A.J. WATKINS, C. KITCHER

Electrical Installation Calculations

BASIC

Fully up-to-date with 17th Edition IEE Wiring Regs

EIGHTH EDITION

For technical certificate
Level 2

Newnes

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FOR TECHNICAL CERTIFICATE LEVEL 2

EIGHTH EDITION

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CHRIS KITCHER

ELSEVIER

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Contents

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Preface

Mathematics forms the essential foundation of electrical installation work.Without applying mathematical functions we would be unable to work out the size of a room which needs lighting or heating, the size and/or the number of the lights or heaters themselves, the number and/or the strength of the fixings required, or the size of the cables supplying them.We would be unable to accurately establish the rating of the fuse or circuit breaker needed to protect the circuits, or predict the necessary test results when testing the installation. Like it or not you will need to be able to carry out mathematics if you want to be an efficient and skilled electrician.

This book will show you how to perform the maths you will need to be a proficient electrician. It concentrates on the electronic calculator methods you would use in class and in the workplace. The book does not require you to have a deep understanding of how the mathematical calculations are performed – you are taken through each topic step by step, then you are given the opportunity yourself to carry out exercises at the end of each chapter. Throughout the book useful references are made to the 17th edition of BS 7671:2008 *Electrical Wiring Regulations* and the 17th Edition IEE *On-Site Guide.*

Simple cable selection methods are covered comprehensively in this volume so as to make it a useful tool for tradesmen involved in Part P of the building regulations, with more advanced calculations being added in the companion volume, *Electrical Installation Calculations: Advanced.*

Electrical Installation Calculations: Basic originally written by A.J.Watkins and R.K. Parton has been the preferred book for students looking to gain an understanding of electrical theory and calculations for many years. This edition has been updated so that the calculations and explanations comply with the 17th edition wiring regulations. Also included in this new edition are a number of questions and exercises, along with answers to assist students who are intending to study for the City & Guilds 2330 Gola exams.

Chris Kitcher

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Use of calculators

Throughout the 'Basic' and 'Advanced' books, the use of a calculator is encouraged. Your calculator is a tool, and like any tool practice is required to perfect its 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 figure printed on the button is the function performed when the button is pressed. To use the function in small letters above any button the *shift* button must be used.

Practice is important

Syntax error	Appears when the figures are entered in the wrong order.
x^2	Multiplies a number by itself, i.e. $6 \times 6 = 36$. On the calculator this would be $6x^2 = 36$. When a number is multiplied by itself it is said to be *squared*.
x^3	Multiplies a number by itself and then the total by itself again, i.e. when we enter 4 on calculator $x^3 = 64$. When a number is multiplied in this way it is said to be *cubed*.
$\sqrt{\ }$	Gives the number which achieves your total by being multiplied by itself, i.e. $\sqrt{36} = 6$. This is said to be the *square root* of a number and is the opposite of *squared*.
$\sqrt[3]{\ }$	Gives the number which when multiplied by itself three times will be the total. $\sqrt[3]{64} = 4$ this is said to be the *cube root*.

x^{-1}	Divides 1 by a number, i.e. $\frac{1}{4} = 0.25$. This is the *reciprocal* button and is useful in this book for finding the resistance of resistors in parallel and capacitors in series.
EXP	The powers of 10 function, i.e. $25 \times 1000 = 25\,\text{EXP} \times 10^3 = 25\,000$ Enter into calculator 25 EXP 3 = 25 000. (Do not enter the x or the number 10.) If a calculation shows 10^{-3}, i.e. 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: $\frac{32}{(0.8 \times 0.65 \times 0.94)} = 65.46$ Enter into calculator 32 ÷ (0.8 × 0.65 × 0.94) =

Remember: *Practice makes perfect!*

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Simple transposition of formulae

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 line or from below the line to above the line.

Example 1

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

Transpose to find?

