BRAILLE AUTHORITY OF THE UNITED KINGDOM

BRAILLE SCIENCE NOTATION

Royal National Institute of Blind People
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Peterborough, Cambridgeshire
PE2 6XU
2008

Registered Charity No. 1001157

Printed by RNIB, Peterborough 2008

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INTRODUCTION TO 1989 EDITION

It is almost thirty years since the publication of the previous edition of the Braille Science Notation, and the need for a new edition has become increasingly pressing, both in order to update the braille techniques, and to keep pace with the ever changing symbolism of science. The revision was undertaken in stages, and in fact the section on chemistry notation was released as early as December 1985, in order to allow those parts of the previous edition most at odds with current practice to be dispensed with promptly.

This work was carried out in parallel with the revision of the Braille Mathematics Notation (published in 1987), and the two publications are now entirely consistent. Indeed, the section on unit abbreviations is identical to the corresponding section in the Braille Mathematics Notation, and was considered jointly by both committees. It should be emphasised that the transcription of scientific text draws heavily upon the mathematics code, and for this reason a short summary is presented in the first section, and the section on unit abbreviations follows. Other sections give additional techniques and guidance which may be required for specific fields.

The sections on chemistry notation and electronic and logic circuits have been entirely revised in order to resolve problems which had emerged with the previous code, to improve the presentation, and to extend and update the notation. It should be noted that as a result, important changes have been made to the basic methods given for structural formulae in chemistry, and for electronic and logic circuit diagrams. It is recommended that when the special techniques given here for diagrammatic structural formulae and circuit diagrams are used in transcription work, the reader should be forewarned by the insertion of a note referring to the Braille Science Notation 1989 for explanation of the techniques and abbreviations used. It is also worth emphasising here that these special techniques for representing such diagrams are intended as a standard resource for use when it is advantageous to do so; direct diagrammatic representation is still to be regarded as a basic technique for such cases.

We are fortunate that we have been able to set this edition on computer. It is anticipated that in future it will be possible to keep the Braille Science Notation up to date and meeting current needs, and that any errors or omissions can be corrected promptly.

INTRODUCTION TO 2008 EDITION

The current edition of *Braille Science Notation* contains amendments to the 1989 edition needed to preserve conformity with the current 2005 edition of *Braille Mathematics Notation*. In particular, the section on Basic Mathematics Notation has been updated, and the section on Units has been replaced by the current section in *Braille Mathematics Notation*. These changes are fairly minor, and reference may be made to the latter publication for more details. Chemistry notation is not disturbed, except that single letter chemical element symbols now require a dots 56 letter sign as well as a capital sign, when standing alone in ordinary text, according to the general principles. Electronic and logic circuit notation is also unchanged, except for the similar requirement of the dots 56 sign being used with single capital letters in explanations attached to diagrams.

February 2008

BRAILLE SCIENCE NOTATION

1
BASIC MATHEMATICS NOTATION

Full details and additional notation are given in the Braille Mathematics Notation 2005 (BAUK).

Layout

Set out formulae or equations begin in cell 5 with runovers in cell 7.
Dot 5 is used as a hyphen to break an equation at the end of a line.
Dot 6 is used to separate a formula or expression from following punctuation.

Numeral and Letter Fount Signs

Numeral sign: ⠼

Fractions are coded as an upper number followed by a lower number, after the numeral sign.

Ex. ⠼⠃⠌⠆ $\frac{1}{2}$

⠼⠃⠐⠼⠉⠲ $2\frac{3}{4}$

The decimal point is coded as dot 2.

Ex. ⠼⠃⠲⠉ 2·3

Letter fount signs:

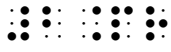
	Small	Capital
Latin	⠰	⠠
Greek	⠨	⠘
Bold Latin	⠸	⠈
Bold Greek	⠸⠨	⠈⠘

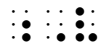
These precede the letter to which they apply. A letter within a mathematical expression without a letter fount sign is assumed to be small Latin; the dots 56 letter fount sign must, however, be asserted when the letter stands alone or starts a mathematical expression within ordinary text, or is an *a - j* immediately following a number.

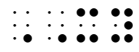
The dots 56 sign is also used before a single capital Latin letter (possibly followed by a simple numerical subscript) when the letter stands alone in ordinary text, or begins a mathematics expression in ordinary text and is followed by a space.

(Note that in accordance with the above, a capital Latin letter acting as a label in a mathematical diagram and not adjacent to ordinary words does not require a dots 56 sign.)

Double letter fount signs have force over subsequent letters until the sequence is interrupted by a space or any other mathematical sign except a lower number, dash or star.

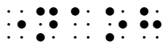
Ex.  $2\pi r$

 or  V (dots 56 used when standing alone in ordinary text)

 XY

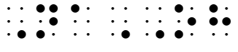
 ABC

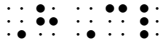
Special letter fount rules exist for chemical formulae: The force of the dot 6 capital sign carries over all letters in an unspaced chemical formula until another letter fount sign or numeral sign intervenes; and dot 5 is used to indicate a two (or three) letter element symbol, letters following that symbol being assumed to be capital unless shown otherwise. For further details see the section on chemistry notation.

Ex. (chemistry notation)  NaOH

 HCl

However, it is possible to represent such formulae unambiguously using the conventions of mathematics braille. In such cases it is advisable to avoid using the dots 56 sign between the letters of a two (or three) letter element symbol by instead using a dot 6 sign before the first letter in the symbol.

Ex. (mathematics notation)  NaOH

 HCl

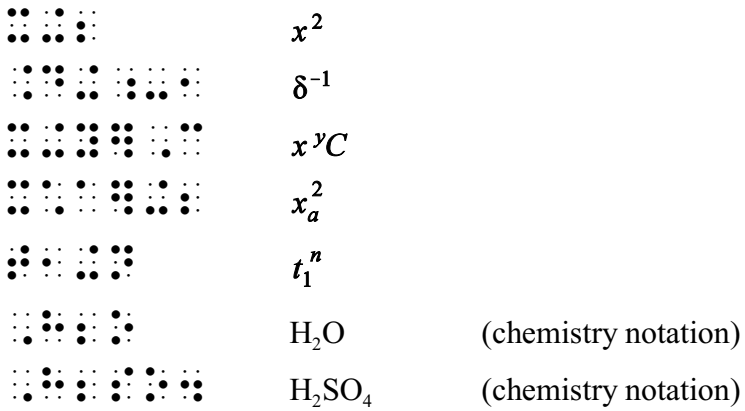
Indices

Subscript sign: 

Superscript sign: 

These indicate that the expression which follows is a subscript or superscript to the

preceding expression. Indices which are whole numbers are brailled as lower numbers without the numeral sign, and if subscripts the subscript sign ⠩ is omitted. Indices other than whole numbers written in the lower part of the cell are ended with the index termination sign ⠻ unless a space or a bracket containing the whole term follows.

Ex. 

x^2

δ^{-1}

x^yC

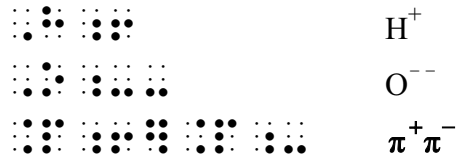
x_a^2

t_1^n

H_2O (chemistry notation)

H_2SO_4 (chemistry notation)

Superscript or subscript + and − signs are brailled without the ⠬ or ⠩ signs.

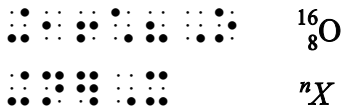
Ex. 

H^+

O^{--}

$\pi^+\pi^-$

Left-hand indices are shown by preceding the main symbol by the index group.

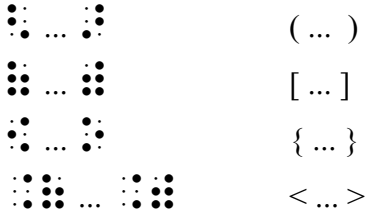
Ex. 

${}^{16}_{8}O$

${}^nX$

Brackets

The following mathematical brackets are used:



(...)

[...]

{ ... }

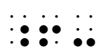
< ... >

Operation and Relation Signs

The following signs are spaced on the left, but not on the right:


+ plus


− minus


± plus or minus


× multiplied by


÷ divided by


= equals


≠ is not equal to


≡ equivalent to


≈ approximately equal to


≥ greater than or equal to


≤ less than or equal to


∝ proportional to


~ swung dash or tilde


∪ union


∩ intersection

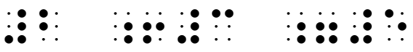

⊂ contained in


⊆ contained in or equal to


⊃ contains


⊇ contains or equal to


∈ is an element of

Ex.  $2 + 3 = 5$

 $A \cap B \subset C$

The following signs are unspaced:


/ fraction line

⠐⠄ . multiplication dot

Ex. ⠼⠁⠌⠼⠃ a/b or $\frac{a}{b}$

The following signs are spaced on both sides:

⠐⠣ < less than

⠐⠜ > greater than

Ex. ⠰⠝ ⠐⠣ ⠼⠋ $n<6$

Arrows

In mathematics and physics equations arrows are spaced on the left but not on the right. In chemistry equations arrows should be spaced on both sides, except for the arrows ↑ and ↓ referring to the preceding terms, which are unspaced from those terms and placed in brackets.

⠒⠕ → ⠪⠒ ←

⠪⠒⠕ ↔ ⠪⠒⠕ ⊢→

⠶⠒⠕ ⇒ ⠶⠪⠒⠕ ⇔

⠒⠒ ↑ ⠒⠒ ↓

⠪⠒⠕ ⇌ or ⥨

⠪⠒⠕ ⇋ or ⥩

⠪⠪⠒⠒ ⥤ or ⥨

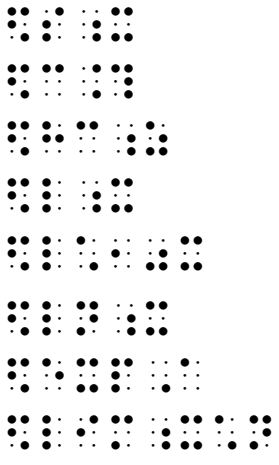
⠪⠒⠪⠒ ⥤ or ⥧

Other arrows may be constructed analogously.

Special Functions

Special functions are introduced by the ⠰⠆ sign, and may be followed by any

mathematical sign; an immediately following small Latin letter thus requiring its letter sign. Trigonometric, hyperbolic, logarithmic and vector analysis functions have special braille abbreviations; otherwise, the function is written as in print (without contractions).

Ex. 

$\sin x$

$\cos \theta$

$\cosh z$

$\log x$

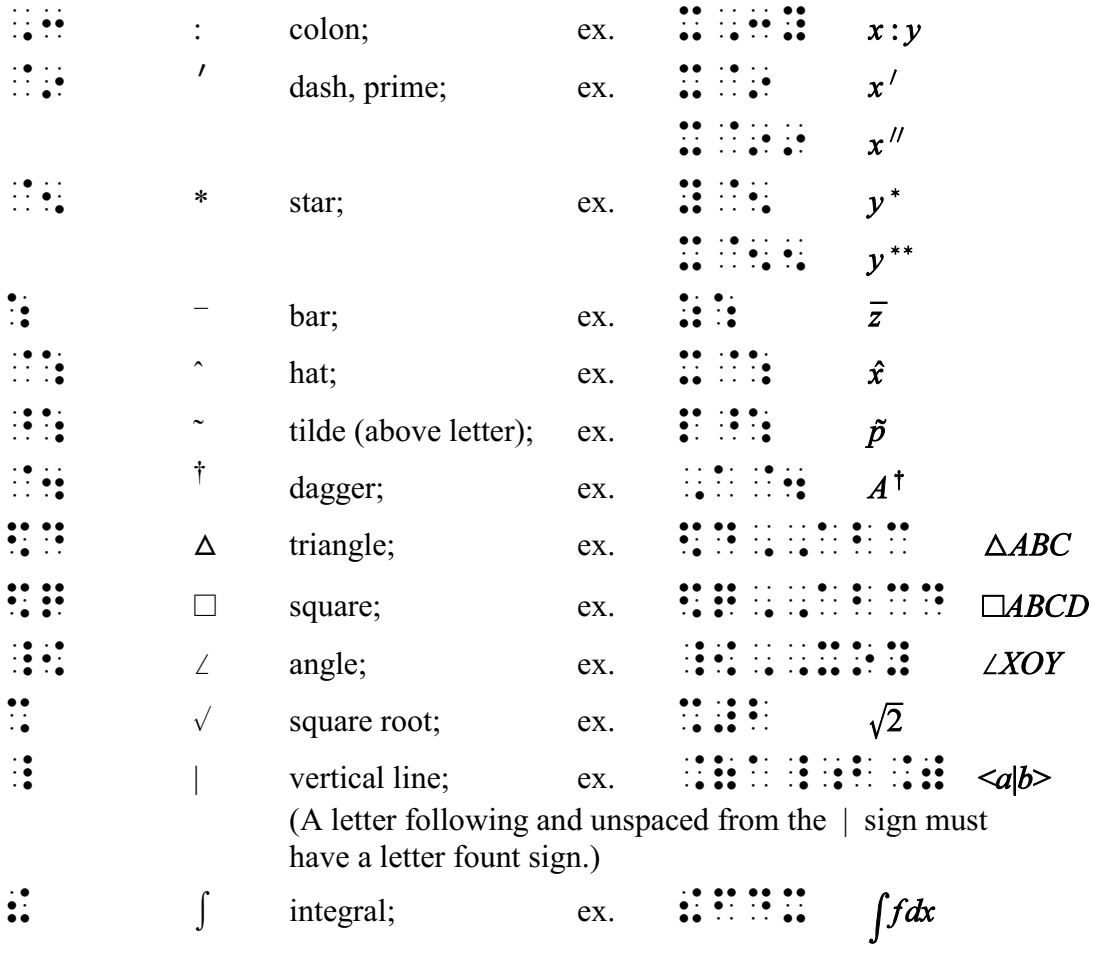
$\log_{10} x$

$\ln x$

$\exp A$

$\lim x_n$

Additional Signs



:	colon;	ex.	$x : y$	
′	dash, prime;	ex.	x'	
			x''	
*	star;	ex.	y^{*}	
			y^{**}	
‾	bar;	ex.	$\bar{z}$	
ˆ	hat;	ex.	$\hat{x}$	
~	tilde (above letter);	ex.	$\tilde{p}$	
†	dagger;	ex.	$A^{\dagger}$	
Δ	triangle;	ex.		$\triangle ABC$
□	square;	ex.		$\square ABCD$
∠	angle;	ex.		$\angle XOY$
√	square root;	ex.	$\sqrt{2}$	
|	vertical line; (A letter following and unspaced from the | sign must have a letter fount sign.)	ex.		$<a\|b>$
∫	integral;	ex.	$\int f dx$	

2
UNITS

(Tables of standard unit abbreviations are given at the end of this section for reference.)

(*Note*: The examples in this section have been chosen to illustrate a variety of print forms as found: this choice is not intended to indicate recommended practice.)

1 Units are placed before or after the number to which they refer, according to print. Units should be spaced in braille, apart from the signs in §**5** denoting units of angle and length in feet and inches, monetary unit abbreviations preceding the number, and single letter monetary unit abbreviations or symbols following the number.

2 Unit abbreviations are generally coded using the usual conventions of literary and mathematics braille notation, e.g. as regards the use of the letter sign and capital sign. Note that the letter sign is not required before unit abbreviations consisting of two or more lower case letters belonging to one word, e.g. cm for centimetre, but it is required where a lower case letter is followed by an upper case letter at the beginning of a unit abbreviation, e.g. mW for milliwatts.

2.1 Capitals should normally be indicated, even in non-capitalized braille. However, conventional informal abbreviations such as MPH, M.P.H., MPG, etc., can be treated as lower case in non-capitalized braille.

2.2 mmHg should be coded with a dot 6 before the abbreviation Hg for mercury, unless the special braille code for chemistry is being used (see section 3).

3 μ is coded as  , Å (ångström) coded as  , Ω (ohm) coded as  , % (percent) coded as  , £ (pounds sterling) coded as  , $ (dollars) coded as , ¢ (cent) coded as  , and € (euro) as  . (See however, §**4**.)

Ex.1 3 metres 

6 m 

(6 metres)

2, 3 m 

(2, 3 metres)

2×10^2 m 

(2×10^2 metres)

£6 

(6 pounds sterling)

£*x*

(*x* pounds sterling)

£5.30p

(5 pounds 30 pence)

£60m

(60 million pounds)

24.60 €

(24 euros 60 cents)

25%

(25 percent)

3 s

(3 seconds)

3 sec

(3 seconds)

1 mol

(1 mole)

20 km

(20 kilometres)

5 ft 10 ins

(5 feet 10 inches)

4 T

(4 teslas)

5 mA

(5 milliamperes)

10 Hz

(10 hertz)

3.3 Pa

(3.3 pascals)

9 GeV

(9 gigaelectronvolts)

6 MW

(6 megawatts)

8 Å

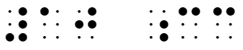
(8 ångströms)

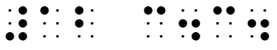
3 µs

(3 microseconds)

20 ml

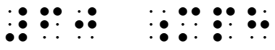
(20 millilitres)

10 cc

(10 cubic centimetres)

12 c.c.

(12 cubic centimetres)

40 m.p.h.

(40 miles per hour)

60 MPH

(60 miles per hour)

6 yr.

(6 years)

4 Unit abbreviations should generally be coded in the same way, whether or not accompanying a number.

£ (spaced) should, however, be coded as  ; and $ (spaced) coded as  . These signs should also be used when the symbols occur in conjunction with letters in a monetary unit. See also §**5.2**.

Ex.2 A$60

(60 Australian dollars)

5 In simple expressions of angle, or length in feet and inches,

° (degrees) is coded as 

′ (minutes, or feet) as 

″ (seconds, or inches) as 

ᶜ (radians, when used instead of rad) as

and follow the number to which they apply, with the whole group unspaced. When the degree sign follows a lower number it should be preceded by the superscript sign  to avoid ambiguity.

Ex.3 6°

(6 degrees)

30′

(30 minutes, or 30 feet)

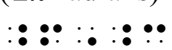
10″

(10 seconds, or 10 inches)

$2\pi^c$

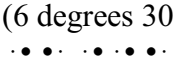
(2π radians)

6°30′



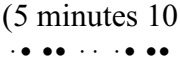
(6 degrees 30 minutes)

5′10″



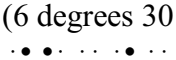
(5 minutes 10 seconds, or 5 feet 10 inches)

6°30′10″



(6 degrees 30 minutes 10 seconds)

$\frac{1}{2}°$



($\frac{1}{2}$ degree)

5.1 In expressions of temperature, and in bearings, the letters C, F; N, S, E, W, are brailled unspaced from the number to which they apply.

