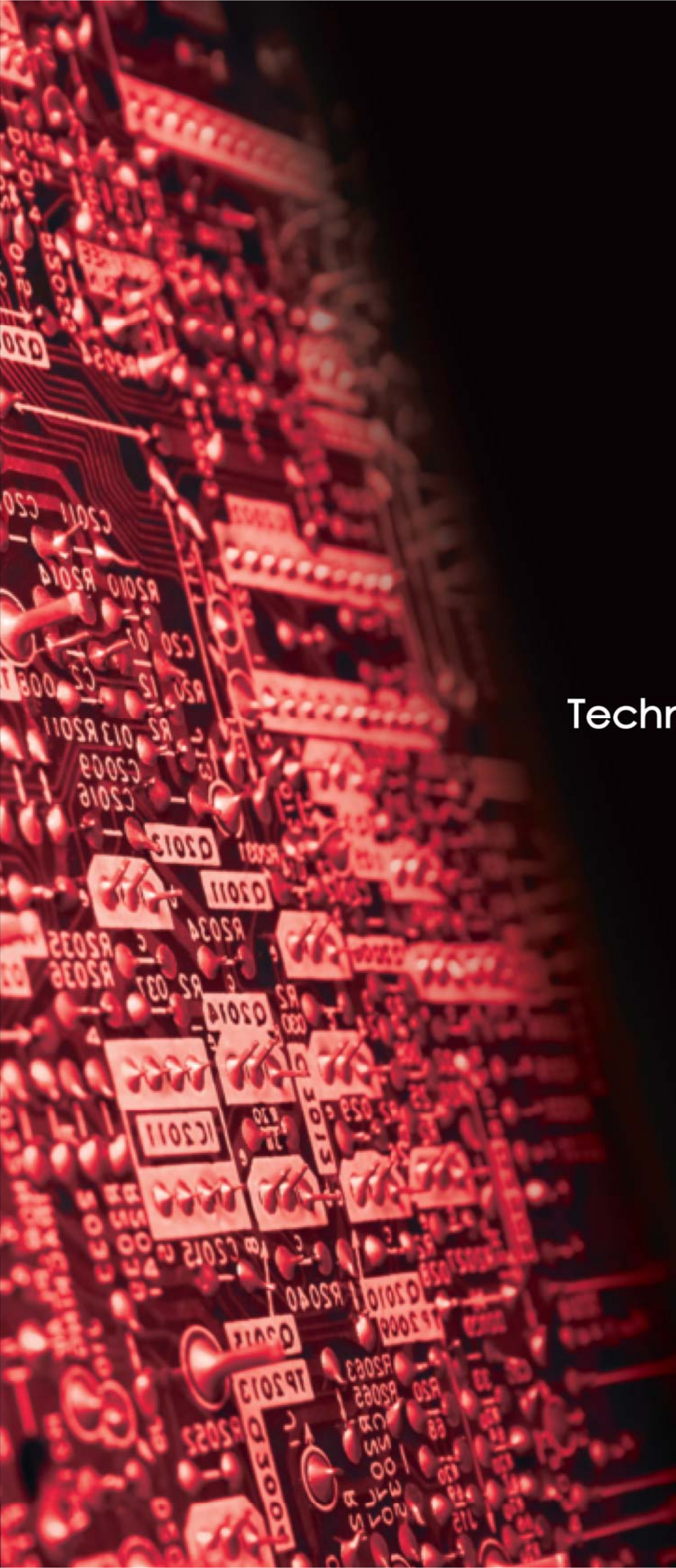

NQ
NATIONAL QUALIFICATIONS

Technological Studies

Data Booklet

Higher

SQA

Technological Studies Data Booklet
Higher

For use in National Qualification Courses
leading to the 2009 examinations and beyond.

Published date: July 2008
Publication code: BB4470
ISBN: 978 1 85969 608 8

Published by the Scottish Qualifications Authority
The Optima Building, 58 Robertson Street, Glasgow G2 8DQ
Ironmills Road, Dalkeith, Midlothian EH22 1LE

www.sqa.org.uk

For an up-to-date list of prices visit the **Publication Sales and Downloads** section of SQA's website.

