A Pocket Handbook for the DRAGON

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Peter Gerrard & Danny Doyle

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&
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Duckworth

First published in 1984 by
Gerald Duckworth & Co. Ltd.
The Old Piano Factory
43 Gloucester Crescent, London NW1

ISBN 0 7156 1788 5

British Library Cataloguing in Publication Data

Gerrard, Peter
A pocket handbook for the Dragon.
– (Duckworth home computing)
1. Dragon 32 (Computer)
I. Title
001.64'04 QA76.8.D7

ISBN 0-7156-1788-5

Cover design: The Tab and the Arcuate stitching pattern are, when applied to a pair of jeans, the trade mark of Levi Strauss & Co., San Francisco, U.S.A.

Printed in Great Britain by
Redwood Burn Ltd., Trowbridge
and bound by Pegasus Bookbinding, Melksham

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Preface

This book is a collection of relevant facts and figures for your Dragon 32 computer. Owing to the way the Dragon 64 has been designed, a lot of this will apply to that newer model as well.

In addition to memory maps, microprocessor instruction set, detailed notes on the available (and unavailable and undocumented) graphics pages, BASIC commands, error messages (again a few that you won't find in the Dragon manual but which none the less exist), and more, this book contains just about any fact or figure about the Dragon that you'll ever need to know.

In response to helpful suggestions from others (including Peter Worlock: thank you!), this handbook includes more than just facts and figures. At the end of the book there is an eight-page collection of useful hints and tips that make use of some of the material contained in the rest of the book. This should make the information contained here that little bit more accessible.

We'd like to thank anyone who, directly or indirectly, has contributed material to us. As ever, your comments are most welcome.

P.G. and D.D.

ASCII tables

Standard ASCII characters (7-bit code)

LSD	MSD	0	1	2	3	4	5	6	7
		000	001	010	011	100	101	110	111
0	0000	NUL	DLE	SP	0	@	P	-	p
1	0001	SOH	DC1	!	1	A	Q	a	q
2	0010	STX	DC2	"	2	B	R	b	r
3	0011	ETX	DC3	£	3	C	S	c	s
4	0100	EOT	DC4	$	4	D	T	d	t
5	0101	ENQ	NAK	%	5	E	U	e	u
6	0110	ACK	SYN	&	6	F	V	f	v
7	0111	BEL	ETB	'	7	G	W	g	w
8	1000	BS	CAN	(	8	H	X	h	x
9	1001	HT	EM	)	9	I	Y	i	y
A	1010	LF	SUB	*	:	J	Z	j	z
B	1011	VT	ESC	+	;	K	[	k	
C	1100	FF	FS	,	<	L		l	
D	1101	CR	GS	-	=	M		m	
E	1110	SO	RS	.	>	N		n	
F	1111	SI	US	/	?	O		o	DEL

The ASCII symbols.

NUL - Null
SOH - Start of Heading
STX - Start of Text
ETX - End of Text
EOT - End of Transmission
ENQ - Enquiry
ACK - Acknowledge
BEL - Bell (audible alert)
BS - Backspace
HT - Horizontal Tabulation
LF - Line Feed
VT - Vertical Tabulation
FF - Form Feed
CR - Carriage Return
SO - Shift Out
SI - Shift In

DLE - Data Link Escape
DC - Device Control
NAK - Negative Acknowledge
SYN - Synchronous Idle
ETB - End of Transmission Block
CAN - Cancel
EM - End of Medium
SUB - Substitute
ESC - Escape
FS - File Separator
GS - Group Separator
RS - Record Separator
US - Unit Separator
SP - Space (Blank)
DEL - Delete

Keyboard CNTL Sequences.

NUL - CNTL 1
SOH - CNTL A
STX - CNTL B
ETX - CNTL C
EOT - CNTL D
ENQ - CNTL E
ACK - CNTL F
BEL - CNTL G
BS - CNTL H/BS
HT - CNTL I/TAB
LF - CNTL J/LF
VT - CNTL K
FF - CNTL L
CR - CNTL M/CR
SO - CNTL N

DLE - CNTL P
DC1/2/3/4 - CNTL Q/R/S/T
NAK - CNTL U
SYN - CNTL V
ETB - CNTL W
CAN - CNTL X
EM - CNTL Y
SUB - CNTL Z
ESC - ESC
FS - CNTL BACKSLASH
GS - CNTL [illegible]
RS - CNTL =
US - CNTL -
SP - Space
SI - CNTL O

ASCII codes

ASCII Codes for keys

KEY	HEX #		DECIMAL #	
	Unshifted	Shifted	Unshifted	Shifted
BREAK	03	03	03	03
CLEAR	0C	-	12	-
ENTER	0D	0D	13	13
SPACE	20	-	32	-
!	21	-	33	-
"	22	-	34	-
#	23	-	35	-
$	24	-	36	-
%	25	-	37	-
&	26	-	38	-
'	27	-	39	-
(	28	-	40	-
)	29	-	41	-
*	2A	-	42	-
+	2B	-	43	-
,	2C	-	44	-
-	2D	-	45	-
.	2E	-	46	-
/	2F	-	47	-
0	30	12	48	12
1	31	-	49	-
2	32	-	50	-
3	33	-	51	-
4	34	-	52	-
5	35	-	53	-
6	36	-	54	-
7	37	-	55	-
8	38	-	56	-
9	39	-	57	-
:	3A	-	58	-
;	3B	-	59	-
<	3C	-	60	-
=	3D	-	61	-
>	3E	-	62	-
?	3F	-	63	-
@	40	13	64	19

KEY	HEX #		DECIMAL #	
	Unshifted	Shifted	Unshifted	Shifted
A	61	41	97	65
B	62	42	98	66
C	63	43	99	67
D	64	44	100	68
E	65	45	101	69
F	66	46	102	70
G	67	47	103	71
H	68	48	104	72
I	69	49	105	73
J	6A	4A	106	74
K	6B	4B	107	75
L	6C	4C	108	76
M	6D	4D	109	77
N	6E	4E	110	78
O	6F	4F	111	79
P	70	50	112	80
Q	71	51	113	81
R	72	52	114	82
S	73	53	115	83
T	74	54	116	84
U	75	55	117	85
V	76	56	118	86
W	77	57	119	87
X	78	58	120	88
Y	79	59	121	89
Z	7A	5A	122	90
[CU]	5E	5F	94	95
[CD]	0A	5B	10	91
[CL]	08	15	8	21
[CR]	09	5D	9	93

Note : CU is the up-arrow key
CD is the down-arrow key
CL is the left-arrow key
CR is the right-arrow key

Basic expressions

In Dragon Basic, numeric expressions are carried out with the following priority.

1) Brackets	()	gives expressions within brackets higher priority.
2) Functions		see section on BASIC functions.
3) Arithmetic operators		exponentiation
	-	negation
	*	multiplication
	/	division
	+	addition
	-	subtraction
4) Relational operators	=	is equal to
	<>	not equal to
	<	less than
	>	greater than
	<=	less than or equal to
	>=	greater than or equal to
5) Logical operators		

These, and the rslational operators, return a value of (-1) if the result of an expression is true, or (0) if it is false.

NOT	X	NOTX	
OR	X	Y	X OR Y
AND	X	Y	X AND Y

To set a particular bit in a memory location, and keep the rest as they were, you must POKE (LOC),PEEK(LOC) OR X. X must have one of the following values:

Value	Bit set
1	0
2	1
4	2
8	3
16	4
32	5
64	6
128	7

To set more than one bit, use a combination of the above values. To check if a bit in a memory location is set, you must POKE (LOC),PEEK(LOC) AND X, where again X comes from the above table.

Basic keywords

[X] indicates the name of a parameter.

AUDIO

Connects or disconnects cassette output to TV, for recording sound effects on tape to be played back later using MOTOR command.

AUDIO ON
AUDIO OFF

CIRCLE

Draws a circle on the graphics screen.

CIRCLE ([X],[Y]),[R],[list of attributes]

X indicates X co-ordinate of position of centre of circle.
Y indicates Y co-ordinate of position of centre of circle.
R indicates radius of circle.

[list of attributes] is made up as follows.

[C],[HW],[START],[END]

C indicates colour of circle.
HW indicates the height/width ratio (for ellipses).
START indicates starting position of circle.
END indicates end position of circle.

CLEAR

Resets all variables to zero if numeric , or null strings if string, reserves space for strings, and sets top of BASIC.

CLEAR [string space],[address]

string space is the number of bytes reserved for strings.
address is the highest address that BASIC will use.

CLOAD

Loads BASIC program from tape in either ASCII or token form.

CLOAD
CLOAD ""
CLOAD "[filename]"

CLOADM

Loads machine code program from tape.

```
CLOADM
CLOADM ""
CLOADM "[filename]"
CLOADM "",[offset]
CLOADM "[filename]",[offset]
```

offset moves program up in memory from the original saved address.

CLOSE

Closes any open files or devices.

```
CLOSE [device number]
```

If device number is not specified, all files currently open are closed.

CLS

Clears the screen and sets the background colour.

```
CLS [colour]
```

COLOR

Sets the background and foreground colours on a graphics page.

```
COLOR [foreground],[background]
```

Note American spelling of colour!

CONT

Continues a program after execution has been halted. It won't work if any program changes are made before issuing the command.

```
CONT
```

CSAVE

Saves a BASIC program onto tape.

```
CSAVE
CSAVE ""
CSAVE "[filename]"
CSAVE "",[A]
CSAVE "[filename]",[A]
```

The 'A' will save the program in ASCII format.

CSAVEM

Saves a machine code program onto tape.

```
CSAVEM "",[start],[end],[entry]
CSAVEM "[filename]",[start],[end],[entry]
```

start indicates first address to be saved.
end indicates last address to be saved.
entry indicates first address to be executed.

DATA

Stores data in program. Data can be either string or numeric, and quotation marks are not needed for strings unless you're using a comma within that string.

```
DATA [number],[string],["string"]
```

DEF FN

Defines a numeric function.

```
DEF FN[name]([var])=[expression]
```

The variable (VAR) used will only affect the expression, and won't change any variable of the same name elsewhere in the program.

DEFUSR

Defines a machine code routine.

```
DEFUSR[n]=[address]
```

DEL

Deletes program lines.

```
DEL [X-Y]
```

Deletes from and including line X up to and including line Y.

DEL [X-] deletes from line X onwards.
DEL [-Y] deletes from start of program to line Y.
DEL [-] deletes the entire program.
DEL [X] deletes line X.

DIM

Dimensions a string or numeric array.

```
DIM [array]([size]),[array]([size])
```

This defines an array to hold (size) number of elements. Arrays can be multi-dimensional (e.g. DIM A$(2,2,2,2)).

DRAW

Draws a line on a graphics page.

DRAW [list of parameters]

The list of parameters may contain any or all of the following, where X and Y are horizontal and vertical co-ordinates and Z is simplv the number of positions to be moved:

M : move draw position (MX,Y or offset by M+X,+Y)
U : move/draw position up (UY)
D : move/draw position down (UY)
L : move/draw position left (UX)
R : move/draw position right (UX)
E : move/draw position at 45 degree angle (EZ)
F : ditto but at 135 degrees (FZ)
G : ditto but at 225 degrees (GZ)
H : ditto but at 315 degrees (HZ)
X : execute a substring and return
C : change colour to whatever
A : tilt everything at an angle
S : scale everything
B : before any movement command ceases to draw but still moves
N : before any movement command doesn't update position but returns to original cursor position

Phew!

EDIT

Goes into edit mode.

EDIT [line]

In edit mode, there are a number of commands that can be used:

```
xC  : change x characters
xD  : delete x characters
H   : delete rest of line and await new input
I   : insert new characters
K   : delete rest of line from current position
xKc : delete rest of line up to xth occurrence of
      character 'c'
L   : list current state of line
xSc : search through line for xth occurrence of
      character 'c'
X   : extend line and await new input

xSPACE        : move along x spaces
x([CL])       : move left x space (CL is left arrow
SHIFT([CU]) : leave insert mode and return to edit mode
ENTER         : leave edit mode and store line.
```

To recall a line as it was before you edited it, press SHIFT([CU]), then press A and ENTER.

ELSE

See IF

END

Halts program execution.

END

EXEC

Transfers program execution to machine code routine.

EXEC [address]

Go to the address specified.

FOR

Start of a program loop.

FOR [variable]=[x1]TO[x2]STEP[x3] .... NEXT [variable]

Set the variable equal to x1. Increment it in steps of x3 (if omitted, this defaults to 1), and repeat it until the variable is equal to x2 plus x3. Program execution is then transferred to the statement immediately after the NEXT statement.

If x1 is less than x2, then STEP must be used, and x3 must be a negative number. The variable is then decremented on each pass through the loop.

GET

This saves a rectangle of a graphics screen and stores it in a variable array for later recall (see PUT).

GET ([X1],[Y1])-([X2],[Y2]),[variable],G

This saves the rectangle from the diagonally opposed corners X1,Y1 and X2,Y2. The G specifies 'save full graphic detail'. It may be omitted.

GOSUB

This performs a subroutine.

GOSUB [line number]

This transfers program execution to [line number], where execution continues until a RETURN statement is encountered. When it is, the program returns to the statement following the GOSUB.

GOTO

This transfers program execution to another line.

GOTO [line number]

IF

This indicates the start of a conditional relationship.

IF [condition] THEN [result] ELSE [another result]

If a condition is true, then we can either execute a statement or branch to another line number. If it isn't, program execution continues at the line after the IF statement, unless the optional ELSE is used, in which case the statement or line number specified after the ELSE is executed.

INPUT

Used for getting data from the user via the keyboard.

INPUT "[prompt]";[variable1],[variable2],etc....

When this is used, program execution halts until the user types something in and presses ENTER. If no prompt is given, the semi-colon after it must be omitted.

INPUT#-1

Inputs data from tape.

INPUT#-1,[variable1],[variable2],etc....

This gets data from tape that has previously been saved using PRINT#-1.