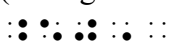
Ex.4 30°F

(30 degrees Fahrenheit)

10°C

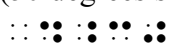
(10 degrees Celsius)

50°S



(50 degrees south)

N30°W



(North 30° west)

5.2 In combined units (see §**7**), °, °F and °C are coded as

respectively.

These abbreviations are also used in braille when the unit symbol is not attached to a number.

6 Indices attached to unit abbreviations or words, should be shown as lower numbers

immediately following the ⠘⠔ superscript sign.

Ex.5 5 km^2 ⠼⠑⠅⠍⠘⠔⠃
(5 kilometre^2)

6 s^{-1} ⠼⠋⠎⠘⠤⠼⠁
(6 second^{-1})

7 In combined units, a dot 3 should be inserted between the individual units unless an index or stroke is present at that point. A group consisting of a multiplying prefix attached to a basic unit symbol (e.g. kg, cm, etc.) is to be regarded as a single unit, and so a dot 3 separator should not intervene.

The stroke / should be brailled as ⠸⠌ .

7.1 In print, the individual units in combined units are usually separated by spaces or half-spaces if not by a stroke (dots are also occasionally used). The dot 3 separator should, however, always be used between individual units in braille according to §**7**, even when no separation is shown between them in print.

Ex.6 3 N m ⠼⠉⠝⠍
(3 newton metres)

6 N/m^2 ⠼⠋⠝⠸⠌⠍⠘⠔⠃
(6 newtons per metre^2)

4 m s ⠼⠙⠍⠎
(4 metre seconds)

10 ms ⠼⠁⠚⠍⠎
(10 milliseconds)

metre s ⠍⠑⠞⠗⠑⠎⠲
(metre seconds. This example shows the letter sign used before s for second when the dot 3 might otherwise be read as an apostrophe.)

5 g m^{-1} ⠼⠑⠛⠍⠘⠤⠼⠁
(5 gram metre^{-1})

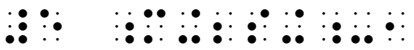
30 m/s ⠼⠉⠚⠍⠸⠌⠎
(30 metres per second)

m/s^2 ⠍⠸⠌⠎⠘⠔⠃
(metre per second^2)

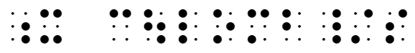
4 rad s^{-1} ⠼⠙⠗⠁⠙⠎⠘⠤⠼⠁
(4 radians second^{-1})

10^{-3} N s m^{-2} 

(10^{-3} newton second $metre^{-2}$)

5 m^2 s^{-1} 

(5 $metre^2$ $second^{-1}$)

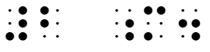
x coulomb/s 

(*x* coulombs per second)

8 Long combined units may be split at the end of a braille line using the dot 5 mathematical hyphen. A dot 3, if present at that point, remains before the dot 5 hyphen. A stroke at that point should be taken onto the new line. Short unit expressions should not be divided.

It is preferable for spaced units not to be separated from their preceding number at the end of a braille line.

9 The dot 6 mathematical separation sign is not required after a unit abbreviation before following punctuation unless the abbreviation ends with an index or one of the angle symbols given in §**5**.

Ex.7 2 m. 

(2 metres.)

7 m^2. 

(7 $metre^2$.)

5°. 

(5 degrees.)

TABLES

(SI units and prefixes are taken from The Association for Science Education booklet: *SI Units, Signs, Symbols and Abbreviations* (1981). Other non-SI units are taken from *Nuffield Advanced Science Book of Data* (1982).)

SI UNITS

Name	**Symbol**	**Name**	**Symbol**
metre	m	coulomb	C
kilogram	kg	volt	V
second	s	ohm	Ω
ampere	A	siemens	S
kelvin	K	farad	F
candela	cd	weber	Wb
mole	mol	tesla	T
radian	rad	henry	H
steradian	sr	lumen	lm
hertz	Hz	lux	lx
newton	N	becquerel	Bq
pascal	Pa	gray	Gy
joule	J	sievert	Sv
watt	W		

MULTIPLYING PREFIXES

These may be attached to any of the above units. (Exceptionally kg already has a prefix attached, but other multiples e.g. mg, g, are formed in the obvious way.)

Sub-multiple	**Prefix**	**Symbol**	**Multiple**	**Prefix**	**Symbol**
10^{-1}	deci	d	10^{1}	deca	da
10^{-2}	centi	c	10^{2}	hecto	h
10^{-3}	milli	m	10^{3}	kilo	k
10^{-6}	micro	μ	10^{6}	mega	M
10^{-9}	nano	n	10^{9}	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P
10^{-18}	atto	a	10^{18}	exa	E

(These prefixes are also sometimes used before units in the following table.)

OTHER NON-SI UNIT SYMBOLS

Name	**Symbol**
ångström	Å
astronomical unit	au (also AU)
atmosphere	atm
atomic mass unit	u
biot	Bi
British thermal unit	Btu
calorie	cal
curie	Ci
day	d
debye	D
decibel	dB
degree (angular)	°
degree Celsius	°C
degree Fahrenheit	°F
dyne	dyn
electronvolt	eV
foot	ft (also ′)
franklin	Fr
gallon	gal
gauss	G
hectare (100 ares)	ha
horsepower	hp
hour	h
hundredweight	cwt
inch	in (also ″)
kilogram-force	kgf
(kilopond)	kp
knot	kn
litre	l (also L)
micron	m (also μ)
mile (nautical)	n mile (braille as n. mile)
minute (angle)	′
minute (time)	min (m is also used in time of day, e.g. 18 h 23 m)
oersted	Oe
ounce	oz
ounce (fluid)	fl oz (A space is left between fl and oz in braille.)
pint	pt
poise	P
pound (weight)	lb
pound-force	lbf
rad or röntgen	R
rem	Rem

second (angle)	″
stokes	St
ton-force	ton f (braille as tonf)
tonne	t
torr	Torr
X unit	Xu
yard	yd
year	a

3
CHEMISTRY NOTATION

NOTE

The method of coding structural formulae given in sections **17-26** of this code is intended to be an alternative or an addition to diagrammatic representation, to be used when convenient. Diagrammatic representation should generally be regarded as the primary method. Section **17** should, however, be generally used to represent structural formulae printed linearly with dots indicating bonds.

The coding of structural formulae by these methods is not intended to be necessarily unique: several of the examples given have alternative codings which may be preferred in particular contexts.

In some work it may be found advantageous to waive the stated convention of prefixing formulae in chemical equations by the dot 6 letter fount sign, for example, in chemistry textbooks. In such cases, however, advance notice should be given.

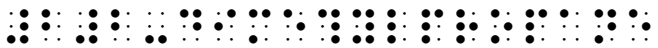
GENERAL NOTATION

Chemical Names

1 The use of italics for prefixes in chemical names (e.g. *cyclo*, *iso*, etc.) should be disregarded in braille.

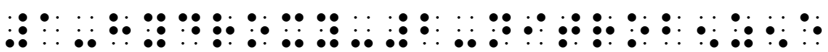
2 In organic chemistry, punctuation (e.g. commas or colons) between numbers in chemical names indicating the position of groups should be omitted, the numbers being coded as an unspaced sequence.

Ex. 2,2-Dimethylpropane



2.1 Otherwise, commas within chemical names should be replaced by hyphens (unspaced), and hyphens be transcribed directly.

Ex. 1-Hydroxy,2-nitrobenzene



3 Roman or Arabic oxidation numbers attached to chemical names should be brailled after a hyphen. Brackets, if present, should be coded as standard English brackets.

Ex. Copper(II) Sulphate

This method should be used when the oxidation number is shown as a superscript in print.

Ex. Copper^{II} Sulphate

Chemical Formulae

4 Individual chemical element symbols (as listed in the table of elements) are coded by placing a dot 6 before single letter symbols, and a dot 5 before two (or three) letter symbols.

Ex. O H Fe Cl Uub

4.1 The symbols R (representing an alkyl radical), X (representing a halide), etc. are similarly coded using a dot 6; and the abbreviations Me, Ph, Et, Hb, etc. (representing the chemical groups methyl, phenyl, ethyl, haemoglobin, etc.), coded using a dot 5.

Ex. R Me

4.2 When a single letter symbol (possibly followed by a simple numerical subscript) stands alone in ordinary text, or begins an equation in ordinary text and is followed by a space, it should additionally be preceded by the dots 56 sign.

Ex. (in ordinary text) H H_2

5 In an unspaced chemical formula, the dot 6 letter sign has force over all subsequent letters until another letter fount sign, or numeral sign, intervenes.

Ex. NO 3NO

5.1 The special dot 5 chemical element sign applies specifically to the following 2 letters; (unspaced) letters following these 2 letters are assumed to be capital unless another letter fount sign, or numeral sign, intervenes.

(In the case of the new 3-letter symbols Uub, Uut, etc., used to denote the heavy elements Ununbium, Ununtrium, etc, the dot 5 sign correspondingly applies instead to the following 3 letters.)

Ex. CuO 5CuO

HCl NaCl

5.2 It is not normally necessary to state or restate the dot 6 letter fount sign within a structural formula (see §**17-26**) unless another letter fount sign intervenes.

6 Mathematical brackets are used as required, though brace brackets will often need to be substituted for, to avoid ambiguity.

Ex. Al(O)Cl

7 Atomic mass numbers and atomic numbers attached to element symbols are coded with the superscript and subscript signs and lower numbers.

Ex. $^{238}_{92}U$ $_{92}U^{238}$

8 Numerical subscripts attached on the right to chemical element symbols, or expressions in brackets, are coded as lower numbers without numeral signs.

Ex. O_2 H_2O

$CuCl_2$ $Ca(OH)_2$

8.1 Literal or compound subscripts are coded with the subscript sign.

Ex. $C_nH_{2n+1}OH$

8.2 When subscripts follow superscripts on the right-hand side (e.g. the mass number), the subscript sign should precede the lower number.

Ex. $_{8}O^{16}_{2}$

(Mass numbers shown as right-hand superscripts should always be coded to precede right-hand subscripts indicating the number of atoms of the element in the molecule, although print may not give a clear indication of this order.)

9 A dot in a chemical formula acting as a separator (e.g. placed before water of crystallization), is shown as dot 3.

Ex. $CuSO_4 \cdot 5H_2O$

10 Electrons shown in print as dots attached to element symbols (e.g. in active species), are shown as a dot 3 for one electron, dots 36 for two electrons, etc., following the symbol.

Ex. $Cl\cdot$

11 Ionic charge is shown as the appropriate number of + or − signs unspaced from the group, element or particle symbol (only the initial + or − sign carries the dots 56 sign),

Ex. H^{+} SO_4^{--}

$[NH_4]^{+}$ $5e^{-}$

or as a superscript number followed by a + or − sign.

Ex. Fe^{3+} CO_3^{2-}

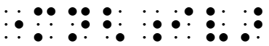
12 Oxidation numbers are shown as the appropriate superscript group,

Ex. $Cu^{I}_{2}O$ $Cu^{ii}SO_4$

$Fe^{(III)}Cl_3$

or may directly follow the element symbol (in brackets).

Ex. Mn(IV)



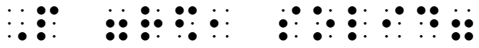
13 The abbreviations (s), (g), (l), ©, (aq), (cr), etc., specifying the state of an element or compound should be placed in standard English brackets (with s, g, c and l preceded by a letter sign), separated by a space from the preceding symbol or expression (whether or not a space is shown in print).

Ex. Mg (s) O_2 (g)

13.1 Longer descriptions may also occur, and are coded similarly.

Ex. P_4 (white, solid)

P (red, solid)



Electronic Configuration

14 When the electronic configuration of an atom is shown in print as a series of numbers (referring to the different shells) separated by dots, the dot separators should be omitted in braille, the repetition of the numeral sign being sufficient.

Ex. Na (2.8.1)

14.1 Other methods of representation used in print should be adhered to in braille, and coded using the usual rules.

Ex. Ar $1s^2 2s^2 2p^6 3s^2 3p^6$

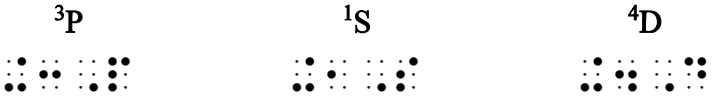
Mg $[Ne]3s^2$

15 Term symbols indicating the state of an atom are coded with superscript and subscript signs (the subscript sign is only required for the right-hand suffix when it is not an integer).

Ex. $^3P_2$ $^1S_0$ $^4D_{5/2}$

The right-hand suffix may be absent in such symbols.

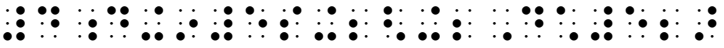
Ex. ^3P ^1S ^4D



15.1 When such symbols are preceded by other symbols, they should be enclosed in brackets in order to make clear the proper attachment of the indices.

Ex. $6s6p\,^3P_1$

$4d^9 5s^2\,^2D_{5/2}$

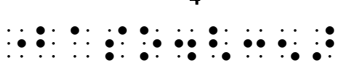


Chemical Equations and Set Out Formulae

16 Set out chemical formulae or equations should begin on a separate line in cell 5, with all runovers in cell 7. Standard mathematical symbols (e.g. +, =, →) are used as required.

16.1 Horizontal arrows should be both preceded and followed by a space in chemical equations. The vertical arrows ↑ and ↓ used in an equation to indicate an evolved gas and a precipitate respectively, refer to the immediately preceding formula: they should be unspaced from that formula, but placed in brackets to avoid ambiguity.

Ex. $BaSO_4\downarrow$



16.2 Information above or below an arrow or equality sign in an equation is coded by the usual method with the superscript or subscript signs respectively, and is placed in round brackets when consisting of more than one spaced word or term.

Ex. $H_2S \overset{400°C}{\rightleftharpoons} H_2 + S$

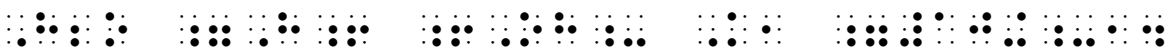
$NO \xrightarrow[O_2+H_2O]{} HNO_3\ (aq)$

Information is often placed both above and below an arrow in print merely for convenient use of space (i.e. the position being immaterial). In such cases the information may be brailled entirely as a superscript, with punctuation inserted as necessary.

Ex. $N_2 \xrightarrow[\text{Haber process}]{H_2} NH_3$

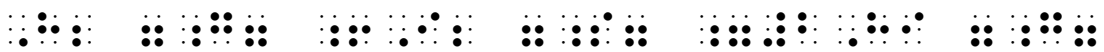
16.3 Additional information given in print after an equation, or before an equation starting in the left-hand margin (not an equation number), should be brailled immediately following the equation after 1 space (with runovers again in cell 7 for set out equations).

Ex. $H_2O = H^+ + OH^-$ $\qquad K_1 = 10^{-14}$



16.4 The abbreviations (s), (g), etc. referred to in §**13** may be present in an equation, and are spaced on both sides.

Ex. $H_2\ (g) + I_2\ (s) = 2HI\ (g)$



STRUCTURAL FORMULAE

17 Structural formulae are chemical formulae in which the chemical bonds (or some of the bonds) are shown explicitly.

A standard covalent bond is shown in print as a single line or a single dot between elements or groups of elements in a formula.

A single bond is coded as dot 4.

Ex. H_3C-CH_3 $CH_3 \cdot CH_3$

A double bond is coded as dots 45.

Ex. $H_2C=CH_2$ $CH_2:CH_2$

A triple bond is coded as dots 456.

Ex. $HC\equiv CH$ $CH:CH$

(In this context, the above bond signs are not regarded as letter fount signs.)

17.1 Bonds shown in print as a single dotted or dashed line (e.g. hydrogen bonds, or partially ionized bonds) are coded as ⠒ .

Ex. O----H----O

(See however §**23**.)

The ⠒ sign should not be used for bonds shown in print as dashed lines merely as a means of 3-D representation of molecules.

17.2 Bonds shown in print as an arrow (dative, semi-polar or coordinate bonds) are coded as ⠒ when the arrow head points to the following symbol or group, and ⠒ when it points to the preceding symbol or group.

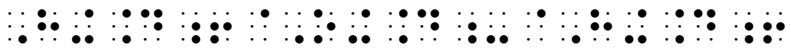
Ex. $O=O \rightarrow O$ $\quad\quad$ $O \leftarrow O=O$

17.3 Multiple bonds composed of different types of these bonds are coded as a combination of their respective bond symbols.

Ex. $O \equiv N \equiv O$

18 It is not necessary to use the ⠸ terminator after a superscript or subscript, before a following bond symbol.

Ex. $H^{\delta+}— O^{\delta-}— H^{\delta+}$



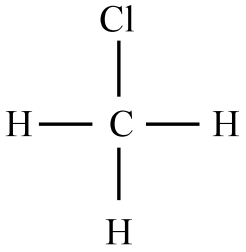
19 A sequence of groups each contained in special ⠐⠣ . . . ⠸⠜ brackets in a structural formula indicates that each of those groups as well as the immediately following group are bonded to the group preceding that sequence.

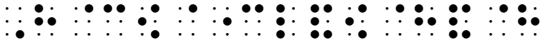
It may be found helpful when reading such a formula to read ⠐⠣ as "branch", and ⠸⠜ as "and", though when reviewing the formula it is probably easiest to keep principally in mind the role of the ⠐⠣ and ⠸⠜ signs as brackets according to the above rule.

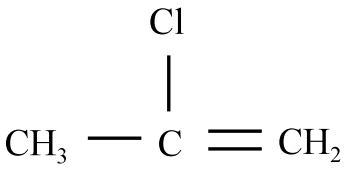
19.1 The initial bond of a ⠐⠣ . . . ⠸⠜ bracketed group should be enclosed within the opening bracket.

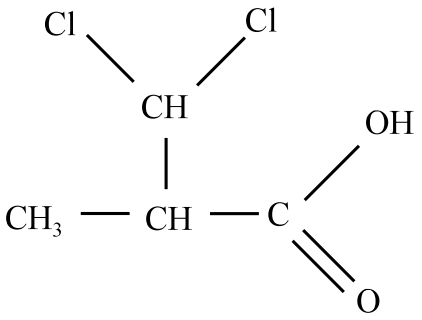
19.2 A ⠐⠣ . . . ⠸⠜ bracketed group may itself contain ⠐⠣ . . . ⠸⠜ bracketed groups to show the required structure.

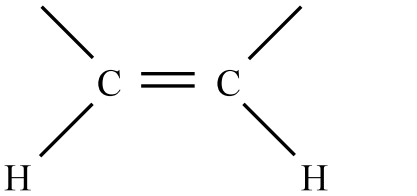
Ex.