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Contents

Preface

This data booklet is intended for use by candidates in examinations in Technological Studies at Higher level. It is recommended that candidates should become familiar with the contents of the data booklet through use in undertaking units of these courses.

It should be noted that the range of data contained in the booklet has been limited to that syllabus content which may be assessed through written examination papers. This range should be supplemented by other resource material as necessary during the course, eg by using data sheets. However, should any additional information (or data not included in this booklet) be required in an examination, such information will be included in the examination paper.

Teachers/lecturers should note that all of the material contained in this booklet is likely to be examined at some time. With regard to tables of information, not every entry in a table will necessarily be involved in examination questions.

From the variety of data offered in this booklet, candidates will be expected to demonstrate the ability to select an appropriate:

- item of information
- formula
- material property
- operational amplifier circuit
- PBASIC instruction

Basic Units and Decimal Prefixes

Basic Units			
Quantity	**Symbol**	**Unit**	**Abbreviation**
Length	ℓ, L	metre	m
Distance	*s, x*	metre	m
Time	t	second	s
Velocity	v	metre/second	m/s
Mass	m	kilogram	kg
Force	F	newton	N
Work	W	joule	J
Energy	E	joule	J
Power	P	watt (J/s)	W
Stress	σ	newton/metre^2	N/m^2
Strain	ε	no unit	
Temperature	T, t	kelvin, celsius	K, °C
Current	I	ampere (amp)	A
Voltage	V	volt	V
Resistance	R	ohm	Ω
Frequency	f	hertz	Hz

Decimal Prefixes		
Prefix	**Symbol**	**Multiplying Factor**
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

Applied Electronics

Basic Equations

Ohm's law	$V = IR$
Resistors in series	$R_T = R_1 + R_2 + R_3$
Resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
for 2 resistors in parallel	$R_T = \frac{R_1 R_2}{R_1 + R_2}$ $\left(R_T = \frac{\text{product}}{\text{sum}}\right)$
Kirchhoff's 1st Law	$\Sigma I = 0$ (Algebraic sum of currents at a node is zero)
Kirchhoff's 2nd Law	$\Sigma E = \Sigma IR$ (Algebraic sum of supply voltages = sum of voltage-drops, in a closed loop)
Voltage Divider Rule	$\frac{V_1}{V_2} = \frac{R_1}{R_2}$ (Ratio of Voltages = Corresponding Ratio of Resistances)
Electrical Power	$P = VI = \frac{V^2}{R} = I^2 R$
Bi-polar transistor gain	$h_{FE} = \frac{I_c}{I_b}$
MOSFET transconductance	$g_m = \frac{\Delta I_D}{\Delta V_{GS}}$

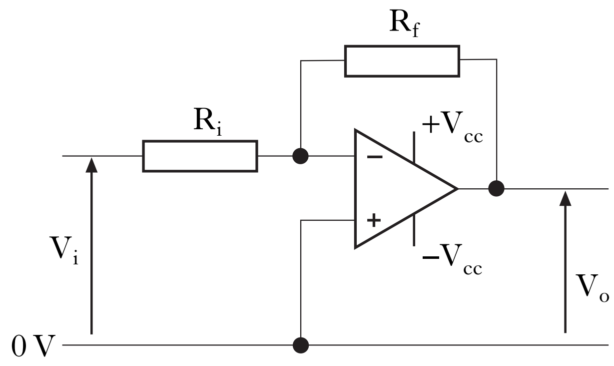
Typical Operational Amplifier Circuits

V_o = output voltage V_i = input voltage V_{cc} = supply voltage

R_f = feedback resistance R_i = input resistance $A_v = \text{gain} = \dfrac{\text{output voltage}}{\text{input voltage}}$