LET

This assigns a value to a variable.

LET [variable]=[expression]

The use of LET is optional.

LIST

This lists a program onto the screen. It is displayed at great speed, and can be halted using the SHIFT and '@' keys together.

LIST [X-Y]

This follows the same procedures for X and Y as DEL, except that to list an entire program you must just enter LIST.

LLIST

This lists a program onto a line printer.

LLIST [X-Y]

This follows exactly the same procedures for X and Y as LIST.

LINE

This, amazingly enough, draws a line!

LINE ([X1],[Y1]) - ([X2],[Y2]),[a],[b]

This draws a line from X1,Y1 to X2,Y2. If X1,Y1 is omitted, the end point of the last LINE or DRAW is used as the starting point. If there hasn't been a previous LINE or DRAW, then X1,Y1 is assumed to be (126,96).

[a] is either PSET or PRESET. If PSET, then the line is drawn in the foreground colour, if PRESET then the line is drawn in the background colour and is thus effectively erased.

[b] is either B or BF. If B, then a rectangle is drawn using X1,Y1 and X2,Y2 as the two opposing corners. If BF, then a rectangle is still drawn, but it is also filled in with the current foreground colour.

LINE INPUT

This allows data to be entered from the keyboard.

LINE INPUT "[prompt string]";[variable]
LINE INPUT [variable]

This works in the same way as INPUT, except that LINE INPUT will take an entire line of input, including leading spaces, blanks etc. Everything is then placed in a string variable.

Note that you cannot use numeric variables with LINE INPUT.

MOTOR

This turns the cassette motor on and off, allowing control of the motor from within a program (see AUDIO).

MOTOR ON
MOTOR OFF

NEW

This removes the current BASIC program from memory. It doesn't actually wipe the memory out, but instead merely changes a few internal pointers so that the program can no longer be accessed.

See the 'Useful hints and tips' section for a method of recovering a program that has accidentally been NEWed.

NEW

ON ... GOSUB

This is a multiple branching statement to a set of subroutines.

ON [variable] GOSUB [line number1],[line number2], ...

If [variable] is equal to one, the program will branch to the subroutine at [line number1], if it equals 2, it will branch to [line number2], and so on. Be careful to match up RETURNs with multiple GOSUB statements like this.

ON ... GOTO

As above, but this merely sends program execution to a specified line, without expecting a RETURN to be found there.

ON [variable] GOTO [line number1],[line number2], ...

OPEN

This opens a data file for reading or writing data.

OPEN "[a]",#-1,[filename]

If 'a' is set as 'O', then the file will be opened for writing data, and if it's set to 'I' then the file will be opened for reading data.

PAINT

This fills in a section of a graphics page.

PAINT ([X],[Y])
PAINT ([X],[Y]),[colour]

PAINT ([X],[Y]),[colour],[border]

This paints in a section of screen starting at the co-ordinates X and Y, using the [colour] specified. If no colour is named, then the foreground colour is assumed. It fills in everything until it reaches a boundary coloured in the [border] colour.

PCLEAR

This reserves memory for use with graphical displays.

PCLEAR [x]

This reserves 'x' graphics pages. If you're using text onlv programs, use PCLEAR1 at the start of your program.

PCLS

This clears the current graphics page being used.

PCLS [x]

This clears the graphics page to colour [x]. If 'x' is not specified, then the current background colour is used.

PCOPY

This copies graphics pages.

PCOPY [x] TO [y]

Copy graphics page x to graphics page y.

PLAY

Used for playing music, this is a multi-parameter command.

PLAY [command string]

where command string can contain any or all of the following:

```
A-G    : musical notes
1-12   : musical tones
Ox     : octave x
Vx     : volume x
Lx     : length of note
Tx     : tempo
Px     : wait for x amount of time
Xx$    : execute x string and return
# or + : sharp note
-      : flat note
.      : play note half as long again.
```

PMODE

This selects the resolution and graphics page to be used.

PMODE [x1],[x2]

This selects the resolution to be x1, and the graphics page to be used to be x2. See the graphics section for further information.

POKE

This puts a specific value into a specific memory location.

POKE [location],[value]

This puts the value [value] into memory location [location]

PRESET

This sets a specified X,Y co-ordinate on the graphics page to the background colour.

PRESET ([X],[Y])

PRINT

This displays information on the screen.

PRINT "[expression]"[separator]"[expression"]etc....

If the expression is not within quotes, it can be either a numeric or string variable. Anything within quotes is literally printed as it is written. The separator can be a comma (splits output into two 15 column displays), a semi-colon (prints the next expression on the next column space), or a space (as with a semi-colon, but the cursor does not remain in its last print position).

PRINT USING

This is a very detailed way of formatting printed output.

PRINT USING [format string][output]

[output] is simply a list of variables to be printed, separated by commas.

However, [format string] is a lot more daunting, and can contain:

'.'	: indicates column to display decimal point in
'#'	: indicates column to display a digit
','	: put a comma to the left of every third digit before the decimal point
'**'	: fill all unfilled columns to the left with asterisks
'$'	: precede number with a dollar sign
'$$'	: place dollar sign immediately to left of number (i.e. not just at start of specified field)
'*$'	: fill unused columns to left of dollar sign with asterisks
'+'	: specify whether a number is positive or negative by displaying sign
'-'	: as above, but only specifies negative numbers
'[4CU]'	: display number in exponential form
'!'	: print only first character of a string
'%spc%'	: specifies the length (number of 'spc') to which a string variable will be printed

PRINT@

This prints the output at a specified location.

PRINT@ [location],[expression]

This prints the expression at the location numbered (location lying between 0 and 511 on the screen).

PRINT#

Prints data to external devices.

```
PRINT#-1,[data]
PRINT#-2,[data]
PRINT USING#-1,[format string];[data]
PRINT USING#-2,[format string];[data]
```

This prints data either to cassette (#-1) or a printer (#-2).

PSET

This sets a point on a graphics page to a specified colour.

```
PSET ([X],[Y],[C])
```

This sets the point X,Y to the colour C.

PUT

This puts a previously stored array (see GET) onto a graphics page.

```
PUT ([X1],[Y1])-([X2],[Y2]),[a],[b]
```

This puts the array stored in [a] onto the graphics page at top left hand corner X1,Y1 and bottom right hand corner X2,Y2.

[b] determines how it is placed there. If [b] is PSET, then all the points in the array are set. If it is PRESET, then all the points are reset. If it is AND, then all points common to the screen and the array are set, if it's OR, then all points that are set on the screen OR in the array are set, and if it's NOT, then that area of the screen is reversed.

READ

This reads the next item from a DATA statement.

```
READ [variable1],[variable2], ...
```

See RESTORE.

REM

This allows remarks to be placed in a program, for greater legibility when listing the program

```
REM [expression]
' [expression]
```

RENUM

Used for renumbering all or part of a program listing.

RENUM [newline],[startline],[increment]

This renumbers in steps of [increment], starting at the number [newline], commencing from the line [startline] in the old program. GOTOs, GOSUBs, IFs, THENs and ELSEs are all renumbered accordingly.

RESET

This sets a point on the text screen to the background colour.

RESET ([X],[Y])

In other words, the point at X,Y is effectively erased from the screen.

RESTORE

This allows previously READ data to be re-read.

RESTORE

The data pointer will now point back to the very first item of data.

RETURN

Returning from a subroutine.

RETURN

See GOSUB.

RUN

This commences program execution at either the first line, or a specified other line.

RUN [line number]

SCREEN

This sets a graphics or a text screen and the colour set to be used therein.

SCREEN [type],[colour set]

[type] is either 0 for text or 1 for graphics. [colour set] depends on current PMODE setting (see graphics commands and colour codes sections for further information).

SET

This sets a point on the text screen to a specified colour. Any points other than the point specified in the character block containing that point are re-set to black.

SET ([X],[Y],[C])

SKIPF

This allows you to move past a file on tape. If a filename is specifed, the computer will run on through the tape until the end of that file, and then stop the cassette motor.

SKIPF
SKIPF ""
SKIPF "[filename]"

SOUND

This generates a sound of a specified pitch and duration

SOUND [pitch],[duration]

STOP

From within a program, this terminates program execution. The program can be re-started from the next executable statement using CONT.

STOP

TRON and TROFF

This turns the trace mode on or off.

TRON
TROFF

Basic functions

ABS

This returns the absolute value of a number.

ABS ([number])

This will give us a numerical value, regardless of whether [number] is positive or negative.

ASC

This returns the Dragon's idea of the ASCII code for specified characters.

ASC ([string])

This gives us the ASCII code of the first character in [string].

ATN

This returns the arctangent of a number in radians. For those rusty on the geometry side, arctangent is the inverse of tangent.

ATN ([number])

As with all the geometric functions, numbers must be converted to radians before being used.

CHR$

This takes a number and prints out the ASCII character for that number. See the sections on ASCII characters for further information.

CHR$ ([number])

Some ASCII characters perform actions, as can be seen from the sections on ASCII characters.

COS

This returns the cosine of a number in radians.

COS ([number])

EOF

This indicates the end of a file from tape.

EOF ([file number])

More accurately, it tells us whether or not a given file number has more data to come. If not, and a further INPUT is specified, then an error occurs.

EXP

This is the inverse of LOG (see below).

EXP ([number]).

This raises the natural logarithm 'e' to the power [number].

FIX

A useful routine for removing all digits after the decimal point of a number.

FIX ([number])

HEX$

This converts a number to hexadecimal.

HEX ([number])

This returns the hexadecimal string consisting of the digits A to F and 0 to 9 which is represented by the decimal number [number].

INKEY$

This is used for receiving one character at a time from the keyboard.

INKEY$
Z$=INKEY$

Z$ will equal the last character pressed on the keyboard, apart from those in INPUT etc. statements. In other words, you may have INPUT something, and then issued an INKEY$ command. The INKEY$ command will sit and wait until something is pressed.

INSTR

This searches a specified string for a specified sub-string.

INSTR ([number],[string1],[string2])

This searches through string1 for the occurrence of string2, starting at the [number]th character of string1. This will return either the starting position of string2, or a zero if string2 is found not to exist in string1.

INT

This converts a number to integer format.

INT ([number])

This removes anything after the decimal point, and also (which is were it differs from FIX), rounds numbers down regardless of whether they are positive or negative.

JOYSTCK

This returns a value depending on the position of the joystick (either left or right).

JOYSTCK ([number])

0 indicates the horizontal position of the right joystick.
2 indicates the horizontal position of the left joystick.
1 indicates the vertical position of the right joystick.
3 indicates the vertical position of the left joystick.

LEFT$

A string manipulation command that returns the LEFTmost characters from a string.

LEFT$ ([string],[number])

This returns the leftmost [number] of characters from the string [string].

LEN

This returns the LENgth of a specified string.

LEN ([string])

This returns the number of characters in the string [string], regardless of whether they are control characters, text characters, or whatever.

LOG

This returns the natural logarithm of a number, which must be a positive one.

LOG ([number])

MEM

This returns the amount of free memory still available to the programmer in BASIC.

MEM

This memory is available for programs and data, and does not include any set aside for screen and graphics pages.

MID$

Another string manipulation command, which returns a specified part of a specified string.

MID$([string],[number1],[number2])

This returns a substring of [string], starting at the [number1]th character, and taking [number2] characters. [number2] may be omitted, in which case the substring will consist of all the characters in [string] from the [number1]th onwards.

This command can also work in reverse, in that part of a string can be replaced with another substring. For example:

```
A$="HELLO THERE MY FINE FELLOW"
MID$(A$,16,4)="UGLY"
PRINTA$
```

The result would be:

HELLO THERE MY UGLY FELLOW

PEEK

This returns the contents of a specified memory location

PEEK ([address])

This returns whatever value happens to be stored in memory location [address] at the time.

POINT

This checks for the presence of a dot on a text screen.

POINT ([X],[Y])

If there is a text character at location X,Y then a -1 is returned, if there's nothing there a zero is returned, otherwise the current colour of the dot is returned.

POS

Unusual in that on the Dragon this works for both screen and printer, this returns the current horizontal position of the cursor.

POS ([number])

Here, if the number was equal to 0 the position returned would refer to the screen, and if it equalled 1 the position returned would refer to the printer.

PPOINT

Same as POINT, only this time we're checking for a dot on the graphics screen.

PPOINT ([X],[Y])

If the location specified is turned off, a 0 is returned, otherwise the colour of the dot is returned.

RIGHT$

Another string manipulation command, this returns the RIGHTmost specified number of characters from within a specified string.

RIGHT$ ([string],[number])

This returns the rightmost [number] characters from within [string].

RND

This is used for generating integer random numbers.

RND ([number])

This returns an integer random number in the range 1 and number. If RND is used without a number, then a real number between 0 and 1 is returned.

To generate a number in the range X to Y, use the formula:

RND(X-1)+Y-X+1

SGN

This returns the sign (positive, negative or zero) of a number.

SGN ([number])

-1 is returned if the number's negative, 0 if it equals zero, and +1 if it is positive.

SIN

Another geometric function, this returns the sine of a number, assuming that the number is expressed in radians.

SIN ([number])

STRING$

This is used for building up strings of specified length.

STRING$ ([number1],[number2])

STRING$ ([number1],[string])

In the first instance, a string will be made of length [number1], consisting of the character whose code is [number2]. In the second example, the string will again be of length [number1], but will consist this time of the first character contained in [string].

STR$

This performs a numeric to string conversion.

STR$([number])

This will convert the number contained within [number] into a string, but note that it also adds a leading space to the new string (unlike some machines, which add control characters!).

SQR

This finds the square root of a number.

SQR ([number])

If [number] is negative, then the program will report an error code.

TAN

Our final geometrical function, this returns the tangent of a number, assuming that the number is expressed in radians.

TAN ([number])

TIMER

This either sets or returns the variable TIMER.

TIMER
TIMER= ([number])

In the first case, the computer will print out the length of time, in fiftieths of a second, that it has been switched on for. However, if the value stored in TIMER exceeds 65535, then it is reset to zero.

