

J R C T E C H N I C A L R E P O R T S

GELINA Stability program (GESTA)

*Technical description of the
GESTA application developed
at IRMM*

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GELINA Stability program (GESTA)

Introduction

The GESTA (GELINA Stability) program is a LabVIEW application to analyse and document the long term stability of GELINA. When GELINA is in operation a number of instrument parameters are monitored. This is done by the 'GELINA' program which is a LabVIEW application developed at IRMM by J. Van Gils. The parameters that are monitored are:

- The total number of pretriggers
- The total number of start pulses
- The effective current (referred to as I) which is deduced from the total charge in a given time period
- The neutron output which is monitored by three BF3 counters (referred to as CM1, CM2 and CM3) and two ionization chambers (referred to as CMN and CMS)

The data that are collected and used for the monitoring are also saved in a file. On a weekly basis this file is manually copied to a folder and renamed using the first date of the period (week). These are the monitor files. The purpose of GESTA is to use the data from these monitor-files to analyse the stability of the accelerator and neutron production over a user-defined period. This includes a graphical representation of the data and a statistical analysis of the data. In addition the results can be saved to a file.

The monitor files

The monitor files are tab-separated text files with a *.DAT extension. They include the following data:

- Date
- Time
- Ports
- Current
- Pretriggers (T_p)
- Start pulses (T_0)
- CM1 counts
- CM2 Counts
- CM3 counts
- CMN counts
- CMS counts

Data for the monitor files is collected over periods of 60 seconds. For the T_p , T_0 , CM1, CM2, CM3, CMN and CMS the numbers are accumulated counts for each period. The current value is the last value measured in the period.

An example of the first lines of a monitor file can be found in Appendix A.

For GESTA to be able to identify date and time from the monitor files it is important that the date and time format is fixed. For this reason the 'GELINA' application has been modified to ensure that the date format is like: 23.Jan.11 and the time is like: 18:35:59. This format was chosen to ensure compatibility with most of the existing monitor files.

GESTA functions and features

The function of GESTA is to extract data from one or more monitor files. The extracted data is used to calculate average values and standard deviations and to graphically indicate the stability over time for a number of parameters. The parameters are:

- Frequency
- Current
- CM1
- CM3
- CMN
- CM3/Frequency
- Current/CM3
- CM1/CM3
- CMN/CM3

GESTA filters out data points that are not within a tolerance given by the user. In order to do this the user has to define the Expected Average values and Tolerance values.

When the filtering is done the results are shown in graphs, such that the user can see in which periods the parameters were within the given tolerances. The filtering can be done in two ways, either based on the individual parameters or based on a combination of selected parameters. In individual mode the data are filtered by the individual parameter. In combined mode all the selected criteria are taken into account (like an AND-function). In this way the filtered data fulfil all selected criteria. Note that if no criteria are selected in combined mode no filtering takes place. This gives the possibility to see the complete data set on graphical charts.

A calculation of the average and relative standard deviation on the filtered values is performed. To give the user the full picture and to facilitate the definition of expected average values, calculations on the complete dataset are performed and displayed (named Raw average and Raw relative standard deviation).

The Expected Average values given by the user are also used for the calculations of the relative stability (the data points are relative to the Expected Average values).

The maximum period of time over which the stability will be checked is defined by the monitor file(s) the user chooses to load. Within this period the user can restrict the period to be taken into account for the calculations by selecting a period-start and –end. In addition, the user can choose to group a number of data points. By doing so the average of these data points is taken. This decreases the amount of data points for the charts and will speed up the calculations. Especially when a long period (weeks or even months) is being evaluated it is not desirable to have a resolution of 1 minute anyway.

Calculations

The calculations performed by GESTA are defined as follows:

Variable	Symbol	Unit	Expected average (input)	Tolerance (in %) (input)	Calculated average	Calculated relative standard deviation (in %)	Raw average	Raw relative standard deviation (in %)
Current	Y1	nA	μ_{Y1}	σ_{Y1}	<Y1>	R<S _{Y1} >	<Y1>	R<S _{Y1} >
Pulse frequency	Y2	s ⁻¹	μ_{Y2}	σ_{Y2}	<Y2>	R<S _{Y2} >	<Y2>	R<S _{Y2} >
Count rate for CM1	Y3	s ⁻¹	μ_{Y3}	σ_{Y3}	<Y3>	R<S _{Y3} >	<Y3>	R<S _{Y3} >
Count rate for CM3	Y4	s ⁻¹	μ_{Y4}	σ_{Y4}	<Y4>	R<S _{Y4} >	<Y4>	R<S _{Y4} >
Count rate for CMN	Y5	s ⁻¹	μ_{Y5}	σ_{Y5}	<Y5>	R<S _{Y5} >	<Y5>	R<S _{Y5} >
Current/CM3	Y6	nAS	μ_{Y6}	σ_{Y6}	<Y6>	R<S _{Y6} >	<Y6>	R<S _{Y6} >
CM1/CM3	Y7		μ_{Y7}	σ_{Y7}	<Y7>	R<S _{Y7} >	<Y7>	R<S _{Y7} >
CMN/CM3	Y8		μ_{Y8}	σ_{Y8}	<Y8>	R<S _{Y8} >	<Y8>	R<S _{Y8} >

The quantities listed in the file produced by the monitoring system are defined as:

Date	: X1
Time	: X2
Shutter status	: X3
Current (in nA)	: X4
Number of pretriggers (T _p)	: X5
Number of pulses (T ₀)	: X6
Number of counts registered by CM1	: X7
Number of counts registered by CM2	: X8
Number of counts registered by CM3	: X9
Number of counts registered by CMN	: X10
Number of counts registered by CMS	: X11

The measurement time per point is denoted by T and is fixed at 60 seconds.

Before representing the data, the data is grouped based on a grouping number provided by the user. All data points are averaged over the total measurement time of the grouped data. The average values obtained from the grouped data are represented by the symbol U, using the same numbering.

From the grouped values the following quantities are calculated:

Current	: Y1 = U4
Pulse frequency	: Y2 = U6/T
Count rate for CM1	: Y3 = U7/T
Count rate for CM3	: Y4 = U9/T
Count rate for CMN	: Y5 = U10/T
Count rate CM3/Pulse frequency	: Y6 = Y4/Y2
Current / Count rate CM3	: Y7 = Y1/Y4
Count rate CM1 / Count rate CM3	: Y8 = Y3/Y4
Count rate CMN / Count rate CM3	: Y9 = Y5/Y4

For each of these quantities $Z \in \{Y1, \dots, Y9\}$ the user completes a table with the expected average value μ_Z and tolerance σ_Z . Based on the expected average value a relative value for each observation of the quantity Z is calculated. For each measurement Z_k of the quantity Z the relative value R_{Z_k} is given by

$$R_{Z_k} = \frac{100(Z_k - \mu_Z)}{\mu_Z}$$

The sub index k refers to the k^{th} measurement of quantity Z , with $k = (1, \dots, n)$ and n is total number of grouped data points for each quantity

From the measured points Z_k of each quantity Z the average value $\langle Z \rangle$ and standard deviation $\langle s_Z \rangle$ are derived. The average value $\langle Z \rangle$ and relative standard deviation $R\langle s_Z \rangle$ deduced from the observed values are defined by:

$$\langle Z \rangle = \left(\sum_{k=1}^n Z_k \right) / n \quad \text{and} \quad R\langle s_Z \rangle = \sqrt{\sum_{k=1}^n (Z_k - \langle Z \rangle)^2 / (n-1)} * (100 / \langle Z \rangle)$$

where Z_k are the registered values and n is the total number of data points that have been registered for Z . The data included in the calculations fulfil two conditions:

1) Period of interest defined by the user and

2) $|R_{Z_k}| \leq \sigma_Z$

Note: Condition 2 is not taken into account for the calculations of the Raw Average and the Raw relative standard deviation.

Calculations (divisions) performed with zero as value will not result in a number, but will be indicated as either Inf (Infinite) or NaN (Not a Number).

Inputs and Outputs

Inputs

- Path and name of monitor file(s) to be used for the calculations. The files have a *.DAT extension. The user selects the monitor files that are needed. Note that these files have to be in the same folder.
- Period of interest defined by a start- and a stop-time (maximum period defined by the monitor-files that are selected)
- Expected average values for Current, Frequency, CM1 count rate, CM3 count rate, CMN count rate, CM3/Frequency, Current/CM3, CM1/CM3 and CMN/CM3.
- Tolerances for Current, Frequency, CM1 count rate, CM3 count rate, CMN count rate, Current/CM3, CM1/CM3 and CMN/CM3.
- Number of data points to be grouped (e.g. 10 points cover a measurement period of 10 minutes).
- Individual or combined tolerance selection
- For the combined tolerance checkboxes are used to choose the variable(s) to take into account.

Outputs

- Calculated stability figures
- Graphs divided into four tabs:
 1. Absolute Outputs, four charts:

- A. Operating frequency
 - B. Current
 - C. Monitor CM1 and CM3 (two independent Y-axis)
 - D. Monitor CMN
2. Ratio of Absolute Outputs, four charts:
- E. CM3/Operating frequency
 - F. Current/CM3
 - G. CM1/CM3
 - H. CMN/CM3
3. Relative Outputs, four charts:
- I. Relative Frequency
 - J. Relative Current
 - K. Relative CM1 and CM3 (two independent Y-axis)
 - L. Relative CMN
4. Ratio of Relative Outputs, four charts:
- M. Relative CM3/Frequency
 - N. Relative Current/CM3
 - O. Relative CM1/CM3
 - P. Relative CMN/CMN

Common for the graphs is that all data are averaged over the number of data points to be grouped and, except for the current which is a single measurement, also over the measurement time (60 seconds).

- Arrays with the data-values used for the calculations:
 - A. raw text data from file
 - B. Cleaned-up numeric data
 - C. Numeric data after period selection and grouping
 - D. As C but values per second and with the calculated ratio data.
- Output file containing:
 - Date and Time
 - Comments
 - List of used monitor files
 - Period-start and –stop
 - Grouping number
 - Overall stability figures

The output file is a tab-separated text file with an .xls-extension as default. An example is shown in Appendix B.

LabVIEW Application

GESTA is developed using LabVIEW 2010 and the final program is a LabVIEW application (exe-file). The program must be installed using the GESTA Installer. This ensures a correct installation and places a shortcut icon on the desktop. The installer also installs NI LabVIEW Run-Time Engine 2010 which contains libraries and other files necessary to execute the application. The shortcut icon for the data Sorter is shown in Figure 1.



Figure 1. Icon

User Interface

The user interface of GESTA is divided into six tabs:

1. General
2. Absolute Outputs
3. Absolute Ratio Outputs
4. Relative Outputs
5. Relative Ratio Outputs
6. Raw data

The General tab, shown in Figure 2, is the start-up tab. This is where the user selects which monitor files to load, defines the period, selects grouping number, selects tolerance type and enters the Expected averages and tolerances. After calculations have taken place the overall stability figures are shown here.

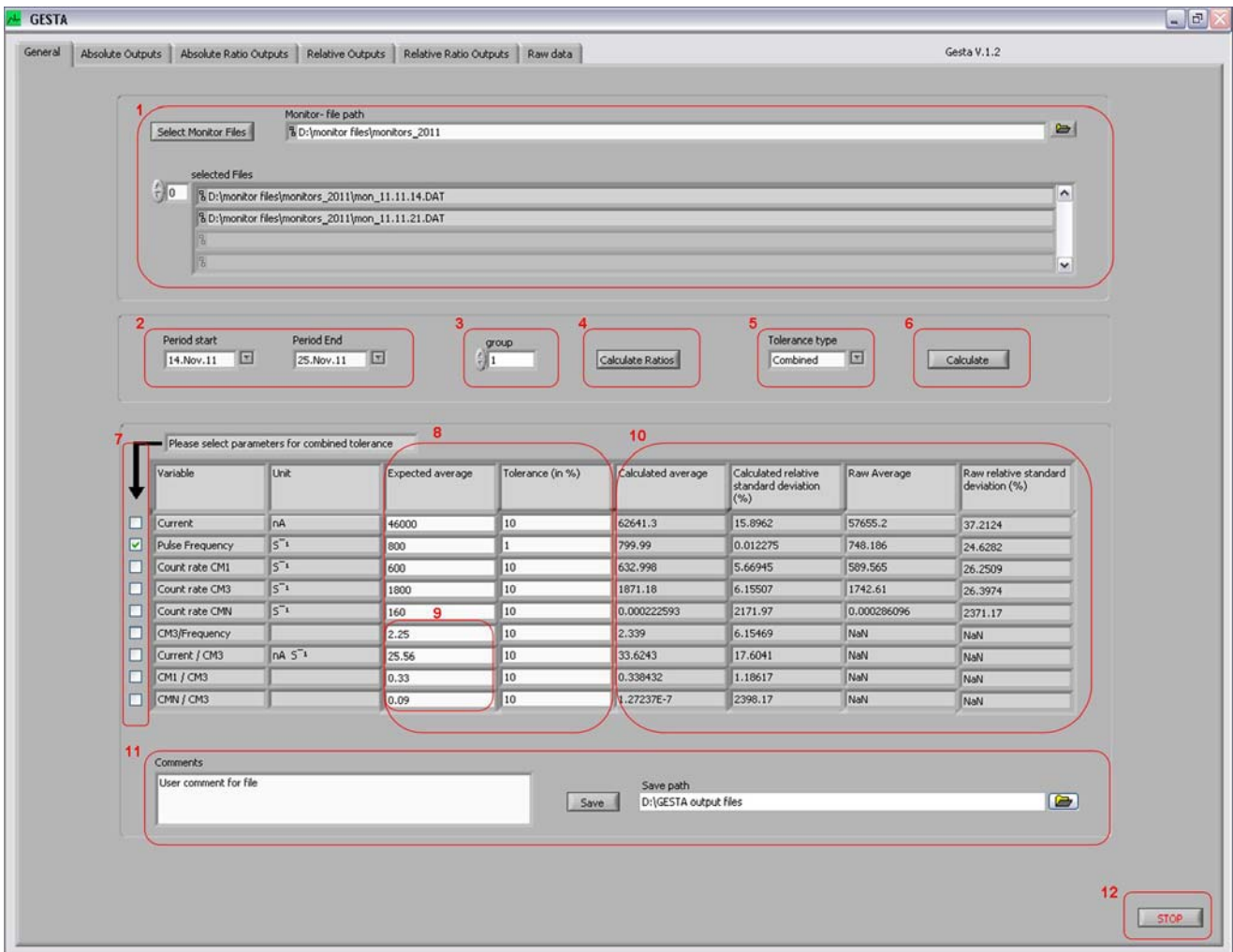


Figure 2. General tab

Description of the various parts of the General tab:

1. Monitor files selection. When the 'Select Monitor Files' button is pressed the user can browse to and select the monitor file(s) that should be used for the calculations. If the 'Monitor-file path' has been filled in, either by typing or by browsing using the button to the right of the field, the browsing for files will start at this location. The selected file(s) are listed below the selection part. A maximum of four files can be shown at a time. If more are selected, either the index selector to the left or the scrollbar to the right can be used for scrolling the total list.
2. Selection of period of interest. The start- and end-date can be selected from the drop down list with the possible dates (depending on the selected monitor files).
3. Number of data points to be grouped.
4. The 'Calculate Ratios' button is used if the user wants that the program calculates the ratios in field number 9 based on the user inputs already given, e.g. to calculate the 'CM3/Frequency' ratio based on the values given for CM3 and Frequency.
5. Selection of Tolerance type, either Individual or Combined.
6. When the 'Calculate' button is pressed the calculations for the data within the period of interest are performed. The results are displayed in the general stability table (see area 10), in the graphs and in the Raw data arrays. The 'Calculate' button can not be used before monitor files are loaded. This button has to be pressed when user inputs are changed (new monitor files, period of interest, grouping, Tolerance type, Selected variables for combined tolerance, Expected average values or Tolerance values) to account for the changes.
7. If the Combined Tolerance type is selected checkboxes appears to let the user select which variables to take into account.
8. User inputs of Expected average values and Tolerances.
9. The Expected average values for the ratios can either be calculated from the user inputs already given or be typed by the user.
10. General stability data as calculated on basis of the data files and user inputs.
11. File save area. When the 'Save' button is pressed, a pop-up window appears. This window asks the user to select path and file name. If the 'Save path' has been filled in, either by typing or by browsing using the button to the right of the field, the browsing will start at this location. The 'Save' button can not be used before calculations has taken place.
12. The 'Stop' button will terminate and close the GESTA application.

The next four tabs are for displaying the graphs. These are divided into Absolute Outputs, Absolute Ratio Outputs, Relative Outputs and Relative Ratio Outputs. The functionality of these tabs are similar, the Absolute Outputs tab is shown in Figure 3. All graphs have auto scaling for the Y-axis and all of the selected period is shown on the X-axis by default.

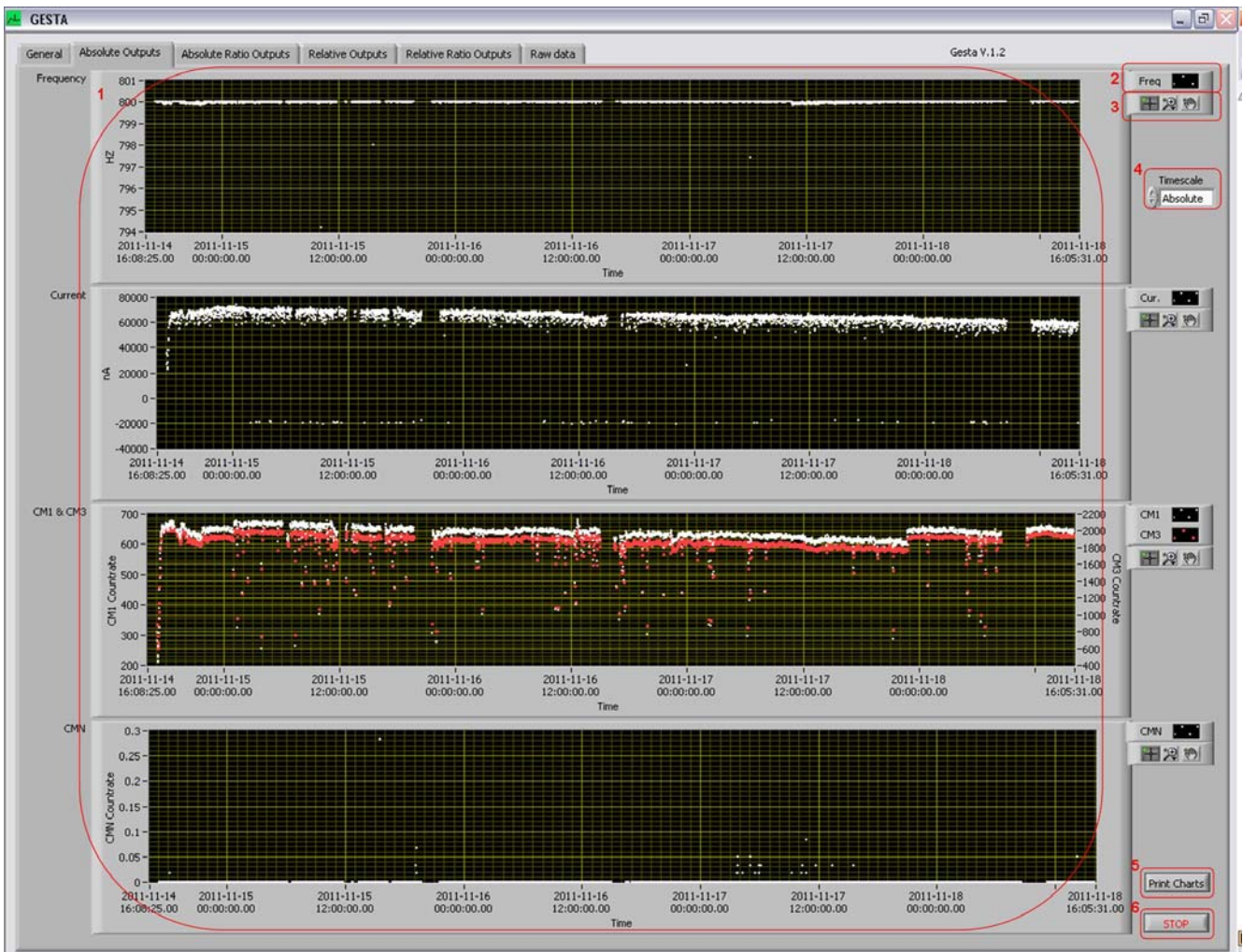


Figure 3. Absolute Outputs tab

Description of the various parts of the Output tabs:

1. Chart area.
2. Plot legend. Here the user can change the label, color, line style, point style etc. for each plot. From here it is also possible to export the plot-data to the clipboard or to Excel.
3. Graph Palette. This consists of three buttons which allows the user to move cursors (cursors will be described later), zoom into a specific area of the plot in different ways and to pan (scroll the display area).
4. Timescale selector. The user can choose between an absolute (date & time) and a relative (number of days) timescale on the x-axis.
5. By pressing the 'Print Charts' button the charts on the present tab can be printed. A standard print-window will open for printer selection.
6. The 'Stop' button will terminate and close the GESTA application.

Right clicking anywhere in a chart will open a pop-up window to select which items should be visible, add an annotation to a plot, clear the plot etc. From here it is possible to add cursors to the plots. This is done by clicking 'Visible Items' and selecting 'Cursor Legend'. By right-clicking in the cursor Legend window it is possible to create cursors that can either follow a plot or be placed freely. The X-Y values corresponding to the cursor placement are displayed in the Cursor legend window.

The Raw data tab is shown in Figure 4. Here it is possible to consult the data that has been used for the calculations. This can be used to clarify the calculation results. The data is presented in four arrays.

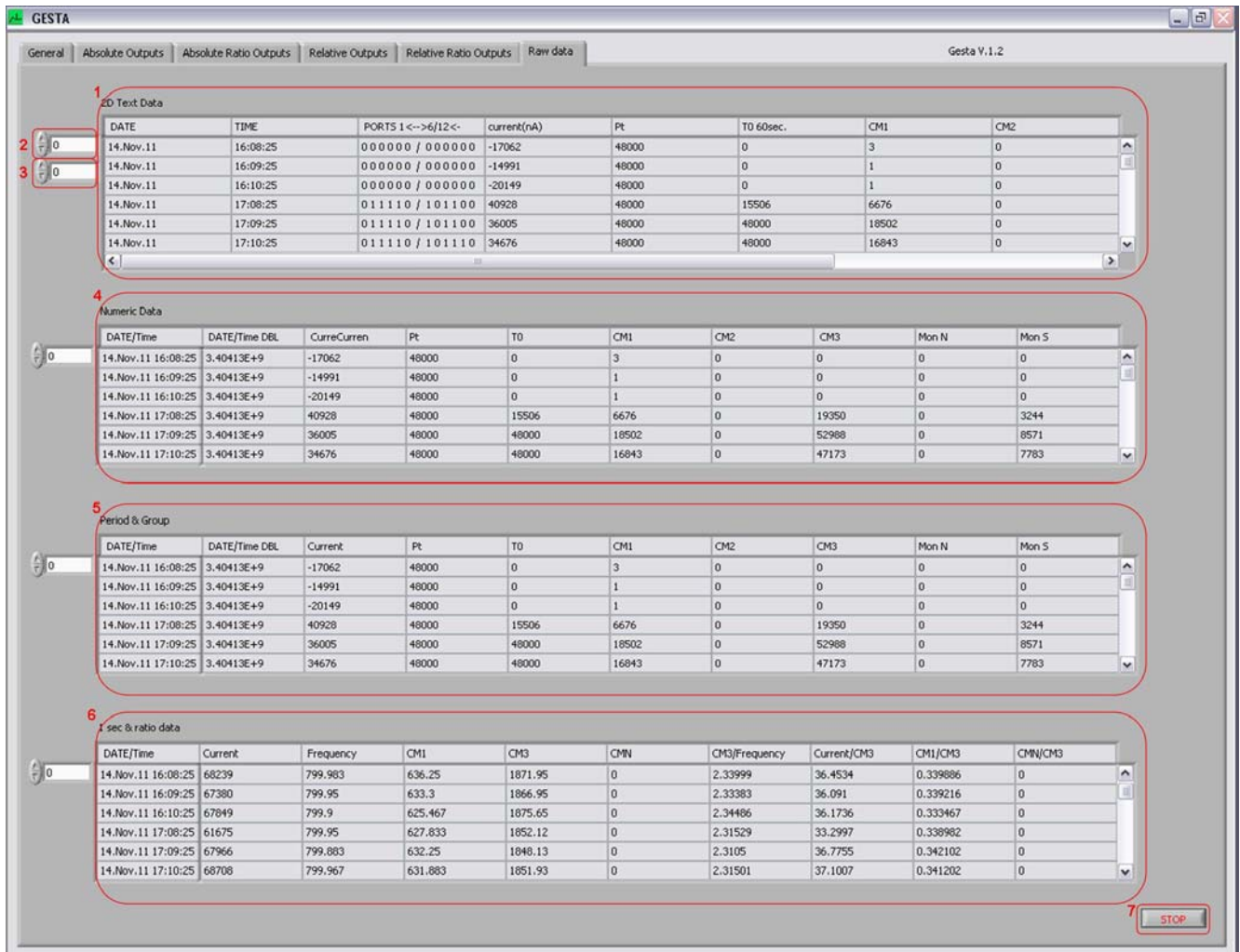


Figure 4. Raw data tab

Description of the various parts of the Raw data tab:

1. 2D text data. In this array the raw text data from the input files are shown.
2. Index display. To move up or down in the arrays the user can either use the index display or the vertical scroll bar to the right of the arrays. The index display can be used for giving in a specific line number or for scrolling by clicking the up- or down-button.
3. The 2D text Data array is horizontally too long to be displayed totally on the front panel. Therefore this array has a second index display and a horizontal scroll bar to enable the user to see all data
4. Numeric Data. This is numeric data after converting from the original text data. Data for the ports has been removed as it is not used for the calculations.
5. Period & Group. This is the numeric data that that has been used for the calculations, so grouped data for the selected period.
6. Sec & ratio data. This is the data after calculations, so values per second and ratio data.
7. The 'Stop' button will terminate and close the GESTA application.

Structure

The application is built using the State Machine pattern. The state diagram is shown in Figure 5.

