

DRAGON

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This document presents a summary of how to use the program DRAGON.EXE distributed from the Davis Associates, Inc. internet web site.

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Running DRAGON

DRAGON is a DOS (IBM PC compatible) program that displays multicolor sequences of interlocking Dragon curves on the screen in graphics mode and can be conditioned to produce sound proportional to the instantaneous display. It can be run "as is," in which case the display will be parametrized by a set of default values, or the display can be tailored to individual tastes by using the DOS environment variable DRAGON. Instructions for doing so follow. We recommend that you first run DRAGON using the default parametrization before you attempt customization.

To run DRAGON, make sure that DRAGON.EXE is in the current directory, or that the directory in which DRAGON.EXE is stored is on the directory path. Then, simply enter

DRAGON

at the DOS prompt.

To terminate DRAGON and return to the DOS prompt, enter

control-c

That is, depress the "control" and the "c" keys simultaneously.

It may be necessary to use the DOS environment variable DRAGON to set the first four DRAGON parameter values to correspond to the characteristics of your display if you find that the display does not function properly. Details are given in the description of the DRAGON environment variable parameters below.

What DRAGON does

Program DRAGON displays, one after the other, Dragon curves corresponding to all 2^N permutations of the N foldings required to construct an N-th order Dragon curve. (See the Davis Associates, Inc. internet web site for further information).

While the overall shape of each N-th order Dragon curve depends upon the specific sequence of N folds required to make it, it is always true that four like Dragon curves starting from the origin in four orthogonal directions (e.g., left, up, right, down) fit, or interlock, together perfectly. DRAGON illustrates this by displaying four interlocked copies of each unique Dragon curve in four different colors chosen at random. An index corresponding to the permutation of the N folds being illustrated can be displayed (DRAGON environment variable, parameter 14).

Program DRAGON can also generate sound proportional to the instantaneous writing position on the screen as the Dragon curves are being drawn (DRAGON environment variable, parameter 15). The computer's internal speaker is used so that no sound card is required.

Customizing DRAGON

DRAGON can be customized by specifying parameter values that override internal defaults using the DOS environment variable DRAGON. Parameters are separated by at least one blank, or by a comma and optional blanks. A parameter that is not to be altered, that is, for which the internal default value is to be used, should be specified by a pair of commas, with or without intervening blanks. Default values are assumed also for parameters beyond the end of the specified list. For example, the following statement issued at the DOS prompt prior to running DRAGON.EXE

```
SET DRAGON = , , , 1.45 12, ,0.1
```

sets parameter 5 = 1.45, parameter 6 = 12 and parameter 8 = 0.1. The internal default values will be used for parameters 1 - 4, 7, and 9 - 18.

To restore the entire set of default parameter values, simply enter

```
SET DRAGON
```

at the DOS prompt.

Summary of DRAGON parameters

No.	Meaning
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- | | |
|-----|------------------------------------------------------|
| 1. | The graphics display mode. |
| 2. | Vertical pixel resolution. |
| 3. | Horizontal pixel resolution. |
| 4. | Number of attributes available for color assignment. |
| 5. | Physical aspect ratio correction factor. |
| 6. | Dragon curve order. |
| 7. | Order of Dragon curve variation presentation. |
| 8. | Nominal Dragon curve segment length. |
| 9. | Dragon curve variation display repeat factor. |
| 10. | Number of Dragon curve variations to be displayed. |
| 11. | Completed Dragon curve display hold time seconds. |
| 12. | Loop count controlling Dragon curve display speed. |

13. Selects display border/no border.
14. Selects display of Dragon curve variation number.
15. Controls generation of tone, or tones.
16. Sets the tone tempo, or rate.
17. Controls the tone sustain (Legato, Normal, Staccato).
18. Controls the time allotted to each tone.

DRAGON parameters in detail

Further information on the first four parameters, which relate to the characteristics of the display, can be found under *Graphics display characteristics* below.

No.	Default	Meaning
1.	9	The graphics display mode as defined by MS-QBASIC.
2.	350	Vertical pixel resolution. I.e., number of active horizontal lines in the display. Must be set to the actual value for the display for proper results.
3.	640	Horizontal pixel resolution. Must be set to the actual value for the display for proper results.
4.	16	Number of attributes available for color assignment. Must not be less than 4.
5.	1.39	A factor to be applied to the vertical direction to render the Dragon curves in a physical 1:1 aspect ratio on the screen. ¹
6.	9	The order (mathematical) of each Dragon curve. That is, the exponent of 2 that specifies the number of segments in each Dragon curve. In the default case, each curve will contain $2^9 = 512$ segments.

¹ To determine a precise value for parameter 5, run DRAGON with parameter 5 equal to 1 (no aspect ratio correction) and a large value for parameter 8. For example, try setting parameter 8 to 2. Use a ruler to measure the actual physical height and width of the lattice on which the Dragon curve is drawn. From the ratio of these measurements, determine the multiplicative factor to be applied to the vertical direction to produce a square lattice. Use this value for parameter 5 and restore parameter 8 to its original value.