In the second example, TIMER acts as a variable and is given the value [number]. It will still be incremented every fiftieth of a second (approximately).

USR

This calls a user-defined machine code routine that was earlier defined using DEF USR.

USR [n]([number])

VAL

The opposite of STR$, this converts a string back to a number again.

VAL ([string]).

This returns the numeric value of the string contained in [string]. If [string] contains a non-numeric character, then onlv characters to the left of that are considered.

VARPTR

This gives the memory location of where a variable is stored in memory.

VARPTR ([number])

This returns the start address of where the variable in [number] is stored. With arrays, if number was equal to, say, the first element of the array A(15), then the value returned would be the start location for that first element. Other elements could then be found, since each one occupies 5 bytes of memory.

Basic error messages

The Dragon is not equipped with the best set of error messages on a home computer, as a glance below will show. How many people can remember what a DS error is? The table below contains them all, including the two Dragon forgot about.

These are only the error messages generated by the computer itself when NOT used with disk drives. There's an additional set of messages for those (some are repeated e.g. FD ERROR can mean Bad File Data, or Full Directory!), and they are repeated at the back of the disk drive manual, albeit in cryptic form. But, since this is for the computer, and since the computer manual doesn't list all of them anyway, here we go.

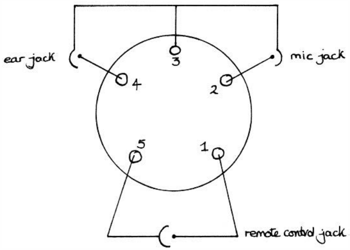
MESSAGE	EXPLANATION
/0	An attempt has been made to divide by zero.
AO	An attempt has been made to open a file which is already open.
BS	This usually occurs when an attempt has been made to use an array subscript that is outside range it was defined to lie in.
CN	A 'can't continue error'. Usually when the user has typed in CONT after altering a program.
DD	A 're-dimensioned array error', when an attempt has been made to re-dimension an already dimensioned array.
DN (*)	A device number error, which refers either to the screen or keyboard, the tape deck, or the printer.
DS	A direct statement error, which usually occurs when a data file on tape contains a direct statement.
FC	An illegal function call error, which occurs when a parameter is out of range, either in a statement or a function.
FD	A 'file data' error. This occurs when the wrong type of data is being read in from a data file. That is, a string variable is trying to be read into a numeric one, or vice versa.

MESSAGE	EXPLANATION
FM	A 'file mode' error. This happens when you try to input data to a file that is waiting for output, or attempt to output data to an input file.
ID	An illegal direct statement. This occurs when you've attempted to use in direct mode a command that can only be executed from within a program.
IE	An attempt has been made to input data from beyond the end of a file.
IO	An Input/Output error. This is either caused by incorrect adjustment of the cassette deck (e.g. volume too high or too low), or by a tape that is faulty.
LS	A 'string too long' error, which occurs when a string exceeds 255 characters in length.
NF	A 'next without for' error, which occurs when a NEXT statement is found where it wasn't expected (i.e. there is no corresponding FOR statement)
NO	A file hasn't been opened, and you can't read from or write to a file without opening it first.
OD	An 'out of data' error. An attempt has been made to read some data that doesn't exist, or there are no elements left to read in a data statement.
OM	An 'out of memory' error. This occurs when there is absolutely no memory left (either free or unreserved) in the computer.
OS	No room left for strings, since it's all been taken up. To correct, you can either try a CLEAR, or reserve more string space at the start of your programs.
OV	An overflow error. The result of a calculation is too large for the computer to handle.
RG	A 'return without gosub' error. That is, the computer has found a RETURN statement without a corresponding GOSUB statement.
SN	The most common one of all, a syntax error! This occurs when the Dragon can't understand something, usually as the result of a spelling mistake, a missing space or punctuation mark, or an incorrect number of parameters.
ST	A 'string formula too complex' error. That is, a string formula within a BASIC statement is too long, so you'll have to break it up a bit.
TM	A 'type mismatch' error, which occurs when numeric data is assigned to a variable, or vice versa.

MESSAGE	EXPLANATION
UF (*)	An 'unidentified function' error, which occurs when an attempt has been made to use a function that has not previously been defined in the program.
UL	An 'unidentified line number' error, which occurs when the program attempts to branch to a line which doesn't exist.

(*) Error code not in original manual.

Cassette port



Centronics standards

CENTRONICS PARALLEL INTERFACE

Notes

Busy is set if:

1) Data is being received.
2) Printer is printing.
3) Printer is offline.
4) An error condition is present.

On pins 02-09 a high level represents binary ONE, a low level represents binary ZERO. All printable characters (i.e. codes having a ONE in DATA 6 or DATA 7) are stored in the printer buffer. Control characters (i.e. codes ZERO in both DATA 6 and DATA 7) are used to specify special control functions. These codes are not stored in the buffer except when they specify a print command and are preceded by at least one printable character in that line.

PIN	CODE	FUNCTION
01	STROBE	Read Data Pulse.
02	DATA 1	Data lines.
03	DATA 2	ditto.
04	DATA 3	ditto.
05	DATA 4	ditto.
06	DATA 5	ditto.
07	DATA 6	ditto.
08	DATA 7	ditto.
09	DATA 8	ditto.
10	ACKNLG	Data Received and Ready for More.
11	BUSY	Not Ready for Data.
12	PE	SET high when Out-of-Paper.
13	+5V	
14	AUTO FEED	Switch Set gives extra line-feed.
15	NC	No Connection.
16	GND LOGIC	Logic Ground.
17	GND CASE	Chassis Ground.
18	NC	No Connection.
19-30	GND	Signal Grounds.
31	INT	Reset and Buffer Clear.
32	ERROR	See Notes on BUSY.
33	GND	Signal Ground.
34	NC	No Connection.
35	+5V	
36	SLCT IN	Optional DC1/DC3.

Character codes

HEX		Ø	1Ø	2Ø	3Ø	4Ø	5Ø	6Ø	7Ø
	DEC	Ø	16	32	48	64	8Ø	96	112
Ø	Ø	@	P		Ø	@	P		Ø
1	1	A	Q	!	1	A	Q	!	1
2	2	B	R	"	2	B	R	"	2
3	3	C	S	#	3	C	S	#	3
4	4	D	T	$	4	D	T	$	4
5	5	E	U	%	5	E	U	%	5
6	6	F	V	&	6	F	V	&	6
7	7	G	W	'	7	G	W	'	7
8	8	H	X	(	8	H	X	(	8
9	9	I	Y	)	9	I	Y	)	9
A	10	J	Z	*	:	J	Z	*	:
B	11	K	[	+	;	K	[	+	;
C	12	L	÷	,	÷	L	÷	,	÷
D	13	M	]	—	=	M	]	—	=
E	14	N	÷	•	÷	N	÷	•	÷
F	15	O	—	/	?	O	—	/	?

HEX		2Ø	3Ø	4Ø	5Ø	6Ø	7Ø
	DEC	32	48	64	8Ø	96	112
Ø	Ø		Ø	@	P	@	P
1	1	!	1	A	Q	A	Q
2	2	”	2	B	R	B	R
3	3	#	3	C	S	C	S
4	4	$	4	D	T	D	T
5	5	%	5	E	U	E	U
6	6	&	6	F	V	F	V
7	7	‘	7	G	W	G	W
8	8	(	8	H	X	H	X
9	9	)	9	I	Y	I	Y
A	1Ø	*	:	J	Z	J	Z
B	11	+	;	K	[	K	[
C	12	,	÷	L	÷	L	÷
D	13	—	=	M	]	M	]
E	14	●	÷	N	÷	N	÷
F	15	/	?	O	—	O	—

Colour codes

PMODE #	Colour Set	Two-Colour Combination	Four-Colour Combination
4	Ø	Black / Green	—
	1	Black / Buff	—
3	Ø	—	Green / Yellow / Blue / Red
	1	—	Buff / Cyan / Magenta / Orange
2	Ø	Black / Green	—
	1	Black / Buff	—
1	Ø	—	Green / Yellow / Blue / Red
	1	—	Buff / Cyan / Magenta / Orange
Ø	Ø	Black / Green	—
	1	Black / Buff	—

CODE	COLOUR
Ø	Black
1	Green
2	Yellow
3	Blue
4	Red
5	Buff
6	Cyan
7	Magenta
8	Orange

Disk commands

For the benefit of those with disk drives who'd like a handy list of all the new commands, here we go:

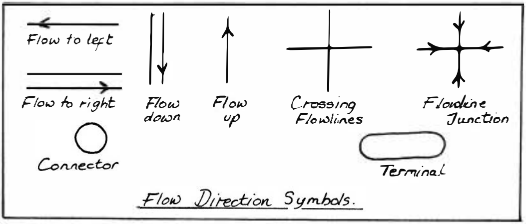
Command	Purpose
AUTO	Generate automatic line numbers.
BACKUP	Makes a backup copy of a whole disk.
BEEPx	Makes x separate beeps.
BOOT	Boots a new operating system into RAM.
CHAIN	Loads and runs a BASIC program with all variables intact.
CLOSE	Closes all disk files.
COPY	Copies files from one disk to the same disk, or another one.
CREATE	Reserves disk space for a file.
DIR	Prints out the disk directorv.
DRIVEx	Selects a drive (from 1 to 4).
DSK INIT	Formats a disk.
ERL	Gives the line at which the last error occurred.
ERR	Gives the code of the last error generated.
ERROR GOTOx	Jump to line x if an error occurs.
FLREAD	Reads a record from a file (like LINE INPUT).
FRE$	Gives the amount of free string space.
FREAD	Reads a record from a file.
FREE	Gives the number of free bytes on a disk.
FWRITE	Writes a record to a file.
HIMEM	Gives highest memory location used by BASIC.
KILL	Erases a file from disk.
LOAD	Used to load BASIC or machine code programs.
LOC	Gives position of the read pointer.
LOF	Gives the length of a file in bytes.
MERGE	Merges a file from disk.
PROTECT	Protects files against accidental erasure.
RENAME	Renames a file on disk.
RUN "name"	Loads and runs BASIC programs.
SAVE	Saves BASIC or machine code programs.
SREAD	Reads a record from a specific sector.
SWAP A.B	Swaps the values of A and B.
SWRITE	Writes a file to a specific sector.
VERIFY	Turns off and on automatic verifying.
WAITx	Pauses program execution for x milliseconds.

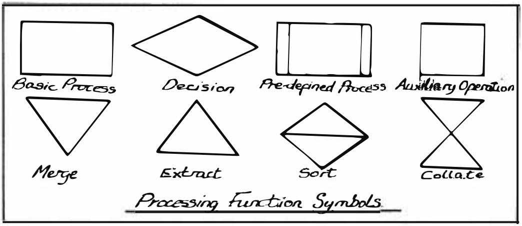
Edge connector

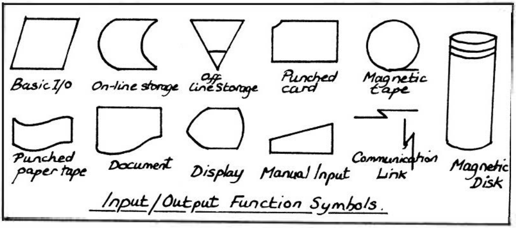
This 40 pin connector is configured as follows:

PIN NUMBER	PURPOSE
1	-12V
2	+12V
3	HALT
4	NMI
5	RESET
6	E (6809 CLOCK)
7	Q (6809 CLOCK)
8	CB1
9	+5V
10-17	D0-D7
18	READ/WRITE
19-31	A0-A12
32	C000-FEFF (CHIP SELECT)
33-34	0V
35	ANALOGUE IN
36	FF40-FF5F SELECT
37-39	A13-A15
40	TURNS OFF INTERNAL ROM

Flow charting







Graphics notes

The graphics capabilities of the Dragon are probably superior to those of almost any other home computer, and yet their use (and documentation) remain a mystery to most.

In this (and in the 'Useful Hints and Tips' section), we're going to try to cram in as much graphical information as possible. You've got the actual commands in the two earlier sections on BASIC, so without further ado let's start on graphics modes.

There are actually 14 of these, although only seven are implemented on the Dragon's version of BASIC.

Mode	Resolution X	Resolution Y	Implemented in BASIC	Number of colours per screen	Number of bytes per screen
1 (A/N)	32	16	Yes	2	0.5K
2 (S/G 4)	64	32	Yes	8	0.5K
3 (S/G 6)	64	48	No	4	0.5K
4 (S/G 8)	64	64	No	8	2.0K
5 (S/G 12)	64	96	No	8	3.0K
6 (S/G 24)	64	192	No	8	6.0K
7 Graphic	64	64	No	4	1.0K
9 Graphic	128	64	No	2	1.0K
10 Graphic	128	96	Yes	2	1.5K
11 Graphic	128	96	Yes	4	3.0K
12 Graphic	128	192	Yes	2	3.0K
13 Graphic	128	192	Yes	4	6.0K
14 Graphic	256	192	Yes	2	6.0K

Note: A/N signifies alphanumeric.
S/G signifies semigraphical.

Screens and pages

The video memory is divided up even further than this into the text screen section and the graphics screen section, which is itself divided up into 8 pages, each one taking up 1.5K of memory.

13824	3600				
		PAGE 8	PMODE0 SCREEN8		
12288	3000			PMODE1&2 SCREEN4	
		PAGE 7	PMODE0 SCREEN7		
10752	2A00				PMODE3&4 SCREEN2
		PAGE 6	PMODE0 SCREEN6		
9216	2400			PMODE1&2 SCREEN3	
		PAGE 5	PMODE0 SCREEN5		
7680	1E00				
		PAGE 4	PMODE0 SCREEN4		
6144	1800			PMODE1&2 SCREEN2	
		PAGE 3	PMODE0 SCREEN3		
4608	1200				PMODE3&4 SCREEN1
		PAGE 2	PMODE0 SCREEN2		
3072	0C00			PMODE1&2 SCREEN1	
		PAGE 1	PMODE0 SCREEN1		
1536	0600				
1024	0400	TEXT SCREEN	STANDARD TEXT AND SEMIGRAPHICS4		

Screen start addresses

There is a 7 bit register in the video graphics chip which determines where the start of the screen will be in memory. To get the actual memory location, the value in this register must be multiplied by 512. Being a 7 bit register, it is controlled by 14 (2 per bit) different memory locations, as indicated below.

