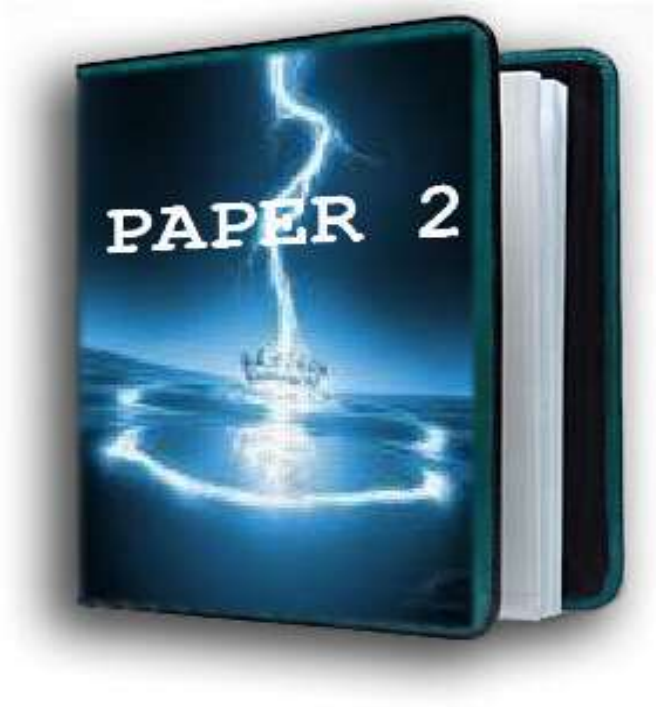
INSTALLATION RULES PAPER 2



STUDY GUIDE

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STUDY GUIDE

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INTRODUCTION

During the course of any class, you will be required to process a great deal of information and since your knowledge of the subject will be tested, you will need an effective way to learn the concepts and remember them and study guides are a proven methodology that will help you outline and remember the important pieces of information. The Installation Rules Study Package is provided to do just that and to ensure that your understanding of the material covered in the Regulation Standards is solidified. It is designed to make your exam preparation less of a headache for you and to shorten your preparation time. It consists of the **Study Guide**, the **Past Exam Papers** with **Memos** and the **Exam Simulator Software**. The Study Package is designed to be easy-to-use instrument to help you pass the exams convincingly on the first try. The design of the Installation Rules Study Package is based on the principle that, for a product to be effective, it must be simple and easy to use.

ABOUT THE AUTHOR

The Author of the Installation Rules Study Package is a registered Installation Electrician in terms of the Electrical Installation Regulations. He passed the Installation Rules Exams with distinctions [Paper 1 with **92%**, Paper 2 with **82%**]. He has for the past few years thoroughly researched every topic that is covered in the Exams and his research revealed specific content areas and concepts that are critical for one to know, understand and apply in order to be victorious in the Exams. The author has taken that information and compiled the Installation Rules Study Package that is guaranteed to produce positive results. The Author is devoted to consistently provide the best Installation Rules Study Package and Support that not only meet the student's needs but also that surpass their expectations.

OUR OBJECTIVE

We have done our best in making sure that the Installation Rules Course objectives are met by providing our students with an excellent Study Package packed with detailed, step by step examples and many Exam–Style questions. The main objective of our Study Package is to give our students the **Knowledge**, the **Practice** and the **Confidence** necessary to pass their Exams with flying colours on their first try.

STUDY PACKAGE FEATURES

The Installation Rules Exams are not easy but with the right tools at your disposal and hard work you can make it. The Study Package consists of the **Study Guide**, **Revision Exercises**, the **Exam Simulator Software** and **Past Exam Papers** with **Memos**. These study tools ensures that your understanding of the material covered in the course is solidified and at the same time ensuring that all the objectives and aims of the Installation Rules course are satisfied. Past Exam papers together with memorandum are provided to give you an idea of how to answer Exam questions. The Installation Rules Study Package offer a self-paced method of preparing for the exams in the shortest possible time. The Student will go through all the sections of the regulation book without guessing which sections of the standards they need to focus on. In short, the tools focuses on all important areas of the course with great emphasis on sections that will be in the actual exam sitting. **We encourage our students to concentrate on the material presented in the Study Guide.**

THE STUDY GUIDE

The Study Package is completely updated to the latest electrical Regulation Book and Standards. The information provided in the Study Guide is divided into three sections: **Section 1** gives the Student carefully worked out examples of calculations, **Section 2** is divided into Modules – in these modules the Student is guided through the theory part of the course by answering questions similar to the ones they will face in the exam and **Section 3** consists of the revision exercises to test the Student's understanding of the material covered.