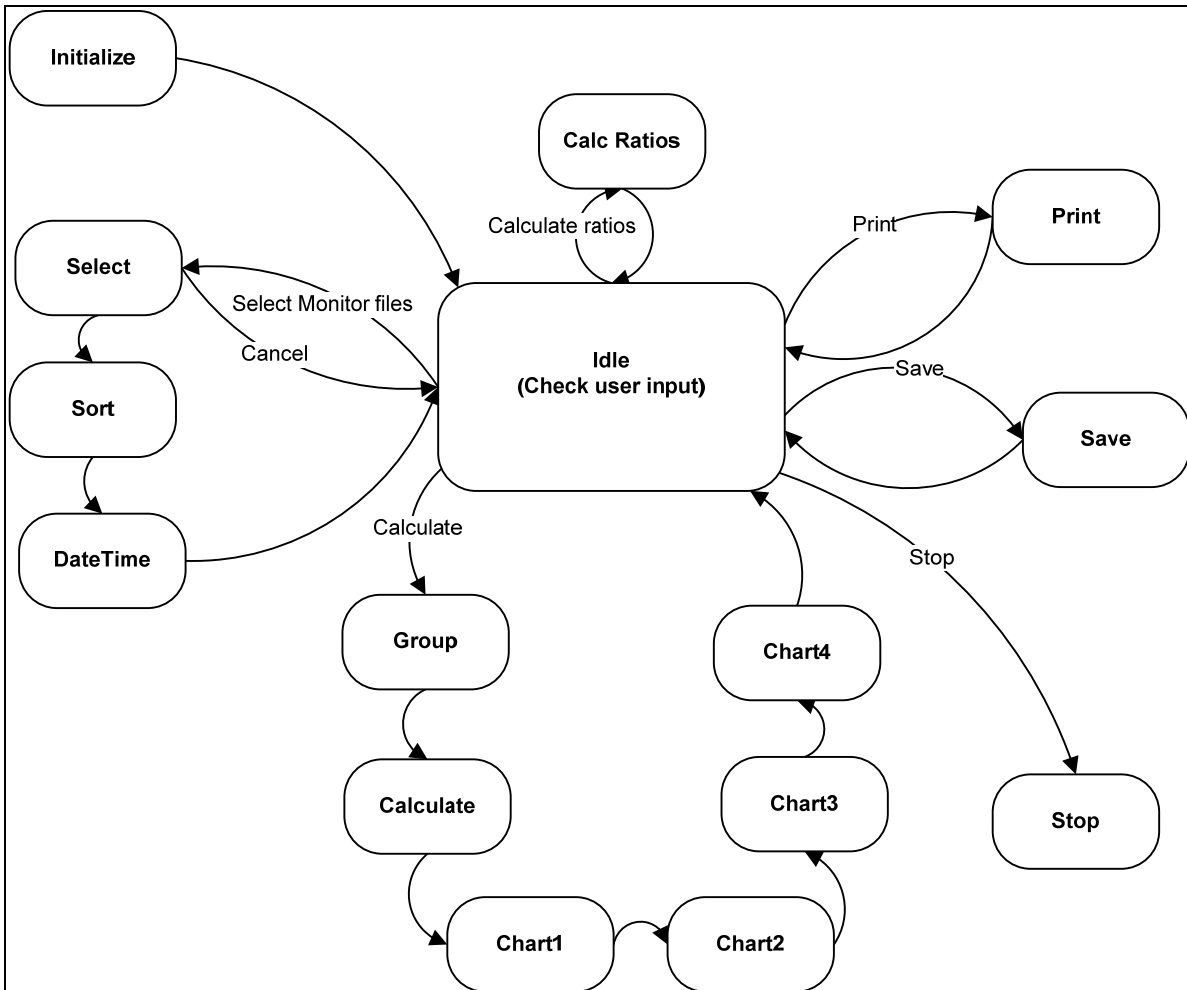


Figure 5. State diagram

The LabVIEW program (without sub-VI's) can be found in Appendix C.

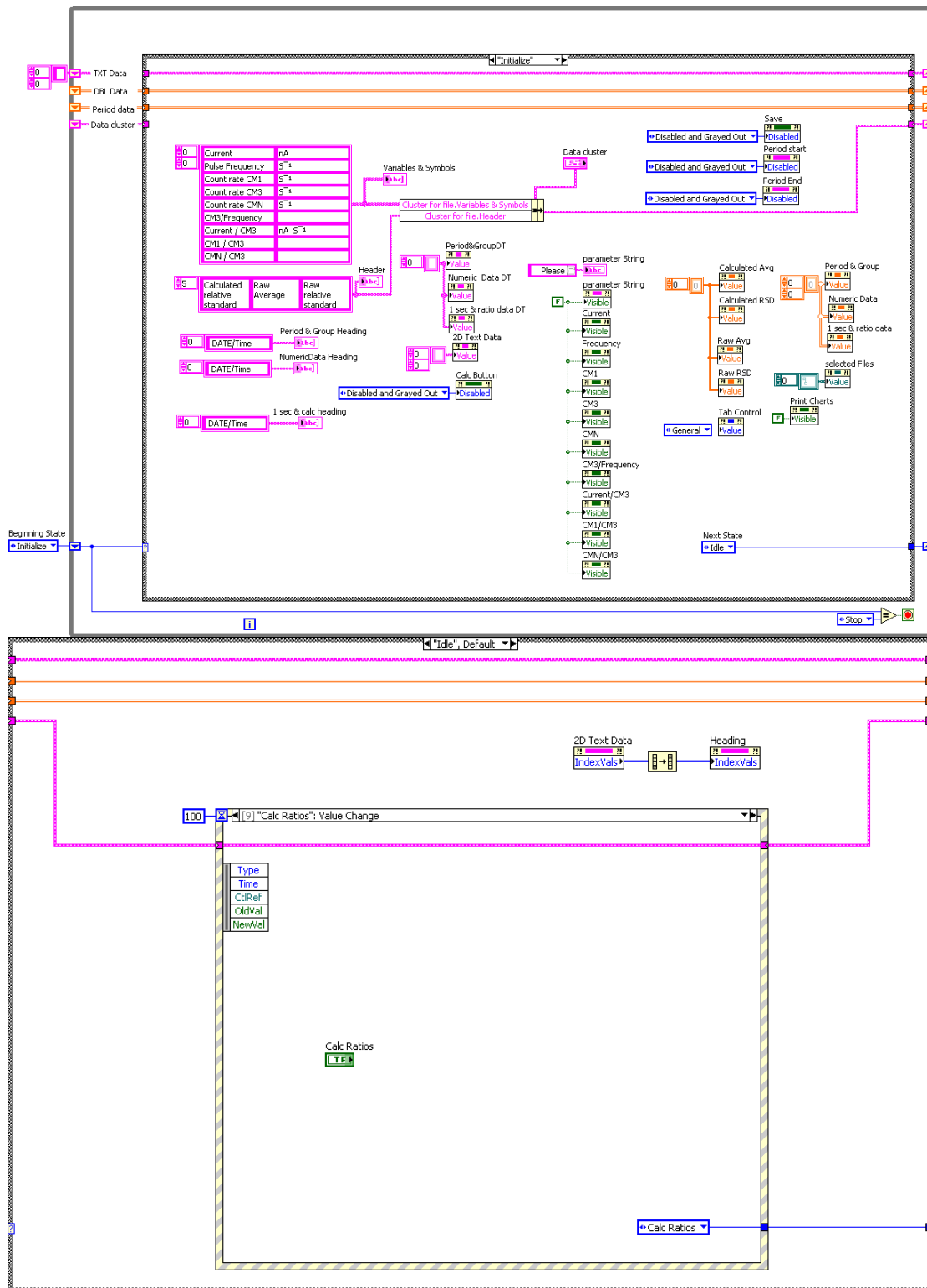
Conclusion

With GESTA it is possible to check the stability of GELINA as a function of time. This is done by extracting data from monitor files which have been created (dating back several years) during operation of GELINA. By applying user defined filtering on the data, the user can verify in which periods operating parameters of GELINA are within a user specified range. The results are represented in graphs. For documentation purposes the graphs and the data-points can be printed or exported to other programs, e.g. Excel. The calculated stability figures and related data can be saved in a file.

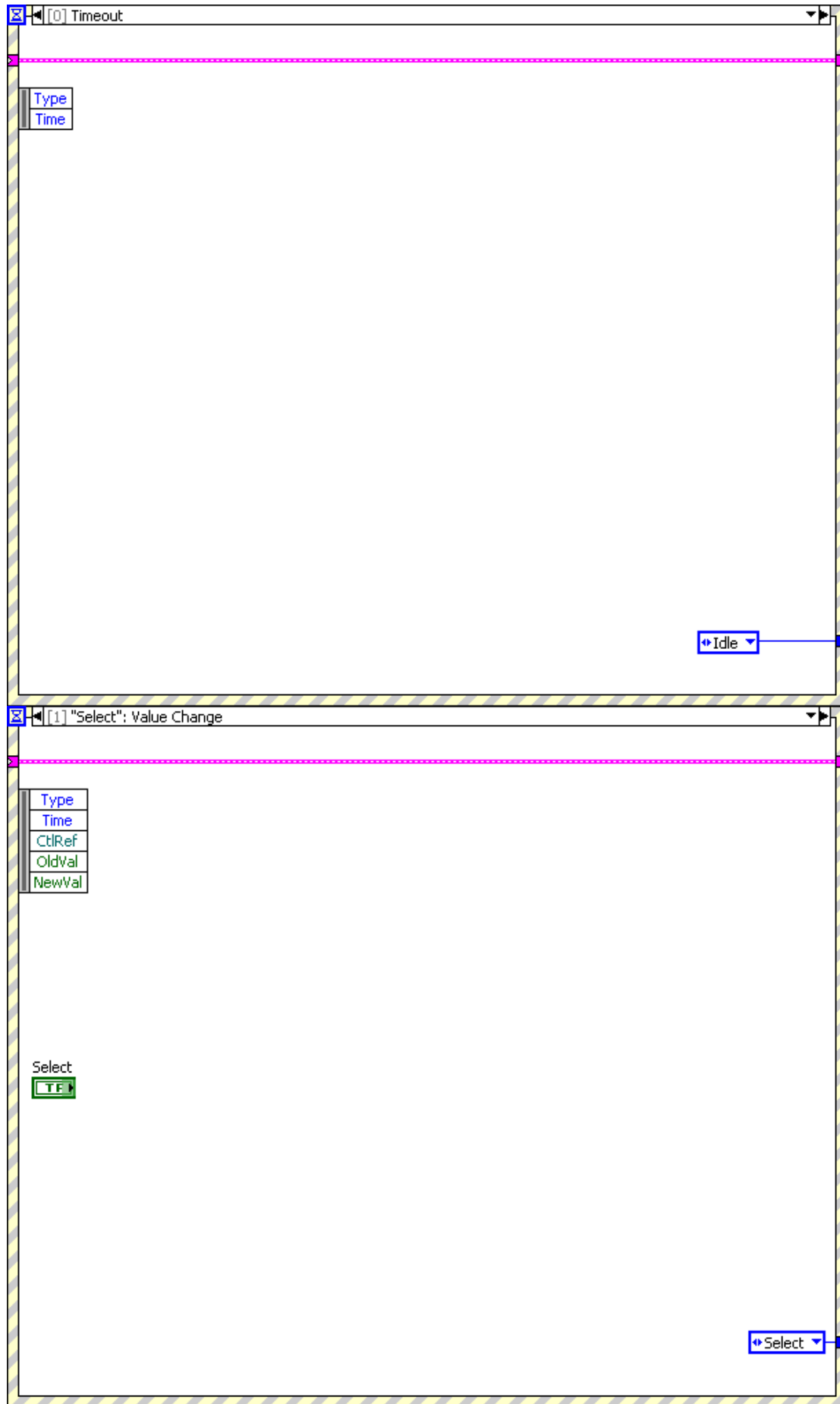
Appendix A. Monitor file.

