EIGHTH EDITION

ELECTRICAL INSTALLATION CALCULATIONS: ADVANCED

LEVEL 3

CHRISTOPHER KITCHER
AND A. J. WATKINS

ROUTLEDGE

ELECTRICAL INSTALLATION CALCULATIONS: ADVANCED LEVEL 3

All the essential calculations required for advanced electrical installation work

- The established series for carrying out correct electrical installation calculations – continuously in print for over 40 years.
- This new edition is fully up to date with the amendments to the 17th Edition IET Wiring Regulations.
- An essential aid to the City & Guilds certificates.

Electrical Installation Calculations: Advanced provides a step-by-step guide to the successful application of the calculations required in day-to-day electrical engineering practice.

Now in its eighth edition, *Electrical Installation Calculations: Advanced* is in line with the amendments to the 17th Edition IET Wiring Regulations (BS 7671:2008) and references the material covered to the Wiring Regulations throughout. The content also meets the requirements of the 2365 Level 3 Diploma in Electrotechnical Technology from City & Guilds. Essential calculations which may not necessarily feature as part of the requirements of the syllabus are retained for reference by professional electrical installation engineers based in industry, or for those students wishing to progress to higher levels of study.

The book's structure and improved design make finding the required calculations easy. Key terms are explained in a glossary section and worked examples and exercises are included throughout the text. A complete question and answer section is included at the back of the book to enable readers to check their understanding of the calculations presented.

Christopher Kitcher has 50 years' experience in the electrical industry. He is a Lecturer in Electrical Installation at Central Sussex College and an NICEIC inspector for Microgeneration Certification Scheme (MCS). For the last 17 years he has worked in the college environment while maintaining his electrical skills by periodically working on site.

ELECTRICAL INSTALLATION

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Electrical Installation Calculations: Advanced

Preface

Being able to carry out mathematical calculations is a vital part of electrical installation courses and indeed electrical installation work.

The structure of electrical installation courses continually changes as do the course titles and numbers, however electrical science remains the same, and like it or not anyone wanting to become an electrician will need to have a good understanding of how to carry out electrical calculations.

The calculations which need to be performed vary from those which an electrician needs almost on a daily basis, such as cable calculation or the amount of energy required to run a particular piece of equipment, to more complex calculations such as those required for electromagnetism.

This book will show you how to carry out these calculations as simply as possible using electronic calculator methods. These methods will be useful both in the classroom and the workplace. It is not necessary for you to have a deep understanding of how the mathematical functions are performed. Each topic is shown using a step-by-step process with lots of exercises provided to give you the opportunity to test yourself at the end of each chapter.

This edition has been completely updated to the 17th edition of BS 7671 amendment 1: 2011 and the *IET On-Site Guide*, useful references are made to these documents throughout.

It does not matter which electrical course you are attending, this book along with the basic calculations book will be invaluable.

Table of Contents

Use of Calculators

1

Throughout books 1 and 2 the use of a calculator is encouraged. Your calculator is a tool, and like any tool practice is required to perfect their use. A scientific calculator will be required, and although they differ in the way the functions are carried out, the end result is the same.

The examples are given using a Casio fx-83MS.

The character printed on the button is the function performed when the button is pressed. To use the small letter functions on the top of any button the ***shift*** button must be used.

Practice is important.

Syntax error: will appear when the figures are entered in the wrong order.

x^2: will multiply a number by itself, eg $6 \times 6 = 36$. On the calculator this would be $6\ x^2 = 36$. When a number is multiplied by itself it is said to be ***squared***.

x2: will multiply a number by itself and then the total by itself again, eg when we enter 4 on calculator $x^3 = 64$. When a number is multiplied in this way it is said to be ***cubed***.

$\sqrt{\ }$: will give you the number which achieves your total by being multiplied by itself, eg $\sqrt{36} = 6$. This is said to be the ***square root*** of a number, and is the opposite of ***squared***.

$\sqrt[3]{\ }$: will give you the number which when multiplied by itself three times will be your total $\sqrt[3]{64} = 4$. This is said to be the ***cube root***.

x^{-1}: will divide 1 by a number, eg $\frac{1}{4} = 0.25$. This is the ***reciprocal*** button and is useful in this book for finding the resistance of resistors in parallel and capacitors in series.