THE EXAM SIMULATOR

The Exam Simulator does not generate Exam questions haphazardly – most of the questions generated will be in the actual exam. What the Exam Simulator does is that it systematically generates ten Exam questions in Internet Explorer similar to the ones the student will face in the actual Exam session. The Exam Simulator helps to solidify the Student's understanding of the material covered in the regulation books while at the same time helps the Student to build the confidence necessary to face the actual exam sitting. Generate as many exam sessions as you like and for each exam session generated set aside 3 hours to answer the Exam questions.

WELCOME

We would like to welcome you to the **Installation Rules Paper Two Study Guide** and we thank you for investing in our study material. If you have never taken this Exam or have attempted it before, this Study Guide together with the accompanying Software will give you some idea of what to expect the actual Exam session to be like and to sharpen your skills on how to answer such Exam questions.

The Installation Rules Study Tools ensures that your understanding of the material covered in the Regulation Standards is solidified and also ensures that all the objectives and aims of the Installation Rules Course are satisfied - keep in mind that for the Installation Rules exams you are required to demonstrate **sufficient knowledge**, **understanding** and **application** of the regulation standards.

The information provided in this guide is divided into two sections: **Section 1** gives you worked out examples of calculations and some theory questions for Paper Two. Most of the examples are taken from Past Exam Papers. **Section 2** is divided into Modules – make sure to answer **ALL** the questions in these Modules. For ease of use each question in the Modules have **Page numbers** next to them indicating where to get the answer to that particular question in the Regulation Book. We have included answers to **Module 5**, and for answers to calculation questions please refer to Examples.

First, start and work through the Study Guide then next do the Assignments and Revision Exercises – the Revision Questions are in a separate file. For more revision and practice run the Exam Simulator and give yourself THREE hours per session to answer generated questions – you may use this as the final preparation for the Exam.

Paper 2 Study Package will surely give you Sufficient Knowledge, Understanding, Practice and the Confidence required to pass your exam with flying colours on the first try.

"The best preparation for tomorrow is doing your best today."

"He who is well prepared has half won the battle."

The Installation Rules Study Mate Team

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SANS 10142-1 LATEST EDITION: The Wiring Of Premises Part 1 & 2 [LV Installations]

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Annexure B:	**Installation Components**
Annexure D:	**Calculation Of Voltage Drop**
Annexure F:	**Conductors In Conduits**
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SANS 1973 LATEST EDITION: Low Voltage Switch Gear, Control Gear Assemblies-
Safety Of Assemblies With A Rated Prospective Short-Circuit Current Of Up To & Including 10 kA

IMPORTANT TABLES FOR PAPER 2

The following Tables will be required in solving many of paper 2 calculations:

- ❑ **Table 6.3 (b)**
- ❑ **Table 6.4 (b)**
- ❑ **Table 6.8**
- ❑ **Table 6.22**
- ❑ **Table 6.23**
- ❑ **Table 6.24**
- ❑ **Table 6.28**
- ❑ **Table D.1**
- ❑ **Table D.2**
- ❑ **Table D.3**

IMPORTANT FORMULAE

RESISTANCE

A material that is capable of conducting electric current is called a conductor and an arrangement of electrical conductors for the purpose of carrying electric current is called a circuit. The ability of any conductor in an electrical circuit to pass current is judged by its electrical **RESISTANCE**. Resistance is the ability of a conductor to oppose the flow of electric current. The greater the value of this resistance in any conductor, the less current will flow. The resistance of a conductor depends mainly on FOUR things:

- The **LENGTH** of the conductor.
- The **CROSS SECTIONAL AREA** of the conductor.
- The **MATERIAL** of which the conductor is made.
- The **TEMPERATURE** of the conductor. **Note: We will not cover the effects of temperature in this course**

The resistance is greater in longer conductors than in shorter ones, we say **RESISTANCE (R) IS PROPORTIONAL TO THE LENGTH (L)** and is written as **$R \propto L$** ($\propto$ means proportional to). The longer the conductor, the greater the value of the conductor's resistance and so the less current will flow through the conductor.