BIT NUMBER	MEMORY LOCATION		ACTION
	HEX	DEC	
6	FFD3	65491	SET BIT 6
6	FFD2	65490	RESET BIT 6
5	FFD1	65489	SET BIT 5
5	FFD0	65488	RESET BIT 5
4	FFCF	65487	SET BIT 4
4	FFCE	65486	RESET BIT 4
3	FFCD	65485	SET BIT 3
3	FFCC	65484	RESET BIT 3
2	FFCB	65483	SET BIT 2
2	FFCA	65482	RESET BIT 2
1	FFC9	65481	SET BIT 1
1	FFCB	65480	RESET BIT 1
0	FFC7	65479	SET BIT 0
0	FFC6	65478	RESET BIT 0

PMODES

For different PMODEs and colour-sets, there are a variety of different colours available to us. Needless to say, the greater the resolution displayed on screen, the fewer colours we have access to.

The following table shows the various relationships.

PMODE No.	Colour set	Colours Available
4	0	Black/Green
4	1	Black/Buff
3	0	Green/Yellow/Blue/Red
3	1	Buff/Cyan/Magenta/Orange
2	0	Black/Green
2	1	Black/Buff
1	0	Green/Yellow/Blue/Red
1	1	Buff/Cyan/Magenta/Orange
0	0	Black/Green
0	1	Black/Buff

The next table shows how our selection of PMODE number determines how many screens we can store in memory at the same time, and therefore how many screens we can have access to at once for producing animated effects.

PMODE No.	Pages/Screen	No. of screens
4	4	2
3	3	2
2	2	4
1	2	4
0	1	8

Description of graphics modes

As we've seen earlier in this graphics section, although the Dragon only allows us to use 7 different graphics modes, there are in fact 14 available altogether on the video chip itself.

However, since you can only use 7 of them, there seems little point in going into a detailed description of how all of them work. Thus the following tables refer only to the 7 modes that we can access.

Each table will show the resolution available, the amount of memory required to store a screen, and so on.

==

MODE1
=====

Type: Alphanumeric/Normal Text

Resolution: 32 by 16

Characters displayed: in normal format.

How they are stored in memory:

```
 0      Line 1 Character 1
 1      Line 1 Character 2
 .             .
 .             .
 .             .
 .             .
 .             .
 32     Line 2 Character 1
 33     Line 2 Character 2
```

The numbers relate to the amount by which the start address of the screen is offset to display that character.

Amount of memory required for screen: 0.5K

Memory address of any char. at (X,Y) = 32*Y+X+START ADDRESS

Border Colour: Black
Foreground colour: Colourset1=Orange
Colourset0=Green

How to select this screen:

This is the standard screen at power on.

==

==

MODE2

Type: Semi Graphic 4

Resolution: 32 by 16

Characters displayed: in quarter squares.

How they are stored in memory:

```
 0      Line 1 Character 1
 1      Line 1 Character 2
 .             .
 .             .
 .             .
 .             .
 .             .
 32     Line 2 Character 1
 33     Line 2 Character 2
```

The numbers relate to the amount by which the start address of the screen is offset to display that character.

Amount of memory required for screen: 0.5K

Memory address of any char. at (X,Y) = 32*Y+X+START ADDRESS

Border Colour: Black

Character Colour:

Bits Set	Colour
000	Green
001	Yellow
010	Blue
011	Red
100	Buff
101	Cyan
110	Magenta
111	Orange

Bits set refers to bits 4,5 and 6 of each memory location on the screen.

How to select this screen:

Set/Reset when in text mode.

==

MODE10
=====

Type: Graphics only

Resolution: 128 by 96 (two colours)

How they are stored in memory:

```
 0      Row 1 Columns 1 to 8
 1      Row 1 Columns 9 to 16
 .            .
 16     Row 2 Columns 1 to 8
 .            .
 .            .
 .            .
 1534   Row 96 Columns 113 to 120
 1535   Row 96 Columns 121 to 128
```

The numbers relate to the amount by which the start address of the screen is offset to display that character.

Amount of memory required for screen: 1.5K

Memory address of any char. at (X,Y) =
ROW*16+FIX((COLUMN-1)/8)+START ADDRESS

```
Border Colour: Green (colour set 0)
               Buff  (colour set 1)
Character Colour: Bits Set  Colour
                     0       Black (colour set 0)
                     1       Green (colour set 0)
                     0       Black (colour set 1)
                     1       Buff  (colour set 0)
```

Bits set refers to individual bit for each pixel on screen.

How to select this screen:

PMODE0

MODE11

Type: Graphic only (4 colours)

Resolution: 128 by 96

How characters are stored in memory:

As bit pairs, and thus each byte holds four columns.

Amount of memory required for screen: 3.0K

Memory address of any char. at (X,Y) =
32*ROW+FIX((COLUMN-1)/4)+START ADDRESS

Border Colour: Green (colour set 0)
Buff (colour set 1)

Character Colour:

Bits Set	Colour	
00	Green	(colour set 0)
01	Yellow	(colour set 0)
10	Blue	(colour set 0)
11	Red	(colour set 0)
00	Buff	(colour set 1)
01	Cyan	(colour set 1)
10	Magenta	(colour set 1)
11	Orange	(colour set 1)

Bits set refers to the bit pairs for each bvte of on-screen memory.

How to select this screen:

PMODE1

==

MODE12
=====

Type: Graphic only (2 colours)

Resolution: 128 by 192
How characters are stored in memory:

As individual bits, and thus each byte holds eight columns.

Amount of memory required for screen: 3.0K

Memory address of any char. at (X,Y) =
16*ROW+FIX((COLUMN-1)/8)+START ADDRESS

Border Colour: Green (colour set 0)
Buff (colour set 1)

Character Colour:

Bits Set	Colour	
1	Green	(colour set 0)
0	Black	(colour set 0)
1	Buff	(colour set 1)
0	Black	(colour set 1)

Bits set refers to the individual bit for each byte of on-screen memory.

How to select this screen:

PMODE2

==

MODE13
=====

Type: Graphic only (4 colours)

Resolution: 128 by 192
How characters are stored in memory:

As bit pairs, and thus each byte holds four columns.

Amount of memory required for screen: 6.0K

Memory address of any char. at (X,Y) =
32*ROW+FIX((COLUMN-1)/4)+START ADDRESS

Border Colour: Green (colour set 0)
Buff (colour set 1)

Character Colour:

Bits Set	Colour	
00	Green	(colour set 0)
01	Yellow	(colour set 0)
10	Blue	(colour set 0)
11	Red	(colour set 0)
00	Buff	(colour set 1)
01	Cyan	(colour set 1)
10	Magenta	(colour set 1)
11	Orange	(colour set 1)

Bits set refers to the bit pairs for each byte of on-screen memory.

How to select this screen:

PMODE3

===

MODE14
=====

Type: Graphic only (2 colours)

Resolution: 256 by 192
How characters are stored in memory:

As individual bits, and thus each byte holds eight columns.

Amount of memory required for screen: 6.0K

Memory address of any char. at (X,Y) =
16*ROW+FIX((COLUMN-1)/8)+START ADDRESS

Border Colour: Green (colour set 0)
Buff (colour set 1)

Character Colour:

Bits Set	Colour	
1	Green	(colour set 0)
0	Black	(colour set 0)
1	Buff	(colour set 1)
0	Black	(colour set 1)

Bits set refers to the individual bit for each byte of on-screen memory.

How to select this screen:

PMODE4

===

Hex/Dec convertor

Decimal & Hexadecimal Conversions

HEXADECIMAL COLUMNS											
6		5		4		3		2		1	
HEX	DEC	HEX	DEC	HEX	DEC	HEX	DEC	HEX	DEC	HEX	DEC
0	0	0	0	0	0	0	0	0	0	0	0
1	1,048,576	1	65,536	1	4,096	1	256	1	16	1	1
2	2,097,152	2	131,072	2	8,192	2	512	2	32	2	2
3	3,145,728	3	196,608	3	12,288	3	768	3	48	3	3
4	4,194,304	4	262,144	4	16,384	4	1,024	4	64	4	4
5	5,242,880	5	327,680	5	20,480	5	1,280	5	80	5	5
6	6,291,456	6	393,216	6	24,576	6	1,536	6	96	6	6
7	7,340,032	7	458,752	7	28,672	7	1,792	7	112	7	7
8	8,388,608	8	524,288	8	32,768	8	2,048	8	128	8	8
9	9,437,184	9	589,824	9	36,864	9	2,304	9	144	9	9
A	10,485,760	A	655,360	A	40,960	A	2,560	A	160	A	10
B	11,534,336	B	720,897	B	45,056	B	2,816	B	176	B	11
C	12,582,912	C	786,432	C	49,152	C	3,072	C	192	C	12
D	13,631,488	D	851,968	D	53,248	D	3,328	D	208	D	13
E	14,680,064	E	917,504	E	57,344	E	3,584	E	224	E	14
F	15,728,640	F	983,040	F	61,440	F	3,840	F	240	F	15

Notes.

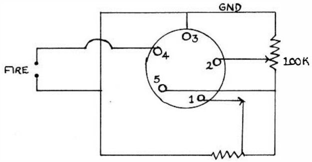
To convert from hexadecimal to decimal, first find the corresponding column position for each hexadecimal digit. Make a note of the decimal equivalents, then add the noted values together to obtain the converted decimal value.

To convert from decimal to hexadecimal, find the largest decimal value in the table that will fit into the number to be converted. Next make a note of the hex equivalent and column position. Calculate the decimal remainder, and repeat the process on this and any subsequent remainders.

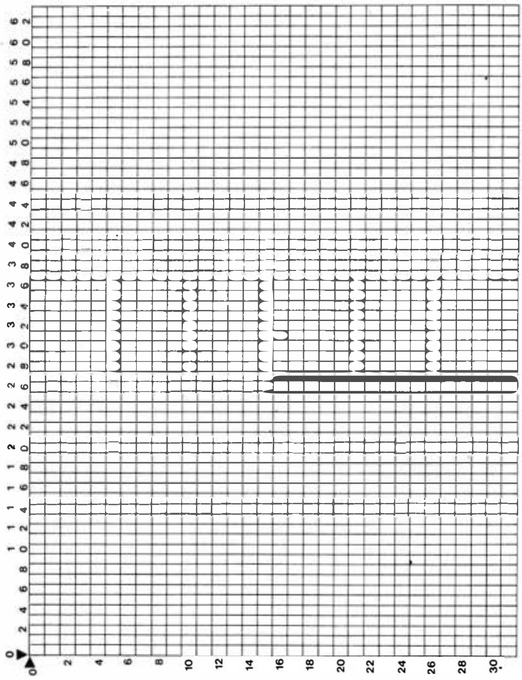
Hyperbolic functions

FUNCTION	BASIC EQUIVALENT
SECANT	SEC(X)= 1/COS(X)
COSECANT	CSC(X)= 1/SIN(X)
COTANGENT	COT(X)= 1/TAN(X)
INVERSE SINE	ARCSIN(X)=ATN(X/SQR(−X*X+1))
INVERSE COSINE	ARCCOS(X)= −ATN(X/SQR (−X*X +1)) +π/2
INVERSE SECANT	ARCSEC(X)=ATN(X/SQR(X*X−1))
INVERSE COSECANT	ARCCSC(X)=ATN(X/SQR(X*X −1)) + (SGN(X)− 1 *π/2
INVERSE COTANGENT	ARCCOT(X)=ATN(X)+π/2
HYPERBOLIC SINE	SINH(X)=(EXP(X)−EXP(−X))/2
HYPERBOLIC COSINE	COSH(X)=(EXP(X)+EXP(−X))/2
HYPERBOLIC TANGENT	TANH(X)=EXP(−X)/(EXP(x)+EXP (−X))*2+1
HYPERBOLIC SECANT	SECH(X)= 2/(EXP(X)+ EXP(−X))
HYPERBOLIC COSECANT	CSCH(X)=2/(EXP(X)−EXP(−X))
HYPERBOLIC COTANGENT	COTH(X)=EXP(−X)/(EXP(X) −EXP(−X))*2+1
INVERSE HYPERBOLIC SINE	ARCSINH(X)=LOG(X+SQR(X*X+1))
INVERSE HYPERBOLIC COSINE	ARCCOSH(X)=LOG(X+SQR(X*X−1))
INVERSE HYPERBOLIC TANGENT	ARCTANH(X)=LOG((1+X)/(1−X))/2
INVERSE HYPERBOLIC SECANT	ARCSECH(X)=LOG((SQR (−X*X+1)+1/X)
INVERSE HYPERBOLIC COSECANT	ARCCSCH(X)=LOG((SGN(X)*SQR (X*X+1/x)
INVERSE HYPERBOLIC COTAN-GENT	ARCCOTH(X)=LOG((X+1)/(x−1))/2

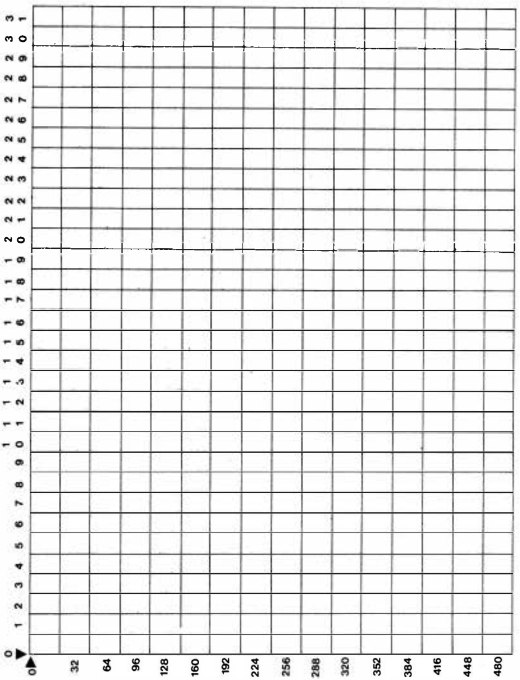
Joystick slot



Low resolution grid



Print@grid


0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
0 32 64 96 128 160 192 224 256 288 320 352 384 416 448 480

