



ESDU 06005

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Dwell-Rise-Fall-Dwell cam laws. Computer program

**Associated software: VIEWpac W0605
ESDUpac A0605**

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The Mechanisms Committee, which first met in 1975, is continuing the work that previously was the responsibility of the former Gearing and Mechanisms Committee, which first met in November 1964. Like the earlier Committee it has the cooperation of many engineers and scientists in industry, research establishments and universities from whom much assistance and information is being received.

DWELL-RISE-FALL-DWELL CAM LAWS. COMPUTER PROGRAM

Data Items in the series on Dwell-Rise-Fall-Dwell cam laws are:

- Item 06002 ^[1] - Sections 1 to 8: segments having equal rise and fall periods,
- Item 06003 ^[2] - Sections 9 to 13: segments having asymmetric rise and fall periods,
- Item 06004 ^[3] - Sections 14 to 23: examples,
- Item 06005 ^[4] - Computer program.

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DWELL-RISE-FALL-DWELL CAM LAWS. COMPUTER PROGRAM

1. INTRODUCTION

This Data Item provides guidance on the use of computer programs, W0605 and A0605, to aid the selection of cam laws suitable for symmetric Dwell-Rise-Fall-Dwell (DRFD) follower motions, *i.e.* those having equal rise and fall periods. They include motions having an intermediate constant-velocity (V) component in both the rise and fall actions (DRVFD). The program also analyses the complete follower motion. See ESDU 06002^[1] for these types of symmetric motion, including the converse DFRD and DFVRD follower actions.

An associated Data Item, ESDU 06003^[2] refers to asymmetric follower motions of the DRFD, DFRD, DRVFD and DFVRD types having unequal periods for the rise and fall actions. ESDU 06004^[3] contains examples to illustrate the application of these motions.

The current version of the computer program is restricted to symmetric DRFD and DRVFD rise and fall segments where values are entered for the cam segment angles and follower lift (or swing) as specified (positive) values. It is anticipated that future versions of the computer program will provide the ability to determine asymmetric motion segments including ones formed from blended profiles.

The theoretical background that describes alternative forms of the mechanism and follower motion, including definitions and terminology, is explained in Section 2 of ESDU 06002^[1]. The design procedures for deriving alternative types of blended motion are given in Sections 4 and 5 of ESDU 06002^[1]. Their use is illustrated by examples in ESDU 06004^[3].

Throughout this Data Item the description of follower motion is based on the presumption that it is cam driven. However, while the computerised procedure is applicable to all configurations of a disc cam mechanism driving either a translating or swinging follower, it can also be used to analyse any DRFD or DRVFD motion, whatever the type of input drive.

The current version of the computer program calculates the Dwell-Rise-Fall-Dwell (DRFD) motion of either a translating or swinging follower at specified intervals of input motion and is supplied in two executable forms:

- (i) a Winteracter[©] VIEWpac[†] program, W0605v##.EXE[‡] (described in Section 2),
- and (ii) a Microsoft[©] program, A0605v##.EXE[‡] (described in Section 3).

The type of follower motion required determines the input quantities necessary to produce the motion profile and run the program. It is strongly recommended that the Winteracter version of the program, W0605, is used since it allows data input files to be created from within the program by following descriptive screen prompts, or by using data imported via previously created files. When all motion data have been entered or edited, the program automatically sets the values of the numerous identifiers and kinematic parameters that define the motion data in the input file. Section 4.1 provides a list of all input file parameters.

[†] The term VIEWpac describes the Winteracter version of an executable program (see ESDU 04013^[12]). Winteracter is a trade name registered by Interactive Software Services Limited.

[‡] The symbols ## refer to an encoded version number of the program, *e.g.* if the version number is 1.0 then ## is 10. Thus the full name of Version 1.0 of the executable program W0605 will be W0605v10.EXE and must be used when accessing the file.