DATE	TIME	PORTS 1<-->tcurrent(nA)	Pt	T0 60sec.	CM1	CM2	CM3	Mon N	Mon S
14.Nov.11	16:08:25	0 0 0 / 0 0 0 0	-17062	48000	0	3	0	0	0
14.Nov.11	16:09:25	0 0 0 / 0 0 0 0	-14991	48000	0	1	0	0	0
14.Nov.11	16:10:25	0 0 0 / 0 0 0 0	-20149	48000	0	1	0	0	0
14.Nov.11	17:08:25	1 1 0 / 1 0 1 1	40928	48000	15506	6676	0	19350	0
14.Nov.11	17:09:25	1 1 0 / 1 0 1 1	36005	48000	48000	18502	0	52988	0
14.Nov.11	17:10:25	1 1 0 / 1 0 1 1	34676	48000	48000	16843	0	47173	0
14.Nov.11	17:11:25	1 1 0 / 1 0 1 1	26589	48000	48000	15829	0	44652	0
14.Nov.11	17:12:25	1 1 0 / 1 0 1 1	24166	48001	48001	13817	0	39616	0
14.Nov.11	17:13:25	1 1 0 / 1 0 1 1	22916	48000	48000	12765	0	36559	0
14.Nov.11	17:14:25	1 1 0 / 1 0 1 1	24166	48000	48000	12504	0	35548	0
14.Nov.11	17:15:25	1 1 0 / 1 0 1 1	27878	48001	48001	13574	0	38201	0
14.Nov.11	17:16:25	1 1 0 / 1 0 1 1	33661	48000	48000	15558	0	44519	0
14.Nov.11	17:17:25	1 1 0 / 1 0 1 1	37646	48000	48000	18283	0	51341	0
14.Nov.11	17:18:25	1 1 0 / 1 0 1 1	37919	48000	47999	19369	0	56863	0
14.Nov.11	17:19:25	1 1 0 / 1 0 1 1	45382	48000	48000	21119	0	61867	0
14.Nov.11	17:20:25	1 1 0 / 1 0 1 1	47179	48000	48000	23268	0	67888	0
14.Nov.11	17:21:25	1 1 0 / 1 0 1 1	49641	48001	43586	23299	0	67624	0
14.Nov.11	17:22:25	1 1 0 / 1 0 1 1	55502	48000	48000	26915	0	80038	0
14.Nov.11	17:23:25	1 1 0 / 1 0 1 1	55463	48000	48000	29177	0	87734	0
14.Nov.11	17:24:25	1 1 0 / 1 0 1 1	61050	48000	48000	31262	0	93361	0
14.Nov.11	17:25:25	1 1 0 / 1 0 1 1	58823	48000	48000	31262	0	93361	0
14.Nov.11	17:26:25	1 1 0 / 1 0 1 1	57768	48000	48000	32976	0	99335	0
14.Nov.11	17:27:25	1 1 0 / 1 0 1 1	57612	48000	48000	34258	0	106306	0
14.Nov.11	17:28:25	1 1 0 / 1 0 1 1	59214	48000	48000	35110	0	108804	0
14.Nov.11	17:29:25	1 1 0 / 1 0 1 1	64684	48000	48000	36146	0	112740	0
14.Nov.11	17:30:25	1 1 0 / 1 0 1 1	62457	48000	47999	37487	0	116363	0
14.Nov.11	17:31:25	1 1 0 / 1 0 1 1	60816	48000	48000	37669	0	116354	0
14.Nov.11	17:32:25	1 1 0 / 1 0 1 1	61753	48000	48000	38105	0	117425	0
14.Nov.11	17:33:25	1 1 0 / 1 0 1 1	61988	48000	48000	37965	0	118046	0
14.Nov.11	17:34:25	1 1 0 / 1 0 1 1	64684	48000	48000	38332	0	116877	0
14.Nov.11	17:35:25	1 1 0 / 1 0 1 1	61363	48000	48000	39087	0	120075	0
14.Nov.11	17:36:25	1 1 0 / 1 0 1 1	63160	48000	48000	38662	0	119524	0
14.Nov.11	17:37:25	1 1 0 / 1 0 1 1	66325	48000	48000	38614	0	118964	0
14.Nov.11	17:38:25	1 1 0 / 1 0 1 1	65895	48000	48000	39771	0	120697	0
14.Nov.11	17:39:25	1 1 0 / 1 0 1 1	65817	48000	48000	39433	0	121217	0
14.Nov.11	17:40:25	1 1 0 / 1 0 1 1	65074	48000	48000	39196	0	120718	0
14.Nov.11	17:41:25	1 1 0 / 1 0 1 1	68083	48000	48000	39737	0	121750	0
14.Nov.11	17:42:25	1 1 0 / 1 0 1 1	67888	48000	48000	39244	0	121317	0
14.Nov.11	17:43:25	1 1 0 / 1 0 1 1	63394	48000	48000	39555	0	120984	0
14.Nov.11	17:44:25	1 1 0 / 1 0 1 1	61245	48000	48000	39529	0	122124	0
14.Nov.11	17:45:25	1 1 0 / 1 0 1 1	63863	48000	48000	39305	0	120963	0
14.Nov.11	17:46:25	1 1 0 / 1 0 1 1	64801	48000	48000	39111	0	120126	0
14.Nov.11	17:47:25	1 1 0 / 1 0 1 1	62926	48001	48001	39222	0	120533	0
14.Nov.11	17:48:25	1 1 0 / 1 0 1 1	64645	48000	48000	38171	0	119325	0
14.Nov.11	17:49:25	1 1 0 / 1 0 1 1	66090	48000	47999	38530	0	119389	0
14.Nov.11	17:50:25	1 1 0 / 1 0 1 1	63551	48000	48000	39509	0	120704	0
14.Nov.11	17:51:25	1 1 0 / 1 0 1 1	62847	48000	47998	38613	0	119958	0
14.Nov.11	17:52:25	1 1 0 / 1 0 1 1	64801	48000	47998	39091	0	120500	0
14.Nov.11	17:53:25	1 1 0 / 1 0 1 1	64957	48000	47999	38940	0	121153	0
14.Nov.11	17:54:25	1 1 0 / 1 0 1 1	63902	48001	48000	38950	0	120252	0
14.Nov.11	17:55:25	1 1 0 / 1 0 1 1	67380	48000	47998	39055	0	121940	0
14.Nov.11	17:56:25	1 1 0 / 1 0 1 1	63746	48001	47999	39458	0	122389	0
14.Nov.11	17:57:25	1 1 0 / 1 0 1 1	65387	48000	47999	39461	0	121070	0

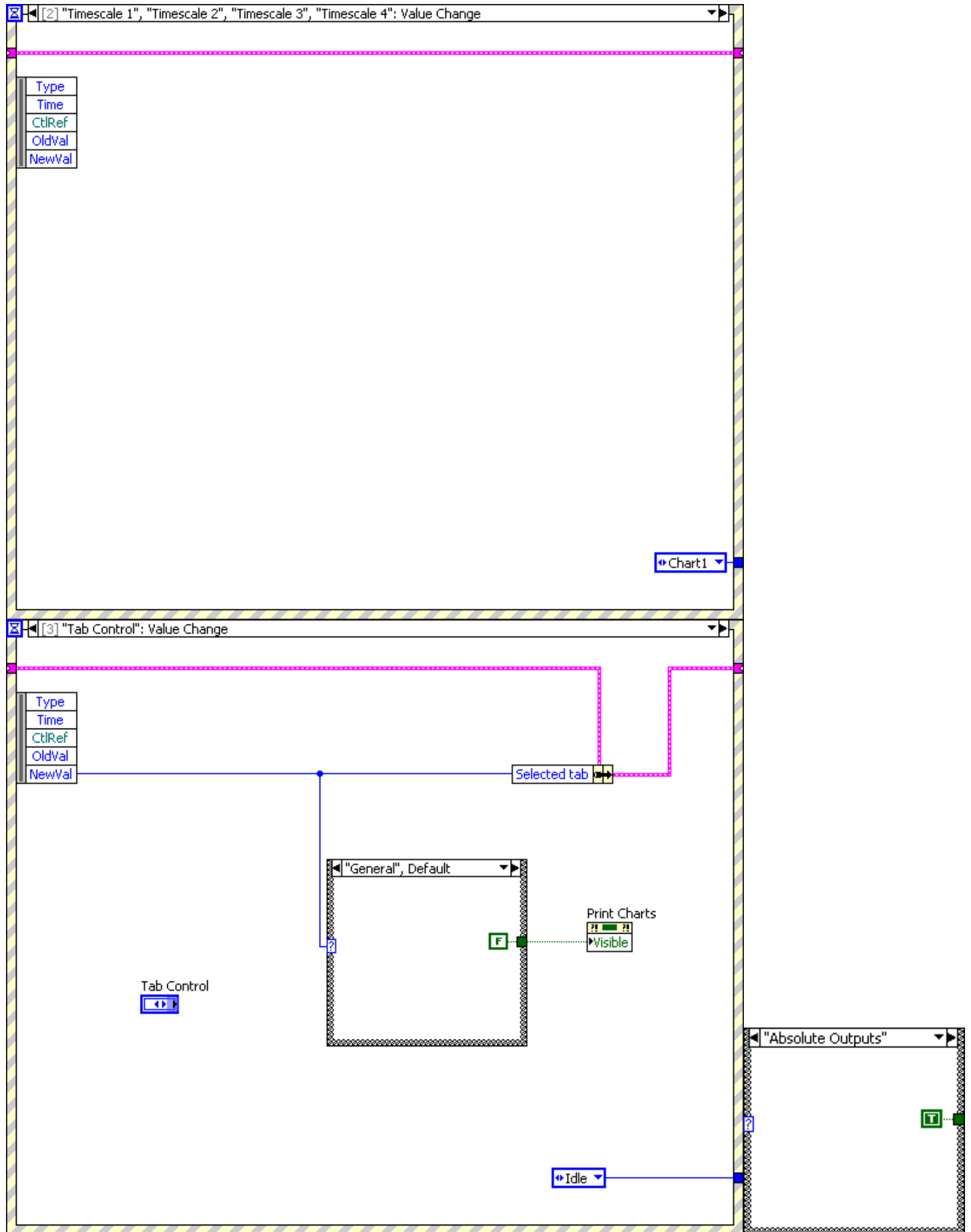
Appendix C. LabVIEW block diagram.



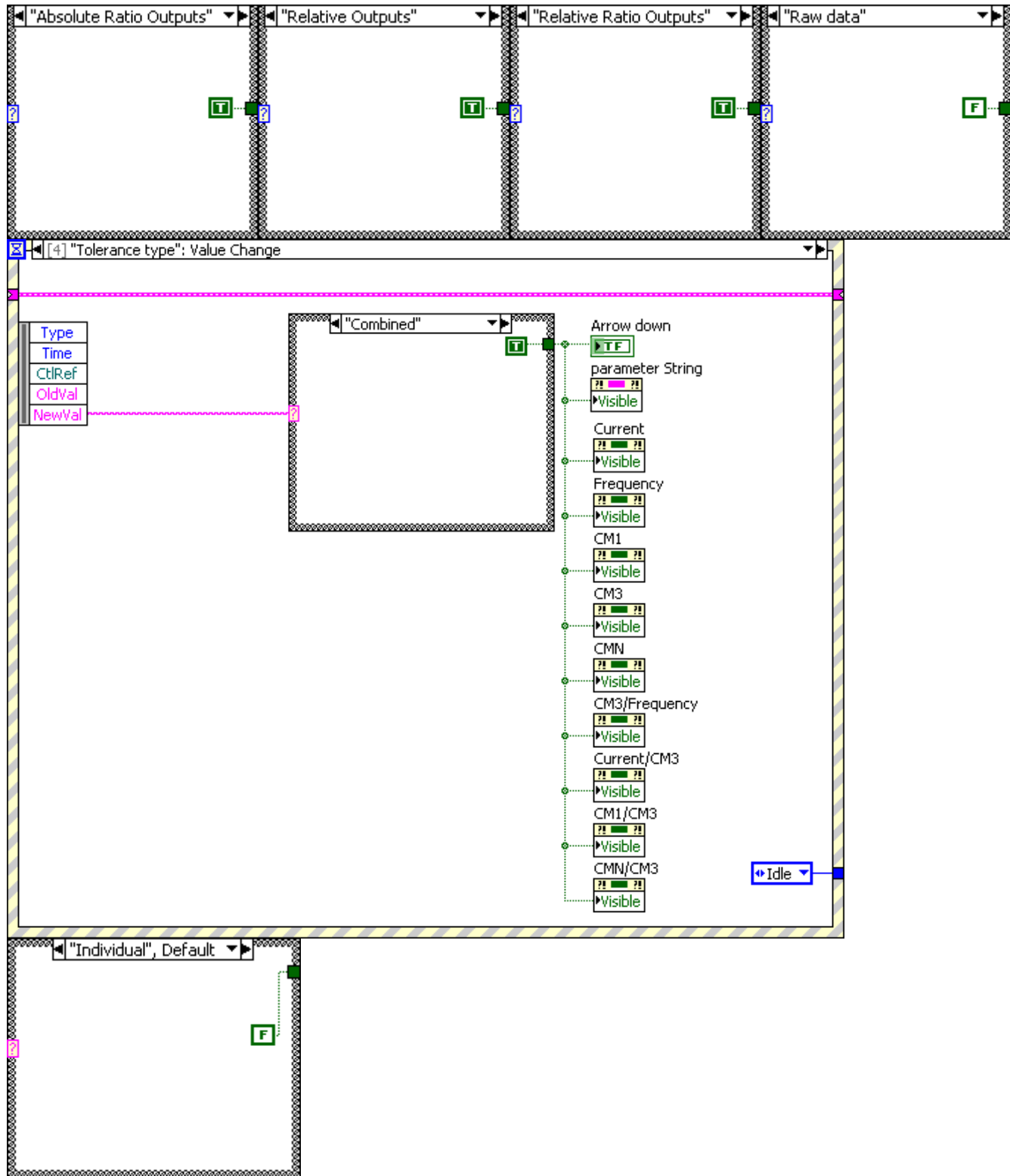
Appendix C. LabVIEW block diagram.