6809 M/C instruction set

INDEXED ADDRESSING MODES

TYPE	FORMS	NON INDIRECT Assembler Form	Post-Byte OP Code	+	+ #	INDIRECT Assembler Form	Post-Byte OP Code	+	+ #
CONSTANT OFFSET FROM R	NO OFFSET	,R	1RR00100	0	0	[,R]	1RR10100	3	0
	5 BIT OFFSET	n, R	0RRnnnnn	1	0	defaults to 8-bit			
	8 BIT OFFSET	n, R	1RR01000	1	1	[n, R]	1RR11000	4	1
	16 BIT OFFSET	n, R	1RR01001	4	2	[n, R]	1RR11001	7	2
ACCUMULATOR OFFSET FROM R	A—REGISTER OFFSET	A, R	1RR00110	1	0	[A, R]	1RR10110	4	0
	B—REGISTER OFFSET	B, R	1RR00101	1	0	[B, R]	1RR10101	4	0
	D—REGISTER OFFSET	D, R	1RR01011	4	0	[D, R]	1RR11011	7	0
AUTO INCREMENT/DECREMENT R	INCREMENT BY 1	,R+	1RR00000	2	0	not allowed			
	INCREMENT BY 2	,R++	1RR00001	3	0	[,R++]	1RR10001	6	0
	DECREMENT BY 1	,-R	1RR00010	2	0	not allowed			
	DECREMENT BY 2	,--R	1RR00011	3	0	[,--R]	1RR10011	6	0
CONSTANT OFFSET FROM PC	8 BIT OFFSET	n, PCR	1XX01100	1	1	[n, PCR]	1XX11100	4	1
	16 BIT OFFSET	n, PCR	1XX01101	5	2	[n, PCR]	1XX11101	8	2
EXTENDED INDIRECT	16 BIT ADDRESS	—	—	-	-	[n]	10011111	5	2

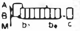
R = X, Y, U, or S
X DONT CARE

NOTES:

1 Given in the table are the base cycles and byte counts To determine the total cycles and byte counts add the values from the 6809 indexing modes' table
2 R1 and R2 may be any pair of 8 bit or any pair of 16 bit registers
The 8 bit registers are A, B, CC, DP
The 16 bit registers are X, Y, U, S, D, PC
3 EA is the effective address
4 The PSH and PUL instructions require 5 cycles plus 1 cycle for each byte pushed or pulled
5 5(6) means 5 cycles if branch not taken, 6 cycles if taken
6 SWI sets I&F bits SWI2 and SWI3 do not affect I&F
7 Conditions Codes set as a direct result of the instruction
8 Value of half-carry flag is undefined
9 Special Case—Carry set if b7 is SET

LEGEND:

OP	Operation Code (Hexadecimal)	Z	Zero (byte)
	Number of MPU Cycles	V	Overflow, 2's complement
#	Number of Program Bytes	C	Carry from bit 7
+	Arithmetic Plus	↕	Test and set if true, cleared otherwise
	Arithmetic Minus	•	Not Affected
	Multiply	CC	Condition Code Register
$\overline{M}$	Complement of M		Concatenation
→	Transfer Into		Logical or
H	Half-carry from bit 3		Logical and
N	Negative (sign bit)		Logical Exclusive or

INSTRUCTION/	FORMS	INHERENT			DIRECT			EXTENDED			IMMEDIATE			INDEXED[1]			RELATIVE			DESCRIPTION	5	3	2	1	0
		OP	~	#	OP	~	#	OP	~	#	OP	~	#	OP	~	#	OP	~[5]	#		H	N	Z	V	C
ABX		3A	3	1																B + X → X (UNSIGNED)	•	•	•	•	•
ADC	ADCA				99	4	2	B9	5	3	89	2	2	A9	4+	2+				A + M + C → A	↕	↕	↕	↕	↕
	ADCB				D9	4	2	F9	5	3	C9	2	2	E9	4+	2+				B + M + C → B	↕	↕	↕	↕	↕
ADD	ADDA				9B	4	2	BB	5	3	8B	2	2	AB	4+	2+				A + M → A	↕	↕	↕	↕	↕
	ADDB				DB	4	2	FB	5	3	CB	2	2	EB	4+	2+				B + M → B	↕	↕	↕	↕	↕
	ADDD				D3	6	2	F3	7	3	C3	4	3	E3	6+	2+				D + M M + 1 → D	↕	↕	↕	↕	↕
AND	ANDA				94	4	2	B4	5	3	84	2	2	A4	4+	2+				A ∧ M → A	•	↕	↕	0	•
	ANDB				D4	4	2	F4	5	3	C4	2	2	E4	4+	2+				B ∧ M → B	•	↕	↕	0	•
	ANDCC										1C	3	2							CC ∧ IMM → CC					1
ASL	ASLA	48	2	1																A 	8	↕	↕	↕	↕
	ASLB	58	2	1																B	8	↕	↕	↕	↕
	ASL				08	6	2	78	7	3				68	6+	2+				M	8	↕	↕	↕	↕
ASR	ASRA	47	2	1																A 	8	↕	↕	•	↕
	ASR	57	2	1																B	8	↕	↕	•	↕
	ASR				07	6	2	77	7	3				67	6+	2+				M	8	↕	↕	•	↕
BCC	BCC																24	3	2	Branch C = 0	•	•	•	•	•
	LBCC																10 24	5(6)	4	LongBranch C = 0	•	•	•	•	•
BCS	BCS																25	3	2	Branch C = 1	•	•	•	•	•
	LBCS																10 25	5(6)	4	Long Branch C = 1	•	•	•	•	•
BEQ	BEQ																27	3	2	Branch Z = 0	•	•	•	•	•
	LBEQ																10 27	5(6)	4	Long Branch Z = 0	•	•	•	•	•
BGE	BGE																2C	3	2	Branch ≥ Zero	•	•	•	•	•
	LBGE																10 2C	5(6)	4	Long Branch ≥ Zero	•	•	•	•	•
BGT	BGT																2E	3	2	Branch > Zero	•	•	•	•	•
	LBGT																10 2E	5(6)	4	Long Branch > Zero	•	•	•	•	•
BHI	BHI																22	3	2	Branch Higher	•	•	•	•	•
	LBHI																10 22	5(6)	4	LongBranch Higher	•	•	•	•	•
BHS	BHS																24	3	2	Branch Higher or Same	•	•	•	•	•
	LBHS																10 24	5(6)	4	LongBranch Higher or Same	•	•	•	•	•
BIT	BITA				95	4	2	B5	5	3	85	2	2	A5	4+	2+				Bit Test A (M ∧ A)	•	↕	↕	0	•
	BITB				D5	4	2	F5	5	3	C5	2	2	E5	4+	2+				Bit Test B (M ∧ B)	•	↕	↕	0	•
BLE	BLE																2F	3	2	Branch ≤ Zero	•	•	•	•	•
	LBLE																10 2F	5(6)	4	LongBranch ≤ Zero	•	•	•	•	•
BLO	BLO																25	3	2	Branch Lower	•	•	•	•	•
	LBLO																10 25	5(6)	4	Long Branch Lower	•	•	•	•	•
BLS	BLS																23	3	2	Branch Lower or Same	•	•	•	•	•
	LBLS																10 23	5(6)	4	Long Branch Lower or Same	•	•	•	•	•
BLT	BLT																2D	3	2	Branch < Zero	•	•	•	•	•
	LBLT																10 2D	5(6)	4	Long Branch < Zero	•	•	•	•	•
BMI	BMI																2B	3	2	Branch Minus	•	•	•	•	•
	LBMI																10 2B	5(6)	4	LongBranch Minus	•	•	•	•	•
BNE	BNE																26	3	2	Branch Z ≠ 0	•	•	•	•	•
	LBNE																10 26	5(6)	4	LongBranch Z ≠ 0	•	•	•	•	•
BPL	BPL																2A	3	2	Branch Plus	•	•	•	•	•
	LBPL																10 2A	5(6)	4	LongBranch Plus	•	•	•	•	•

INSTRUCTION/	FORMS	INHERENT			DIRECT			EXTENDED			IMMEDIATE			INDEXED[1]			RELATIVE				5	3	2	1	0
		OP	~	#	OP	~	#	OP	~	#	OP	~	#	OP	~	#	OP	~[5]	#	DESCRIPTION	H	N	Z	V	C
BRA	BRA																20	3	2	Branch Always	•	•	•	•	•
	LBRA																16	5	3	Long Branch Always	•	•	•	•	•
BRN	BRN																21	3	2	Branch Never	•	•	•	•	•
	LBRN																10 21	5	4	Long Branch Never	•	•	•	•	•
BSR	BSR																8D	7	2	Branch to Subroutine	•	•	•	•	•
	LBSR																17	9	3	Long Branch to Subroutine	•	•	•	•	•
BVC	BVC																28	3	2	Branch V = 0	•	•	•	•	•
	LBVC																10 28	5(6)	4	Long Branch V = 0	•	•	•	•	•
BVS	BVS																29	3	2	Branch V = 1	•	•	•	•	•
	LBVS																10 29	5(6)	4	Long Branch V = 1	•	•	•	•	•
CLR	CLRA	4F	2	1																0 → A	•	0	1	0	0
	CLRB	5F	2	1																0 → B	•	0	1	0	0
	CLR				0F	6	2	7F	7	3				6F	6+	2+				0 → M	•	0	1	0	0
CMP	CMPA				91	4	2	B1	5	3	81	2	2	A1	4+	2+				Compare M from A	8	↕	↕	↕	↕
	CMPB				D1	4	2	F1	5	3	C1	2	2	E1	4+	2+				Compare M from B	8	↕	↕	↕	↕
	CMPD				10 93	7	3	10 B3	8	4	10 83	5	4	10 A3	7+	3+				Compare M:M + 1 from D	•	↕	↕	↕	↕
	CMPS				11 9C	7	3	11 BC	8	4	11 8C	5	4	11 AC	7+	3+				Compare M:M + 1 from S	•	↕	↕	↕	↕
	CMPU				11 93	7	3	11 B3	8	4	11 83	5	4	11 A3	7+	3+				Compare M:M + 1 from U	•	↕	↕	↕	↕
	CMPX				9C	6	2	BC	7	3	8C	4	3	AC	6+	2+				Compare M:M + 1 from X	•	↕	↕	↕	↕
	CMPY				10 9C	7	3	10 BC	8	4	10 8C	5	4	10 AC	7+	3+				Compare M:M + 1 from Y	•	↕	↕	↕	↕
COM	COMA	43	2	1																$\overline{A}$ → A	•	↕	↕	0	1
	COMB	53	2	1																$\overline{B}$ → B	•	↕	↕	0	1
	COM				03	6	2	73	7	3				63	6+	2+				$\overline{M}$ → M	•	↕	↕	0	1
CWAI		3C	20	2																CC ∧ IMM → CC Wait for Interrupt					7
DAA		19	2	1																Decimal Adjust A	•	↕	↕	0	↕
DEC	DECA	4A	2	1																A − 1 → A	•	↕	↕	↕	•
	DECB	5A	2	1																B − 1 → B	•	↕	↕	↕	•
	DEC				0A	6	2	7A	7	3				6A	6+	2+				M − 1 → M	•	↕	↕	↕	•
EOR	EORA				98	4	2	B8	5	3	88	2	2	A8	4+	2+				A ∨ M → A	•	↕	↕	0	•
	EORB				D8	4	2	F8	5	3	C8	2	2	E8	4+	2+				B ∨ M → B	•	↕	↕	0	•
EXG	R1,R2	1E	7	2																R1 ↔ R2[2]	•	•	•	•	•
INC	INCA	4C	2	1																A + 1 → A	•	↕	↕	↕	•
	INCB	5C	2	1																B + 1 → B	•	↕	↕	↕	•
	INC				0C	6	2	7C	7	3				6C	6+	2+				M + 1 → M	•	↕	↕	↕	•
JMP					0E	3	2	7E	4	3				6E	3+	2+				EA[3] → PC	•	•	•	•	•
JSR					9D	7	2	BD	8	3				AD	7+	2+				Jump to Subroutine	•	•	•	•	•
LD	LDA				96	4	2	B6	5	3	86	2	2	A6	4+	2+				M → A	•	↕	↕	0	•
	LDB				D6	4	2	F6	5	3	C6	2	2	E6	4+	2+				M → B	•	↕	↕	0	•
	LDD				DC	5	2	FC	6	3	CC	3	3	EC	5+	2+				M:M + 1 → D	•	↕	↕	0	•
	LDS				10 DE	6	3	10 FE	7	4	10 CE	4	4	10 EE	6+	3+				M:M + 1 → S	•	↕	↕	0	•
	LDU				DE	5	2	FE	6	3	CE	3	3	EE	5+	2+				M:M + 1 → U	•	↕	↕	0	•
	LDX				9E	5	2	BE	6	3	8E	3	3	AE	5+	2+				M:M + 1 → X	•	↕	↕	0	•
	LDY				10 9E	6	3	10 BE	7	4	10 8E	4	4	10 AE	6+	3+				M:M + 1 → Y	•	↕	↕	0	•
LEA	LEAS													32	4+	2+				EA[3] → S	•	•	•	•	•
	LEAU													33	4+	2+				EA[3] → U	•	•	•	•	•
	LEAX													30	4+	2+				EA[3] → X	•	•	↕	•	•
	LEAY													31	4+	2+				EA[3] → Y	•	•	↕	•	•