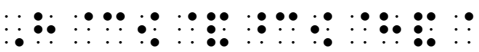












20 A long structural formula may be divided at the end of a braille line using the dot 5 mathematical hyphen. A division should not be made immediately after a bond sign or an opening bracket, nor should the division separate indices from the symbols to which they are attached.

(A long empirical formula may also be divided in this way, but this should only occur rarely since such formulae are seldom of sufficient length to justify it – it will usually be better to braille the whole formula on the next line.)

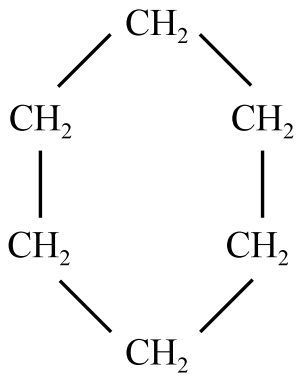
Structures Containing Rings

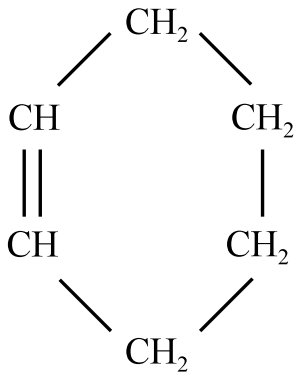
21 A structure containing closed rings is coded by first giving a linear structure omitting the bonds which close rings.

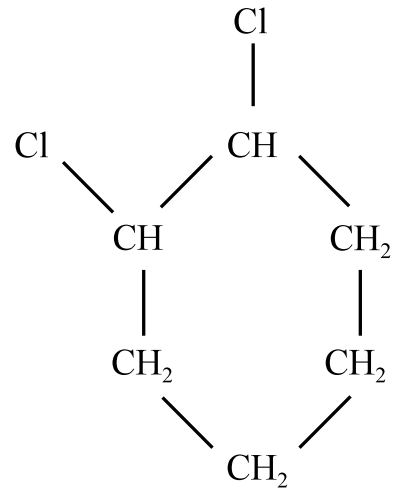
This sequence is regarded as divided into groups by the bond signs, and these groups numbered in this order (including any ⠣ and ⠜ bracketed groups of elements). Each ring closing bond is indicated by giving the numbers of the groups bonded as an upper number and lower number preceded by a numeral sign. These ring closure numbers are brailled as an unspaced sequence after the linear structure sequence.

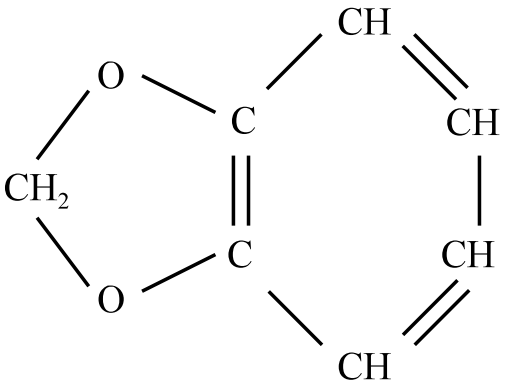
If a ring closing bond is not a single covalent bond, the bond sign is placed in round brackets after the relevant ring closure numbers.

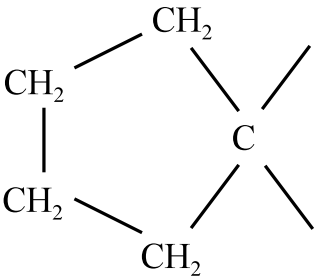
Ex.





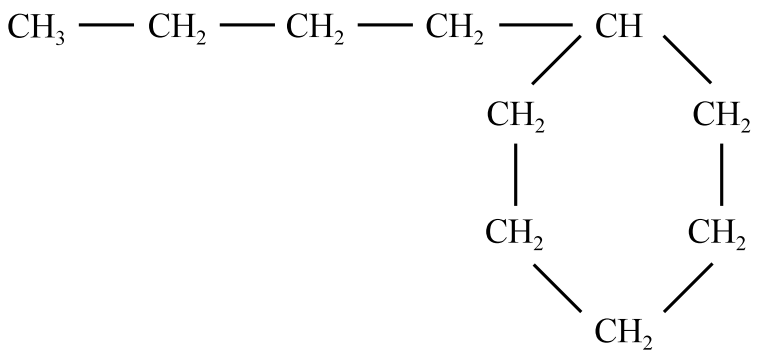


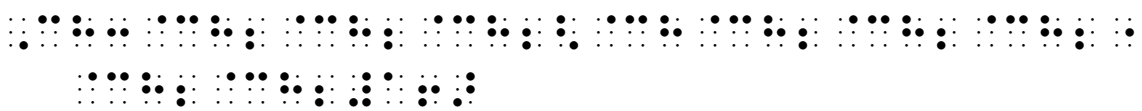




21.1 Round brackets enclosing sequences with ring closure numbers indicate that these ring numbers only count groups within the brackets. This device may be used to allow convenient numbering of sub-rings in complex formulae.

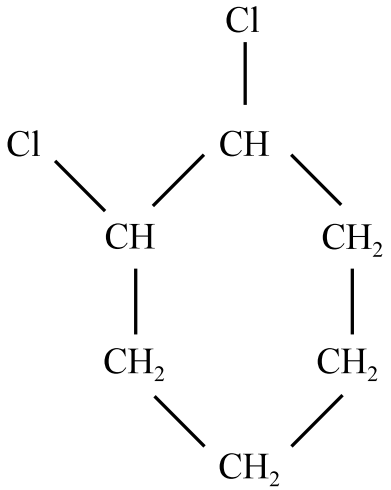
Ex.

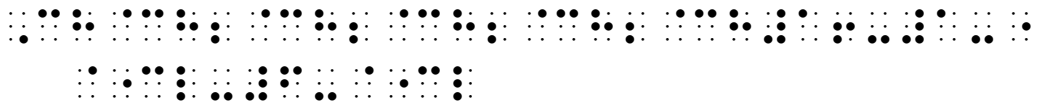


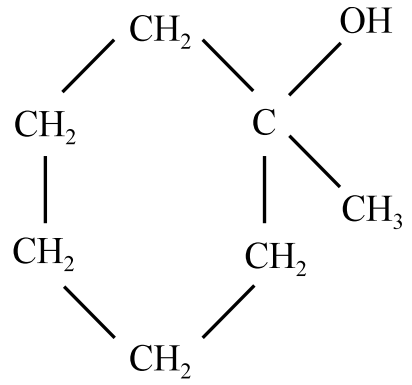


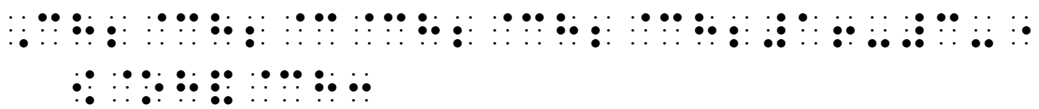
22 Groups bonded to a basic ring structure may either be coded using ⠦ and ⠴ brackets (as in the example in §**21**), or may be stated separately after a sequence giving that basic ring structure (with its ring closure numbers). In this method, the basic ring structure is followed by the sequence: hyphen; the number of the group in the ring sequence to which the bonding group joins; hyphen; the bonding group (preceded by the bond sign). Further bonding groups (if present) are shown subsequently by the same method.

Ex.



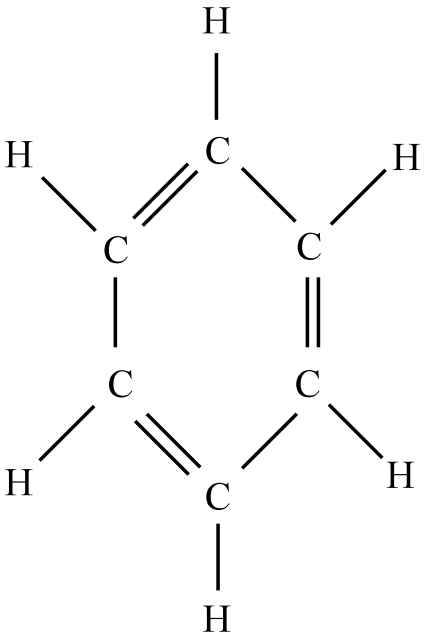




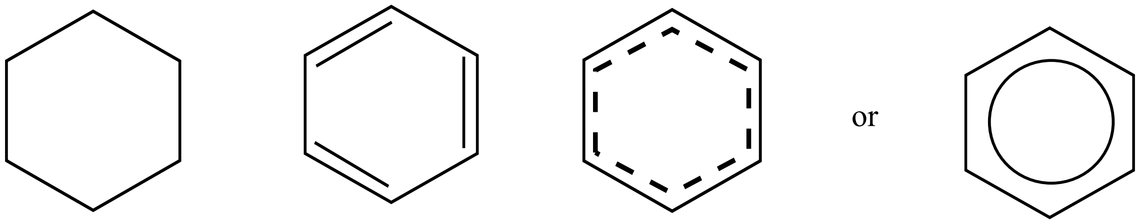


This method is often preferred, since it allows an uncluttered presentation of the basic ring structure.

23 The benzene ring

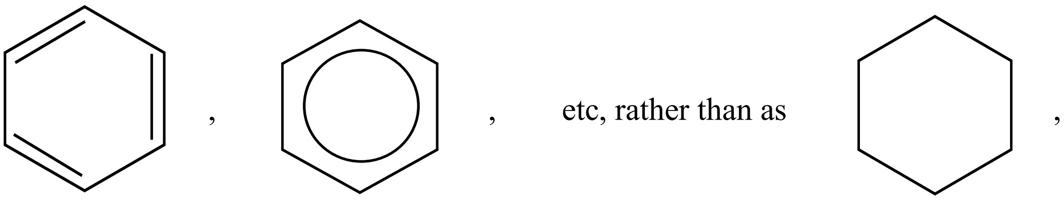


when symbolically represented in print as



is coded as ⠿ (see however §**25**). (This braille symbol is not used when the carbon atoms are explicitly shown in print; in that case the full structure given in print should be represented in braille.)

When it is the consistent intention in print to show the benzene ring as

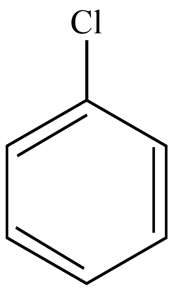


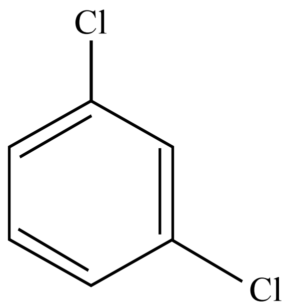
this latter symbol when it occurs represents cyclohexane, and should not be coded as ⠿ , but by using §**25**.

23.1 The carbon atoms in the benzene ring are, when required, numbered clockwise with 1 taken either as the carbon atom to which the immediately preceding group bonds (if present), or otherwise the carbon atom to which the immediately following group bonds.

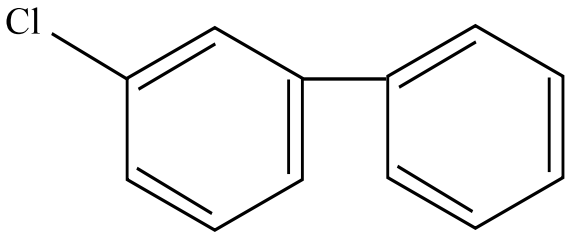
23.2 Groups simply attached to the benzene ring are indicated using the method for ring structures described in §**22**, with the positions in the benzene ring numbered as in §**23.1**. Unless there is a group preceding (and bonded to) the benzene ring, the first group following the ⠿ sign is, however, not preceded by a number and hyphens, since it *defines* position 1 of the ring.

Ex.



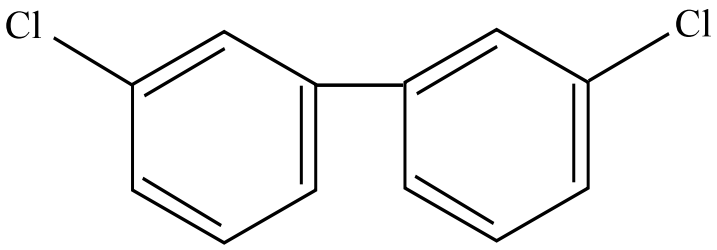


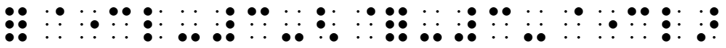
⠿⠈⠐⠉⠇ ⠿⠈⠐⠉⠇⠤⠼⠉⠤⠈⠐⠉⠇



23.3 Round brackets may be used as in §**21.1** to associate numbers indicating positions on a ring with a particular ring.

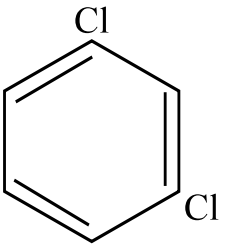
Ex.

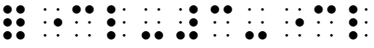




23.4 When bonds attaching groups to benzene rings are omitted in print, they should be omitted in braille.

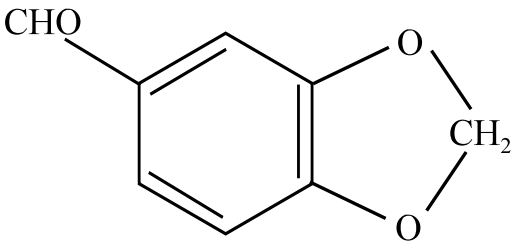
Ex.

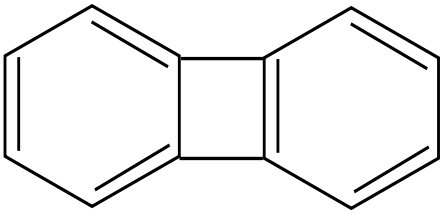


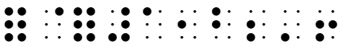


23.5 The benzene ring may itself form part of a larger ring structure. The benzene ring as a whole is then numbered as a group in the complete structure, and the positions on the benzene ring are indicated by stating the position number (determined as in §**23.1**) following the number assigned to the whole benzene ring, after a dot 2. (When expressed as lower numbers, a dot 3 is used instead of a dot 2.)

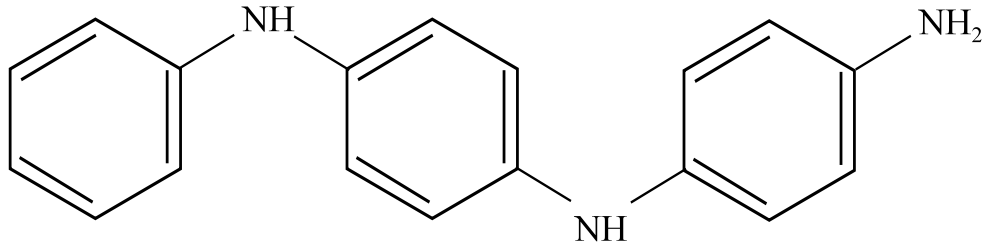
Ex.





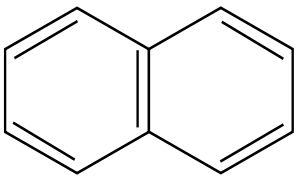
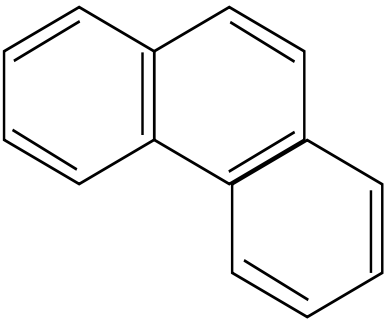


23.6 When a benzene ring is part of a complex structure and the numbering of the positions around the ring is determined by the immediately preceding group, the position of the bond to the following group is indicated by giving the number of that position after the ⠻ ring sign (unspaced).



Fused Benzene Rings

24 Polycyclic ring structures such as

naphthalene  , phenanthrene 

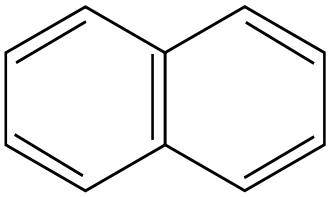
etc., are coded as a sequence of ⠶ signs with pairs of numbers between successive ⠶ signs to indicate the relative position of the respective rings.

24.1 Carbon atoms within each component benzene ring are numbered clockwise (carbon atoms common to more than one ring are thus numbered more than once).

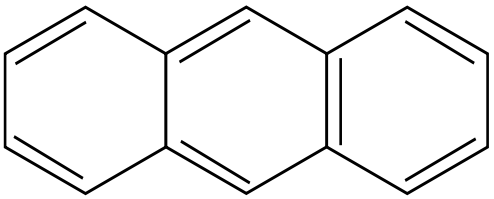
24.2 The numbers between two successive ⠶ signs in a sequence state the numbers of the carbon atoms (as members of the first ring) which are shared with the second ring. The numbering within that second ring is then determined by counting the first stated of the shared carbon atoms as 1 in the second ring (the rest being numbered clockwise).

24.3 When the first ⠶ sign in such a sequence is not preceded by another group, the numbering in the first two rings is determined by the rule that the shared carbon atoms are numbered 1 and 2 in the first ring, and that numbered 1 in the first ring is numbered 1 in the second ring. In this case it is unnecessary to state the attachment position numbers 1, 2 between these ⠶ signs.

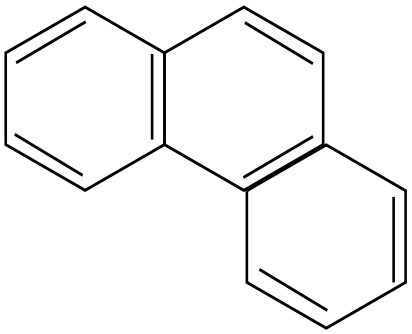
Ex.

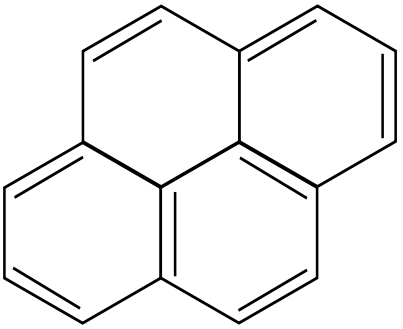


⠶⠶



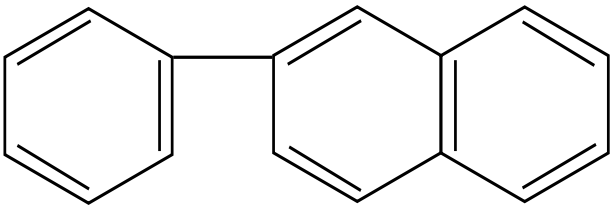
⠶⠶⠂⠒⠂⠶⠶

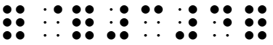




24.4 When the first ⠻ sign in such a sequence is preceded by another group, the numbering of its carbon atoms is determined by §**23.1**.