Section 2 of this Item provides guidance on the use of the Winteracter version of the computer program, W0605, including the procedure for use of the graphical user interface required to enter and edit all input data, to run an analysis and access the output data files and graphical plots. **Section 3** provides similar guidance on the use of Microsoft[®] computer program A0605. **Section 4** defines the content and form of the input files associated with programs W0605 and A0605. A worked example includes sample input and output files from both programs and graphical output plots from program W0605. **Section 5** gives guidance on the effective use of the computer program for designing mechanisms with DRFD or DRVFD follower motion.

1.1 Type of Follower Motion

The follower motion for the complete rise and fall segment may be defined in one of three ways, as a single cam law, by direct blending or by blending with an intermediate constant velocity (CV) component.

1.1.1 Single cam law

A single cam law is chosen for the complete rise and fall segment of the motion from the cam laws recommended for DRFD cams (see ESDU 06002^[1]). The five cam laws presented by the computer program are:

- Double Harmonic Motion (DHM)
- Triple Harmonic Motion (THM)
- 2-4-5 Polynomial motion
- 3-4-5-6 Polynomial motion
- 3-5-6-7-8 Polynomial motion

1.1.2 Direct blending

This method forms the complete rise and fall motion segment by blending two components of cam laws chosen in such a way that there is continuity of follower displacement, velocity and acceleration between the two components (see Sketches 4.1 and 4.2 of ESDU 06002^[1]). The blending process is accomplished in one of five ways, by:

- (a) ensuring continuity of jerk at the blend point,
 - (b) specifying the Blending Ratio,
 - (c) specifying the Acceleration Ratio,
 - (d) specifying the maximum follower velocity
- or by (e) specifying the maximum follower acceleration.

The cam laws for Components *N1* and *N2* are chosen from two distinct lists recommended for blending DRFD motions. The six cam laws presented by the computer program for Component *N1*, from the dwell to the blending point, are:

- Cycloidal motion
- Modified Trapezoidal Acceleration motion
- Modified Sinusoidal Acceleration motion
- Triple Harmonic Modified Trapezoidal Acceleration motion
- 3-4-5 Polynomial motion
- 4-5-6-7 Polynomial motion

and the three cam laws presented by the computer program for Component *N2*, from the blending point to maximum displacement at the reversal of follower velocity, are:

- Simple Harmonic Motion (SHM)
- Constant-Cosine-Constant Acceleration motion (CCCA)
- Double Harmonic Motion (DHM)

1.1.3 Blending of two components of cam laws with an intermediate constant velocity component

This method involves the insertion of an intermediate constant velocity component between Components *N1* and *N2* of a blended DRVFD motion (see Sketches 5.1 and 5.2 of ESDU 06002^[1]). The blending process is accomplished in one of two ways:

- (a) by specifying the start and end cam angles of the constant velocity component,
- or (b) by specifying both the acceleration ratio and the cam angle subtended by the constant velocity component.

The cam laws are selected from those given for Components *N1* and *N2* in Section 1.1.3.

1.2 Program Application

General instructions for running the computer programs together with the required input data are described. However, if you do have any difficulty in using this program please contact ESDU and we will do all that we can to assist you to overcome the problem.

Every reasonable effort has been made to ensure that the program performs the intended calculations satisfactorily. However, in common with other providers of software, no representation as to the suitability or fitness of the program for any particular purpose is made and no liability for any loss occasioned by any persons as a direct or indirect result of use of the program whether arising from negligence or otherwise can be accepted. In no event shall ESDU or any individuals associated with the development of the program be liable for any damages, including loss of profit or consequential loss, arising out of or in connection with the program.

2. GUIDANCE ON USE OF PROGRAM W0605

This section includes a comprehensive guide to the choice of values for entry to the computer program, W0605, and should be read in conjunction with Section 4 when entering data[†]. The units defined for program input, given in Section 4.1, must be used. The output from program W0605 is described in Section 2.4. Design guidance, including recommendations for efficient use of the program, is contained in Section 5.