INSTRUCTION/	FORMS	INHERENT			DIRECT			EXTENDED			IMMEDIATE			INDEXED[1]			RELATIVE			DESCRIPTION	5	3	2	1	0
		OP	~	#	OP	~	#	OP	~	#	OP	~	#	OP	~	#	OP	~	#		H	N	Z	V	C
LSL	LSLA	48	2	1																A } C ← b7 … b0 ← 0	•	↕	↕	↕	↕
	LSLB	58	2	1																B	•	↕	↕	↕	↕
	LSL				08	6	2	78	7	3				68	6+	2+				M	•	↕	↕	↕	↕
LSR	LSRA	44	2	1																A } 0 → b7 … b0 → C	•	0	↕	•	↕
	LSRB	54	2	1																B	•	0	↕	•	↕
	LSR				04	6	2	74	7	3				64	6+	2+				M	•	0	↕	•	↕
MUL		3D	11	1																A × B → D (Unsigned)	•	•	↕	•	9
NEG	NEGA	40	2	1																$\bar{A}$ + 1 → A	8	↕	↕	↕	↕
	NEGB	50	2	1																$\bar{B}$ + 1 → B	8	↕	↕	↕	↕
	NEG				00	6	2	70	7	3				60	6+	2+				$\bar{M}$ + 1 → M	8	↕	↕	↕	↕
NOP		12	2	1																No Operation	•	•	•	•	•
OR	ORA				9A	4	2	BA	5	3	8A	2	2	AA	4+	2+				A ∨ M → A	•	↕	↕	0	•
	ORB				DA	4	2	FA	5	3	CA	2	2	EA	4+	2+				B ∨ M → B	•	↕	↕	0	•
	ORCC										1A	3	2							CC ∨ IMM → CC					7
PSH	PSHS	34	5+*	2																Push Registers on S Stack	•	•	•	•	•
	PSHU	36	5+*	2																Push Registers on U Stack	•	•	•	•	•
PUL	PULS	35	5+*	2																Pull Registers from S Stack	•	•	•	•	•
	PULU	37	5+*	2																Pull Registers from U Stack	•	•	•	•	•
ROL	ROLA	49	2	1																A } C ← b7 ← b0	•	↕	↕	↕	↕
	ROLB	59	2	1																B	•	↕	↕	↕	↕
	ROL				09	6	2	79	7	3				69	6+	2+				M	•	↕	↕	↕	↕
ROR	RORA	46	2	1																A } C b7 → b0	•	↕	↕	•	↕
	RORB	56	2	1																B	•	↕	↕	•	↕
	ROR				06	6	2	76	7	3				66	6+	2+				M	•	↕	↕	•	↕
RTI		3B	6/15	1																Return From Interrupt					7
RTS		39	5	1																Return From Subroutine	•	•	•	•	•
SBC	SBCA				92	4	2	B2	5	3	82	2	2	A2	4+	2+				A − M − C → A	8	↕	↕	↕	↕
	SBCB				D2	4	2	F2	5	3	C2	2	2	E2	4+	2+				B − M − C → B	8	↕	↕	↕	↕
SEX		1D	2	1																Sign Extend B into A	•	↕	↕	0	•
ST	STA				97	4	2	B7	5	3				A7	4+	2+				A → M	•	↕	↕	0	•
	STB				D7	4	2	F7	5	3				E7	4+	2+				B → M	•	↕	↕	0	•
	STD				DD	5	2	FD	6	3				ED	5+	2+				D → M:M + 1	•	↕	↕	0	•
	STS				10 DF	6	3	10 FF	7	4				10 EF	6+	3+				S → M:M + 1	•	↕	↕	0	•
	STU				DF	5	2	FF	6	3				EF	5+	2+				U → M:M + 1	•	↕	↕	0	•
	STX				9F	5	2	BF	6	3				AF	5+	2+				X → M:M + 1	•	↕	↕	0	•
	STY				10 9F	6	3	10 BF	7	4				10 AF	6+	3+				Y → M:M + 1	•	↕	↕	0	•
SUB	SUBA				90	4	2	B0	5	3	80	2	2	A0	4+	2+				A − M → A	8	↕	↕	↕	↕
	SUBB				D0	4	2	F0	5	3	C0	2	2	E0	4+	2+				B − M → B	8	↕	↕	↕	↕
	SUBD				93	6	2	B3	7	3	83	4	3	A3	6+	2+				D − M:M + 1 → D	•	↕	↕	↕	↕
SWI	SWI*	3F	19	1																Software Interrupt 1	•	•	•	•	•
	SWI2*	10 3F	20	2																Software Interrupt 2	•	•	•	•	•
	SWI3*	11 3F	20	2																Software Interrupt 3	•	•	•	•	•
SYNC		13	≥2	1																Synchronize to Interrupt	•	•	•	•	•
TFR	R1,R2	1F	7	2																R1 → R2*	•	•	•	•	•
TST	TSTA	4D	2	1																Test A	•	↕	↕	0	•
	TSTB	5D	2	1																Test B	•	↕	↕	0	•
	TST				0D	6	2	7D	7	3				6D	6+	2+				Test M	•	↕	↕	0	•

6809 mnemonics

OP	MNEM	MODE	~	#	OP	MNEM	MODE	~	#
ØØ	NEG	DIRECT	6	2	1C	ANDCC	INMED	3	2
Ø3	COM	"	6	2	1D	SEX	INHERENT	2	1
Ø4	LSR	"	6	2	1E	EXG	"	8	2
Ø6	ROR	"	6	2	1F	TFR	INHERENT	7	2
Ø7	ASR	"	6	2	2Ø	BRA	RELATIVE	3	2
Ø8	ASL/LSL	"	6	2	21	BRN	"	3	2
Ø9	ROL	"	6	2	22	BHI	"	3	2
ØA	DEC	"	6	2	23	BLS	"	3	2
ØC	INC	"	6	2	24	BHS/BCC	"	3	2
ØD	TST	"	6	2	25	BLO/BCS	"	3	2
ØE	JMP	"	3	2	26	BNE	"	3	2
ØF	CLR	DIRECT	6	2	27	BEQ	"	3	2
12	NOP	INHERENT	2	1	28	BVC	"	3	2
13	SYNC	INHERENT	2	1	29	BVS	"	3	2
16	LBRA	RELATIVE	5	3	2A	BPL	"	3	2
17	LBSR	RELATIVE	9	3	2B	BMI	"	3	2
19	DAA	INHERENT	2	1	2C	BGE	"	3	2
1A	ORCC	INMED	3	2	2D	BLT	RELATIVE	3	2

OP	MNEM	MODE	~	#	OP	MNEM	MODE	~	#
2E	BGT	RELATIVE	3	2	44	LSRA	INHERENT	2	1
2F	BLE	"	3	2	46	RORA	"	2	1
3Ø	LEAX	INDEXED	4	2	47	ASRA	"	2	1
31	LEAY	"	4	2	48	ASLA/LSLA	"	2	1
32	LEAS	"	4	2	49	ROLA	"	2	1
33	LEAU	"	4	2	4A	DECA	"	2	1
34	PSHS	INHERENT	5	2	4C	INCA	"	2	1
35	PULS	"	5	2	4D	TSTA	"	2	1
36	PSHU	"	5	2	4F	CLRA	"	2	1
37	PULU	"	5	2	5Ø	NEGB	"	2	1
39	RTS	"	5	1	53	COMB	"	2	1
3A	ABX	"	3	1	54	LSRB	"	2	1
3B	RTI	"	6/15	1	56	RORB	"	2	1
3C	CWAI	"	21	2	57	ASRA	"	2	1
3D	MUL	"	11	1	58	ASLB/LSLB	"	2	1
3F	SWI	"	19	1	59	ROLB	"	2	1
4Ø	NEGA	"	2	1	5A	DECB	"	2	1
43	COMA	"	2	1	5C	INCB	"	2	1

OP	MNEM	MODE	~	#	OP	MNEM	MODE	~	#
5D	TSTB	INHERENT	2	1	77	ASR	EXTENDED	7	3
5F	CLRB	"	2	1	78	ASL/LSL	"	7	3
6Ø	NEG	INDEXED	6	2	79	ROL	"	7	3
63	COM	"	6	2	7A	DEC	"	7	3
64	LSR	"	6	2	7C	INC	"	7	3
66	ROR	"	6	2	7D	TST	"	7	3
67	ASR	"	6	2	7E	JMP	"	4	3
68	ASL/LSL	"	6	2	7F	CLR	"	7	3
69	ROL	"	6	2	8Ø	SUBA	IMMED	2	2
6A	DEC	"	6	2	81	CMPA	"	2	2
6C	INC	"	6	2	82	SBCA	"	2	2
6D	TST	"	6	2	83	SUBD	"	4	3
6E	JMP	"	3	2	84	ANDA	"	2	2
6F	CLR	"	6	2	85	BITA	"	2	2
7Ø	NEG	EXTENDED	7	3	86	LDA	"	2	2
73	COM	"	7	3	88	EORA	"	2	2
74	LSR	"	7	3	89	ADCA	"	2	2
76	ROR	"	7	3	8A	ORA	"	2	2

OP	MNEM	MODE	~	#	OP	MNEM	MODE	~	#
8B	ADDA	IMMED	2	2	9E	LDX	DIRECT	5	2
8C	CMPX	"	4	3	9F	STX	"	5	2
8D	BSR	RELATIVE	7	2	AØ	SUBA	INDEXED	4	2
8E	LDX	IMMED	3	3	A1	CMPA	"	4	2
9Ø	SUBA	DIRECT	4	2	A2	SBCA	"	4	2
91	CMPA	"	4	2	A3	SUBD	"	6	2
92	SBCA	"	4	2	A4	ANDA	"	4	2
93	SUBD	"	6	2	A5	BITA	"	4	2
94	ANDA	"	4	2	A6	LDA	"	4	2
95	BITA	"	4	2	A7	STA	"	4	2
96	LDA	"	4	2	A8	EORA	"	4	2
97	STA	"	4	2	A9	ADCA	"	4	2
98	EORA	"	4	2	AA	ORA	"	4	2
99	ADCA	"	4	2	AB	ADDA	"	4	2
9A	ORA	"	4	2	AC	CMPX	"	6	2
9B	ADDA	"	4	2	AD	JSR	"	7	2
9C	CMPX	"	6	2	AE	LDX	"	5	2
9D	JSR	"	7	2	AF	STX	"	5	2

OP	MNEM	MODE	~	#	OP	MNEM	MODE	~	#
BØ	SUBA	EXTENDED	5	3	C2	SBCB	IMMED.	2	2
B1	CMPA	"	5	3	C3	ADDD	"	4	3
B2	SBCA	"	5	3	C4	ANDB	"	2	2
B3	SUBD	"	7	3	C5	BITB	"	2	2
B4	ANDA	"	5	3	C6	LDB	"	2	2
B5	BITA	"	5	3	C8	EORB	"	2	2
B6	LDA	"	5	3	C9	ADCB	"	2	2
B7	STA	"	5	3	CA	ORB	"	2	2
B8	EORA	"	5	3	CB	ADDB	"	2	2
B9	ADCA	"	5	3	CC	LDD	"	3	3
BA	ORA	"	5	3	CE	LDU	"	3	3
BB	ADDA	"	5	3	DØ	SUBB	DIRECT	4	2
BC	CMPX	"	7	3	D1	CMPB	"	4	2
BD	JSR	"	8	3	D2	SBCB	"	4	2
BE	LDX	"	6	3	D3	ADDD	"	6	2
BF	STX	"	6	3	D4	ANDB	"	4	2
CØ	SUBB	IMMED	2	2	D5	BITB	"	4	2
C1	CMPB	"	2	2	D6	LDB	"	4	2

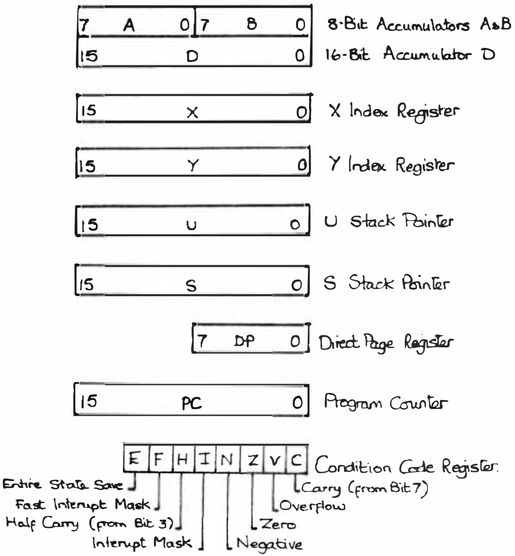
OP	MNEM	MODE	~	#	OP	MNEM	MODE	~	#
D7	STB	DIRECT	4	2	E9	ADCB	INDEXED	4	2
D8	EORB	"	4	2	EA	ORB	"	4	2
D9	ADCB	"	4	2	EB	ADDB	"	4	2
DA	ORB	"	4	2	EC	LDD	"	5	2
DB	ADDB	"	4	2	ED	STD	"	5	2
DC	LDD	"	5	2	EE	LDU	"	5	2
DD	STD	"	5	2	EF	STU	"	5	2
DE	LDU	"	5	2	FØ	SUBB	EXTENDED	5	3
DF	STU	"	5	2	F1	CMPB	"	5	3
EØ	SUBB	INDEXED	4	2	F2	SBCB	"	5	3
E1	CMPB	"	4	2	F3	ADDD	"	7	3
E2	SBCB	"	4	2	F4	ANDB	"	5	3
E3	ADDD	"	6	2	F5	BITB	"	5	3
E4	ANDB	"	4	2	F6	LDB	"	5	3
E5	BITB	"	4	2	F7	STB	"	5	3
E6	LDB	"	4	2	F8	EORB	"	5	3
E7	STB	"	4	2	F9	ADCB	"	5	3
E8	EORB	"	4	2	FA	ORB	"	5	3