The resistance is less in conductors with a larger cross sectional area, we say **RESISTANCE (R) IS INVERSELY PROPORTIONAL TO THE CROSS SECTIONAL AREA (A)** and is written as **$R \propto 1/A$** (or **$R \propto A^{-1}$**). The greater the cross sectional area, the lower the value of the conductor's resistance and so the more current will flow through the conductor.

Provided that the dimensions (length and cross sectional area) of any conductor do not change, its resistance will remain the same. If two conductors of exactly the same dimensions have a different resistance, they must be made of different materials. One way to describe a material (any material) is by its **RESISTIVITY** or specific resistance. This is the amount of resistance present in a piece of the material **OF STANDARD DIMENSIONS**. The resistivity of a material is defined as the resistance of a piece of material having a length of one metre and a cross sectional area of one square metre. Resistivity is given the symbol **ρ**. This is not a small letter p but a lower case Greek letter r (called **rho**) and is measured in a unit called the **OHMS METER**, written **Ω•m.** The resistivity of a copper conductor at 20°C is 1.72×10^{-8} Ω.m but we will use **0.022μ Ω.m** in this guide – **μ** is equal to **10^{-6}**. Resistivity of aluminium conductor at 20°C is 2.7×10^{-8} Ω.m

VOLTAGE DROP – HOW DO I CALCULATE IT?

It will be helpful to read this section of the Study Guide together with **Section: 5.3.2 and 6.2.7** of SANS 10142. It is important to lower the effects of the voltage drop in a circuit and one of the ways to achieve this is by increasing the size or cross sectional area of the conductors – this in turn lowers the overall resistance of the cable. However, larger cable sizes increase cost, so it is important to calculate the voltage drop and find the optimum conductor size that will reduce voltage drop to safe levels while remaining cost effective.

One may use any of the following methods to calculate the voltage drop of a cable and we will use the first FIVE methods in this course. **Note** – for a balanced three phase circuits take care to multiply by **√3** [Square Root Of 3] except if Method 3 is used. Also, for unbalanced three phase loads and single phase loads include the voltage drop on neutral conductor as well.

METHOD 1

Use Ohm's Law:

$$V_d = I \times R$$

V_d is the voltage drop in **Volt**

I is the current in **Amperes**

R is the resistance in **Ohms**

METHOD 2

We have shown from the preceding section that :

$$R = \frac{\rho \times L}{A}$$

Replacing R in Ohm's Law we have:

$$V_d = \frac{I \times \rho \times L}{A}$$

V_d is the voltage drop in **Volt**

I is the current in **Amperes**

ρ is the resistivity of conductor in **Ohms meter or Ω.m**

L is the length of conductor in **m**

A is the conductor's cross-sectional area in m^2

PSCC CALCULATIONS: AC SUPPLY

Impedance Of The Phase Conductor:

$$Z_{Conductor} = \frac{L \times \sqrt{(R^2 + X^2)}}{1000}$$

Source Transformer Impedance:

$$Z_{Transformer} = \frac{V^2}{P \times 10^3} \times \frac{Z\%}{100}$$

Total Impedance Of The Upstream Network:

$$Z_{Total} = Z_{Transformer} + Z_{Conductor}$$

Loop Impedance:

$$Z_{Loop} = Z_{Transformer} + Z_{Conductor} + Z_{ECC}$$

Three Phase PSCC:

$$PSCC\ (3\Phi) = \frac{V}{\sqrt{3} \times Z_{Total}}$$

Single Phase PSCC:

$$PSCC\ (1\Phi) = \frac{V}{Z_{Total}}$$

Two Phase PSCC:

$$PSCC\ (2\Phi) = \frac{V_{Line}}{2 \times Z_{Line}}$$

PSCC CALCULATIONS: DC SUPPLY

The PSCC Of The Batteries: → $PSCC = \frac{E_B}{R_{BBr}}$

Open Circuit Voltage Of The Batteries: → $E_B = 1{,}05 \times U_{NB}\ V$

Where U_{NB} Is Given By: → $U_{NB} = 2{,}0\ V/cell$

Total Resistance Of The Upstream Network: → $R_{BBr} = 0{,}9 \times R_B + R_{BL} + R_y$

EXAMPLES 1 – 29

VOLTAGE DROP CALCULATIONS

EXAMPLE 6
VOLTAGE DROP CALCULATION

With reference to FIGURE 1 on the next page, calculate the following:

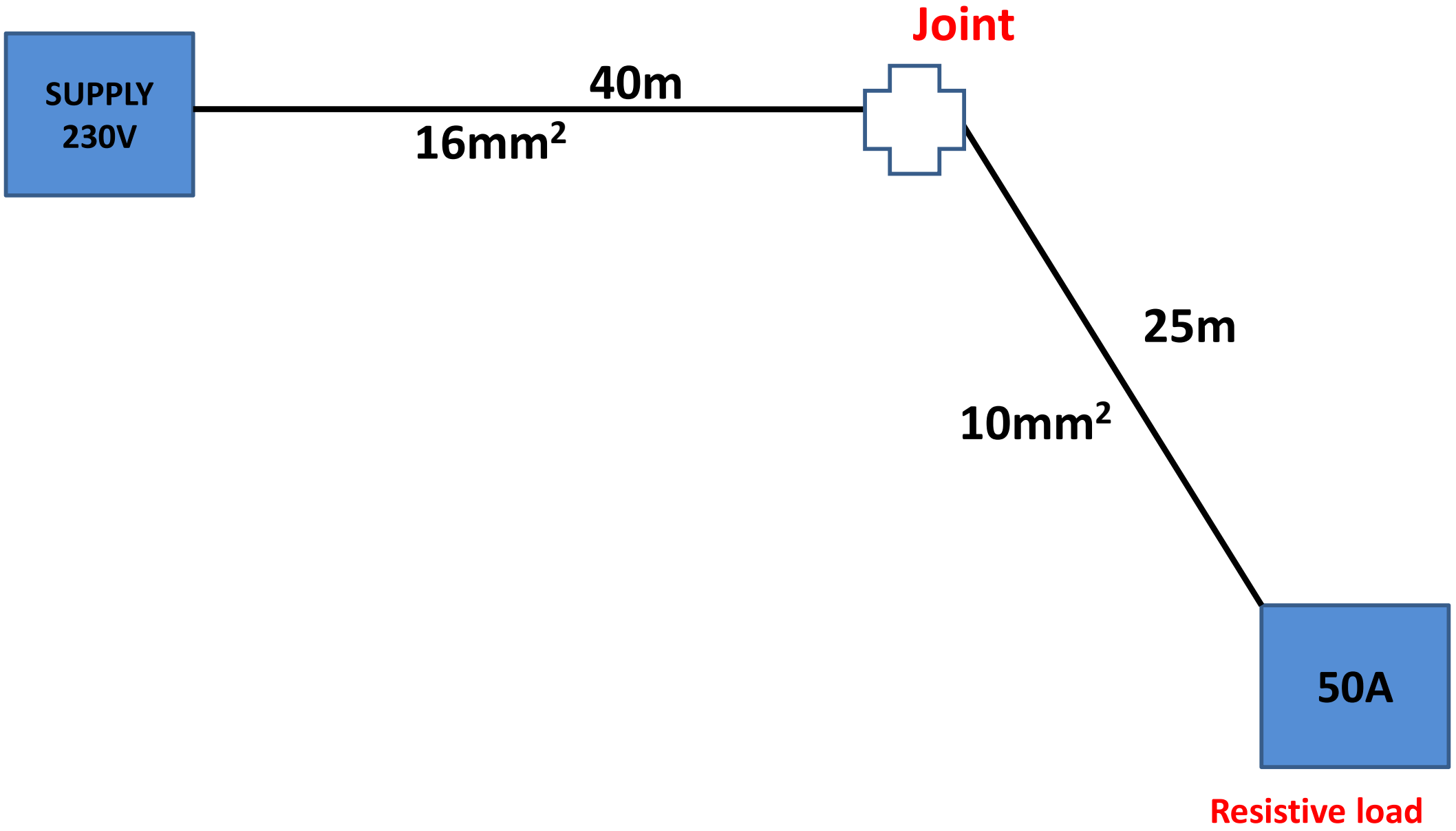
1. The total volt drop of the supply.

2. Test the answer in (1) above by making use of any other method.

3. The total resistance of the supply cable.

4. By making use of Table D.1 only, calculate the actual length of a 10 mm^2 copper ECC conductor if the total resistance of the conductor is 0,22 Ohms.

FIGURE 1



EXAMPLES 30 – 31

GENERAL CALCULATIONS :

BASIC PRINCIPLES

EXAMPLE 31

GENERAL CALCULATIONS: BASIC PRINCIPLES

1. Name FOUR factors that influence the resistance of a conductor.

2. Calculate the maximum value of the protection device if the following is given: length of the ECC is 100 meters 4mm^2 copper.