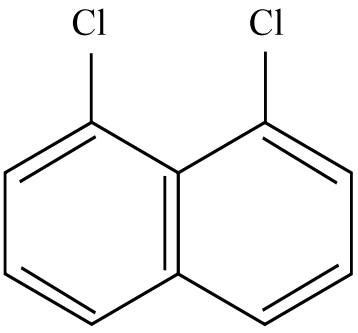
Ex.

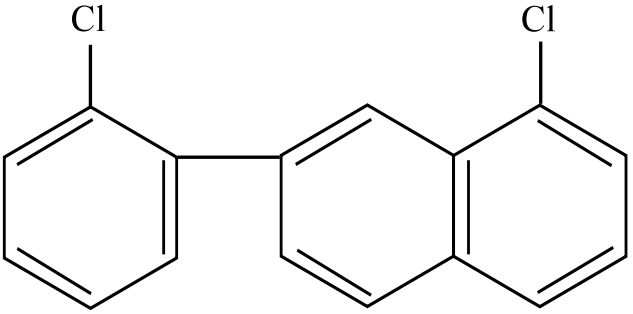


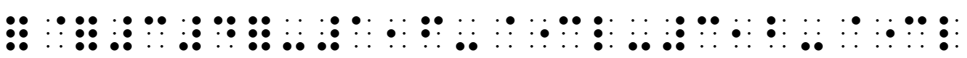


24.5 Groups attached to these polycyclic rings are coded by the usual methods. (Each ⠻ sign is counted as a separate group in a structural formula, even though bond signs may not intervene.)

Ex.





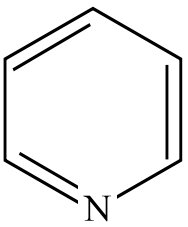


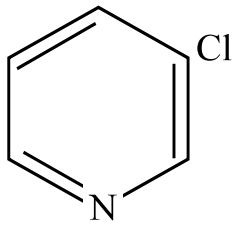
(This shows compound ring position numbers applying unambiguously to a partly linear sequence. In such cases, all groups in the initial basic sequence should be counted, and care taken to avoid ambiguity.)

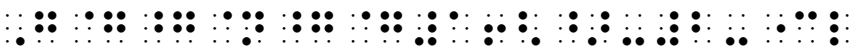
Other Symbolic Forms

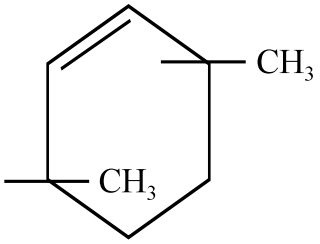
25 Structures symbolically represented in print by the omission of carbon symbols and their attached hydrogen symbols, but for which the methods using the ⠻ ring symbol given in §**23** and §**24** are inapplicable, are coded by indicating each site of an omitted carbon atom by the sign ⠒ . Bonding between these sites is shown using the standard bond symbols, and the ⠒ symbol is generally treated in the code as an element symbol.

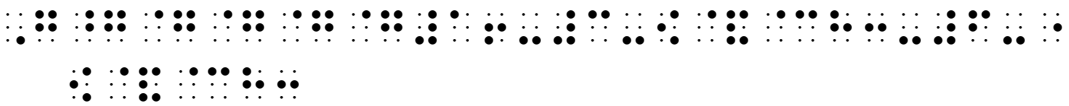
Ex.





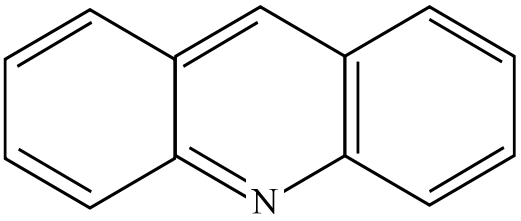






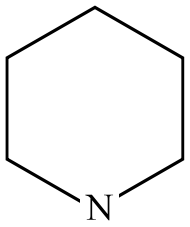
25.1 The ⠸ sign may be used in conjunction with ⠨ signs.

Ex.



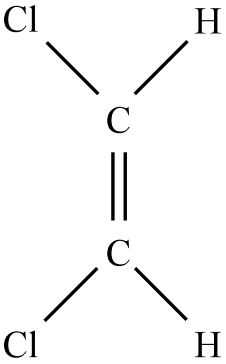
25.2 The bonds within rings represented symbolically in print may all be shown as single lines, i.e. the distinction between single and double bonds is not made explicit. In such cases the single dot 4 bond sign should be used, it being understood that its use is symbolic in this sense.

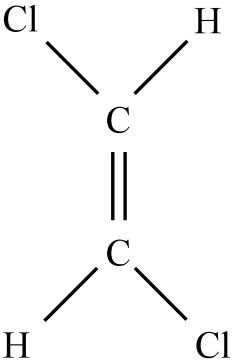
Ex.



Isomerism

26 When it is necessary to indicate the relative positions of groups in discussions of isomerism, the order of attached groups should be governed by a definite stated rule. E.g. in the following, the attached hydrogen and chlorine atoms are brailled in the order left to right as appears in print:



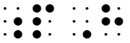


Diagrams are, however, especially recommended to represent such information.

ADDITIONAL NOTATION

27 The symbols M for molarity, N for normality, and m for molality, referring to concentrations of solutions, when attached to a preceding number should be unspaced from that number in braille. (They are not regarded as unit symbols here.)

Ex. 2M 0.5N 1m

28 pH should be coded as  , and be spaced or unspaced from a following number, according to print.

Ex. pH 7

TABLE OF ELEMENTS

Each element is placed in alphabetical order of its symbol and is followed by its atomic number.

Ac	actinium, 89	Ge	germanium, 32	Pr	praseodymium,59
Ag	silver, 47	H	hydrogen, 1	Pt	platinum, 78
Al	aluminium, 13	He	helium, 2	Pu	plutonium, 94
Am	americium, 95	Hf	hafnium, 72	Ra	radium, 88
Ar	argon, 18	Hg	mercury, 80	Rb	rubidium, 37
As	arsenic, 33	Ho	holmium, 67	Re	rhenium, 75
At	astatine, 85	I	iodine, 53	Rh	rhodium, 45
Au	gold, 79	In	indium, 49	Rn	radon, 86
B	boron, 5	Ir	iridium, 77	Ru	ruthenium, 44
Ba	barium, 56	K	potassium, 19	S	sulphur, 16
Be	beryllium, 4	Kr	krypton, 36	Sb	antimony, 51
Bi	bismuth, 83	La	lanthanum, 57	Sc	scandium, 21
Bk	berkelium, 97	Li	lithium, 3	Se	selenium, 34
Br	bromine, 35	Lr	lawrencium, 103	Si	silicon, 14
C	carbon, 6	Lu	lutetium, 71	Sm	samarium, 62
Ca	calcium, 20	Md	mendelevium, 101	Sn	tin, 50
Cd	cadmium, 48	Mg	magnesium, 12	Sr	strontium, 38
Ce	cerium, 58	Mn	manganese, 25	Ta	tantalum, 73
Cf	californium, 98	Mo	molybdenum, 42	Tb	terbium, 65
Cl	chlorine, 17	N	nitrogen, 7	Tc	technetium, 43
Cm	curium, 96	Na	sodium, 11	Te	tellurium, 52
Co	cobalt, 27	Nb	niobium, 41	Th	thorium, 90
Cr	chromium, 24	Nd	neodymium, 60	Ti	titanium, 22
Cs	caesium, 55	Ne	neon, 10	Tl	thallium, 81
Cu	copper, 29	Ni	nickel, 28	Tm	thulium, 69
Dy	dysprosium, 66	No	nobelium, 102	U	uranium, 92
Er	erbium, 68	Np	neptunium, 93	V	vanadium, 23
Es	einsteinium, 99	O	oxygen, 8	W	tungsten, 74
Eu	europium, 63	Os	osmium, 76	Xe	xenon, 54
F	fluorine, 9	P	phosphorus, 15	Y	yttrium, 39
Fe	iron, 26	Pa	protactinium, 91	Yb	ytterbium, 70
Fm	fermium, 100	Pb	lead, 82	Zn	zinc, 30
Fr	francium, 87	Pd	palladium, 46	Zr	zirconium, 40
Ga	gallium, 31	Pm	promethium, 61		
Gd	gadolinium, 64	Po	polonium, 84		

4
ELECTRONIC AND LOGIC CIRCUIT DIAGRAMS

INTRODUCTION

Two basic methods for transcribing electronic and logic circuits are described below:

1. Diagrammatic representation.
2. Braille descriptive representation.

Diagrammatic representation is the primary method used in general transcription work, although the particular advantages of the braille descriptive method (e.g. in compactly transcribing complex diagrams with few layout problems) will also merit its use in such work.

The different forms of diagrammatic representation enable the circuit (and any accompanying diagrammatic annotation) to be drawn directly; or to be drawn with the minimum of diagrammatic symbolism if preferred; or to be drawn entirely in braille.

The braille descriptive representation is a powerful method by which the connections in the circuit are expressed sequentially rather than graphically, and may be used otherwise as required.

The methods of diagrammatic representation (except the direct representation) and the braille descriptive method each use the component and connection abbreviations given in Tables A and B. Table C, giving electronic component and logic symbols, is to be used for the identification of symbols and connections.

Other systems of representing circuits do exist and are in use, but these are not described here since they generally require specialist knowledge and involve interpretation of circuits in order to be used effectively, which was felt to be out of place in this general use code.

1. DIAGRAMMATIC REPRESENTATION

In any of the forms of diagrammatic representation described below, one is liable to encounter space problems. It may be found helpful to remove some of the labelling from the diagram by using a key, or it may be necessary to reproduce the diagram in sections. When the latter device is used, the method should be explained beforehand, and the connections between the sections clearly indicated.

(I) Direct Representation

In this form of representation the diagram is reproduced in tactile form as it appears in print. The labelling is in braille, and is generally coded according to the usual mathematics

code conventions. In particular, capital letters will normally require dot 6 letter fount signs, though component type labels (e.g. for transistors) can be treated less formally according to SEB. Block symbols (such as logic gates) are generally more satisfactorily represented as raised shapes rather than in outline.

(ii) Diagrammatic Representation with Components given in Braille

[Refer to examples 1 and 2.]

In this method, the diagram is represented as in (I) above, but with components indicated by the standard braille abbreviations given in Table A, rather than by their graphic symbols. Reference may be made to Table C to identify components. (See the remarks in the *Braille Descriptive Representation* section below for guidance on giving abbreviations for block components such as integrated circuits etc. Refer to the *Logic Symbols* section for guidance on simple logic symbol identifiers.) If a print label derives from the standard braille abbreviation, then this may be used to identify the component. Otherwise the standard braille abbreviation should be used, with the print label explained in a note or key. Components not listed in Table A may either be denoted by abbreviations devised for the purpose (which must be explained) or be drawn out directly. Components with many connections (such as integrated circuits or complex logic symbols) are also more satisfactorily represented graphically.

Special connections are indicated, where appropriate, by the terminal abbreviations given in Table B, placed adjacent to the leads entering the component. (This will not be necessary where such connections are indicated by the component being drawn out directly.) Special connections not listed in Table B may be indicated by abbreviations devised for the purpose, and should be explained in a note or key. Care should be taken to avoid confusion with the standard listed braille abbreviations in such cases. For logic gates (e.g. AND, OR, etc) it will not normally be necessary to label both the inputs and outputs; by simply labelling the outputs it will be clear that the other connections are inputs. This will also apply in other such cases. Print labelling is reproduced (when there is room) directly.

Standard braille abbreviations used as identifiers according to this method and listed in Tables A and B (or those derived from them), and abbreviations devised and used analogously, will not require letter fount signs in the diagram. Such abbreviations should, however, be regarded as being capital, and be indicated as such if necessary elsewhere in this method (e.g. in explanatory notes), even if the abbreviation contains a braille contraction. Ordinary print labelling should be brailled as normal in the diagram, i.e. with letter and/or capital signs.

(iii) Braille Diagrammatic Representation

[Refer to examples 3, 4, 5, 6, 7 and 8.]

In this method the circuit diagram is represented entirely in braille: the components

and special connections are indicated by abbreviations as in (ii) above; the connecting lines are indicated by braille cells used graphically.

Vertical lines are indicated by ⠇ cells aligned vertically, and horizontal lines by lines of ⠒ cells. Corners, cross lines and T-junctions are represented by the appropriate cells, used graphically, to connect up the vertical and horizontal lines. It may be necessary to modify the arrangement of parts of the diagram in order to avoid diagonal lines which are not represented satisfactorily in braille. Solid spots indicating junctions can normally be omitted for T-junctions, but should be shown for cross lines by a full cell at that junction in braille. Cross lines not forming a junction may be shown in print by the graphical device of one wire 'bridging' over the other; this need not be represented in braille – the simple cross lines representation should be used.

Components interrupting horizontal lines should be spaced in that line by one cell before and after. Abbreviations indicating special connections to that component are brailled on that same line, and are placed unspaced from the connecting lead lines (the component abbreviation remaining spaced).

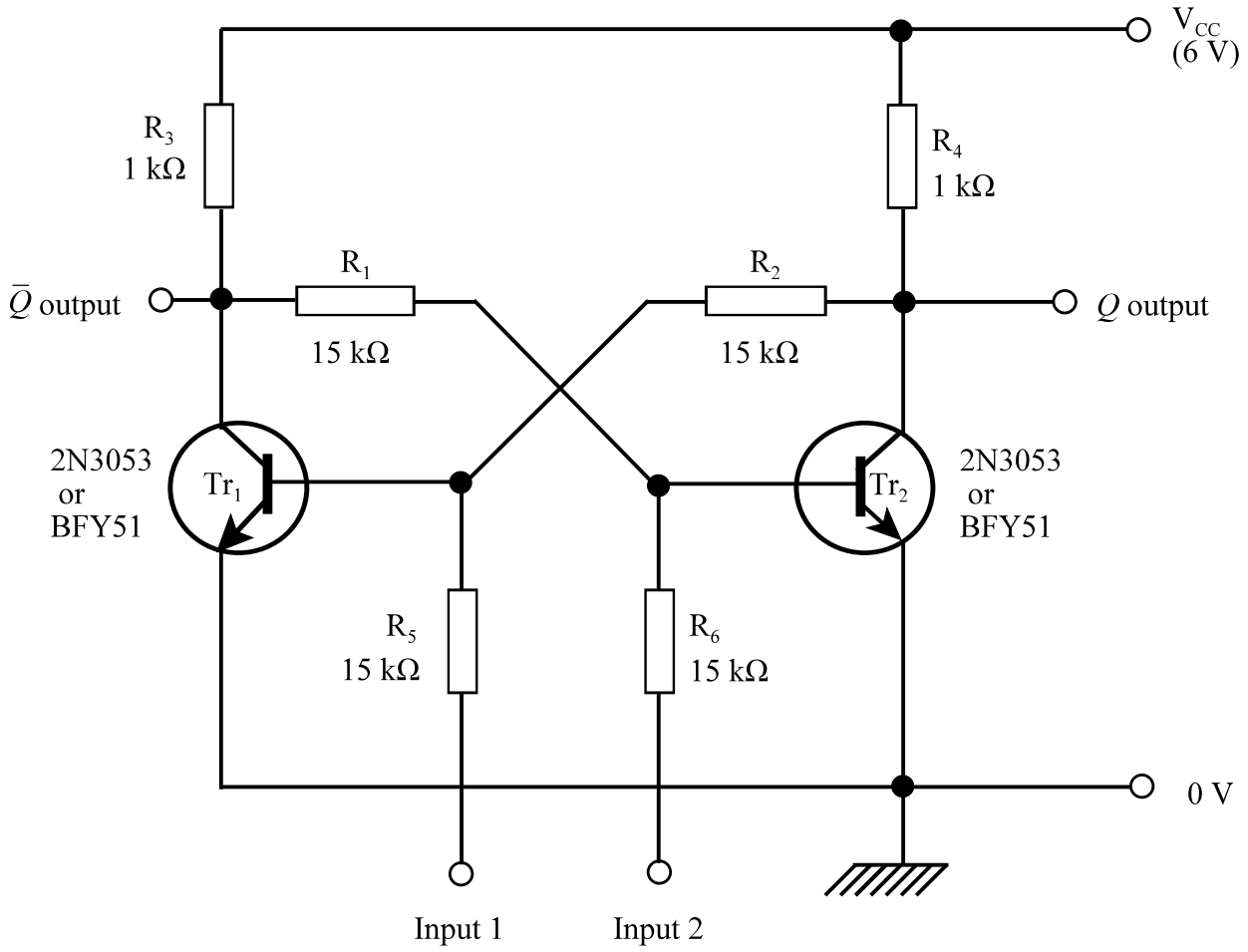
Components interrupting vertical lines should be unspaced in that line. Abbreviations indicating special connections to that component are aligned in that same vertical line and are placed (unspaced) between the component abbreviation and the appropriate connecting lead lines. A two-terminal component abbreviation interrupting a vertical line which has just one adjacent special connection abbreviation should be preceded by a dot 5 in order to distinguish it from the connection abbreviation. (This device will not be necessary when the component has connection abbreviations both above and below it – the component abbreviation is clearly the middle one.)

When a component has several connections on the same side with horizontal leads, they may be placed one above the other, but only the first will be on the same line as the component identifier. [See examples 5 and 7.] The connection lines should be produced so that their ends are aligned vertically (including any connection abbreviations). Components with several vertical leads are treated analogously, although in this case it may be possible for two or more vertical connections on the same side to be placed against a component identifier if the latter consists of several cells. When using this method one should be careful to space components adequately in order that the intended attachment of 'stray end' connections be clear. For greater clarity, a block component can be shown with its outline represented in braille. This will avoid 'stray end' connections (since all the connections will meet the block outline as in print), but will require extra space. [See examples 6 and 8.] Rows and columns of full cells should be used to represent the outline, to distinguish it from connecting leads which are represented as single dot lines. It will not be practicable to represent the special shapes of logic gates etc., so identifying abbreviations will still be required. (It will not normally be necessary, however, to specially indicate the output (or inputs) of such gates, since the position of the connections on the block outline should make this clear.) This method will also enable complex logic symbols to be represented, the full cells being used to represent both the outline as well as the internal sub-blocks of the symbol.