OP	MNEM	MODE	~	#
FB	ADDB	EXTENDED	5	3
FC	LDD	"	6	3
FD	STD	"	6	3
FE	LDU	"	6	3
FF	STU	"	6	3
1Ø21	LBRN	RELATIVE	5	4
1Ø22	LBHI	"	5(6)	4
1Ø23	LBLS	"	5(6)	4
1Ø24	LBHS/LBCC	"	5(6)	4
1Ø25	LBCS/LBLO	"	5(6)	4
1Ø26	LBNE	"	5(6)	4
1Ø27	LBEQ	"	5(6)	4
1Ø28	LBVC	"	5(6)	4
1Ø29	LBVS	"	5(6)	4
1Ø2A	LBPL	"	5(6)	4
1Ø2B	LBMI	"	5(6)	4
1Ø2C	LBGE	"	5(6)	4
1Ø2D	LBLT	"	5(6)	4

OP	MNEM	MODE	~	#
1Ø2E	LBGT	RELATIVE	5(6)	4
1Ø2F	LBLE	"	5(6)	4
1Ø3F	SWI/2	INHERENT	2Ø	2
1Ø83	CMPD	IMMED	5	4
1Ø8C	CMPY	"	5	4
1Ø8E	LDY	"	4	4
1Ø93	CMPD	DIRECT	7	3
1Ø9C	CMPY	"	7	3
1Ø9E	LDY	"	6	3
1Ø9F	STY	"	6	3
1ØA3	CMPD	INDEXED	7	3
1ØAC	CMPY	"	7	3
1ØAE	LDY	"	6	3
1ØAF	STY	"	6	3
1ØB3	CMPD	EXTENDED	8	4
1ØBC	CMPY	"	8	4
1ØBE	LDY	"	7	4
1ØBF	STY	"	7	4

OP	MNEM	MODE	~	#
1ØCE	LDS	IMMED	4	4
1ØDE	LDS	DIRECT	6	3
1ØDF	STS	"	6	3
1ØEE	LDS	INDEXED	6	3
1ØEF	STS	"	6	3
1ØFE	LDS	EXTENDED	7	4
1ØFF	STS	"	7	4
113F	SWI/3	INHERENT	2Ø	2
1183	CMPU	IMMED	5	4
118C	CMPS	"	5	4
1193	CMPU	DIRECT	7	3
119C	CMPS	"	7	3
11A3	CMPU	INDEXED	7	3
11AC	CMPS	"	7	3
11B3	CMPU	EXTENDED	8	4
11BC	CMPS	"	8	4

Machine code register



INDEXED ADDRESSING POST-BYTE REGISTER BIT ASSIGNMENTS

POST-BYTE REGISTER BIT								INDEXED
7	6	5	4	3	2	1	Ø	ADDRESSING MODE
Ø	X	X	X	X	X	X	X	EA=,R ± 4 BIT OFFSET
1	X	X	Ø	Ø	Ø	Ø	Ø	,R+
1	X	X	X	Ø	Ø	Ø	1	,R++
1	X	X	Ø	Ø	Ø	1	Ø	,−R
1	X	X	X	Ø	Ø	1	1	,−−R
1	X	X	X	Ø	1	Ø	Ø	EA=,R ± Ø OFFSET
1	X	X	X	Ø	1	Ø	1	EA=,R ± ACCB OFFSET
1	X	X	X	Ø	1	1	Ø	EA=,R ± ACCA OFFSET
1	X	X	X	1	Ø	Ø	Ø	EA=,R ± 7 BIT OFFSET
1	X	X	X	1	Ø	Ø	1	EA=,R ± 15 BIT OFFSET
1	X	X	X	1	Ø	1	1	EA=,R ± D OFFSET
1	X	X	X	1	1	Ø	Ø	EA=,PC ± 7 BIT OFFSET
1	X	X	X	1	1	Ø	1	EA=,PC ± 15 BIT OFFSET
1	X	X	1	1	1	1	1	EA= ,ADDRESS

ADDRESSING MODE FIELD

I FIELD
FOR B7 = 1 : INDIRECT
FOR B7 = Ø : SIGN BIT

REGISTER FIELD
ØØ : R = X Ø1 : R = Y
1Ø : R = U 11 : R = S

6809 STACKING ORDER

PULL ORDER ↓

CC
A
B
DP
X Hi
X Lo
Y Hi
Y Lo
U/S Hi
U/S Lo
PC Hi
PC Lo

↑ PUSH ORDER

INCREASING MEMORY ↓

6809 VECTORS

FFFE	RESTART
FFFC	NMI
FFFA	SWI
FFF8	IRQ
FFF6	FIRQ
FFF4	SWI2
FFF2	SWI3
FFFØ	RESERVED

PC | S/U | Y | X | DPR | B | A | CCR

PUSH/PULL POST-BYTE

SOURCE	DESTINATION

TRANSFER/EXCHANGE POST-BYTE

REGISTER FIELD

ØØØØ = D (A:B)	Ø1Ø1 = PC
ØØØ1 = X	1ØØØ = A
ØØ1Ø = Y	1ØØ1 = B
ØØ11 = U	1Ø1Ø = CCR
Ø1ØØ = S	1Ø11 = DPR

Memory map

Location Hex	Description
0019	Address of start of BASIC program
001A	Address of end of BASIC program
001B	Address of start of variable storage
001D	Address of start of array storage
001F	Address of start of free memory
0021	Address of start of string stack
0023	Address of upper limit of BASIC
0027	Address of highest available RAM
006C	Current cursor column position
006F	Holds current device number
0071	Warm start flag
0072	Warm start vector
0074	Address of highest memory address
007C	Block tvpe
007D	Number of bytes to be put out
007E/F	Base address of bvtes
0080	Checksum
0081	Error code
0088	Point to next location for screen output
0089	Ditto
008C	Sound frequency
008D	Duration of sound
008F	Blink count
0090/91	Leader bvte count for tapes
0095/96	Cassette motor delay
0099	Line printer field width
009A	Last field width
009B	Line printer width
009C	Print head position for line printer
009D	Transfer address after CLOAD
00B6	Holds current PMODE
0100	SWI 3 vector
0103	SWI 2 vector
0106	SWI 1 vector
0109	NMI vector
010C	IRQ vector
010F	FIRQ vector
0121	Points to BASIC command token table
0123	As above for jump table
0126	As above for function token table
0128	As above for function jump table
0148	Buffer full auto line feed flag
0149	Alpha lock flag
014A	Number of chars. to be printed in end of line
014B	Perform carriage return to printer
014C	Perform line feed
014D	Redundant
014E	Redundant

Location Hex	Description
0151	Start of kevboard rollover table
0152-159	Covers entire keyboard
015A	Left iovstick X position
015B	Left joystick Y position
015C	Right ioystick X position
015D	Right ioystick Y position
01D2	Cassette file name
01D4	Cassette file buffer
01E5	Transfer address used by CSAVEM
0200-3FFF	Buffer for cassettes etc.
0400-5FFF	Text screen default area
0600-07FF	Graphics screen/program/variable storage
0C00-7FFF	User RAM, depending on graphics pages
8006	Poll keyboard
8009	Blink cursor
800C	Write character to text screen
800F	Ditto for line printer (char. in A as above)
8012	Update joystick readings
8015	Turn on cassette relav
8018	Turn off cassette relay
801B	Prepare cassette for writing
801E	Shove byte to cassette from A
8021	Prepare cassette for data
8024	Returns next byte in A
8027	Gets next bit in from cassette
8033	BASIC command word table
8154	BASIC command jump table
81CA	BASIC function word table
8250	BASIC function jump table
82A9	BASIC error message table
82E0	BASIC interpreter
C000-FEFF	Cartridge slot
FF00	PIA
FFF2	SWI 3 vector
FFF4	SWI 2 vector
FFF6	FIRQ vector
FFF8	IRQ vector
FFFA	SWI 1 vector
FFFC	NMI vector
FFFE	Reset vector

Decimal Address	Contents	Hex Address
0 - 1023	System Work Area	0 - 3FF
1024 - 1535	Text Screen	400 - 5FF
1536 - 3071	Graphic - page 1	600 - BFF
3072 - 4607	" " 2	C00 - 11FF
4608 - 6143	" " 3	1200 - 17FF
6144 - 7679	" " 4	1800 - 1DFF
7680 - 9215	" " 5	1E00 - 23FF
9216 - 10751	" " 6	2400 - 29FF
10752 - 12287	" " 7	2A00 - 2FFF
12288 - 13823	" " 8	3000 - 35FF
13824 - 37767	Program & Variables - user's	3600 - 7FFF
37768 - 49151	BASIC ROM	8000 - BFFF
49152 - 65279	Cartridge Port	C000 - FEFF
65280 - 65535	Input/Output	FF00 - FFFF

Powers tables

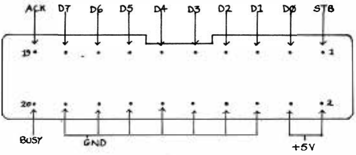
Powers of 2

2^N	N
256	8
512	9
1,024	10
2,048	11
4,096	12
8,192	13
16,384	14
32,768	15
65,536	16
131,072	17
262,144	18
524,288	19
1,048,576	20
2,097,152	21
4,194,304	22
8,388,608	23
16,777,216	24

Powers of 16

16^N	N
1	0
16	1
256	2
4,096	3
65,536	4
1,048,576	5
16,777,216	6
268,435,456	7
4,294,967,296	8
68,719,476,736	9
1,099,511,627,776	10
17,592,186,044,416	11
281,474,976,710,656	12
4,503,599,627,370,496	13
72,057,594,037,927,936	14
1,152,921,504,606,846,976	15

Printer port



RS232 standards

EIA RS232-C (CCITT V24)

Notes

Transmission is serial (asynchronous).
MARK = binary 1 = OFF = -3 to -25 volts.
SPACE = binary 0 = ON = +3 to +25 volts.
25-pin "D" type connector.
Data Control Equipment (DCE) has female connector.
Data Terminal Equipment (DTE) has male connector.
Open circuit drive voltage cannot exceed 25 volts.
Terminator resistance 3-7K ohms.
50 foot maximum DCE, DTE separation.
2500 pico farad max conductor capacitance.

PIN	NAME	DIRECTION	CIRCUIT CCITT	CIRCUIT EIA	FUNCTION
01	FG	-	101	AA	Frame Ground.
02	TD	To DCE	103	BA	Transmitted Data.
03	RD	To DTE	104	BB	Received Data.
04	RTS	To DCE	105	CA	Request To Send.
05	CTS	To DTE	106	CB	Clear To Send.
06	DSR	To DTE	107	CC	Data Set Ready.
07	SG	-	102	AB	Signal Ground.
08	DCD	To DTE	109	CF	Data Carrier Detect.
09		To DTE			Positive DC Test Voltage.
10		To DTE			Negative DC Test Voltage.
11	QM	To DTE	Bell 208A		Equaliser Mode.
12	(S)DCD	To DTE	122	SCF	Secondary Data Carrier Detect.
13	(S)CTS	To DTE	121	SCB	Secondary Clear To Send.
14	(S)TD	To DCE	118	SBA	Secondary Transmitted Data.
	NS	To DCE	Bell 208A		New Synch.
15	TC	To DTE	114	DB	Transmitter Clock.
16	(S)RD	To DTE	119	SBB	Secondary Received Data.
	DCT	To DTE	Bell 208A		Divided Clock Transmitter.
17	RC	To DTE	115	DD	Receiver Clock.
18	DCR	To DTE	Bell 208A		Divided Clock Receiver.
19	(S)RTS	To DCE	120	SCA	Secondary Request to Send.
20	DTR	To DCE	108.2	CD	Data Terminal Ready.
21	SQ	To DTE	110	CG	Signal Quality Detect.
22	RI	To DTE	125	CE	Ring Indicator.
23		To DCE	111	CH	Data Rate Selector.
		To DTE	112	CI	Data Rate Selector.
24	TC	To DCE	113	DA	EXT Transmitter Clock.
25		To DCE	Bell 113B		Busy.

CCITT V24 Circuit Definitions

Circuit 102 - Signal Ground or Common Return

This conductor establishes the signal common return for interchange circuits.

Circuit 103 - Transmitted Data

The data signals originated by the DTE, to be transmitted via the data channel to one or more remote data stations, are transferred on this circuit to DCE.

Circuit 104 - Received Data

The data signals generated by the DCE, in response to data channel line signals received from a remote data station, are transferred on this circuit to the DTE.

Circuit 105 - Request to Send

Controls the data channel transmit function of the DCE.

Circuit 106 - Ready for Sending

Indicates whether the DCE is conditioned to transmit data on the data channel.

Circuit 107 - Data Set Ready

Indicates whether the DCE is ready to operate.

Circuit 108/1 - Connect Data Set to Line

Controls switching of the signal-conversion or similar equipment to or from the line.

Circuit 108/2 - Data Terminal Ready

Controls switching of the signal-conversion or similar equipment to or from the line.

Circuit 109 - Carrier Detect

Indicates whether the received data channel line signal is within appropriate limits, as specified by the relevant recommendation for DCE.

Circuit 110 - Data Signal Quality Detector

Indicates whether there is a reasonable probability of an error in the data received on the data channel.

Circuit 111 - Data Signalling Rate Selector

Used to select one or two data signalling rates of a dual-rate synchronous DCE, or to select one of the two ranges of data signalling rates of a dual-range synchronous DCE.

Circuit 112 - Data Signalling Rate Selector

Used to select one of the two data signalling rates or ranges of rates in the DTE to coincide with the data signalling rate or range of rates in use in a dual-rate synchronous or dual-range asynchronous DCE.

Circuit 113 - Transmitter Signal Element Timing

Provides the DCE with signal element timing information.

Circuit 114 - Transmitter Signal Element Timing

Provides the DTE with signal element timing information.

Circuit 115 - Receiver Signal Element Timing

Provides the DTE with signal element timing information.