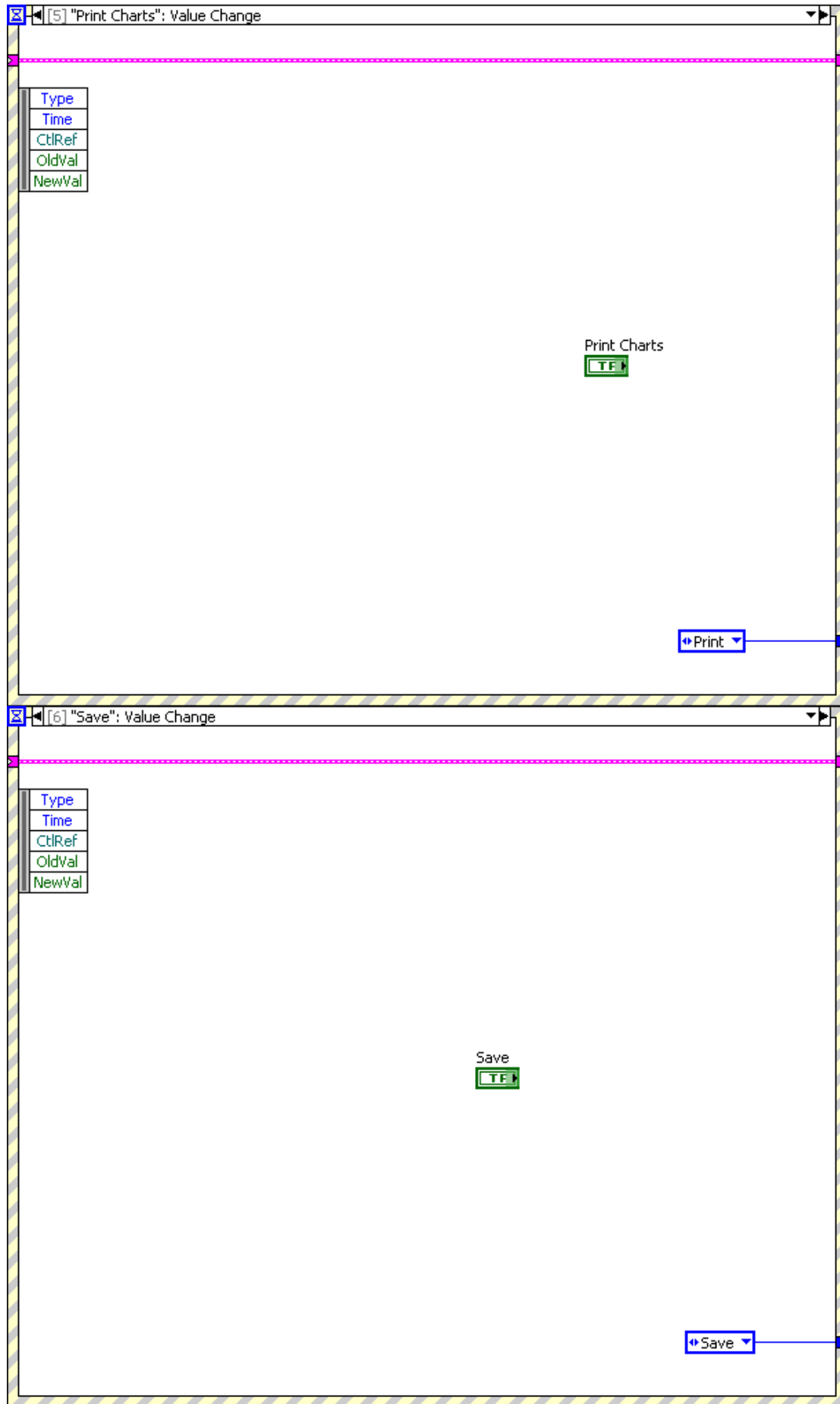
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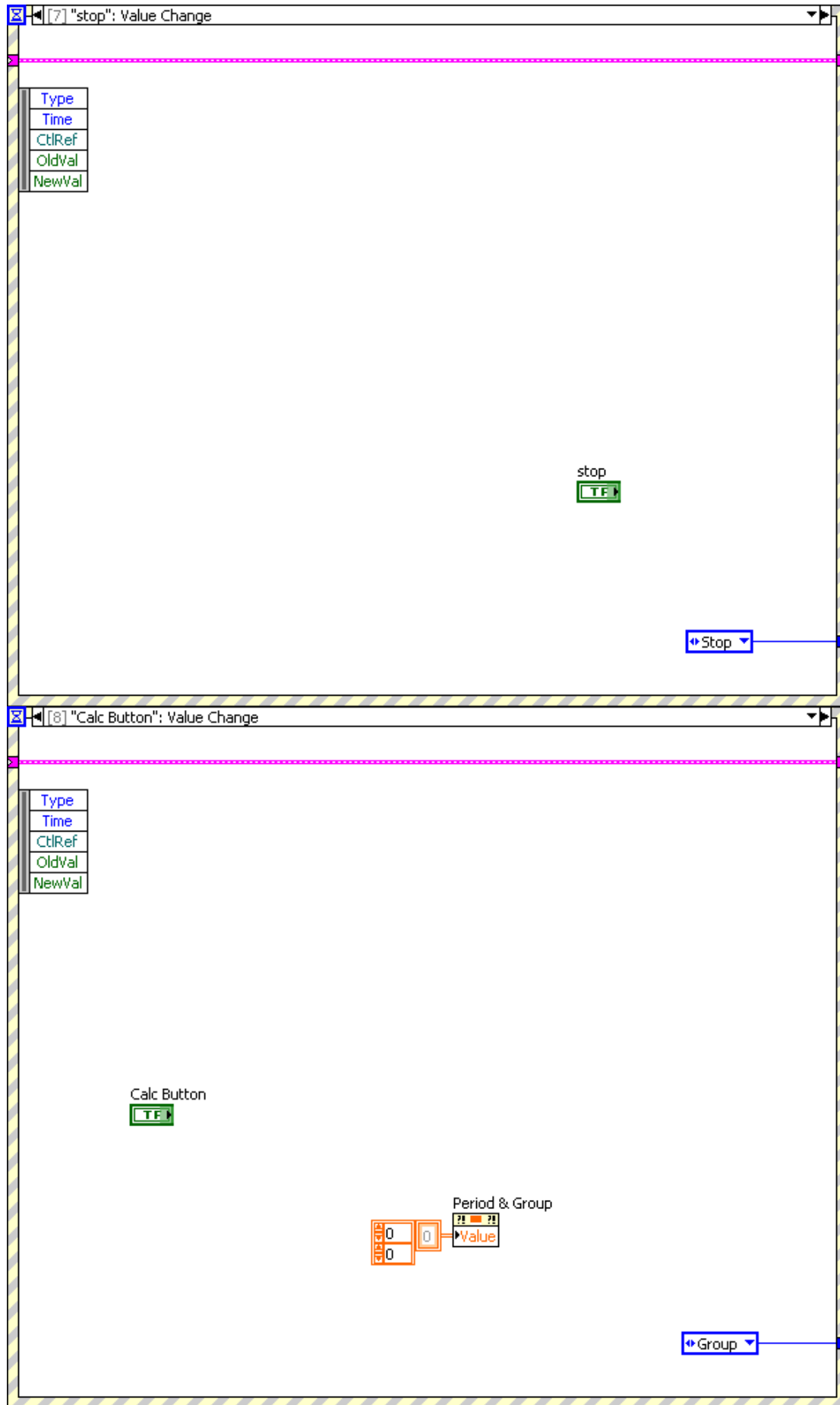
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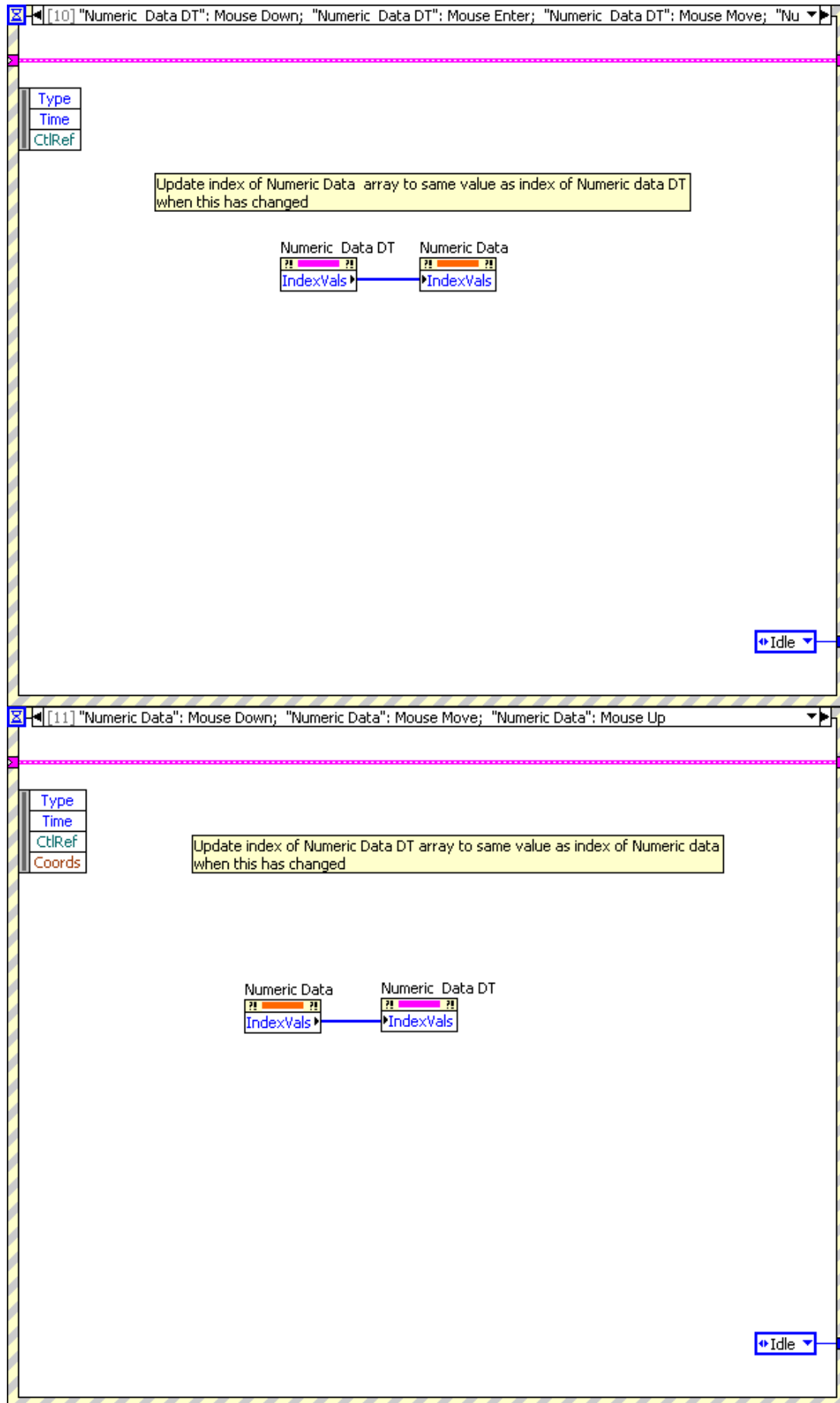
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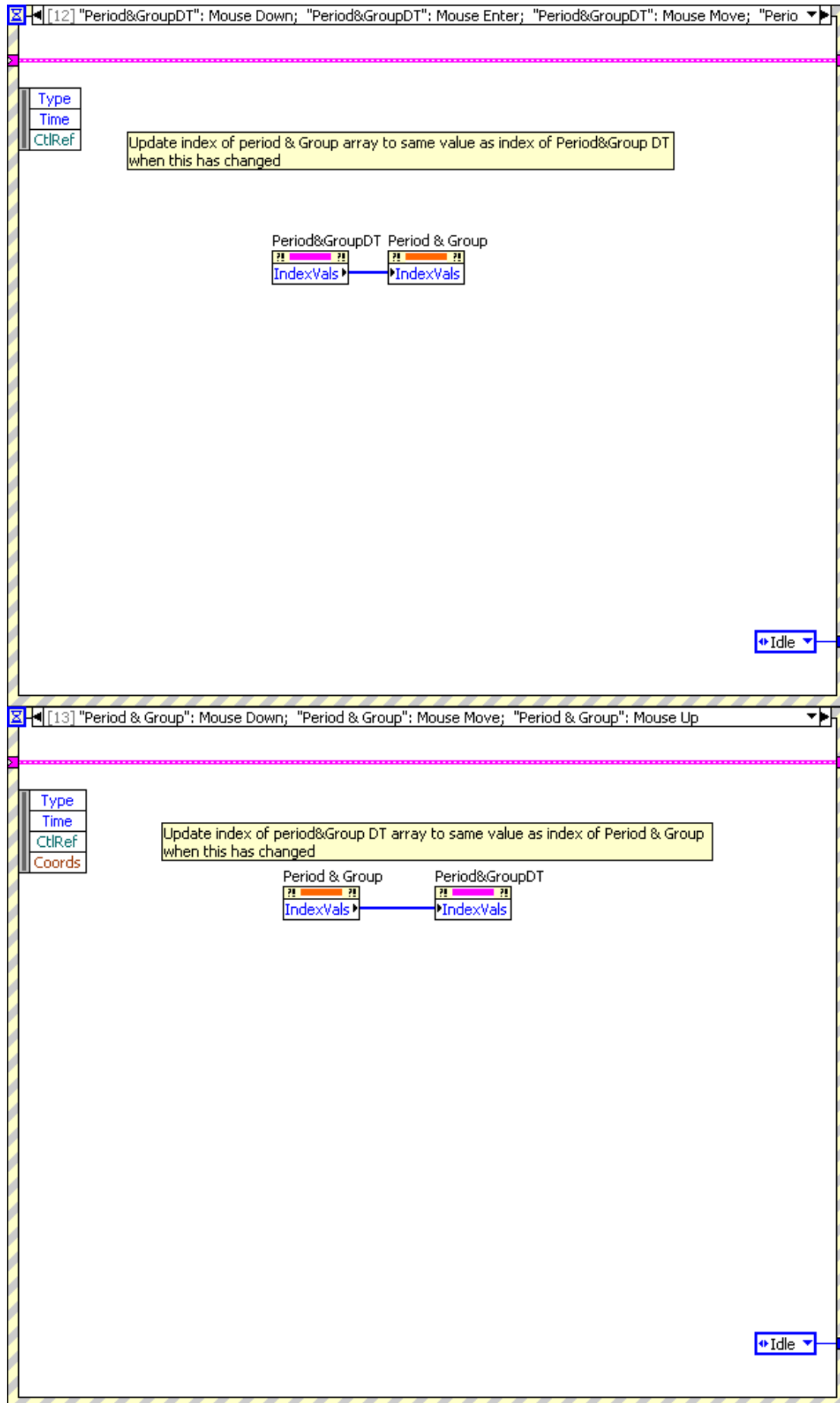