EXP: is for the powers of 10 function, eg $25 \times 1000 = 25 \text{ EXP} \times 10^3 = 25\,000$.

Enter into your calculator 25 EXP 3 = 25000. (Do not enter the × or the number 10.)

If a calculation shows 10^{-3}, eg 25×10^{-3}, enter 25 EXP −3 = (0.025) (*when using EXP if a minus is required use the button* (−)).

Brackets: these should be used to carry out a calculation within a calculation.

Example calculation $\frac{32}{(0.8 \times 0.65 \times 0.94)} = 65.4$

Enter into calculator 32 ÷ (0.8 × 0.65 × 0.94 = 65.46)

Remember ***Practice makes Perfect.***

Simple Transposition of Formulae

2

To find an unknown value:

- the subject must be on the top line and must be on its own;
- the answer will always be on the top line;
- to get the subject on its own, values must be moved;
- any value that moves across the = sign must move from above the line to below the line; or
- from below the line to above the line.

EXAMPLE 1

$3 \times 4 = 2 \times 6$

$3 \times 4 = 2 \times ?$

Transpose to find **?**

$$\frac{3 \times 4}{2} = 6$$

EXAMPLE 2

$$\frac{2 \times 6}{?} = 4$$

Step 1 $2 \times 6 = 4 \times ?$

Step 2 $\frac{2 \times 6}{?} = 4$

Answer $\frac{2 \times 6}{4} = 3$

EXAMPLE 3

$5 \times 8 \times 6 = 3 \times 20 \times ?$

Step 1 move 3×20 away from unknown value, as the known values move across the = sign they must move to bottom of equation $\frac{5 \times 8 \times 4}{3 \times 20} = ?$

Step 2 Carry out the calculation

$$\frac{5 \times 8 \times 6}{3 \times 20} = \frac{240}{60} = 4$$

Therefore

$5 \times 8 \times 6 = 240$ *or* $3 \times 20 \times 4 = 240$ or $5 \times 8 \times 6 = 3 \times 20 \times 4$

SI Units

3

In the United Kingdom and the rest of Europe the units for measuring different properties are known as SI units.

SI stands for **Système Internationale**.

All units are derived from seven base units.

Base quantity	Base unit	Symbol
Time	Second	s
Electrical current	Ampere	A
Length	Metre	m
Mass	Kilogramme	kg
Temperature	Kelvin	K
Luminous intensity	Candela	cd
Amount of substance	Mole	mol

SI DERIVED UNITS

Derived quantity	Name	Symbol
Frequency	hertz	Hz
Force	Newton	N
Energy, work, quantity of heat	joule	J
Electric charge, quantity of electricity	coulomb	C
Power	watt	W
Potential difference, electromotive force	volt	V or U
Capacitance	farad	F
Electrical resistance	ohm	Ω
Magnetic flux	weber	Wb
Magnetic flux density	tesla	T
Inductance	henry	H
Luminous flux	lumen	cd
Area	square metre	m^2
Volume	cubic metre	m^3
Velocity, speed	metre per second	m/s
Mass density	kilogramme per cubic metre	kg/m^3
Luminance	candela per square metre	cd/m^2

SI UNIT PREFIXES

Name	Multiplier	Prefix	Power of 10
Tera	1000 000 000 000	T	1×10^{12}
Giga	1000 000 000	G	1×10^{9}
Mega	1000 000	M	1×10^{6}
Kilo	1000	k	1×10^{3}
Unit	1		
milli	0.001	m	1×10^{-3}
micro	0.000 001	μ	1×10^{-6}
nano	0.000 000 001	η	1×10^{-9}
pico	0.000 000 000 001	ρ	1×10^{-12}

EXAMPLES

mA milliamp = one thousandth of an ampere

km kilometre = one thousand metres

μv micro volt = one millionth of a volt

GW Giga watt = one thousand million watts

kW Kilowatt = one thousand watts

Calculator example:

1 kilometre is 1 metre $\times$ 10^3

Enter into calculator 1 EXP 3 = (*1000*) metres

1000 metres is 1 kilometre $\times$ 10^{-3}