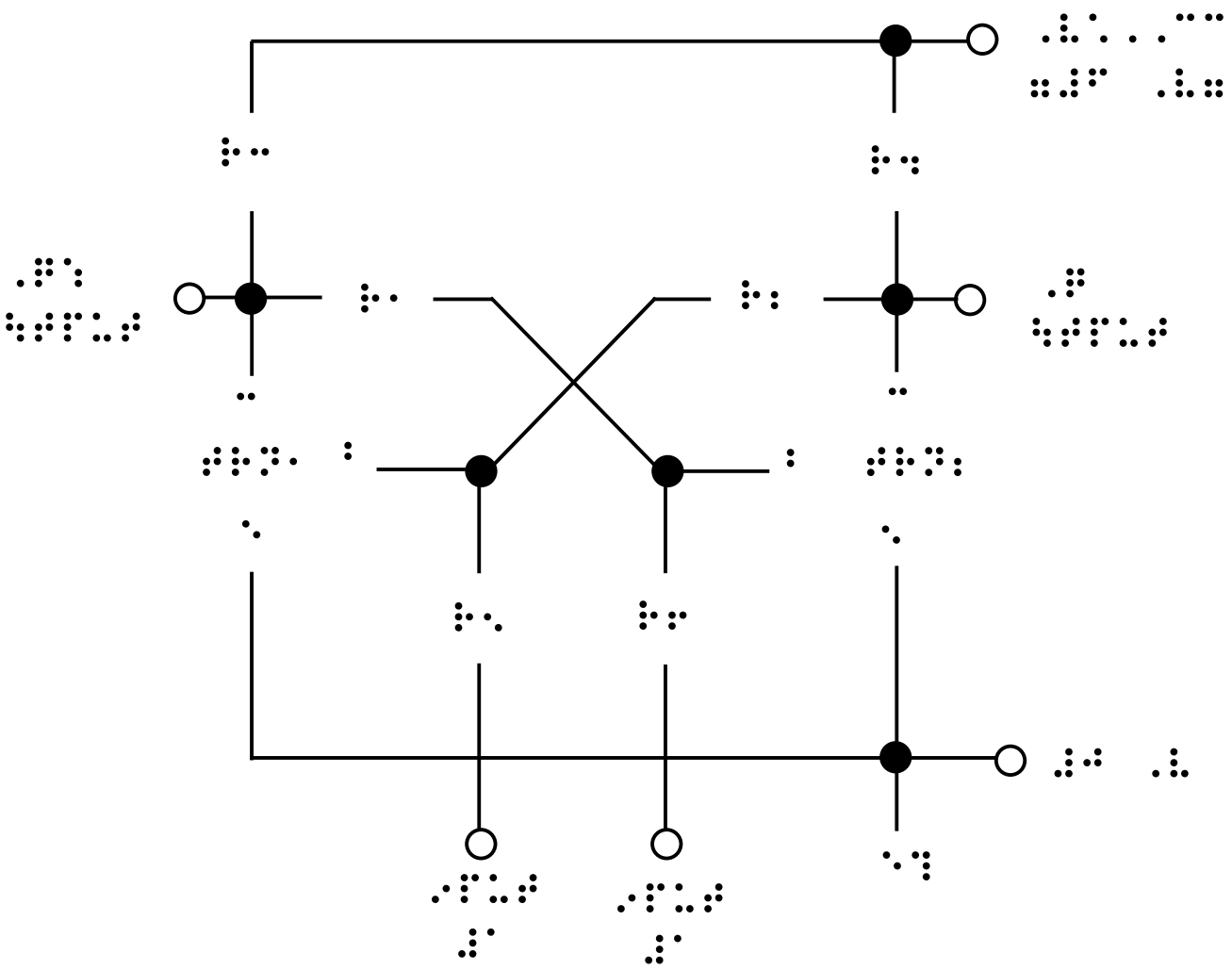
EXAMPLE 1

Bistable

Source diagram:



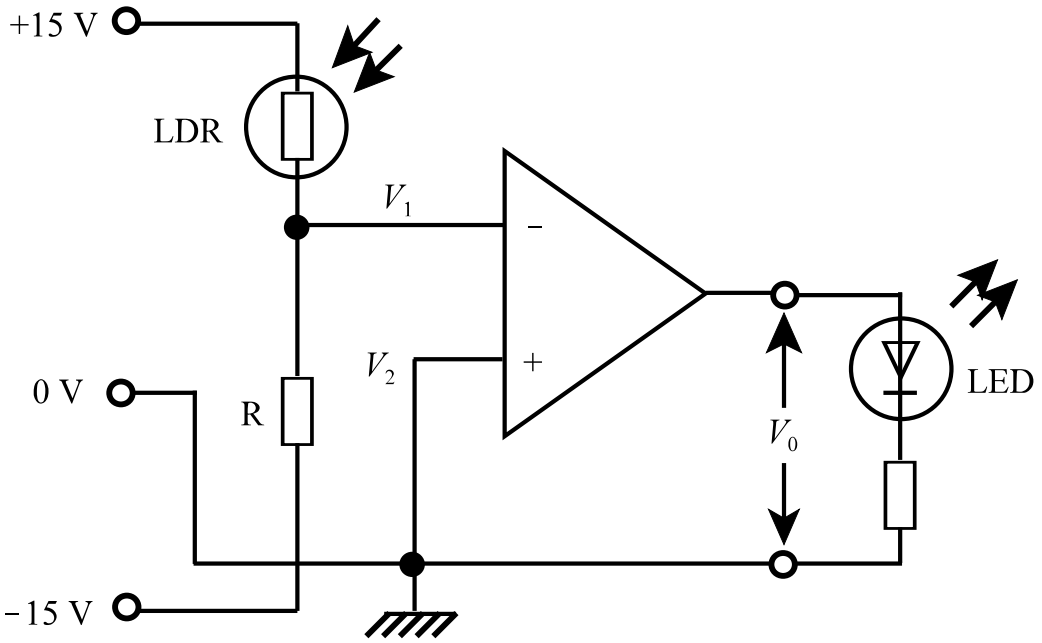
Diagrammatic Representation with Components given in Braille:



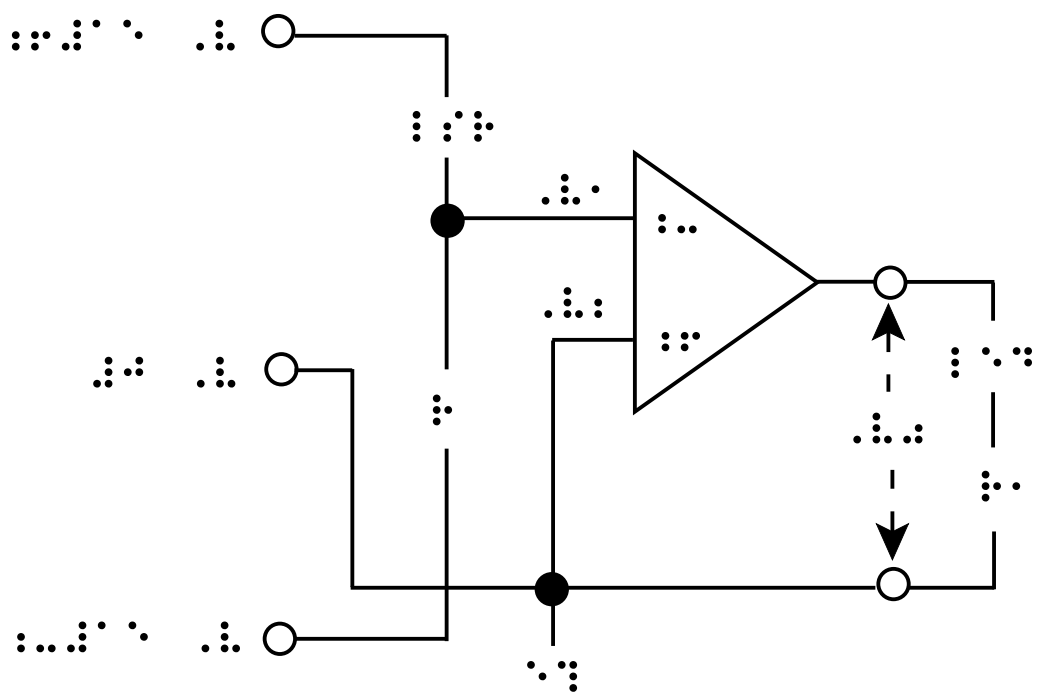
EXAMPLE 2

Alarm Circuit

Source diagram:



Diagrammatic Representation with Components given in Braille:



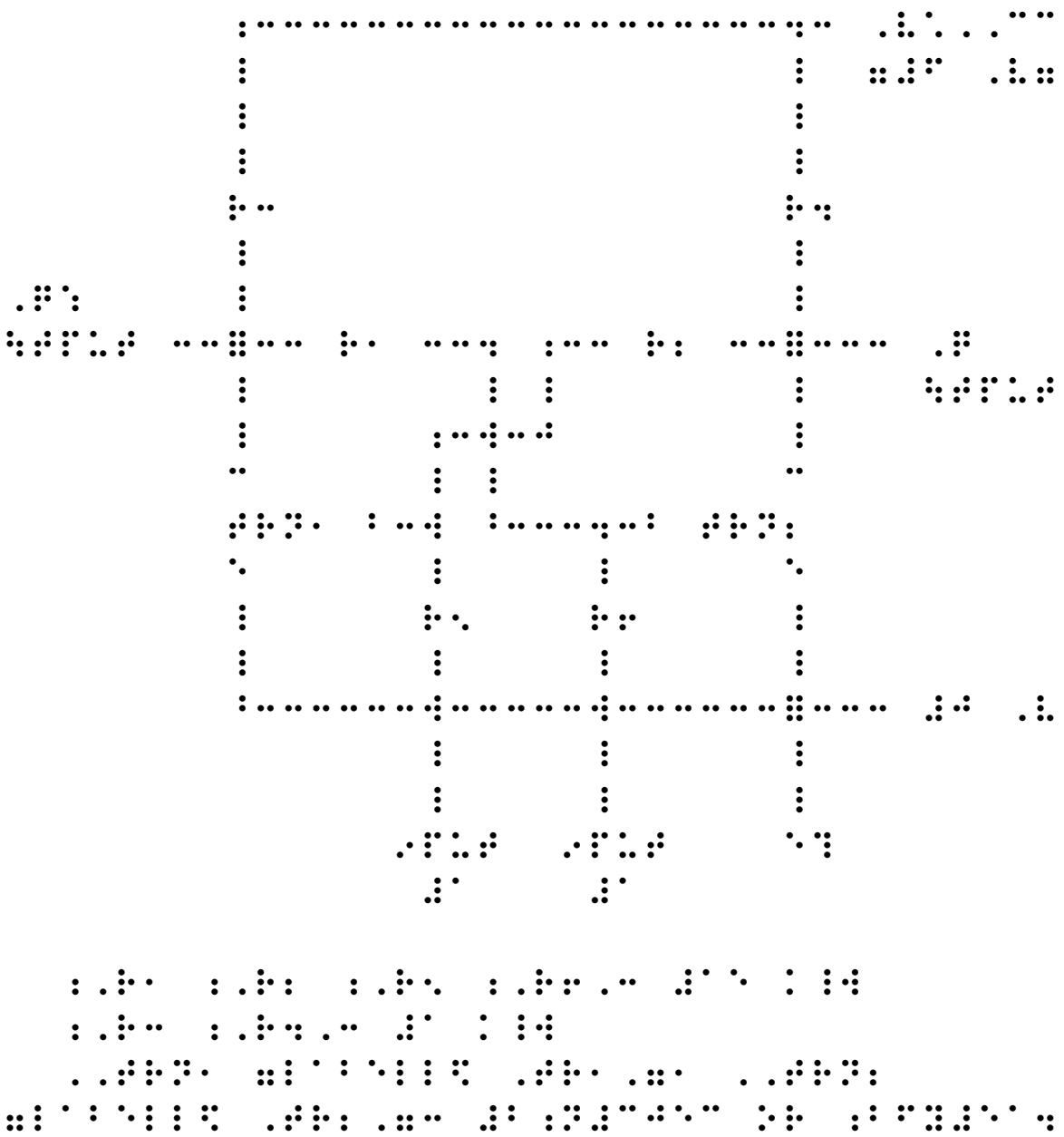
Note:

In this example, the transcriber has chosen to represent the operational amplifier graphically. It could have been represented in braille similarly to Example 4.

EXAMPLE 3

Bistable

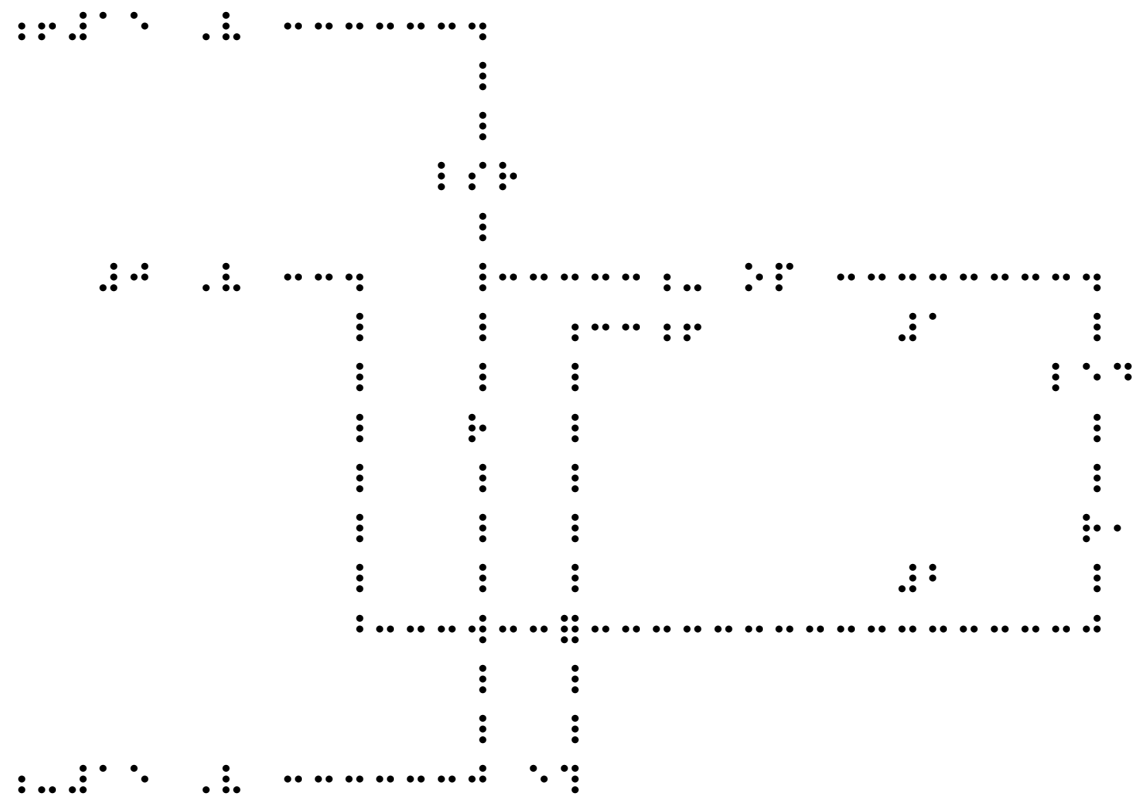
Braille Diagrammatic Representation: (See Example 1 for source diagram)



EXAMPLE 4

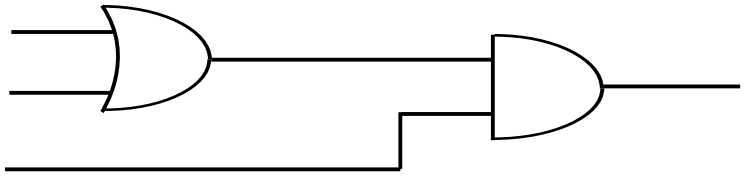
Alarm Circuit

Braille Diagrammatic Representation: (See Example 2 for source diagram)



Simple Logic Gates

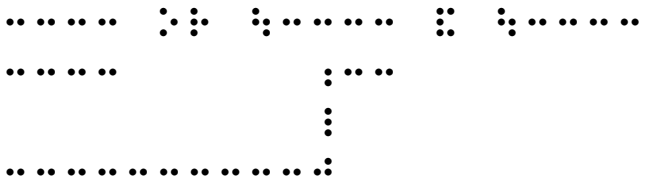
Source diagram:



(non-IEC symbols)

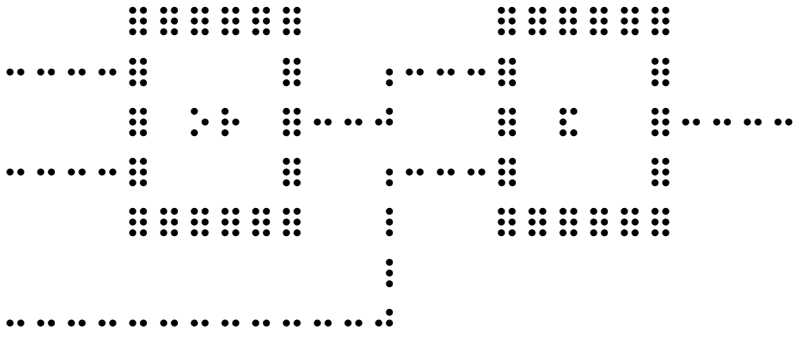
Braille Diagrammatic Representation:

EXAMPLE 5

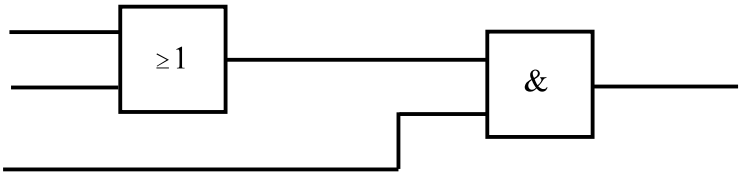


Or:

EXAMPLE 6



Source diagram:



(IEC symbols)

Braille Diagrammatic Representation:

EXAMPLE 7

⠠⠠⠠⠠ ⠿⠒⠤⠃⠄ ⠸⠠⠠⠠⠠ ⠿⠿ ⠸⠠⠠⠠⠠
⠠⠠⠠⠠ ⠒⠠⠠
⠒
⠠⠠⠠⠠⠠⠠⠠⠠⠠⠠⠠⠠⠠⠠⠒

[Logic gate identifiers for IEC style logic symbols consist of a ⠿ sign indicating a "block" component, followed by the "qualifying symbol" which is given in print inside the box. Refer to the *Logic Symbols* section for further guidance on this if required.]

Or:

EXAMPLE 8

⠿⠿⠿⠿⠿⠿⠿⠿⠿ ⠿⠿⠿⠿⠿⠿⠿⠿⠿
⠠⠠⠠⠠⠠⠿ ⠿ ⠒⠠⠠⠠⠠⠿ ⠿
⠿ ⠒⠤⠃⠄ ⠿⠠⠠⠒ ⠿ ⠒ ⠿⠠⠠⠠⠠
⠠⠠⠠⠠⠠⠿ ⠿ ⠒⠠⠠⠠⠠⠿ ⠿
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2. BRAILLE DESCRIPTIVE REPRESENTATION

[Refer to examples 9, 10 and 11.]