2.1 Winteracter VIEWpac Program W0605

This version of the program, named W0605v##.EXE, provides a user-friendly Winteracter Windows graphical user interface (see ESDU 04013^[12] and ESDU 04014^[13]) and is for use on a computer running a Microsoft Windows 95 (or later) operating system. Various other files, including salflibc.dll, help_0605.hlp, help_0605.cnt and swiss.chr, required to run this version of the program, are also provided.

This version of the program:

- allows data to be created from within the program following descriptive screen prompts,
- provides comprehensive embedded on-line help for every quantity, available from both the *Help* menu included in the Tool Bar options (see Sketch 2.2) and via the *F1* key,
- allows program runs to be launched from within the interface,
- provides a text editor that may be used to view, edit and print output files (see Section 4.2),
- allows graphical and hardcopy plots of the motion characteristics of the follower.

2.2 Running Program W0605

The Winteracter program is run by double clicking on the executable file, W0605v##.EXE, located within the installation directory containing the program and associated files (see ESDU 04013^[12] and ESDU 04014^[13]).

The opening and main screen of the program, shown in Sketch 2.1, presents:

- tool bar icons (illustrated and described in Sketch 2.2),
- five input groups: *Titles*, *Files*, *Segment rise and fall periods*, *Follower type* and *Motion data*,
- two output groups; *View* and *Plot*,
- four self-descriptive buttons: *About*, *Help*, *Run* and *Exit program*.

Tool bar icons

The *New* icon allows data to be input directly into the various data sections of the program.

Data from existing files are entered into the various forms of the program with the use of the *Open* icon, which when activated presents a list of the existing files.

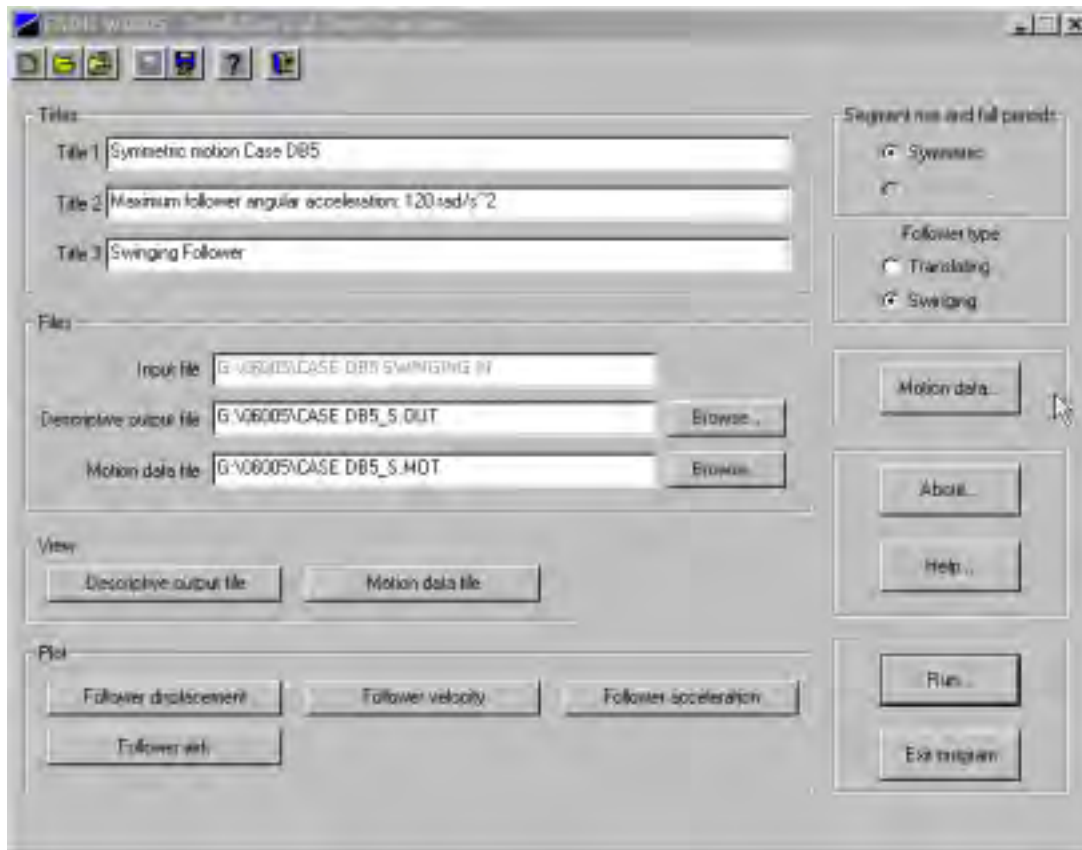
The *Close* icon closes the data file but does not close the complete program.