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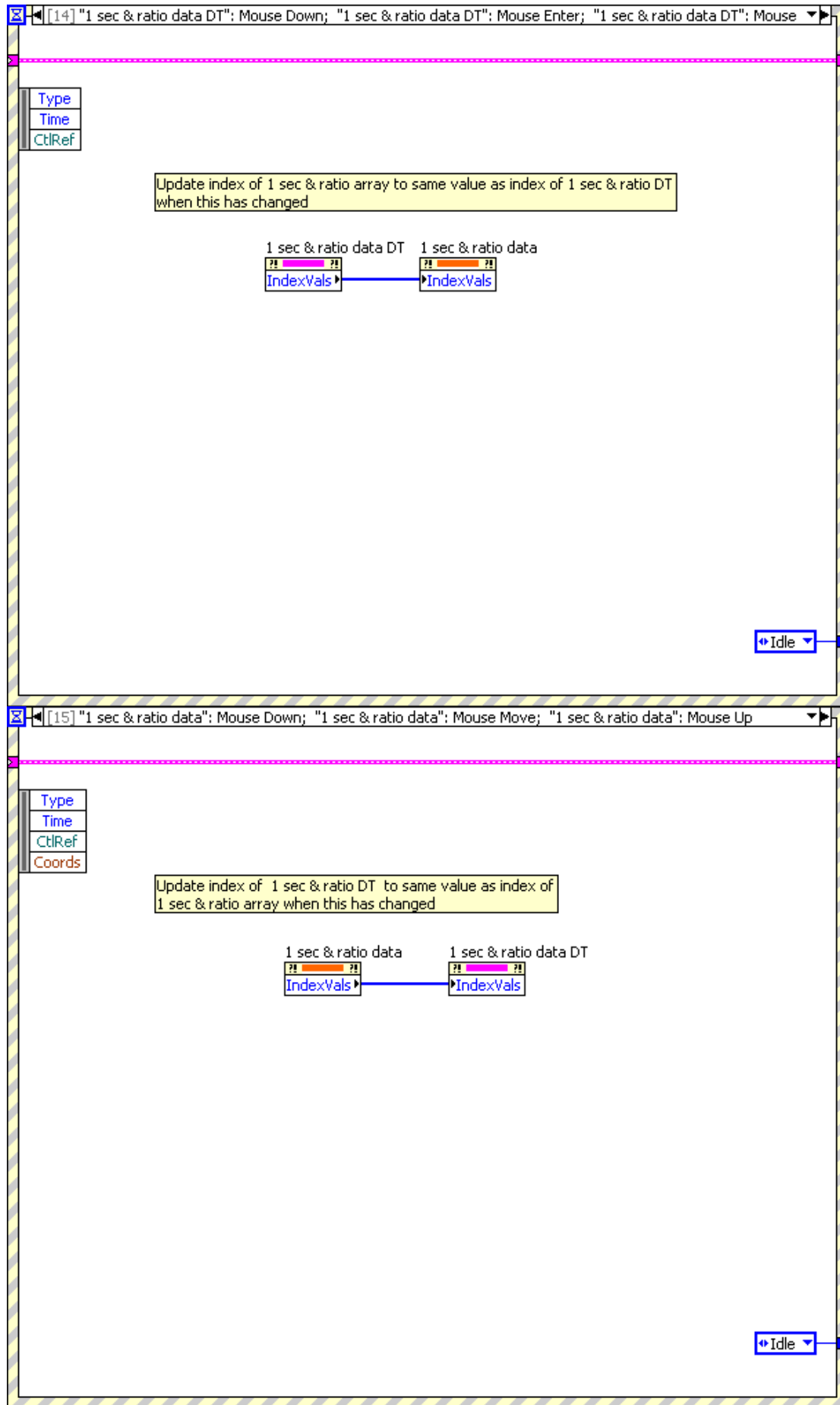
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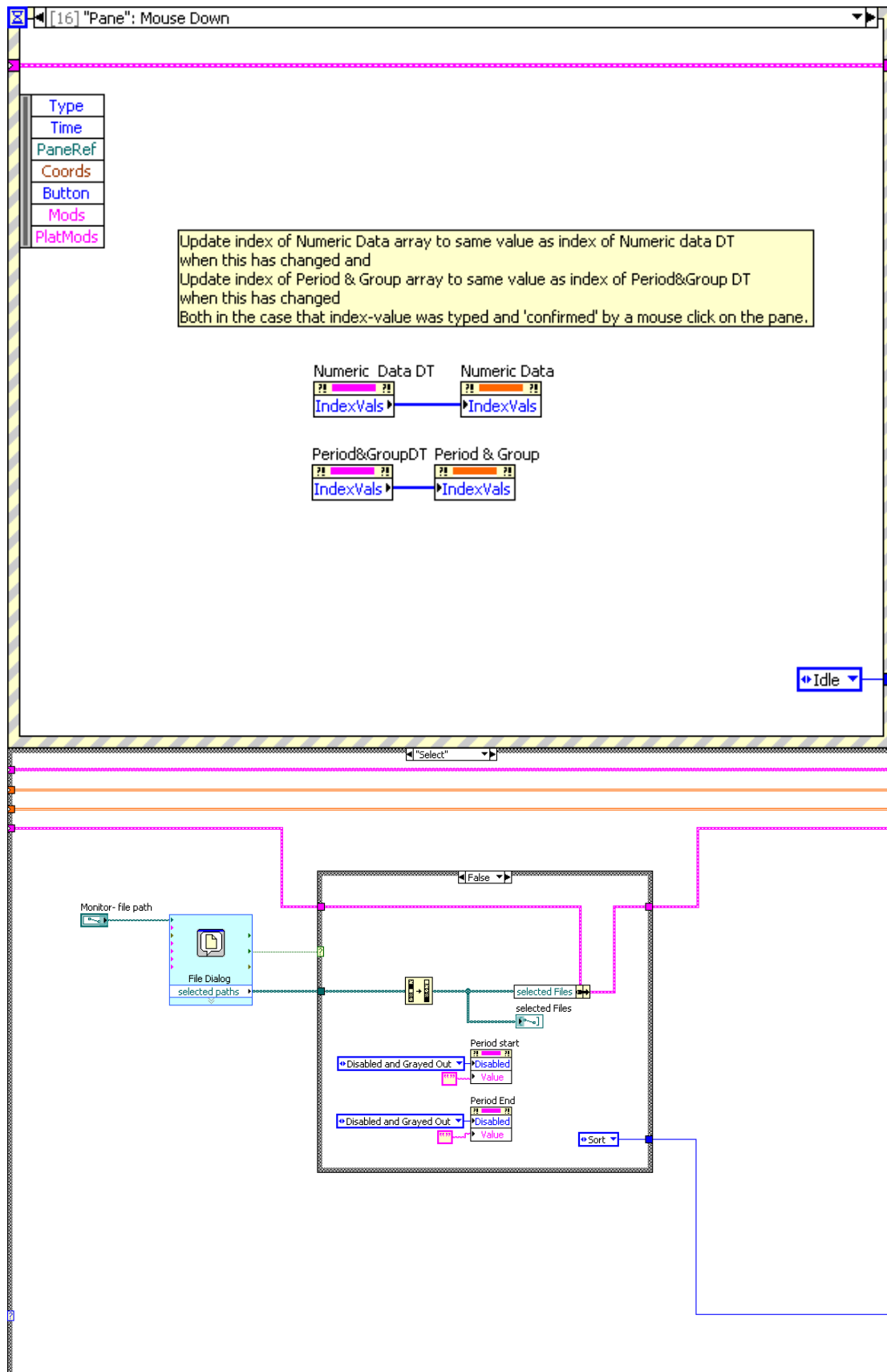
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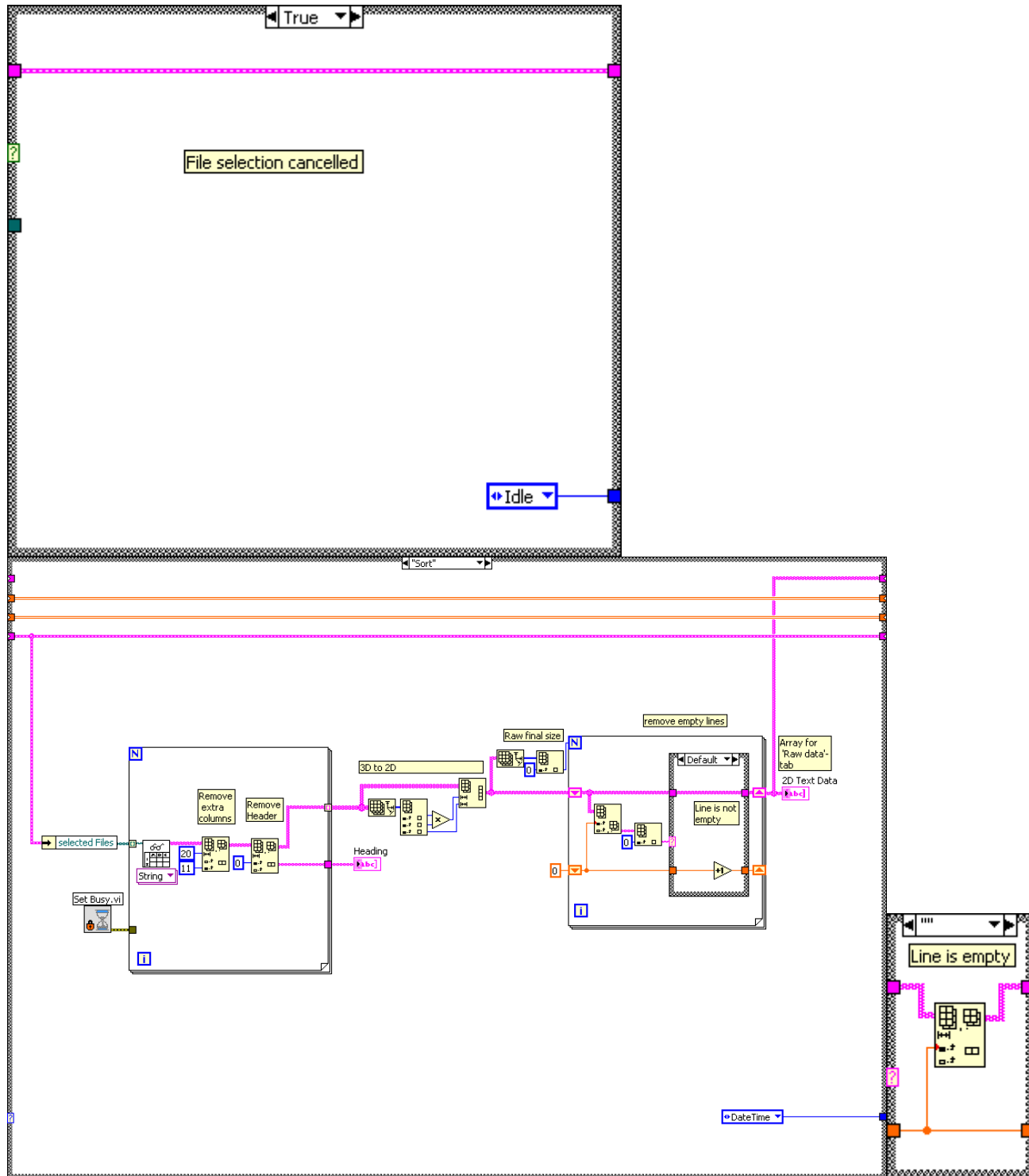
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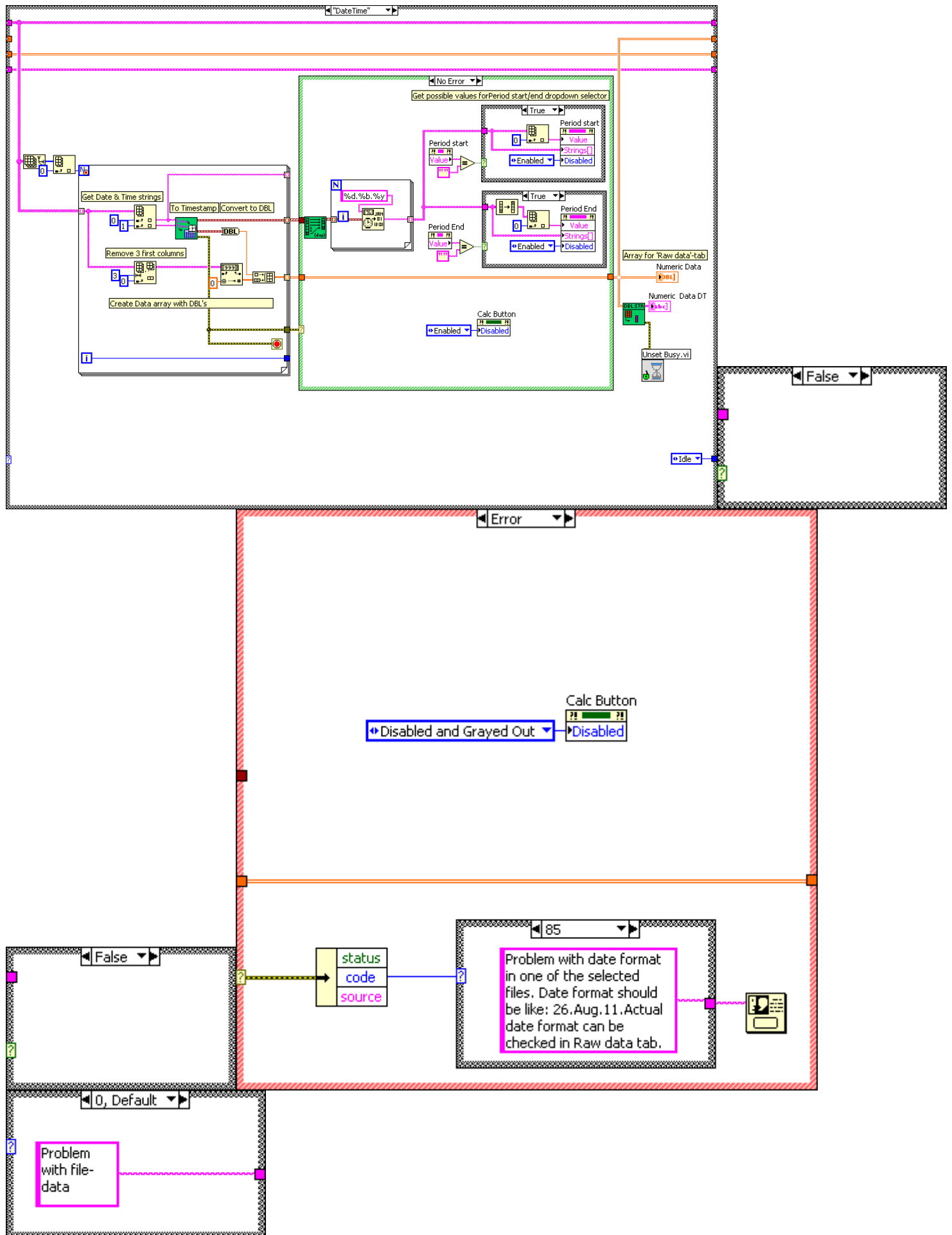