In this method, the circuit is presented in two stages:

(a) Display of Components

This part shows the components, circuit terminals and external connections displayed as an array, set out approximately as they are shown in the print circuit. It should be the aim to keep the braille display compact, with components neatly aligned vertically. Components will normally be spaced in the array, but when it is necessary in order to fit a large array across the page, it is acceptable to braille the components unspaced as long as there are numerical subscripts to separate the identifying abbreviations (see below). Large arrays may also be divided into sections or brailled across facing pages where necessary: in such cases this arrangement should be explained in a note beforehand. The array is preceded and followed by a centred line of three spaced asterisks.

Components are generally identified using the abbreviations given in Table A, with subscript numbers distinguishing components of the same type, numbering components in the order left to right across the rows, and taking the rows from top to bottom. Where a component has a label in the print which stems from the standard braille identifying abbreviation, this print label may be used (with its attached print number or other affix if present); otherwise the standard braille abbreviation should be used and the print label explained later.

Letter fount signs are not normally used before component identifiers in the display even when capital print labels are used for this purpose (since they may generally be understood to be such), though it may be necessary to use letter fount signs to show capital or other letter founts of letters attached to identifiers using the usual mathematics code letter fount sign conventions.

Components without a standard braille abbreviation should be identified by some other suitably chosen abbreviation. This may be derived from the component's name or be the print label if not too long, but should be distinct from those listed in Table A as they refer to those specific components. It may thus be necessary to explain such labels by descriptions or identifying diagrams, in a preliminary note or elsewhere in the text.

Integrated circuits treated as individual components in a circuit may generally be identified by the label IC (with affixed numbers etc. as necessary). The basic non-IEC logic gate symbols AND, OR, etc. have special identifiers. For simplicity, these identifiers may also be used in this method for the IEC equivalent symbols for such elementary (uncombined) gates, though it will generally be advisable to explain in a braille note that the other style of symbol is in fact used in the print. Refer to the section on Logic Symbols for general guidance on logic symbol identifiers. Other components represented as blocks in print may either be identified by a suitably chosen abbreviation which may again be derived from the component's name or be its print label (if present) if it is distinct and not too long, or else be identified by the general block identifier ⠿, with affix as necessary (e.g. as are the master

and slave flip-flops in example 11). Where necessary, these identifiers and any additional information should be explained by descriptions or diagrams. In particular, complex logic symbols are identified by ⠿ symbols which may be expanded by the method given in the section on Logic Symbols, this expansion being placed with the information after the display, or else directly in a drawn out diagram.

Circuit terminals and other external connections are generally indicated by ⠒ symbols, and distinguished by subscript numbers in the same way as components. Certain external connections such as aerial and earth have their own identifiers. External connections which are labelled in print (e.g. a, b, c, etc.) may be labelled in the same way in the braille without using the ⠒ symbol, if they are not too long. Letter fount signs should be used when these labels are letters, to distinguish them from the standard abbreviations given in Tables A and B. When it is not convenient to use such print labels in the display, the ⠒ symbol should be used, with the print notation and other such information explained after the display.

When the circuit does not derive from a print circuit, or is not intended to represent a print circuit, this stage in the presentation may be dispensed with.

(b) Connection of Components, and Other Information

In this part, the connections between the components and terminals displayed in the array are listed, together with additional information explaining the circuit. The information is arranged as a sequence of entries, each starting in cell 1 with runovers in cell 3.

The Additional Information

The additional informal information is given first. This may include the specification of formal ⠒ and ⠿ signs used (e.g. the ⠒ 's as inputs or outputs; the ⠿ 's as being of particular type); voltages of batteries or other connections; print component labels not given in the display or explained elsewhere (but not component values, which can be tabulated later); explanation of special connections not described by the standard abbreviations; etc. Such information will usually be given as a single entry, with punctuation used as appropriate to separate the individual items. It may, however, be desirable to use separate entries for longer items such as expansions of block identifiers using the method explained in the section on logic symbols, for clarity. Letter fount signs should be used when giving such information according to the usual mathematics conventions.

Any ⠒ symbols should be shown as being capital, as are the standard braille abbreviations given in Table A, even if they contain a braille contraction (apart from the ⠿ sign, which is purely symbolic).

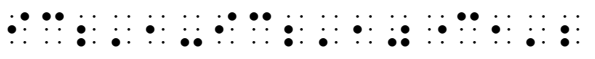
The Terminal Identifiers

In order to specify the connections in the circuit, the terminals of components are identified by appending a number or other label to component identifiers. Terminals listed in Table B are identified by the standard braille abbreviations given in that table; thus, for example, ⠿⠂⠂⠿⠿ indicates the positive terminal of battery 1. Print labels may be used for other terminals where given, but any ambiguities with the standard braille terminal abbreviations should be clarified in a preliminary note to the circuit presentation. It may be necessary to devise abbreviations to identify other special terminals: these may be explained in the 'additional information' entry as described above, or in a preliminary note or key as convenient. Terminal identifiers from Table B, or those devised for the purpose, will not require fount letter signs here unless it is necessary to separate letters A-J from a preceding number, in which case the dot 6 letter fount sign is used. When print labels are used for this purpose, however, capital or other founts should be explicitly shown according to the usual mathematics code conventions, in order that the print be faithfully represented. Terminals without special names (e.g. the two terminals of a resistor) are identified by a lower number (without a numeral sign). When the component has two such terminals the convention of labelling the top or left-hand terminal 1 and the bottom or right-hand terminal 2, should generally be adhered to. A lower number terminal identifier immediately following a lower number component identifier should be separated from it by a dot 3; thus, for example, ⠿⠿⠂⠂⠿ indicates terminal 1 of resistor 2. If a lower number or other distinguishing affix to the component identifier is absent (e.g. if there is only one component of that type in the circuit), then the dot 3 separator should still be used before the lower number terminal identifier. Thus if the circuit had only one resistor R, terminal 1 of that resistor would be indicated as ⠿⠂⠿ . Terminal abbreviations may themselves require numbers or other labels appended in order to specify the terminals. For example, an OR logic symbol may have two inputs, identified as ⠿⠿⠿⠿⠿ and ⠿⠿⠿⠿⠿ respectively.

Terminals of transformers are identified by first indicating the winding, then the connection to the winding. The two ends of a winding should be numbered 1 and 2, and tappings numbered from 3 onwards. It will not normally be necessary to use the "tapping" abbreviation here with these conventions. Thus, for example, the second end of the first winding of transformer 3 would be indicated by ⠿⠂⠂⠿⠂⠂⠿ .

Stating the Circuit Connections

The connections in the circuit are given in a number of sequences. Each sequence consists of those terminals which are directly connected, with the individual terminal identifiers in the sequence separated by dot 5's; thus, for example, ⠿⠂⠂⠿⠿⠿⠂⠂⠿⠿⠂⠂⠿ , indicates that the positive terminal of battery 1 is connected to terminal 1 of resistor 2. Each sequence is normally treated as a separate cell 1 entry (with runovers in cell 3), though when there are several short sequences giving analogous connections (as frequently occur with

complex digital circuits), those sequences may be advantageously placed in a single entry, leaving a blank cell between sequences. It may also be possible to use hyphens to state such cases compactly. For example,  will mean pins 1 to 10 of IC_2 are connected to terminal 2 of C_1.

In general one should try to be fairly systematic in the order in which the connections in the circuit are given. Thus for a complex electronic circuit one might work across the circuit in 'rows' from left to right, and take 'rows' in order from the top-most to the bottom-most, i.e. scanning the circuit as if reading a page, though this will clearly only be an approximate scheme.

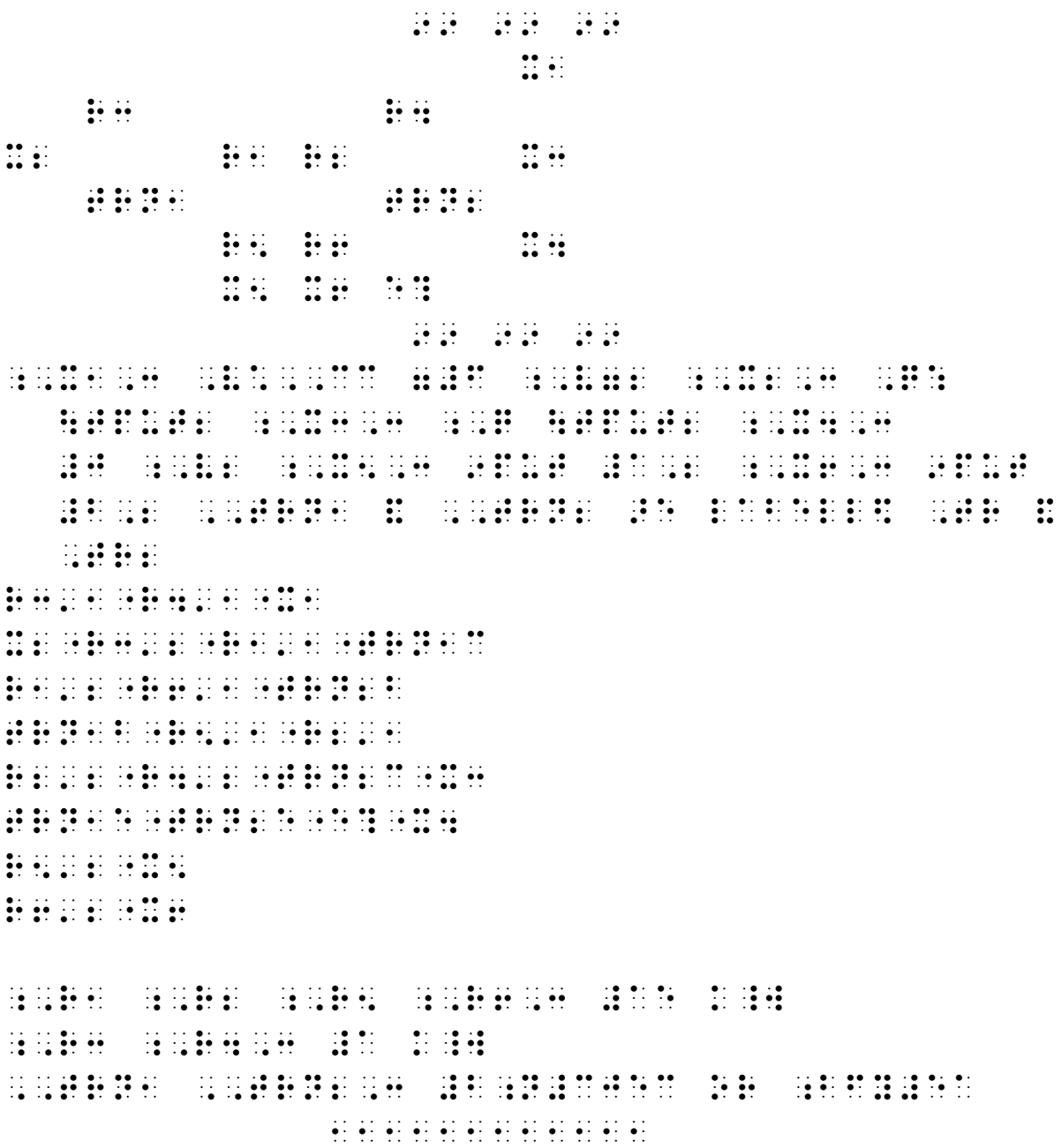
Component values are tabulated beneath the connection entries, after a blank line.

The descriptive representation of the circuit is finished with a centred line of 12 dot 2's.

EXAMPLE 9

Bistable

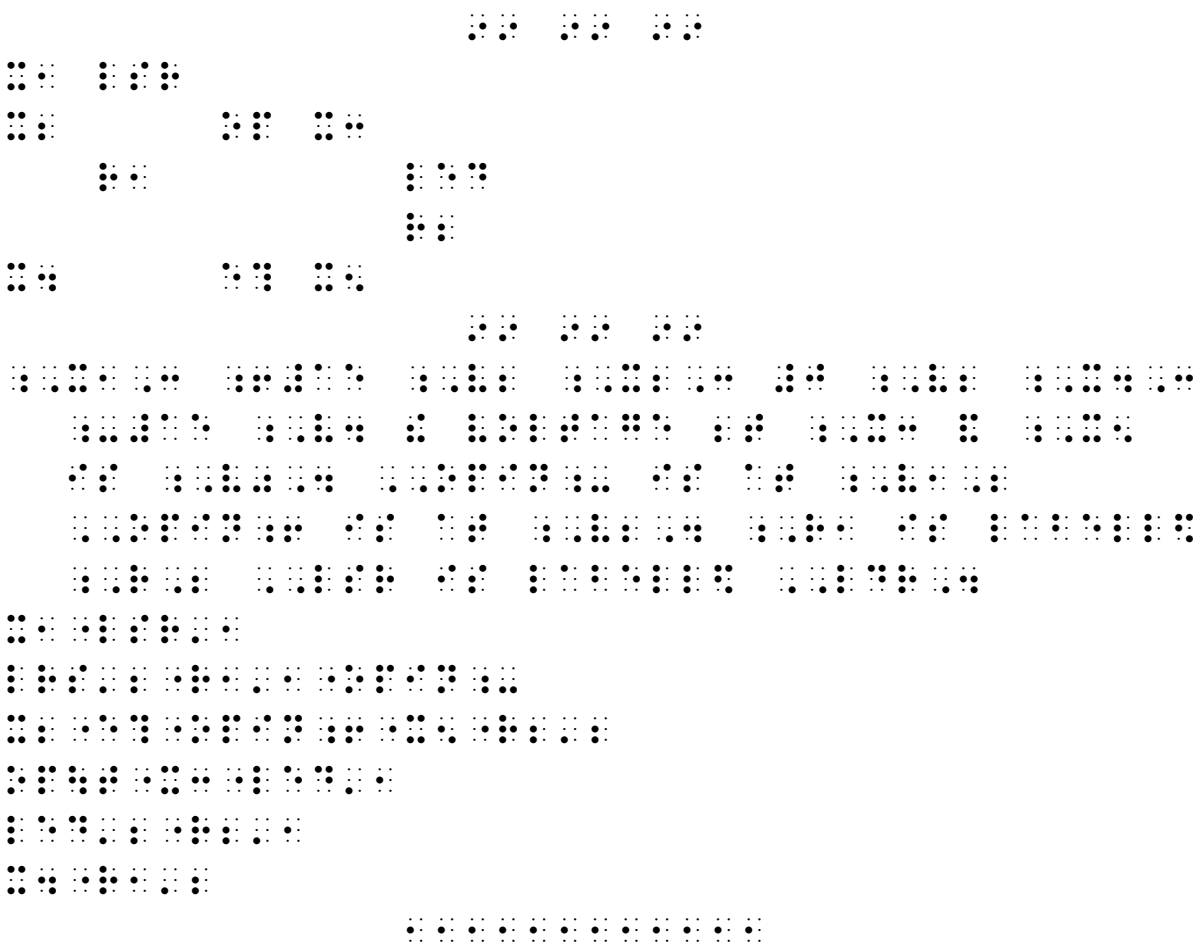
Braille Descriptive Representation: (See Example 1 for source diagram)



EXAMPLE 10

Alarm Circuit

Braille Descriptive Representation: (See Example 2 for source diagram)



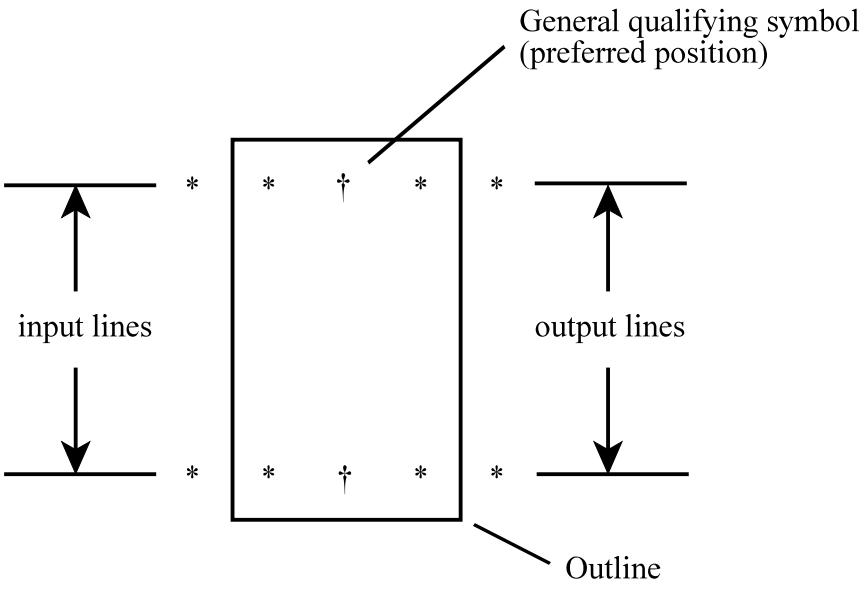
LOGIC SYMBOLS

The following gives conventions for assigning component and terminal identifiers for logic symbols, to be used in the Diagrammatic Representation methods (ii) and (iii), and the Braille Descriptive Representation.

Logic symbols are graphical representations of logic functions. They are used primarily in digital electronics, but have general application in other engineering disciplines. The international standard (IEC standard) for such symbols is that they be represented by rectangular boxes (with various qualifying symbols), but the alternative convention of representing basic logic gates (e.g. AND, OR, etc.) by particular shaped symbols as given in Table C is still widespread.

Table A gives the standard braille abbreviations to be used to represent the basic logic gates when the non-IEC symbol is used in print. For simplicity, these abbreviations can also be used for such elementary (uncombined) gates in the Braille Descriptive Representation when the IEC symbol is used in print, as this avoids the necessity of identifying block symbols representing them in a key. However, if this is done, it will generally be advisable to explain in a braille note that the other style of symbol is in fact used in the print. Otherwise, logic symbols should generally be treated according to the following conventions.

Logic Symbols are composed as shown in the diagram below: –



* possible positions of qualifying symbols

[By convention, inputs are on the left or top, outputs are on the right or bottom of the symbol unless shown otherwise (e.g. by right to left arrows on connecting lines or as indicated by particular qualifying symbols as noted in Table C).]

The braille component identifier for a logical symbol is based on its general qualifying

symbol; that is, the identifier consists of the full cell ⣿ followed by that qualifying symbol if it is directly transcribable, or by an abbreviation representing it if it is graphical, plus a numerical subscript to distinguish similar symbols in the diagram, if necessary for the Braille Descriptive Representation. (When the outline is given in a diagrammatic representation the initial full cell is not required.) Those abbreviations given in Table A should be used for the symbols listed; in other cases suitable abbreviations should be devised for the purpose. If the qualifying symbol contains a space, then it should be placed in mathematical brackets in the component identifier when appending the full cell.