Circuit 116 - Select Standby

Used to select the normal or standby facilities such as signal convertors and communication channels.

Circuit 117 - Standby Indicator

Indicates whether the DCE is conditioned in its standby mode with the pre-determined facilities replaced by their reserves.

Circuit 118 - Transmitted Backward Channel Data

Equivalent to circuit 103, except that it is used for data received on the backward channel.

Circuit 120 - Transmit Backward Channel Line Signal

Equivalent to circuit 105, except that it is used to control the backward channel transmit function of the DCE.

Circuit 121 - Backward Channel Ready

Equivalent to circuit 106, except that it is used to indicate whether the DCE is conditioned to transmit data on the backward channel.

Circuit 122 - Supervisory Carrier Detect

Equivalent to circuit 109, except that it is used to indicate whether the received backward channel line signal is within appropriate limits.

Circuit 123 - Backward Channel Signal Quality Detector

Equivalent to circuit 110, except that it is used to indicate the signal quality of the received backward channel line signal.

Circuit 124 - Select Frequency Groups

Used to select the desired frequency groups available on the DCE.

Circuit 125 - Calling Indicator

Indicates whether a calling signal is being received by the DCE.

Circuit 126 - Select Transmit Frequency

Used to select the required transmit frequency of the DCE.

Circuit 127 - Select Receive Frequency

Used to select the required receive frequency of the DCE.

Circuit 128 - Receiver Signal Element Timing

Provides the DCE with signal element timing information.

Circuit 129 - Request to Receive

Used to control the receive function of the DCE.

Circuit 130 - Transmit Backward Tone

Controls the transmission of a backward channel tone.

Circuit 131 - Received Character Timing

Provides the DTE with character timing information.

Circuit 132 - Return to Non-Data Mode

Used to restore the non-data mode provided with the DCE, without releasing the line connection to the remote station.

Circuit 133 - Ready for Receiving

Controls the transfer of data on circuit 104, indicating whether the DTE is capable of accepting a given amount of data, specified in the appropriate recommendation for intermediate equipment, for example, error control equipment.

Circuit 134 - Received Data Present

Used to separate information messages from supervisory messages, transferred on circuit 104.

Circuit 191 - Transmitted Voice Answer

Signals generated bv a voice answer unit in the DTE are transferred on this circuit to the DCE.

Circuit 192 - Received Voice Answer

Received voice signals, generated by a voice answering unit at the remote data terminal, are transferred on this circuit to the DTE.

Other CCITT "V" Interfaces

V10

Electrical characteristics for unbalanced double-current interchange circuits for general use with integrated circuit equipment in the field of data communications.

V11

Electrical characteristics for balanced double-current interchange circuits for general use with integrated circuit equipment in the field of data communications.

V15

Use of acoustic coupling for data transmission.

V16

Medical analogue data transmission modems.

V19

Modems for parallel data transmission using telephone signalling frequencies.

V20

Parallel data transmission modems standardised for universal use in the general switch telephone network.

V21

200-baud modem standardised for use in the general switched telephone network.

V22

Defines the procedures and standards for 1200 baud full duplex communications over the public switched network.

V23

600/1200-baud modem standardised for use in the general switched telephone network.

V24

List of definitions for interchange circuits between data terminal equipment and data circuit terminating equipment.

V25

Automatic calling and/or answering equipment on the general switched telephone network, including disabling of echo-suppressors on manually established calls.

V26

2400 bits per second modem standardised for use on 4-wire leased telephone-type circuits.

V26 (alternative)

2400/1200 bits per second modem standardised for use in the general switched telephone network.

V27

4800 bits per second modems with manual equaliser standardised for use on leased telephone-type circuits.

V27 (alternative 1)

4800 bits per second modems with automatic equaliser standardised for use on leased telephone-type circuits.

V27 (alternative 2)

4800/2400 bits per second modems standardised for use in the general switched telephone network.

V28

Electrical characteristics for unbalanced double-current interchange circuits.

V29

9600 bits per second modems standardised for use in leased telephone circuits.

V31

Electrical characteristics for single current interchange circuits controlled by contact closure.

V35

Data transmission at 48 kilobits per second using 60-108 KHz group band circuits.

V36

Modems for synchronous transmission using 60-108 KHz group band circuits.

Useful hints and tips

This section is a collection of Dragon miscellanea gleaned over the months. It contains material that we have discovered by ourselves, or seen in various magazines, or even overheard in casual conversation at computer shows, user groups, etc.

It just goes to show how much undocumented information there is floating around about the Dragon, and, even more, how much there is still to be discovered. The publishers would be grateful to hear of any Dragon fact or figure that you've discovered, with a view to sharing this knowledge with everyone else in future publications.

But now, without further ado, and without any concern for presenting things in a logical order (see the index if you get totally lost!), let's start with a few USR functions.

USR functions

As is usual with the Dragon manual, these have been wrongly described. Most people redefine USR0 over and over again, and just use that one for several different reasons. However, USR1 to USR9 can all equally well be used, provided that the call in a Basic program is prefixed by a 0. That is, use A = USR01(A) (for example), rather than USR1(A). For example:

```
10 DEFUSR8=&H8015:REM START OF M/C ROUTINE TO
   TURN THE CASSETTE MOTOR ON
20 DEFUSR9=&H8018:REM START OF M/C ROUTINE TO
   TURN THE CASSETTE MOTOR OFF AGAIN
30 A$=INKEY$:IFA$=""THEN30
40 IFA$="*"THENA=USR08(A):GOTO30
50 IFA$="@"THENA=USR09(A):GOTO30
60 GOTO30
```

All this little demonstration does is to turn the cassette motor on if the'*' key is pressed, and turn it off if the'@' key is pressed. No other key has any effect.

Speeded up Dragon

The POKE to speed up the Dragon is well known (POKE 65495,0), but unfortunately doesn't work on all Dragons. However, there are other ways to speed up certain functions. For instance, INKEY$ is not the fastest of functions, and in a program that requires the user to enter one of the four arrow keys to move a character about on the screen, you might like to use the following four memory locations instead:

For up arrow,read PEEK(341).
For down arrow, read PEEK(342)
For left arrow, read PEEK(343).
For right arrow, read PEEK(344).

These locations return a 255 if the relevant key is not being pressed, but if it is, a value of 223 is put into that location. Thus, by using:

IFPEEK(344)=223THEN move the character up

we can easily handle those four particular keys.

There are some other (safe!) locations in the Dragon that can be POKEd in order to speed things up a little. For instance, if you want to increase the processing speed of your Dragon, try the following:

```
POKE &HFFD7,0
POKE &HFFD9,0
```

The second in conjunction with the first should be safe on all Dragons (it is on ours!). To get things back to normal again, use:

```
POKE &HFFD8,0
POKE &HFFD6,0
```

And more on INKEY$

As we all know, unless specific steps are taken to disable the break key, pressing this will break into a loop that is waiting for a key to be pressed. However, by using the internal routine that handles the INKEY$ function, a program will be seen to be behaving as normal, but will however be inaccessible to people typing BREAK.

Thus, we might have something like:

```
10 PRINT"PRESS ANY KEY TO CONTINUE";EXEC41994
```

This just calls up the internal routine to handle INKEY$.

NEW programs for OLD Dragons

We've mentioned elsewhere in this book that typing in NEW <ENTER> doesn't remove everything from memory, but merely resets internal pointers so that the program can no longer be accessed.

Therefore, it ought to be possible to retrieve a program that has been accidentally NEWed. Provided that no new program lines are entered, no new variables are assigned (and someone hasn't switched the machine off!), the following short program will do the trick.

```
100 CLEAR 200,32749
110 Y=32749
120 DATA 158,25,189.131.48.2,159,27,159.29.159,31,57
130 FORI=1TO14:READX:POKEY+I,X:NEXT
```

This program should always be sitting in your Dragon, and to execute it when you've accidentally said goodbye to a program, use EXEC 32750.

Loading information

As we've seen, the two hex locations &8015 and &8018 (decimal 32789 and 32792 respectively) can be used to turn the cassette motor on and off. There is a third useful location when dealing with cassette decks, and this is the one which handles the CLOADing of a BASIC program.

If you aren't fussed about what filename you're looking for on tape, try EXEC 46800.

Another point about loading programs, is that it is always a good idea to leave a gap between stuff on tape whether it be programs or data. This is usually done with the MOTORON and MOTOROFF commands, but if entered in direct mode, MOTOROFF can take some time to type, thus leaving an inordinately long gap on the tape.

Even worse, you might spell the word incorrectly and leave an extremely long gap as you try to delete characters to get it right! To achieve the same effect as MOTOROFF, just generate a syntax error. For example:

```
H <ENTER>
```

HEX/DEC and OCT

We're all familiar with the fact that the Dragon can handle decimal as well as hexadecimal numbers.

Well, it can also handle octal numbers, by replacing the &H characters with &O.

Thus:

```
PRINT &O number
```

will return the decimal equivalent of the octal number 'number'.

Screen information

The largest part of this book is devoted to the handling of graphics, but even armed with all that knowledge there is a surprising amount of uncharted material concerned with displaying information on the screen.

For instance, to simulate a mixture of text and graphics on the screen, a simple way in BASIC would be simply to switch from one to the other very rapidly. Even better, if your machine can handle the 'speed up' POKE the display will appear relatively flicker free.

Of course, the ultimate goal would be to write this sort of thing in machine code, but as a small BASIC demonstration, how about this:

```
100 PMODE1,1:COLOUR0,5:REM POKE65495,0 IF YOUR
    MACHINE CAN HANDLE IT!
110 PCLS:CIRCLE (125,100),80
120 SCREEN1
130 FORI=1TO10:NEXTI
140 SCREEN0
150 FORI=1TO10:NEXTI
160 GOTO120
```

All this does is draw a circle on a high resolution screen, and then swap from that to the screen displaying the listing.

And more

This is to be used when you require an increase in the normal colour resolution available.

It is possible, in PMODE3, to fool the Dragon into displaying all 256 character positions at a time, which makes pixels overlap. This effectively doubles the resolution, although it does make it very difficult to control the colour. Still, it's probably worth the attempt:

```
100 PMODE3:SCREEN1,0:PCLS
110 PMODE4,1
120 CIRCLE (128,96),96
130 PAINT (128,96)
140 A$=INKEY$:IFA$=""THEN140
```

Run this program as normal, and then delete line 110 to see what kind of effect you can really get out of the Dragon!

And yet more!

In our highest resolution graphics mode, you can normally only display two colours at a time. However, it is possible to get a purple haze on the screen, with the aid of one POKE.

```
10 PMODE3,1:SCREEN1,1:POKE65314,248
```

By doing this, BASIC thinks that you're in four-colour mode, while the video chip is still convinced that you're in two-colour high resolution mode.

Our new colour set now has the values of 2 = light purple, 1 = black and 0 = white.

Let's take a break

We mentioned earlier that there is a way to get around the problem of people BREAKing into Dragon programs while the program sits and waits for a key to be pressed. This involved using an internal routine to collect the key being pressed.

A more unsubtle, but equally effective way, would be to disable the BREAK key totally, so that pressing it would have no effect at all.

To do that, enter the following in direct mode:

```
POKE 411,228
POKE 412,203
POKE 413,4
POKE 414,237
POKE 415,228
```

Once that little piece of code is sitting in the machine, the BREAK key can be disabled by:

```
POKE 410,236
```

and re-enabled with

```
POKE 410,57
```

Back to loading

It is possible, using the CLOADM and CSAVEM commands, to load and save screen images to and from cassette, which could be used to enhance certain programs considerably.

To do this, we need to know where the screen pages are stored in memory, and in order they sit at:

Page No.	Hexadecimal address
0	0600-0BFF
1	0C00-11FF
2	1200-17FF
3	1800-1DFF
4	1E00-23FF
5	2400-29FF
6	2A00-2FFF
7	3000-35FF

On top of this, we need to know that:

PMODE0	uses 1 page.
PMODE1/2	uses 2 pages.
PMODE3/4	uses 4 pages.

CLOADM is obviously the command required to re-load a previously CSAVEMed file, but where to save from?

Assuming for the sake of argument that you're starting with page 1, the following table shows the locations to save:

PMODE	Command
0	CSAVEM "fred",&H600,&HBFF,&H600
1 or 2	CSAVEM "fred",&H600,&H11FF,&H600
3 or 4	CSAVEM "fred",&H600,&H1DFF,&H600

And finally

To round things off, just a few words about GET and PUT. The Dragon manual treats these in a very disdainful manner, and indeed would seem to suggest that the largest screen area that could be GOT (why don't BASIC keywords have past and future tenses?!) and PUT anywhere, in the highest resolution mode, is about 80 by 75 pixels. Not a great deal.

However, all we need to know about any pixel in the highest resolution screen (just 2 colours to play with, remember) is whether that pixel is on or off. Thus one byte can store information about 8 different pixels.

Therefore, to read an entire screen in PMODE4 requires some (256*192)/8 bytes, or 6K. If you believed the manual, it would require almost a quarter of a million bytes!

The following program demonstrates this technique by reading an entire screen (which does take a little while in BASIC), waiting for a key to be pressed, and then PUTting it back to the screen again.

```
100 PMODE4:PCLS:SCREEN1,0
110 FORI=1TO191STEP2:FORJ=1TO255STEP2:PSET(J,I):
    NEXTJ,I
120 DIM A(1250)
130 GET (0,0)-(255,191),A,G:REM SAVE FULL GRAPHIC
    DETAIL
140 PCLS
150 A$=INKEY$:IFA$=""THEN150
160 PUT (0,0)-(255,191),A,PSET
170 A$=INKEY$:IFA$=""THEN170
```

So, using this technique, 2 or 3 pages can be saved in BASIC, and still leave room for a reasonable program to manipulate it all.

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ISBN 0-7156-1788-5

9 780715 617885

Duckworth
The Old Piano Factory
43 Gloucester Crescent, London NW1

ISBN 0 7156 1788 5
IN UK ONLY £2.95 NET

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