3. Calculate from basic principles the maximum value of the protection device, if the following is given: the length of ECC (earth continuity conductor) is 69 meters of copper with an area of 6mm^2.

4. Calculate the maximum value of the protection device if the following is given: length of the ECC is 70 meters 6mm^2 copper.

5. Calculate from first principles, the actual maximum length of the ECC (earth continuity conductor) if the main protection is 63A using a 6mm^2 copper conductor. What is the actual resistance value for the above length?

6. Calculate from basic principles the actual length of a 10mm^2 earth continuity conductor, if the main protection device is 60 amps and the touch voltage not to exceed 30V. What is the actual touch voltage at the load for this conductor?

7. Calculate from basic principles the cross-sectional area of the ECC conductor if the protection rating is 60A and the total length is 150 meters.

EXAMPLES 32 – 40

PSCC CALCULATIONS

AC PSCC

EXAMPLE 39

AC SUPPLY: PSCC CALCULATION

In order to select components that are rated to comply with the installation requirements of SANS 10142-1, certain information is required. Study the attached diagram together with the tables and calculate:

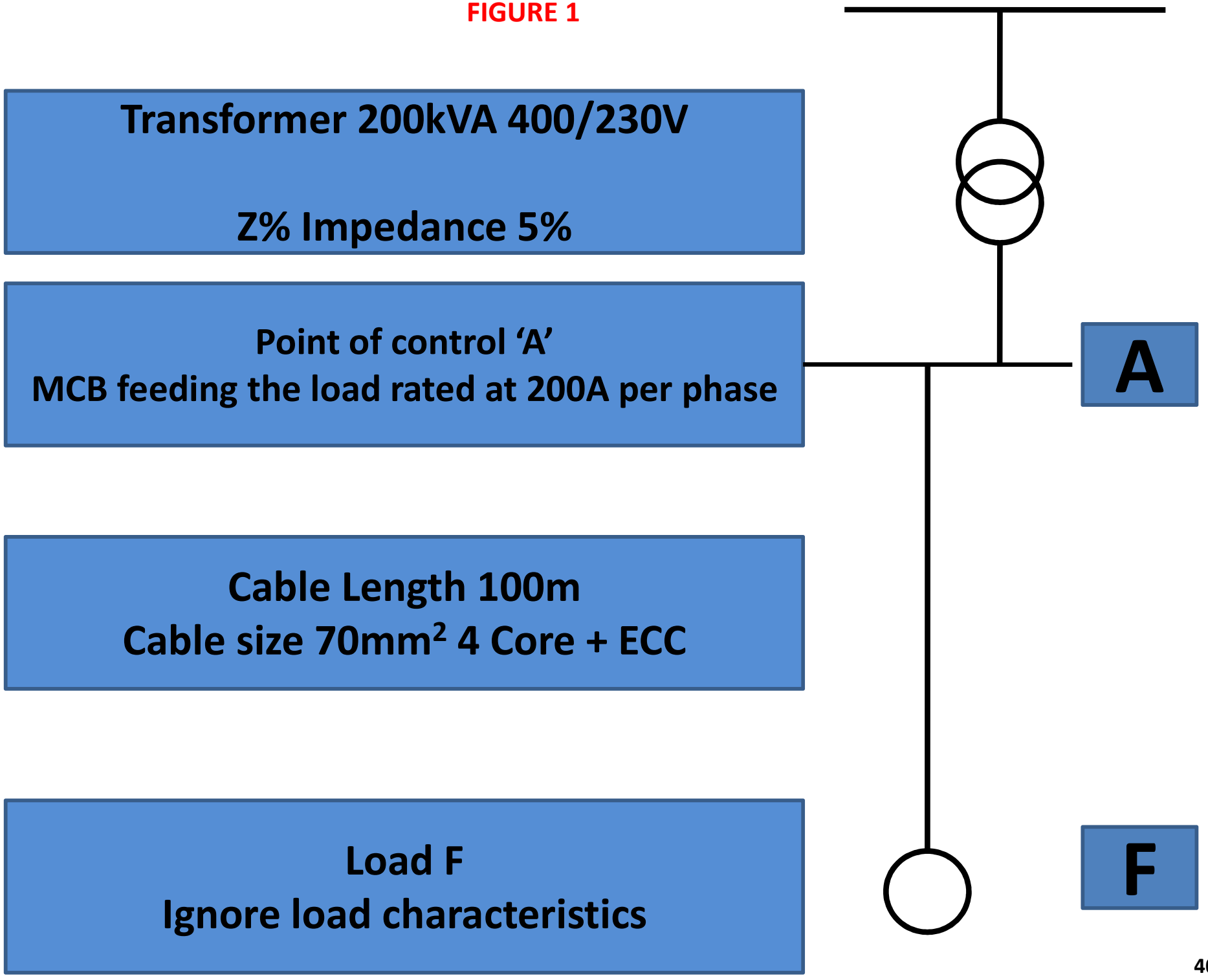
1. Calculate the three-phase prospective fault current at the load (F) from the point of control.