7. 4 A parameter that specifies the order of presentation of the Dragon curve variations as follows:

0 = Natural order
1 = Random order
2 = Bit-reversed order
3 = Gray code order
4 = Anti-Gray code order

Each variation of an N-th order Dragon curve (having 2^N segments) corresponds to the sequence of N folds required to make it. Because each fold can be made in either of two directions, there are 2^N variations of an N-th order Dragon curve. If these variations are represented in binary by the integers 0 through $2^N - 1$, parameter 7 specifies the order in which the variations are to appear.

8. 0.2 The nominal length in inches of each Dragon curve segment assuming an idealized physical display area of 10" x 10". The actual segment length will depend upon the characteristics of the display. Does not include the effects of parameter 5.

To increase or decrease the overall scale of the Dragon curves, simply increase or decrease this parameter value.

9. 1 DRAGON displays four copies of each Dragon curve variation, in unique colors, to illustrate their two-dimensional lattice-filling property. That is, four curves fit perfectly together and, if extended indefinitely, would fill the entire plane.

This parameter selects the number of times the group of four nested curves is displayed, in continuously changing colors, before moving on to the next Dragon curve variation.

If less than or equal to zero, the zeroth Dragon curve variation (the original "classical" Dragon curve) will be displayed in continuously changing colors indefinitely. Remember that DRAGON can be terminated at any time by entering <control-c>.

10. 0 The number of Dragon curve variations to be displayed. If less than or equal to zero (the default), variations will be displayed indefinitely, eventually repeating. Remember that DRAGON can be terminated at any time by entering <control-c>.

11. 1 The number of seconds that the completed Dragon curve variation, after any repeating induced by parameter 9, remains displayed before moving on to the next variation.
12. 1 A loop count used to control the speed of the Dragon curve display. Must be greater than zero. The default value of 1 results in the greatest possible speed.
- Values greater than 1 are used to slow the display on very fast systems.
13. 0 By default, DRAGON displays a border around the edge of the screen. Set this parameter to a non-zero value to disable drawing of the border.
14. 1 By default, DRAGON displays the current Dragon curve variation number in the upper left corner of the screen. Set this parameter to zero to disable display of the variation number.
- Note that the Dragon curve variation number uniquely identifies the Dragon curve variation (sequence of folds), independent of the order (parameter 7) in which the variations are displayed.
15. 0 Controls the generation of a tone, or tones, proportional to the instantaneous position of the "leading edge" of the Dragon curve being displayed as follows:
- 0 = no tone generated (default).
 - 1 = tone proportional to the horizontal position.
 - 2 = tone proportional to the vertical position.
 - 3 = alternating tones proportional to the horizontal and vertical components of the position.
- Error if a value outside this range is specified.
- Note that the generation of sound (non-zero parameter value) will slow down the display considerably.
16. 255 Sets the tempo, or rate, at which tones will be played. The valid range of this parameter is 32 - 255. The greater the value, the more rapidly the tones are played.
- Note that sound is enabled with parameter 15.

17. 0 Controls the fraction of the time allotted for each tone during which the tone is actually generated as follows:

0 = Legato (default). Each tone sustained for its full allotted time.

1 = Each tone sustained for 7/8 of its allotted time.

2 = Staccato. Each tone sustained for 3/4 of its allotted time.

Error if other value specified. Note that sound is enabled with parameter 15.

18. 64 Controls, inversely, the time allotted to each tone. Valid range is 1 - 64. Error if outside this range.

If n is the parameter value, the time allotted to the tone is 1/n of the maximum possible set by parameter 16. Note that sound is enabled with parameter 15.

Graphics display characteristics

The following table may be helpful in resolving difficulties with the display. The display mode numbering convention adopted for use by DRAGON is the same as used by Microsoft QBASIC.

Mode	Vert res	Horiz res	Attrib	Comments
1	200	320	4	
2	200	640	16	
3	348	720	4	Monochrome. Use attrib = 4.
4	400	640	1	Use attrib = 4.
7	200	320	16	
8	200	640	16	
9	350	640	4,16	Attrib depends on adapter memory.
10	350	640	4	
11	480	640	2	Use attrib = 4.
12	480	640	16	

13	200	320	64	
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Mode is an integer that specifies the graphics mode. The vertical and horizontal resolution define the number of pixel positions available in the two directions. The number of attributes is the number of colors that can be selected from the color palette without redefining the relationship between the available colors and attributes.

The default values assumed by DRAGON that define the graphis display are:

Mode = 9
V res = 350
H res = 640
Attrib = 16

If these are not appropriate for your display, use the DOS environment variable DRAGON to specify the correct values before running DRAGON.EXE. For convenience, a SET DRAGON command with the proper values for the display can be added to the AUTOEXEC.BAT file so that DRAGON will run properly whenever the computer is booted.

For more details and other possible selections, see "Screen modes" under the "SCREEN statement" in QBASIC help.