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

Example 2

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

Step 1 $\underline{2\times 6 = 4\times ?}$

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

Answer $\frac{2\times6}{4}=3$

Example 3

$$5\times8\times6=3\times20\times?$$

Step 1: Move 3×20 away from the unknown value, as the known values move across the = sign they must move to the bottom of the equation

$$\frac{5\times8\times6}{3\times20}=?$$

Step 2: Carry out the calculation

$$\frac{5\times8\times6}{3\times20}=\frac{240}{60}=4$$

Therefore

$$5\times8\times6=240$$

$$3\times20\times4=240$$

or

$$5\times8\times6=3\times20\times4.$$

SI units

In Europe and the UK, 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	Kilogram	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	Kilogram 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	Microvolt = one millionth of a volt
GW	Gigawatt = 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 $\times 10^{-3}$

Enter into calculator 1000 EXP −3 = (1) kilometre

1 microvolt is 1 volt $\times 10^{-6}$

Enter into calculator 1 EXP −6 = (10^{-06} or 0.000001) volts (note sixth decimal place).

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Conductor colour identification

	Old colour	*New colour*	*Marking*
Phase 1 of a.c.	Red	Brown	L1
Phase 2 of a.c.	Yellow	Black	L2
Phase 3 of a.c.	Blue	Grey	L3
Neutral of a.c.	Black	Blue	N

Note Great care must be taken when working on installations containing old and new colours.

Exercise 1

1. Convert 2.768 kW to watts.
2. How many ohms are there in 0.45 MΩ?
3. Express a current of 0.037 A in milliamperes.
4. Convert 3.3 kV to volts.
5. Change 0.000 596 MΩ, to ohms.
6. Find the number of kilowatts in 49 378 W.
7. The current in a circuit is 16.5 mA. Change this to amperes.
8. Sections of the 'Grid' system operate at 132 000 V. How many kilovolts is this?
9. Convert 1.68 μC to coulombs.
10. Change 724 mW to watts.
11. Convert the following resistance values to ohms:

    (a) 3.6 $\mu\Omega$
    (b) 0.0016 MΩ
    (c) 0.085 MΩ
    (d) 20.6 $\mu\Omega$
    (e) 0.68 $\mu\Omega$

12. Change the following quantities of power to watts:

    (a) 1.85 kW
    (b) 18.5 mW
    (c) 0.185 MW
    (d) 1850 μW
    (e) 0.0185 kW

13. Convert to volts:

(a) 67.4 mV
(b) 11 kV
(c) 0.240 kV
(d) 9250 μV
(e) 6.6 kV

14. Convert the following current values to amperes:

(a) 345 mA
(b) 85.4 μA
(c) 29 mA
(d) 0.5 mA
(e) 6.4 mA

15. Add the following resistances together and give the answer in ohms: 18.4 Ω, 0.000 12 Ω, 956000 μΩ

16. The following items of equipment are in use at the same time: four 60 W lamps, two 150 W lamps, a 3 kW immersion heater, and a 1.5 kW radiator. Add them to find total load and give the answer in watts.

17. Express the following values in more convenient units:

(a) 0.0053 A
(b) 18 952 W
(c) 19 500 000 Ω
(d) 0.000 006 25C
(e) 264 000 V

18. The following loads are in use at the same time: a 1.2 kW radiator, a 15 W lamp, a 750 W iron, and a 3.5 kW washing machine. Add them together and give the answer in kilowatts.

19. Add 34 250 Ω to 0.56 MΩ and express the answer in ohms.

20. From 25.6 mA take 4300 μA and give the answer in amperes.

21. Convert 32.5 μC to coulombs.

22. Convert 4350 pF to microfarads.

23. 45 μs is equivalent to:

(a) 0.45 s
(b) 0.045 s
(c) 0.0045 s
(d) 0.000 045 s

24. 50 cl is equivalent to:

(a) 51 (b) 0.051 (c) 0.05 ml (d) 500 ml

25. 0.2 m^3 is equivalent to:

(a) 200 dm^3
(b) 2000 cm^3
(c) 2000 dm^3
(d) 200 cm^3

26. 0.6 MΩ is equivalent to:

(a) 6000 Ω
(b) 60 000 Ω
(c) 600 000 Ω
(d) 6000 000 Ω