For diagrammatic representations, terminals are labelled by their qualifying symbol(s) if present (marked * in the diagram on P.57) when directly transcribable, or by abbreviations representing them if they are graphical. Those abbreviations given in Table B should be used for the symbols listed; in other cases suitable abbreviations should be devised for the purpose. When the outline is not shown and a terminal has both external and internal qualifying symbols to the outline, they should be separated by a semicolon (followed by a space) with the group enclosed in mathematical brackets. If the outline is shown, then the qualifying symbols should be placed inside or outside the outline as shown in print.

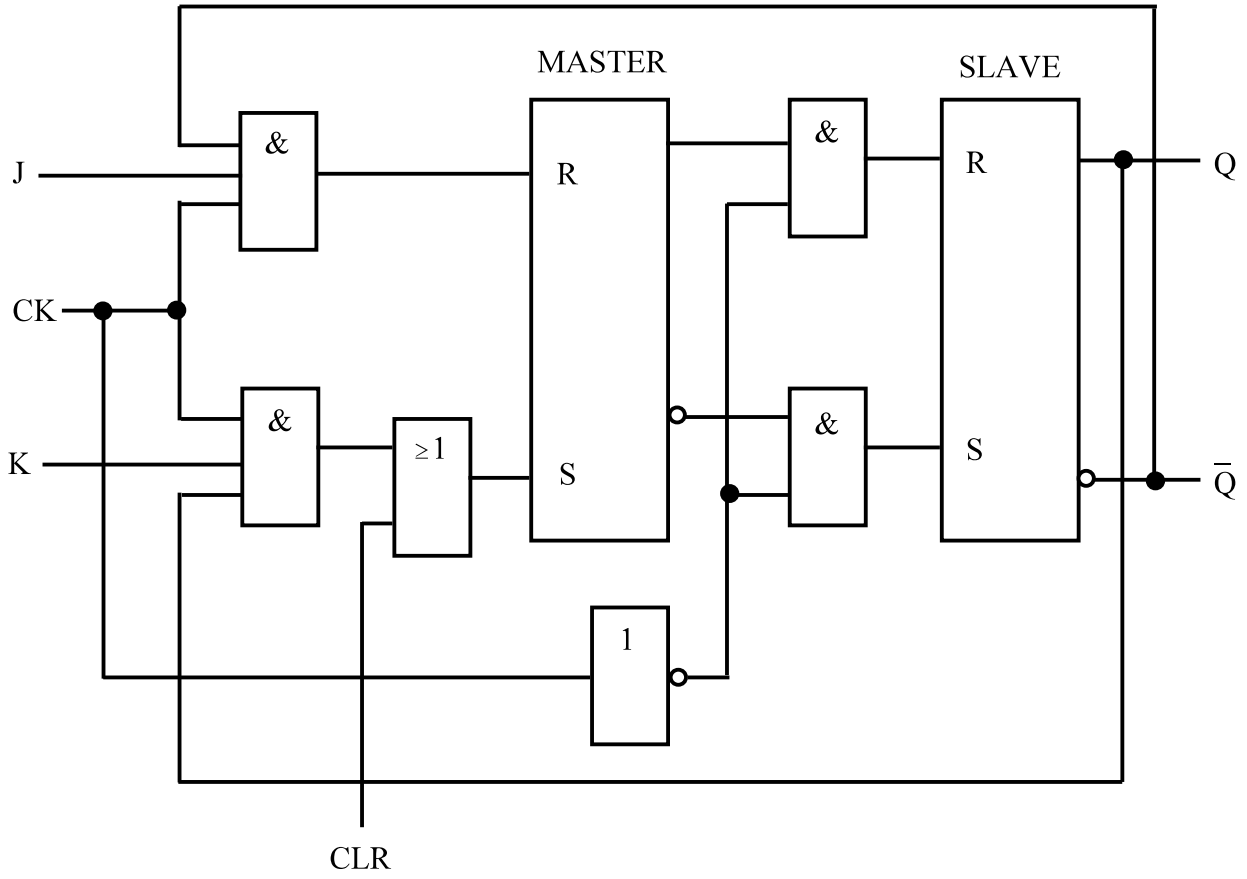
For the Braille Descriptive Representation the terminal identifiers consist of the component identifier followed by the input or output abbreviation as appropriate; with a numerical subscript, or other such label if given in print, to distinguish different inputs or outputs to the symbol if necessary; appended with the qualifying symbol(s) on the terminal as above (if present). Mathematical brackets are used for terminal qualifying symbols containing a space as with general qualifying symbols. When a terminal has both external and internal qualifying symbols to the outline, they should be separated by a semicolon (followed by a space), and brackets enclosing the qualifying group will be necessary.

Standard braille abbreviations for qualifying symbols given in Tables A and B will not require letter fount signs unless it is necessary to separate a letter A-J from a preceding number, in which case the dot 6 letter fount sign is used. Print qualifying symbols and other labelling transcribed directly, however, will require letter fount signs in accordance with the usual mathematics code conventions, unless the print conventions are otherwise made clear beforehand. (Qualifying abbreviations are, in fact, generally in capitals in print.)

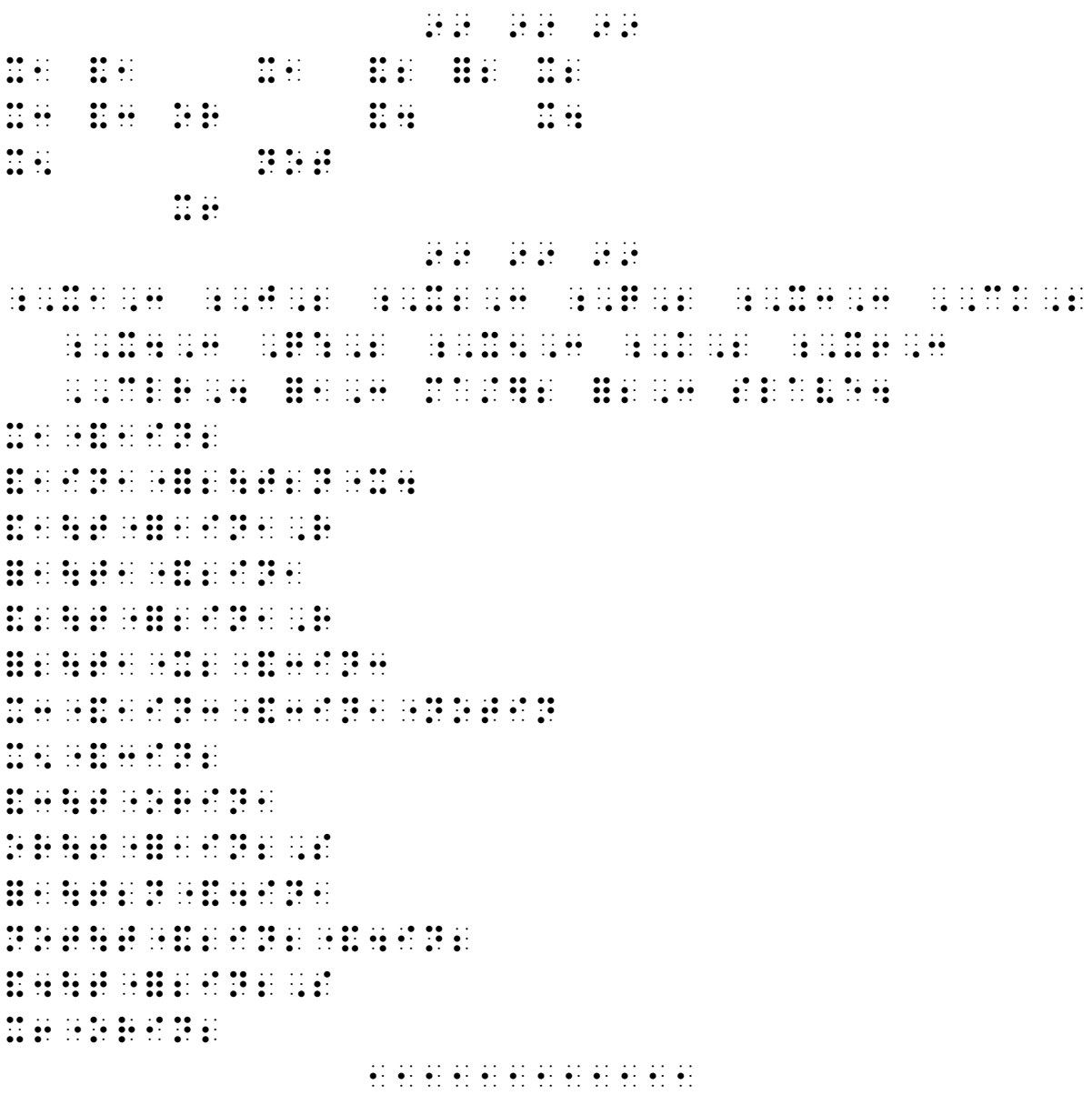
EXAMPLE 11

Master-Slave J-K Flip-flop

Source diagram:



Braille Descriptive Representation:



Composite Logic Symbols

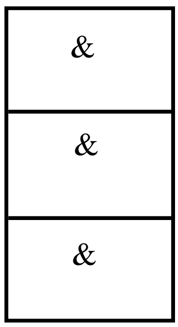
As a means of simplifying diagrams, logic symbols may be shown juxtaposed within a single rectangular outline to form a composite logic symbol. It is the convention that logic symbols are only connected across vertical junctions, not horizontal junctions, within such composite symbols. With the diagrammatic methods of representation, it is best for such composite symbols to be represented with their outlines and internal lines shown, and then treated in the same way as non-composite logic symbols. The following techniques are only required for the braille descriptive method of representation.

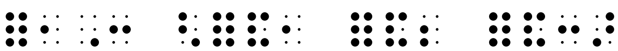
In the display of components in the Braille Descriptive Representation, composite logic symbols should be shown simply by a full cell  with a distinguishing subscript number if required. The composition of this logic symbol is then explained by its 'expansion' given as an entry in the second stage of the presentation of the diagram. The expansion consists of the component identifiers for the constituent logic symbols (with distinguishing numerical subscripts if necessary) set out according to the following two principles:

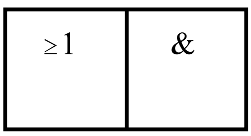
(1) Logic symbols or groups of symbols placed one above the other (implying no connection) are placed within mathematical brackets as a spaced sequence.

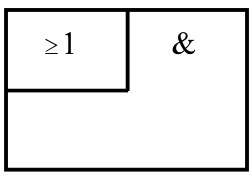
(2) Logic symbols or groups of symbols which butt one against the other (implying a connection) are brailled in the same order, separated by a dot 5.

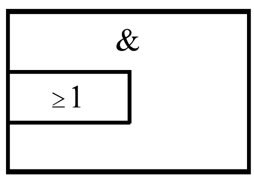
E.g. for

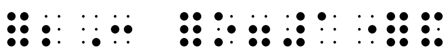


we would write  ;

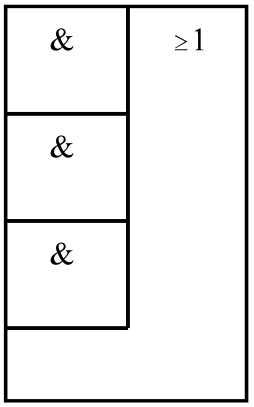
for 

, 

or 

we would write  ;

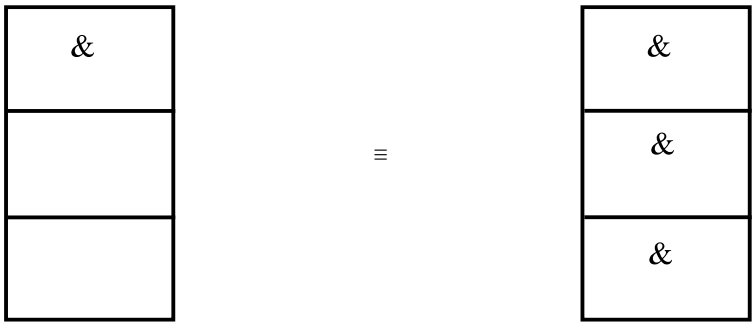
and for



we would write 

Note that the abbreviations for the equivalent non-IEC symbols (OR, NOT, etc) are not used in such composite logic symbols: the print should be transcribed directly.

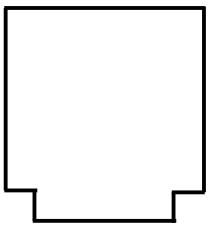
It is the convention in print that logic symbols stacked one above the other and each having the same general qualifying symbol (as in the first example above), may be shown with the qualifying symbol in the top logic symbol only. Thus



When such a symbol is expanded as above, however, the qualifying symbol should be explicitly shown for each of those component logic symbols. The same convention may also be used for qualifiers on inputs or outputs: the qualifiers should again be individually shown for each such connection in the braille.

A logic symbol which has a horizontal line drawn across its top and is placed at the bottom of a stack of logic symbols is a common output element, and is identified by the abbreviation CO (following the full cell). If the common output element also has a general qualifying symbol, then this follows the CO abbreviation after a colon and space, with the pair placed in mathematical brackets after the full cell. [This element signifies that the outputs of each of the logic symbols in the stack above it are inputs to that common output element.]

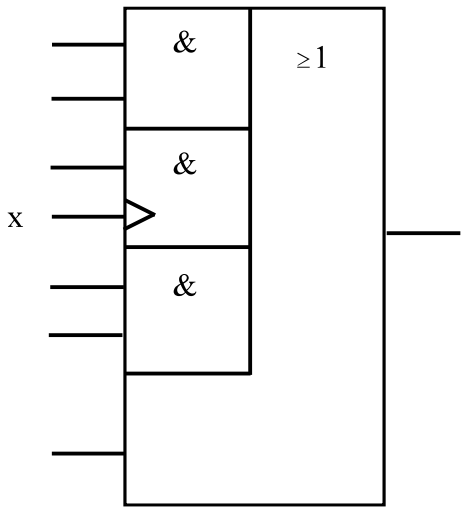
A logic symbol with the characteristic outline



is a common control block, and is identified by the abbreviation CC (following the full cell). If the common control block also has a general qualifying symbol, then this follows the CC abbreviation after a colon and space, with the pair placed in mathematical brackets after the full cell. This is the only distinctively shaped logic symbol in the IEC standard. [It signifies that inputs to the common control block are common inputs to the logic symbols below (subject to any qualifying dependancy notation shown).]

For the Braille Descriptive Representation a terminal identifier for a logic symbol within a composite symbol consists of the usual terminal identifier for the individual component logic symbol (based on its component identifier as given in the expansion of the composite symbol), preceded by the identifier for the composite logic symbol as a whole (as given in the display of components).

For example, in the symbol ⠿⠒ given above,



the connection marked x would be identified by ⠿⠒⠿⠿⠒⠒⠿⠒⠒⠿⠒

TABLE A

Braille Abbreviations for Electronic Components and Logic Symbols

(Underlining indicates the braille contraction.)

aerial: AE
amplifier: AM
astable element: A
astable element, synchronously starting: AS
astable element, stopping after completion of last pulse: AL
astable element, synchronously starting, stopping after completion of last pulse: ASL

battery of cells: B
bell: BL
block symbol, e.g. logic symbol: FOR (This symbol does not require dot 6's in ordinary text; it is not regarded as representing capital letters.)
buffer (flow to the left): BUL
buffer (flow to the right): BUR
buzzer: BZ

capacitor: C
- electrolytic: CEL
- pre-set: CP
- variable: CV
- with inherent variability: CIV

cell: CL
- photovoltaic: CLP

cathode ray tube: CRT
common control block: CC
common output element: CO

diode (semi-conductor): D
- light-emitting: LED
- light-sensitive: LSD
- zener: DZ

display: DS

earphone: EAR
earth: ETH

frame or chassis connection: FR

fuse: FU

heater: H

integrated circuit: IC
inductor: L
- dust core: LD
- ferromagnetic core: LF
- preset: LP (or LDP, LFP)
- variable: LV (or LDV, LFV)
- with intrinsic variability: LIV (or LDIV, LFIV)

lamp: LP
- filament: LPF
- neon: LPN
- signal: LPS
- tubular fluorescent: LPTF

logic gates
- AND: AND
- NAND: NAND
- NOR: NOR
- NOT: NOT
- OR: OR
- exclusive OR: XOR

loudspeaker: LS

meter: M
- ammeter: MA
- frequency meter: MF
- galvanometer: MG
- voltmeter: MV

microphone: MK
monostable
- retriggerable: MR
- non-retriggerable: MNR

motor: MO

operational amplifier: OP

phones: PH
plug: PL
potential divider: PD
power supply: POW
- ac: POWAC
- dc: POWDC

relay: RY
resistor: R
    light sensitive: LSR
    preset: RP
    variable: RV
    with inherent variability: RIV

Schmitt trigger: SCH
signal generator: SG
socket: SKT
switch: S
    normally open: SO
    normally closed: SC
    reed: SR
    reed, normally open: SRO
    reed, normally closed: SRC

thermistor: THER
    ntc (negative temperature coefficient dependent): THEN
    ptc (positive temperature coefficient dependent): THEP
thermocouple: THEC
thermostat: THET
thyristor: THY
transformer: T
    air-core: TA
    dust-core: TD
    ferromagnetic core: TF
    laminated core: TL
transistor
    field effect (f.e.t.), insulated gate, n channel: TRFIN
    field effect (f.e.t.), insulated gate, p channel: TRFIP
    field effect (f.e.t.), junction gate, n channel: TRFJN
    field effect (f.e.t.), junction gate, p channel: TRFJP
    npn: TRN
    pnp: TRP
    unijunction: TRU
triac: TC

valve: V
    diode: VD
    pentode: VP
    tetrode: VTE
    triode: VTR

TABLE B

Braille Abbreviations for Terminals

(Underlining indicates the braille contraction.)