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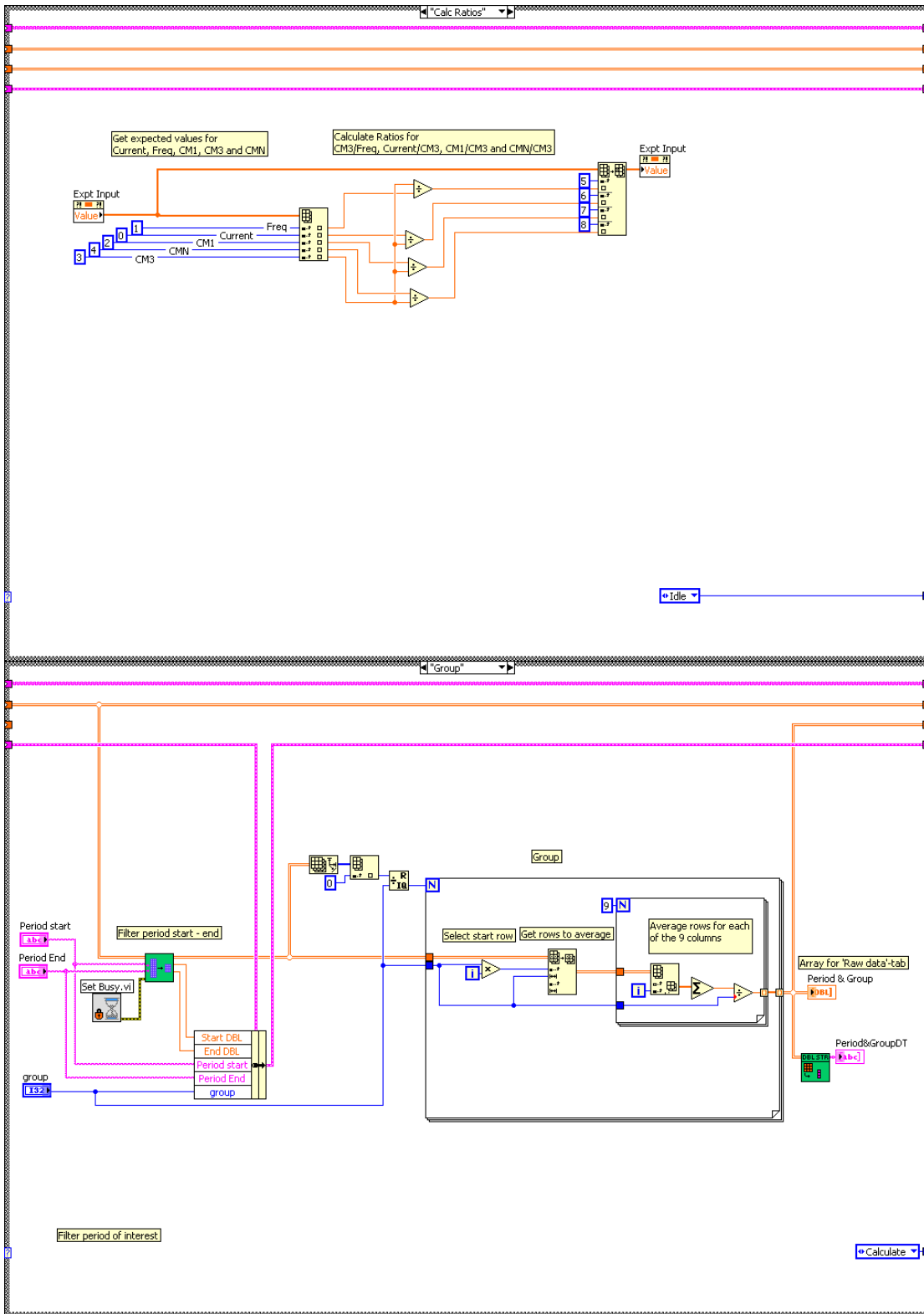
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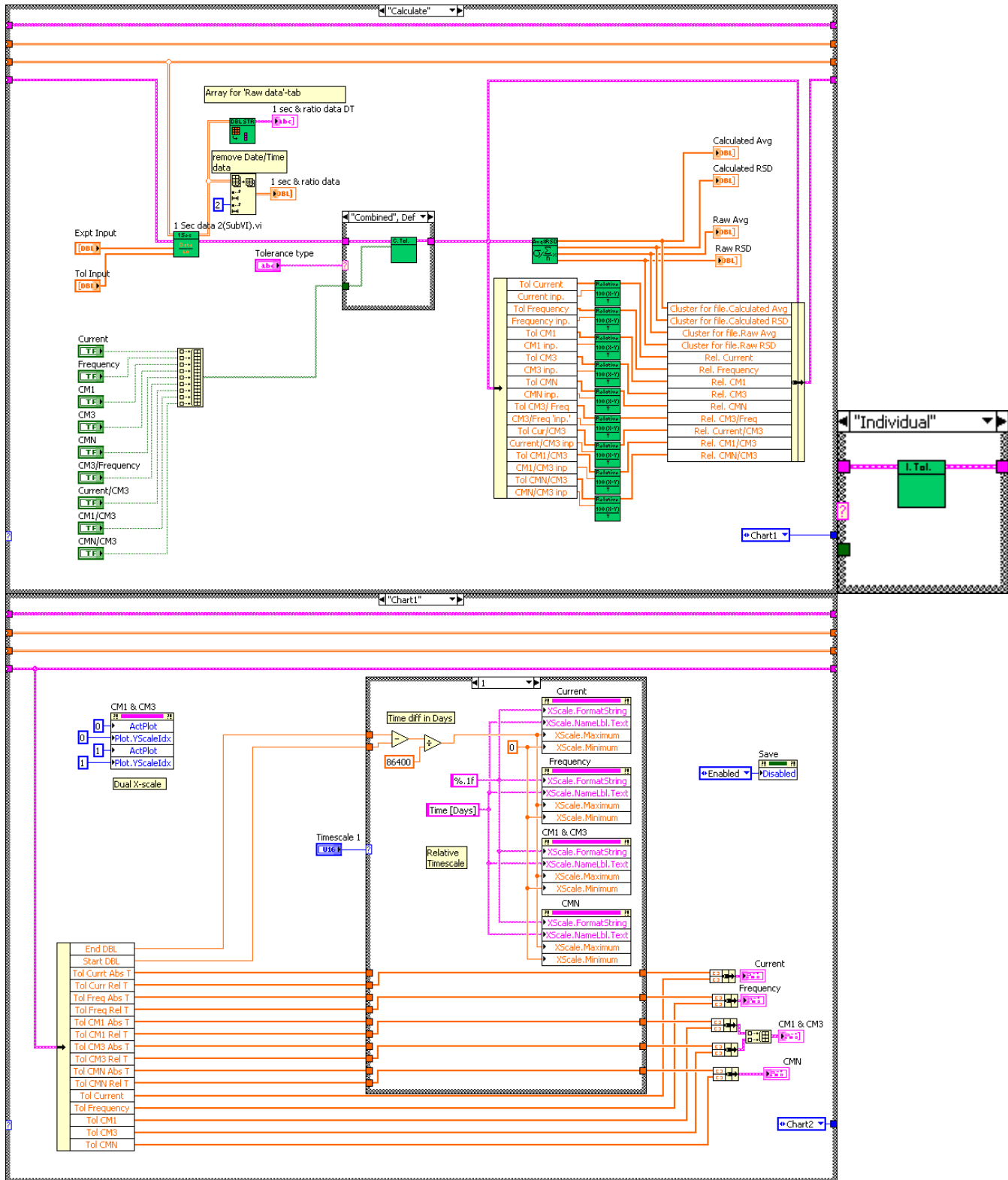
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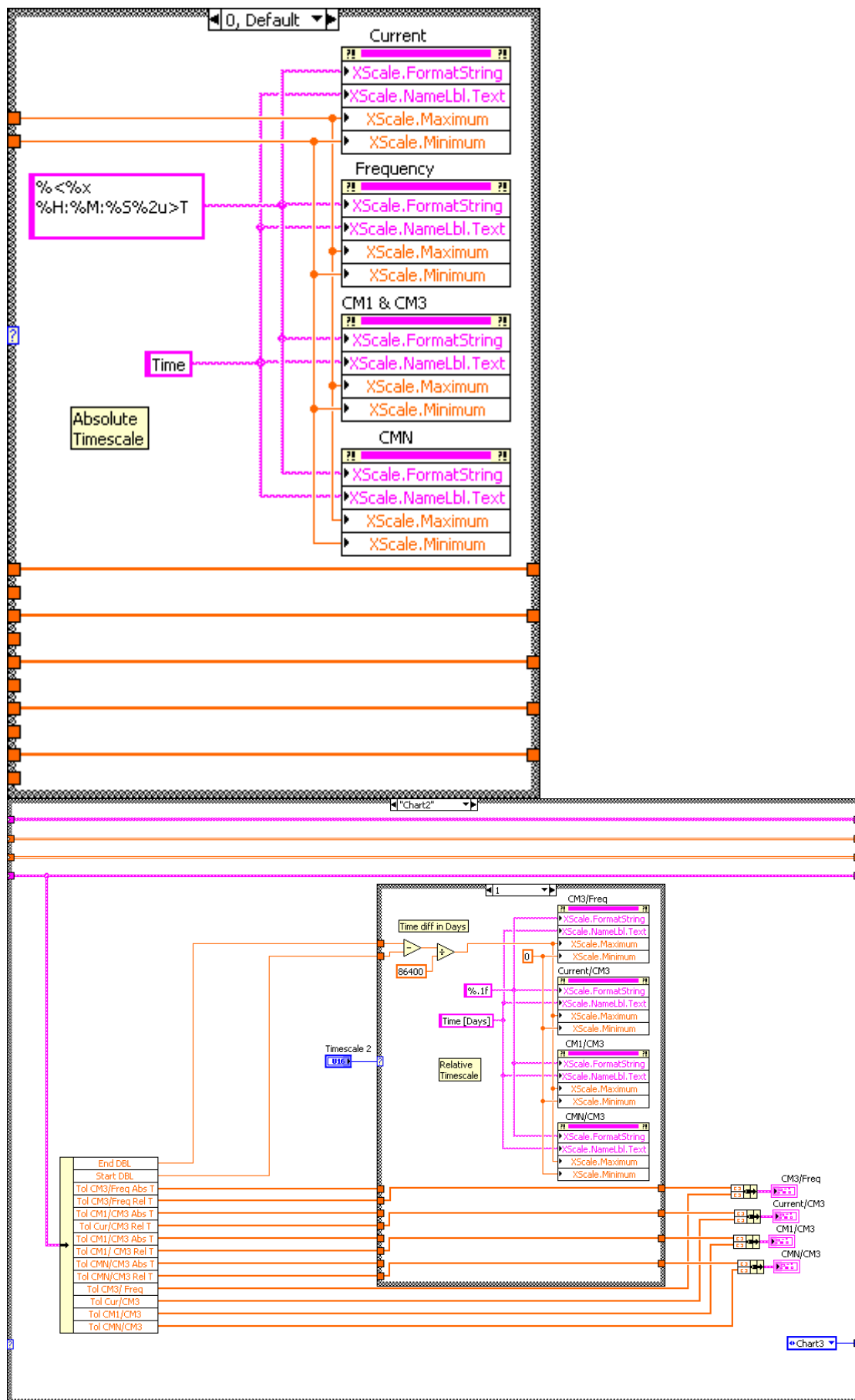
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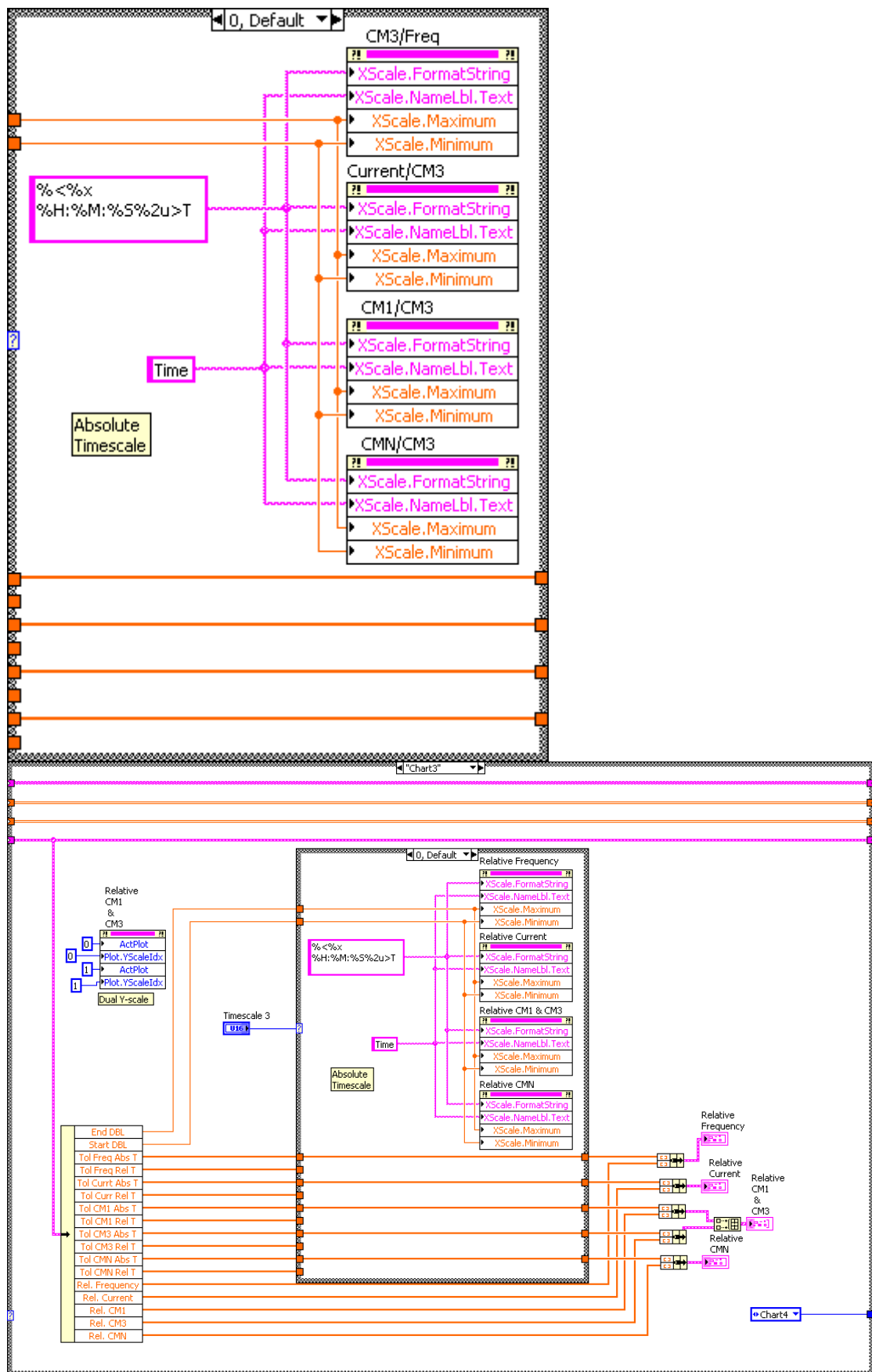