The *Save* icon is only active, *i.e.* ungreyed as shown in Sketch 2.2, when data has been changed within one of the data forms from a previously loaded file. Similarly the *Save As* icon is only active,

[†] It is noted that the executable programs W0605v##.EXE and A0605v##.EXE use identical input parameters, such that the input file (see Section 4.1) can be used directly by either program. The symbols ## refer to an encoded version number of the program, *e.g.* if the version number is 1.0 then ## is 10. Thus the full name of Version 1.0 of the executable program W0605 will be W0605v10.EXE and must be used when accessing the file.

i.e. ungreyed as shown in Sketch 2.2, when sufficient data are present within the data forms. These data files are directly compatible with the data required by Program A0605v##.EXE (see Section 3).

The *Help* and *Exit* program icons are self explanatory.



Sketch 2.1 Main screen of Winteracter program W0605



Sketch 2.2 Tool bar icons

Input groups

The *Titles* group allows up to three descriptive title lines to be entered.

The *Files* group holds the names of the input and two output data files. A click on one of the *Browse* buttons presents a standard dialogue box that can be used to change the file name or directory to which the output will be written.

To select either *Symmetric* or *Asymmetric* in the *Segment rise and fall periods* box, two radio buttons are presented near the top right-hand corner of the main screen window. Only *Symmetric* motion is available in this Version 1.0 of the program so the *Asymmetric* option is unavailable and therefore greyed.

The choice between *Translating* or *Swinging* follower motion is presented via the two radio buttons in the *Follower type* group (see ESDU 82024^[7] for guidance).

Click the *Motion data* button to gain access to the forms for entry of the specific data relating to follower motion.

Output groups

Once the data are entered, but prior to a *Run*, the options within the *View* and *Plot* sections on the main menu are unavailable and therefore greyed. To analyse the follower motion data specification, click the *Run* button on the main program screen (see Sketch 2.1). A dialogue box presents a summary of the success (or otherwise) of the analysis and, if successful, the *View* and *Plot* options become available.

Click the *Descriptive output file* and *Motion data file* buttons in the *View* group to access the (ASCII) text files containing output from the program (see Section 2.4). Examples of these files are shown in Sections 4.2.2 and 4.2.3, respectively. These files may be edited and printed.

To view graphical output, select the *Follower displacement*, or *Follower velocity*, or *Follower acceleration* or *Follower jerk* buttons in the *Plot* group. Each of these motions is shown plotted against cam shaft angle. Examples of these plots are shown in Sections 4.2.4, 4.2.5, 4.2.6 and 4.2.7, respectively. These files may be printed or exported.

2.3 Motion Data

Click on the *Motion data...* button on the main screen of the program (see Sketch 2.1) to display the motion data screen shown in Sketch 2.3.

W0605 - Motion data - Symmetric rise and fall periods

Type of follower motion:

- ☐ Single cam law (SL)
- ☒ Direct blending (DB)
- ☐ Blending with Constant Velocity (CV) component

Follower displacement:

Follower swing degree

Cam angle displacement:

Segment angle degree

Rise starts occurs at degree

Maximum swing occurs at degree

Dwell segment starts at degree

Cam speed rev/min

Calculation interval degree

Enter/edit ancilliary motion data...

OK Rise/Fall segments - Case DB5 Cancel

Sketch 2.3 Motion data screen