2. Calculate the volt drop from the point of control (A) to load(F). Express the answer in terms of percentage voltage drop

3. The actual minimum ECC size that could be used.

4. Calculate the touch voltage that will appear on the ECC at the load F.

FIGURE 1


Transformer 200kVA 400/230V
Z% Impedance 5%
Point of control 'A'
MCB feeding the load rated at 200A per phase
Cable Length 100m
Cable size 70mm² 4 Core + ECC
Load F
Ignore load characteristics
A
F

EXAMPLES 41 – 48

PSCC CALCULATIONS

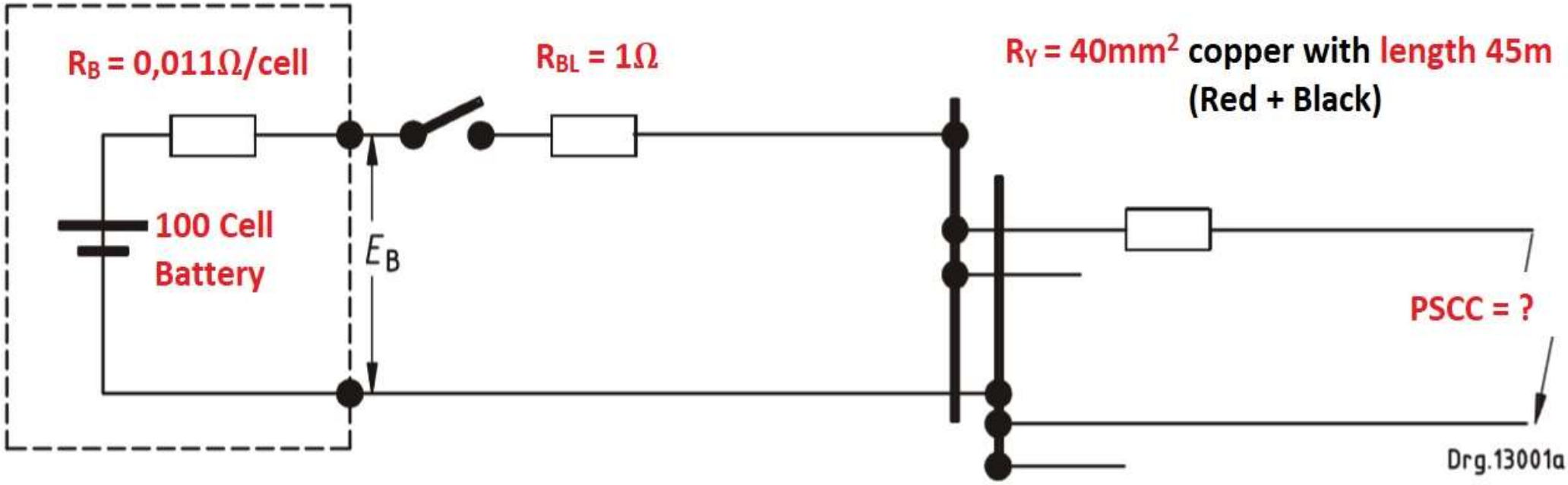
DC PSCC

EXAMPLE 48

DC SUPPLY: PSCC CALCULATION

Study the following Diagram and then calculate:

1. The PSCC.
2. The current flow if a load (R_L) of 110 ohms is connected to the circuit.
3. Describe the classification of the location for the above installation.



EXAMPLES 50 – 60

CONDUIT SIZE CALCULATIONS

ANNEX F

MODULE 7

LOW VOLTAGE SWITCHGEAR, CONTROLGEAR ASSEMBLIES [SANS 1973-3]

[With Answers]