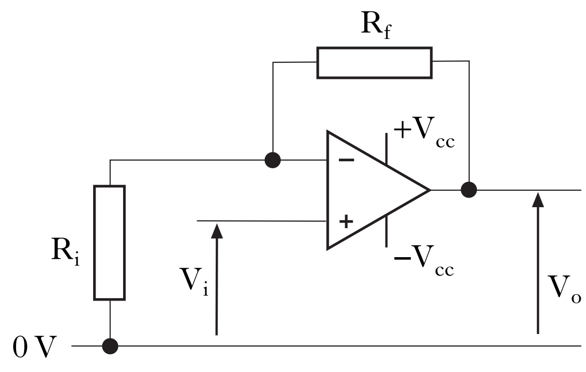
Note: Op-amp output saturates at 85% of V_{cc}

Inverting



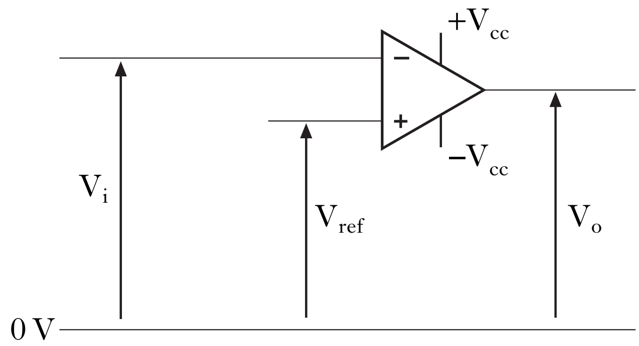
$$A_v = \frac{V_o}{V_i} \qquad A_v = -\frac{R_f}{R_i} \qquad V_o = -\frac{R_f}{R_i}V_i$$

Non-inverting



$$A_v = \frac{V_o}{V_i} \qquad A_v = 1 + \frac{R_f}{R_i} \qquad V_o = \left(1 + \frac{R_f}{R_i}\right)V_i$$

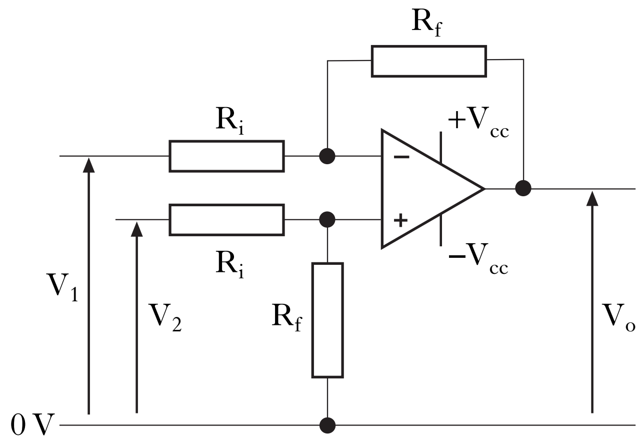
Comparator



If $V_i < V_{ref}$, then V_o saturates positively (85% of $+V_{cc}$)

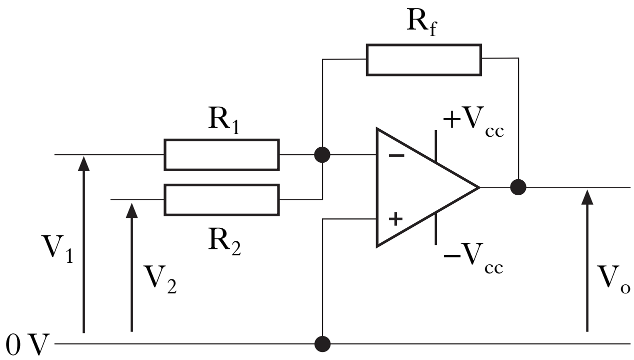
If $V_i > V_{ref}$, then V_o saturates negatively (85% of $-V_{cc}$)

Difference Amplifier



$$A_v = \frac{V_o}{(V_2 - V_1)} \qquad A_v = \frac{R_f}{R_i} \qquad V_o = \frac{R_f}{R_i}(V_2 - V_1)$$