active low: AL
active low, right-to-left signal flow: AL<u>OW</u> dots 25
anode: AN
arm: AR

base: B
bi-threshold: BT

cathode: K
coil (of relay): CL
collector: C
contact: CT

defined by label inside symbol: DL
drain: D
dynamic: DY

emitter: E

filament: F

gate: G
grid: GR

heater: H

input: IN

negative: –
negation: N

open-circuit: OP
open circuit, high type: OPH
open circuit, low type: OPL
output: <u>OU</u>T

passive pull-down: PPD
passive pull-up: PPU

positive: +
postponed: PO

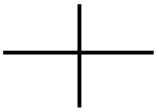
source: S
substrate: SST
supply: SUP

tapping: T
3-state: 3S

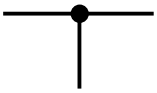
wiper: W

TABLE C

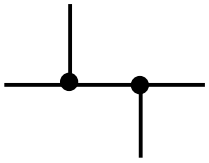
Electronic and Logic Symbols



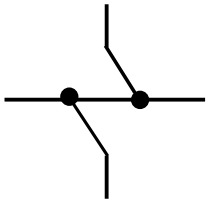
conductors crossing with no connection



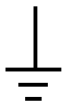
junction of conductors



double junction of conductors

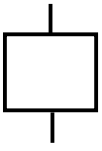


aerial

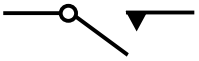


earth

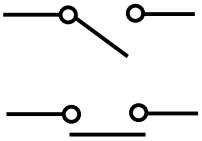
frame or chassis connection



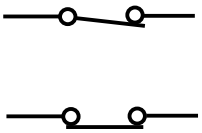
relay coil



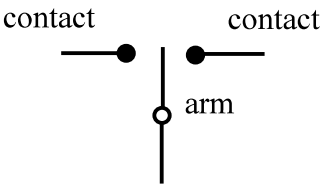
relay contact



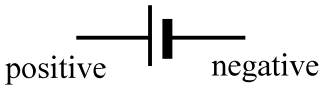
normally open switch



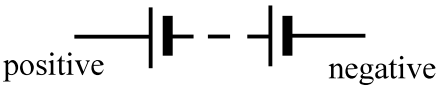
normally closed switch



switch with arm



primary or secondary cell

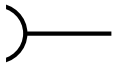


battery of cells

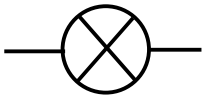
power supply

ac power supply

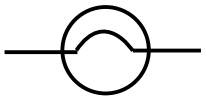
plug (male)



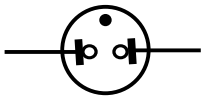
socket (female)



signal lamp

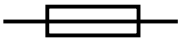


filament lamp



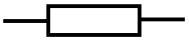
neon lamp

tubular fluorescent lamp



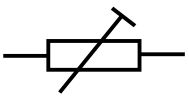
fuse

heater

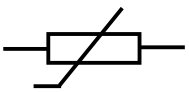


fixed resistor

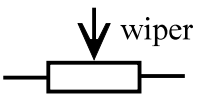
variable resistor



pre-set resistor



resistor with inherent variability



potential divider

capacitor

variable capacitor

pre-set capacitor

capacitor with inherent variability

(polarised) electrolytic capacitor

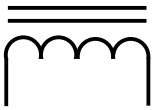
inductor

variable inductor

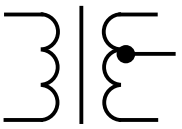
pre-set inductor

inductor with inherent variability

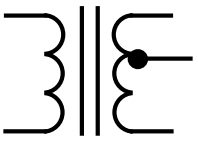
inductor with ferromagnetic core (variability is shown as above)



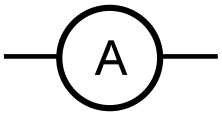
inductor with laminated core (variability is shown as above)



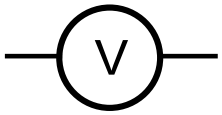
transformer with ferromagnetic core



transformer with laminated core

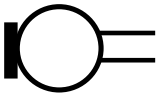


ammeter

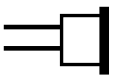


voltmeter

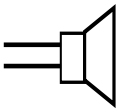
galvanometer



microphone

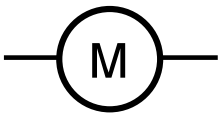


earphone

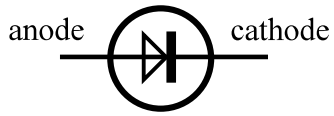


loudspeaker

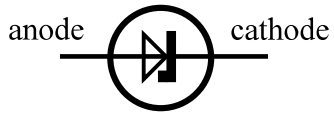
electric bell



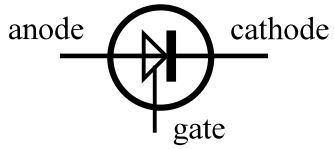
motor



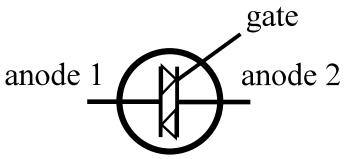
diode/rectifier (the circular envelope may be absent in this and the other diode symbols)



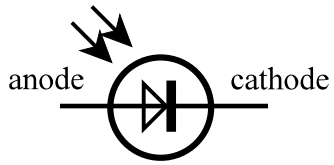
zener diode



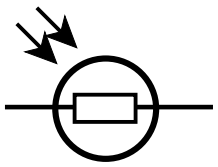
thyristor



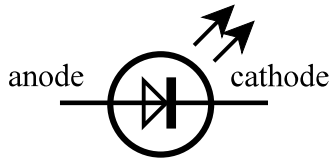
triac



light sensitive diode



light sensitive resistor



light emitting diode (LED)

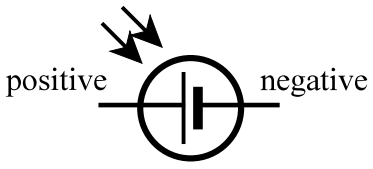
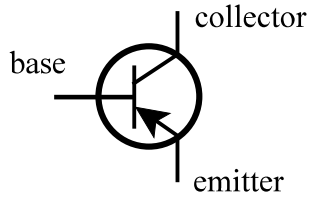
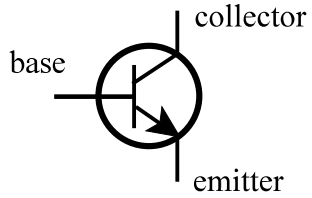


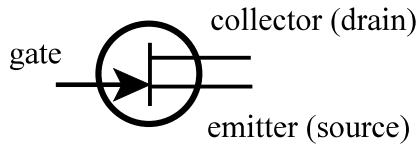
photo-voltaic cell



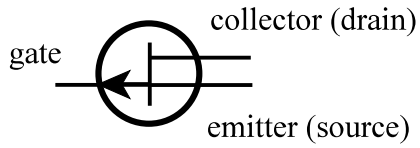
pnp junction transistor



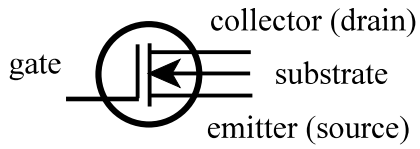
npn junction transistor



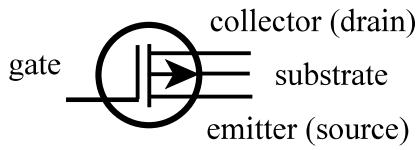
field effect transistor (fet), junction gate, n channel



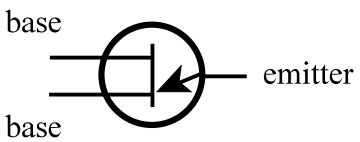
field effect transistor (fet), junction gate, p channel



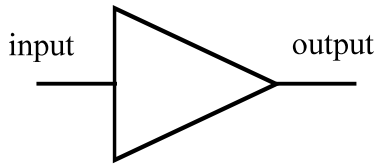
field effect transistor, insulated gate, n channel



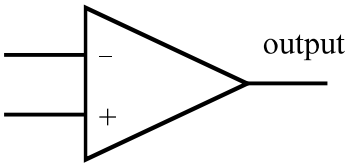
field effect transistor, insulated gate, p channel



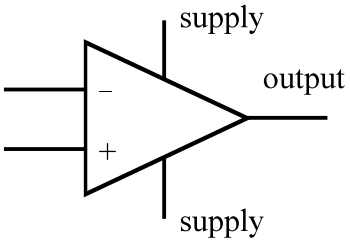
uni-junction transistor, n channel (p channel device has arrow reversed but is uncommon)



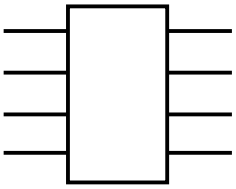
amplifier



operational amplifier

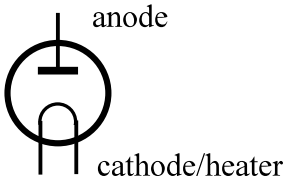


operational amplifier

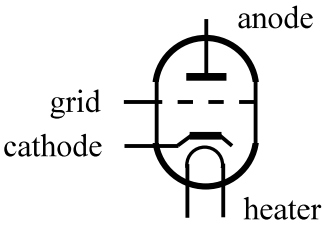


integrated circuit

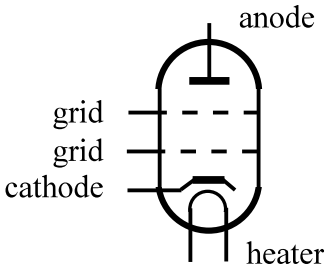
Examples of Valves



diode valve



triode valve



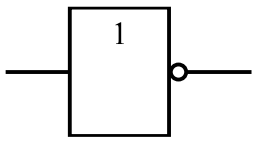
tetrode valve

Logic Symbols

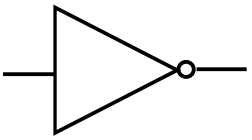
Inputs are on the left; outputs on the right.

Simple Gates [These may have more than the indicated number of inputs]

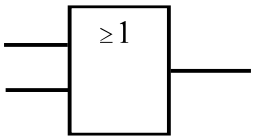
IEC Symbol



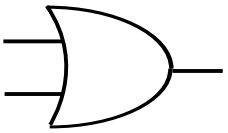
or



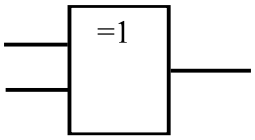
NOT gate



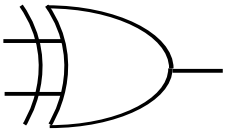
or



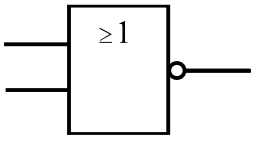
OR gate



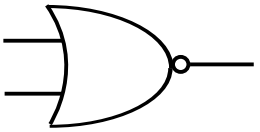
or



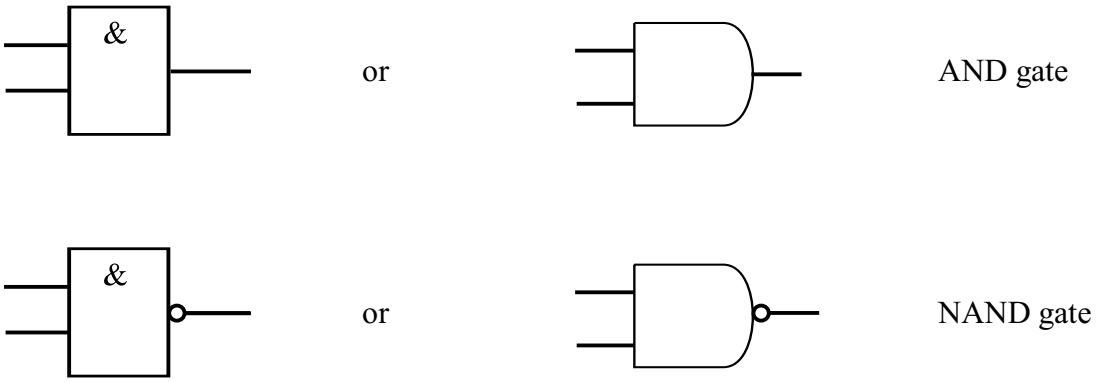
exclusive OR gate



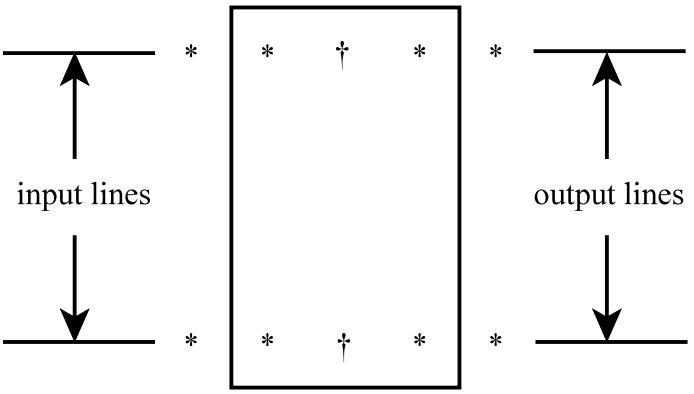
or



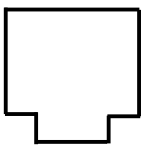
NOR gate



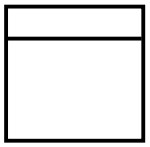
General Logic Symbol



† possible locations for general qualifying symbol
* possible locations for input and output qualifying symbols



common control block



common output element

General Qualifying Symbols

(Only graphical symbols are listed here.)

buffer (flow to the right)

buffer (flow to the left)

Schmitt trigger

retriggerable monostable

non-retriggerable monostable

astable element (The waveform may be absent in this and the other astable elements below.)

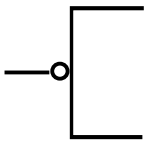
astable element, synchronously starting

astable element, stopping after completion of last pulse

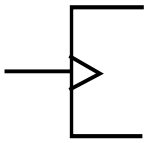
astable element, synchronously starting, stopping after completion of last pulse

Input and Output Qualifying Symbols

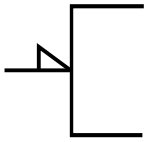
(Only graphical symbols are listed here. A portion of the logic symbol outline and an input or output line are shown for clarity.)



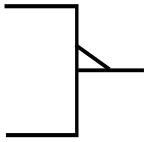
negation



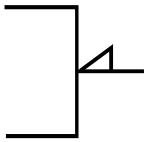
dynamic input



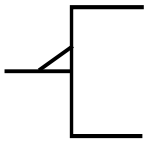
active low input



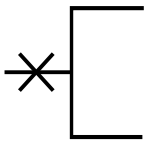
active low output



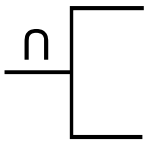
active low input, right-to-left signal flow



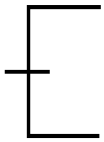
active low output, right-to-left signal flow



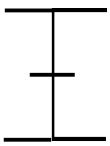
defined by label inside symbol



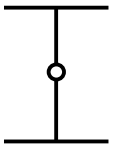
analogue signal



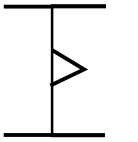
virtual input/output



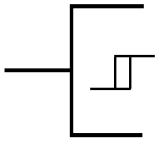
internal connection



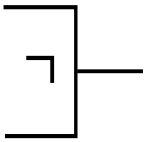
inverting internal connection



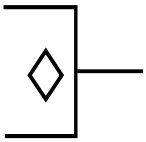
dynamic internal connection



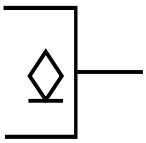
bi-threshold input



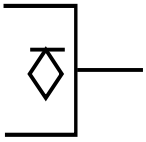
postponed output



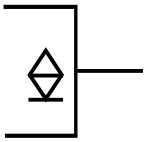
open-circuit output



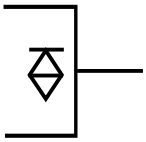
open-circuit low-type output



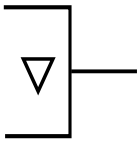
open-circuit high-type output



passive pull-up output



passive pull-down output

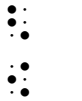


3-state output

5
KARNAUGH MAPS

Karnaugh maps are used as a means of analysing boolean expressions, and can occur in subjects such as digital electronics. A Karnaugh map appears as an array of 0's and 1's with various groupings of these numbers marked.

These may be treated in braille using the following brackets, as demonstrated in the examples below.


stands for a horizontal group

stands for a vertical group


stands for a "square" group

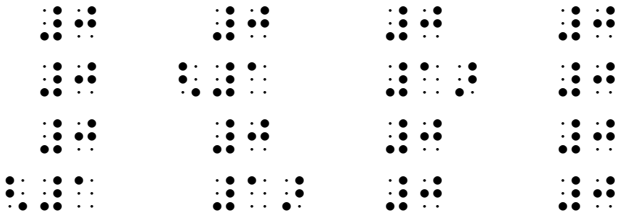

stands for a bottom right corner


stands for a bottom left corner


stands for a top right corner

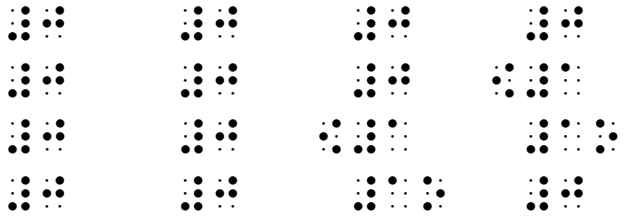

stands for a top left corner

Example 1



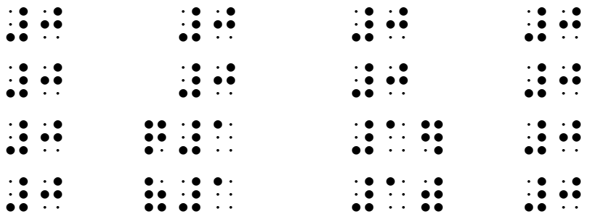
0	0	0	0
0	1	1	0
0	0	0	0
1	1	0	0

Example 2



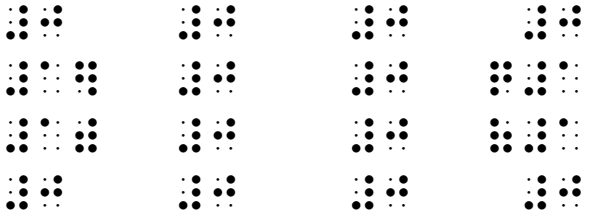
0	0	0	0
0	0	0	1
0	0	1	1
0	0	1	0

Example 3



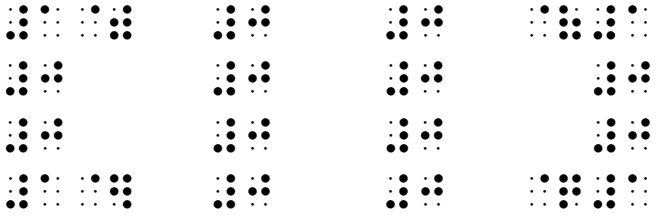
0	0	0	0
0	0	0	0
0	1	1	0
0	1	1	0

Example 4



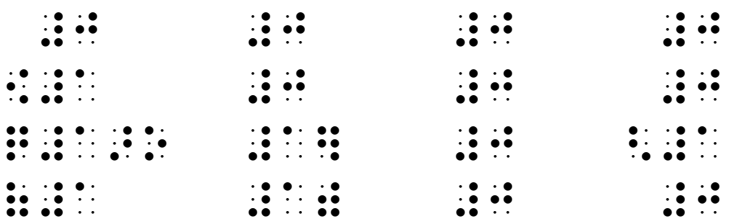
0	0	0	0
1	0	0	1
1	0	0	1
0	0	0	0

Example 5



1	0	0	1
0	0	0	0
0	0	0	0
1	0	0	1

Example 6



0	0	0	0
1	0	0	0
1	1	0	1
1	1	0	0