Summing Amplifier

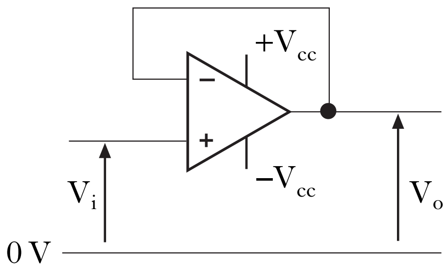


$$A_{v1} = -\frac{R_f}{R_1} \qquad A_{v2} = -\frac{R_f}{R_2} \qquad A_{vn} = -\frac{R_f}{R_n}$$

$$V_o = (A_{v1}V_1) + (A_{v2}V_2) + \ldots\ldots$$

$$V_o = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \ldots\ldots\right)$$

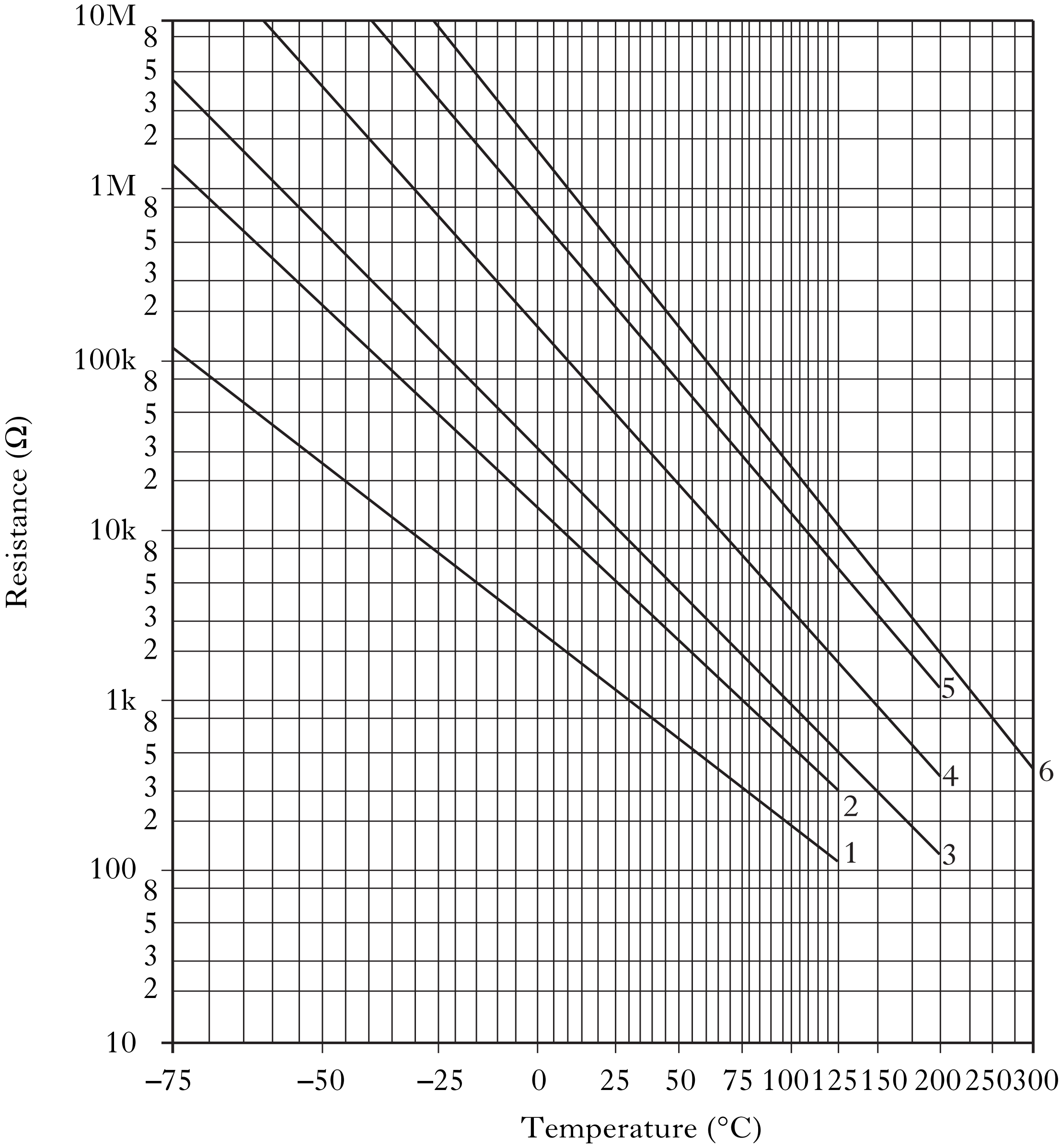
Voltage Follower



$$V_o = V_i$$

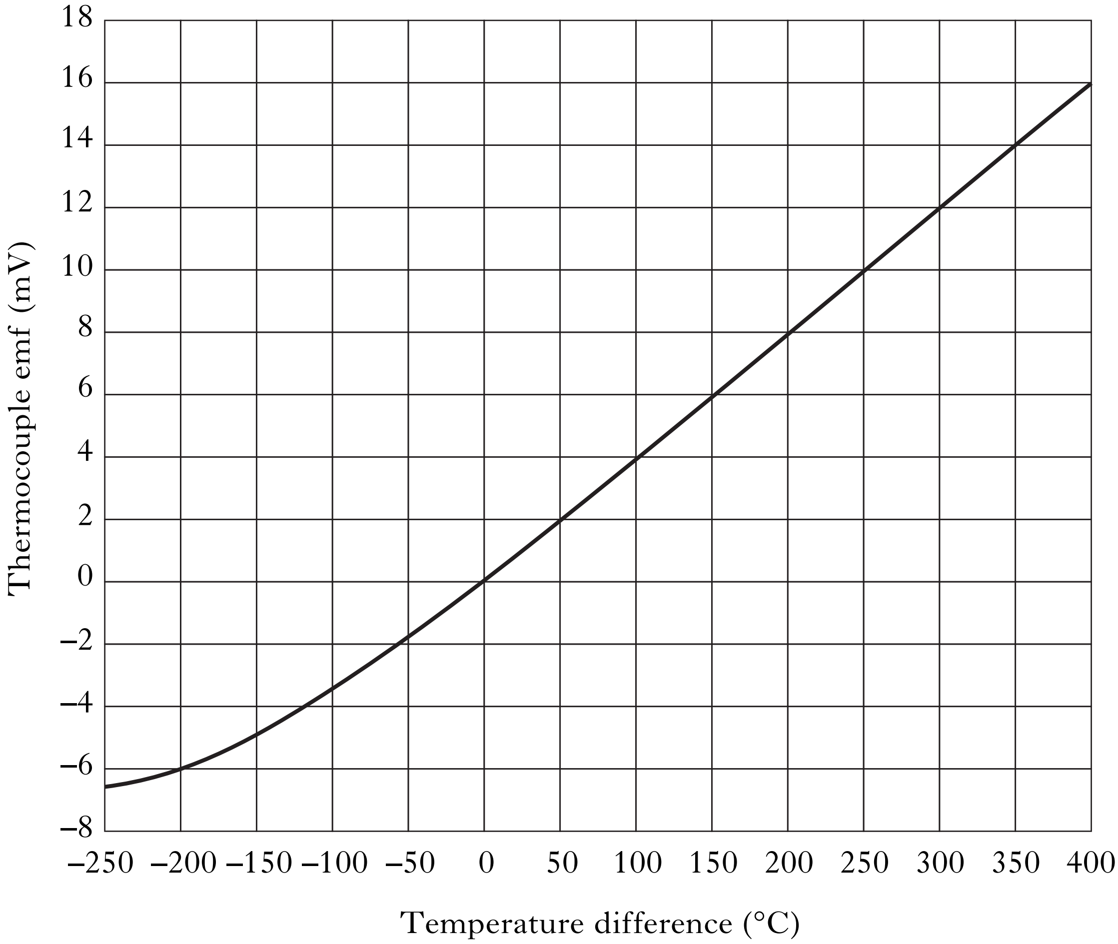
Graphs for Thermistors, Thermocouple and LDR

Thermistors: Resistance-temperature characteristics

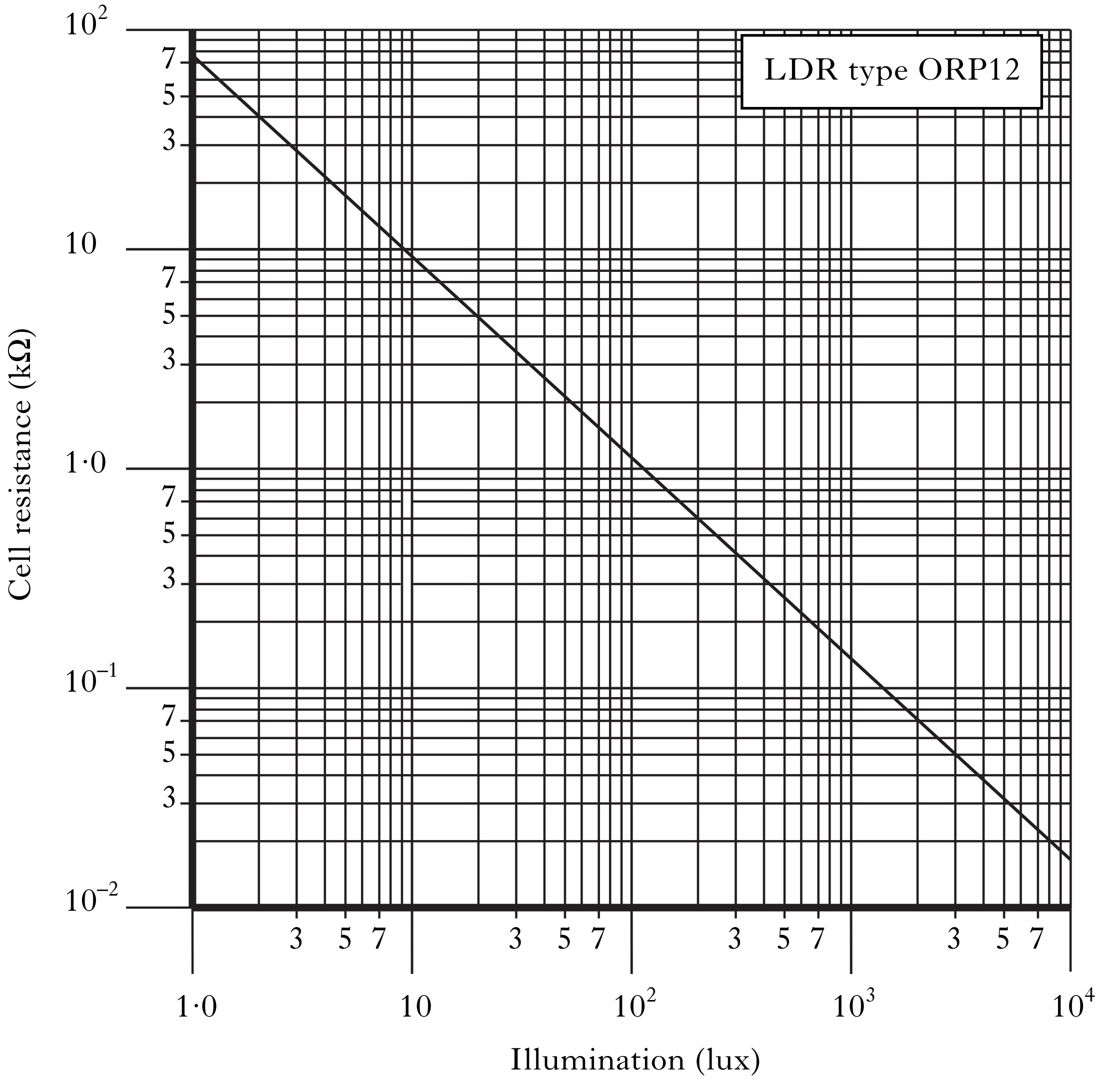


Thermocouple

Typical temperature gradient for type K thermocouple

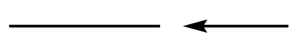
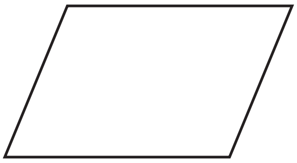
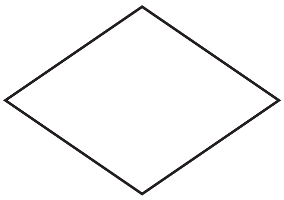


Light Dependent Resistor (LDR)



Systems and Control

Symbols for Flowcharts

Terminator symbol		Used for the start and end of a main program or sub-procedure.
Line symbol		Indicates the direction of program flow. For flow down or to the right arrows are not needed. For flow upwards or to the left, arrows are added.
Input/Output symbol		Used to control outputs or to show that data is being received.
Process symbol		Used for operations which take place within the microcontroller.
Decision symbol		Program flow is determined by a "yes" or "no" answer to the question in the box.
Sub-procedure symbol		Used to call a sub-procedure.

Number Systems and PBASIC Instruction Set

Number Systems								
Bit Number	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Binary	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Decimal	128	64	32	16	8	4	2	1
The default number system is decimal. For binary numbers, the prefix symbol "%" is used.								

PBASIC Instruction Set	
Instruction	**Explanation**
symbol	Allocate a name to a pin or variable
INPUT/OUTPUT	
high *x*	Make pin "x" an output and set it high
low *x*	Make pin " x" an output and set it low
dirs	Set up each pin on PORTB to input or output
pins	Control all pin states at once
TIME	
pause *n*	Create a time delay of *n* (0–65535) milliseconds
PROGRAM FLOW	
goto *label*	Jump to *label*
gosub *label*	Jump to sub-procedure at *label*
return	Return from sub-procedure
if . . . . then *label*	If a condition is met, jump to a *label* (but not to a sub-procedure)
for . . . . next	Establish a loop which repeats a specified number of times
end	End of program flow

Variables
Byte variables (b0–b13) can store values 0–255.
Word variables (w0–w5) can store values 0–65535; w0 contains b0 and b1 within it; w1 contains b2 and b3 within it etc.

Structures and Materials

Basic Formulae

Moment of a force $M = Fx$

x is the perpendicular distance

Principle of Moments $\Sigma M = 0$

Conditions of equilibrium

$\Sigma F_h = 0$

$\Sigma F_v = 0$

$\Sigma M = 0$

Stress $\sigma = \dfrac{F}{A}$

Strain $\varepsilon = \dfrac{\Delta \ell}{\ell}$

Young's Modulus $E = \dfrac{\sigma}{\varepsilon}$

$$\text{Factor of Safety} = \frac{\text{ultimate load}}{\text{safe working load}} = \frac{\text{ultimate stress}}{\text{safe working stress}}$$

Circumference of a circle $= 2\pi r = \pi d$

Area of a circle $= \pi r^2 = \dfrac{\pi d^2}{4}$

Young's Modulus and Stress

Material	Young's Modulus E kN/mm^2	Yield Stress σ_Y N/mm^2	Ultimate Tensile Stress N/mm^2	Ultimate Compressive Stress N/mm^2
Mild steel	196	220	430	430
Stainless steels	190–200	286–500	760–1280	460–540
Low-alloy steels	200–207	500–1980	680–2400	680–2400
Cast iron	120	—	120–160	600–900
Aluminium alloy	70	250	300	300
Soft brass	100	50	80	280
Cast bronze	120	150	300	—
Titanium alloy	110	950	1000	1000
Nickel alloys	130–234	200–1600	400–2000	400–2000
Concrete	—	—	—	60
Concrete (steel reinforced)	45–50	—	—	100
Concrete (post stressed)	—	—	—	100
Plastic, ABS polycarbonate	2·6	55	60	85
Plastic, polypropylene	0·9	19–36	33–36	70
Wood, parallel to grain	9–16	—	55–100	6–16
Wood, perpendicular to grain	0·6–1·0	—	—	2–6
Soda glass	69	3600	—	—
Diamond	1000	50 000	—	—
Gold	82	40	220	—
Ice	9·1	85	—	—

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BB4470 July 2008

ISBN: 978 1 85969 608 8