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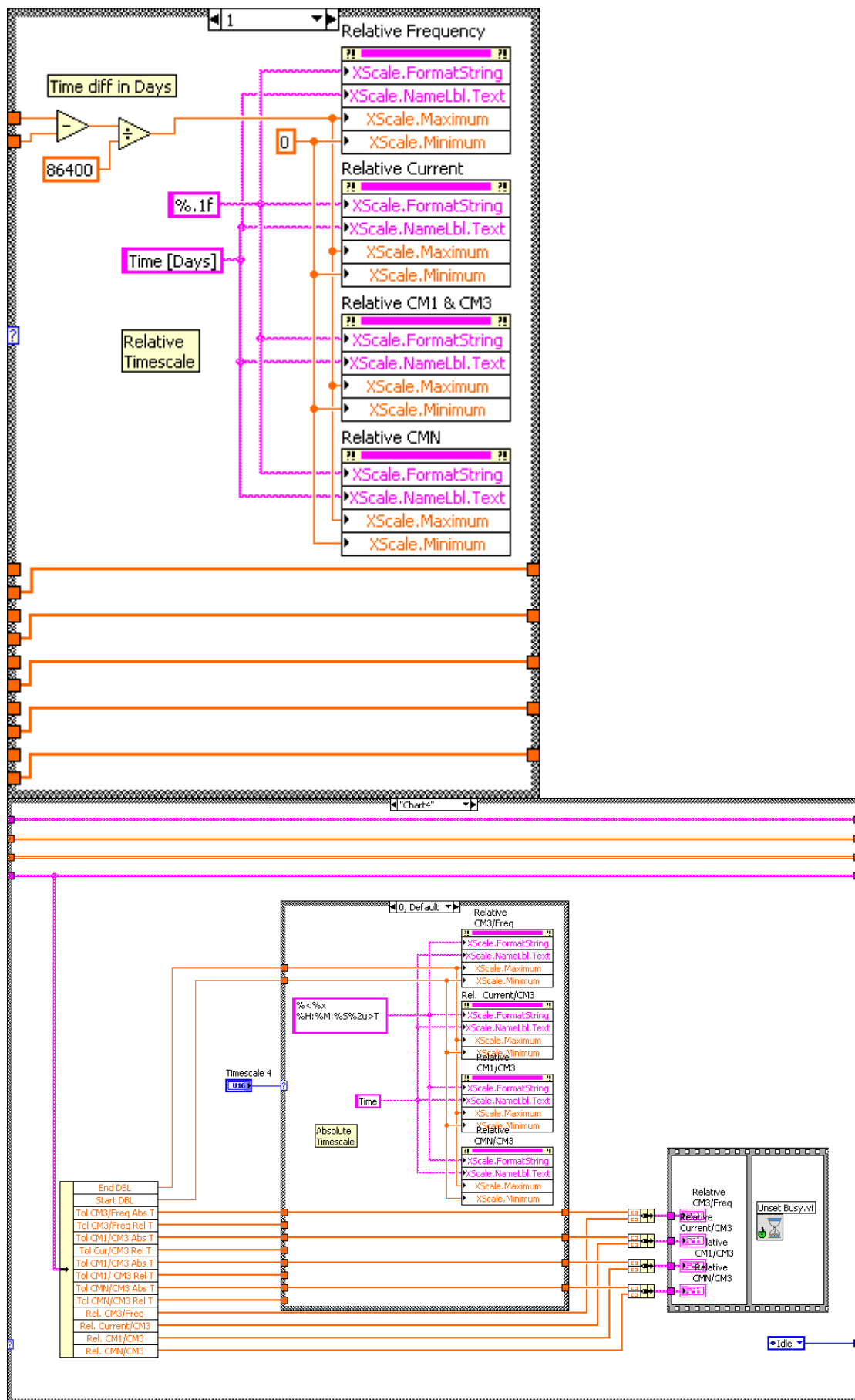
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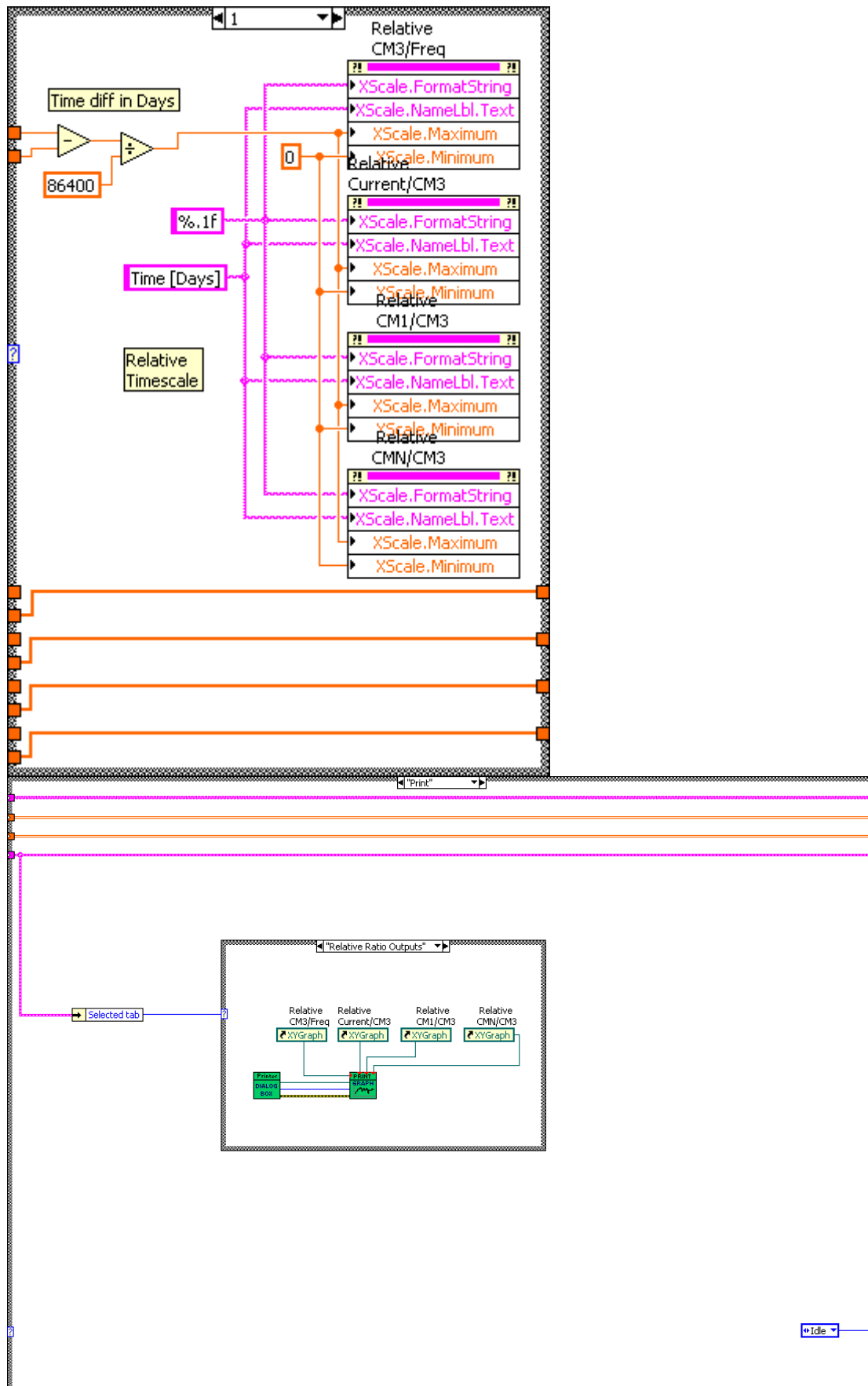
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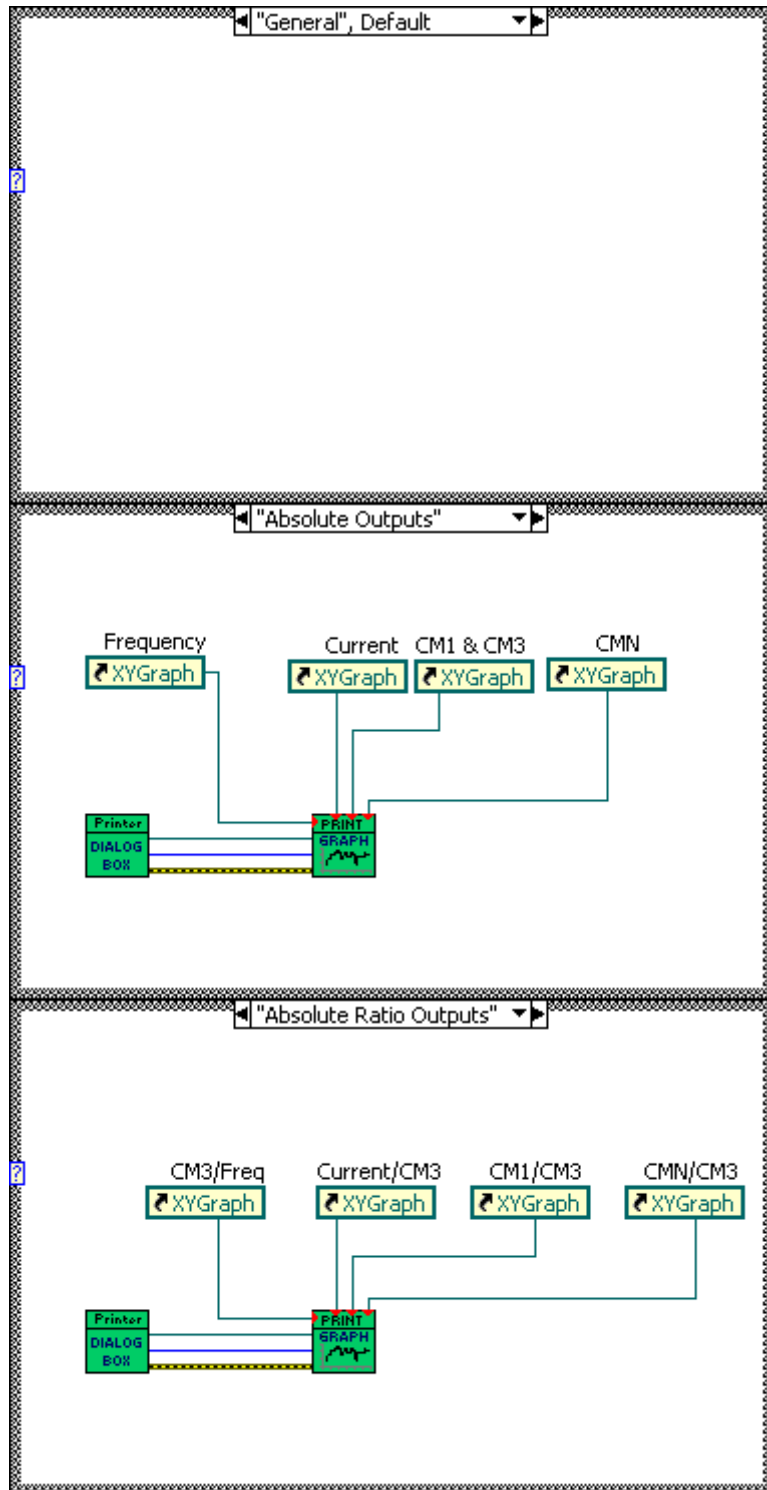
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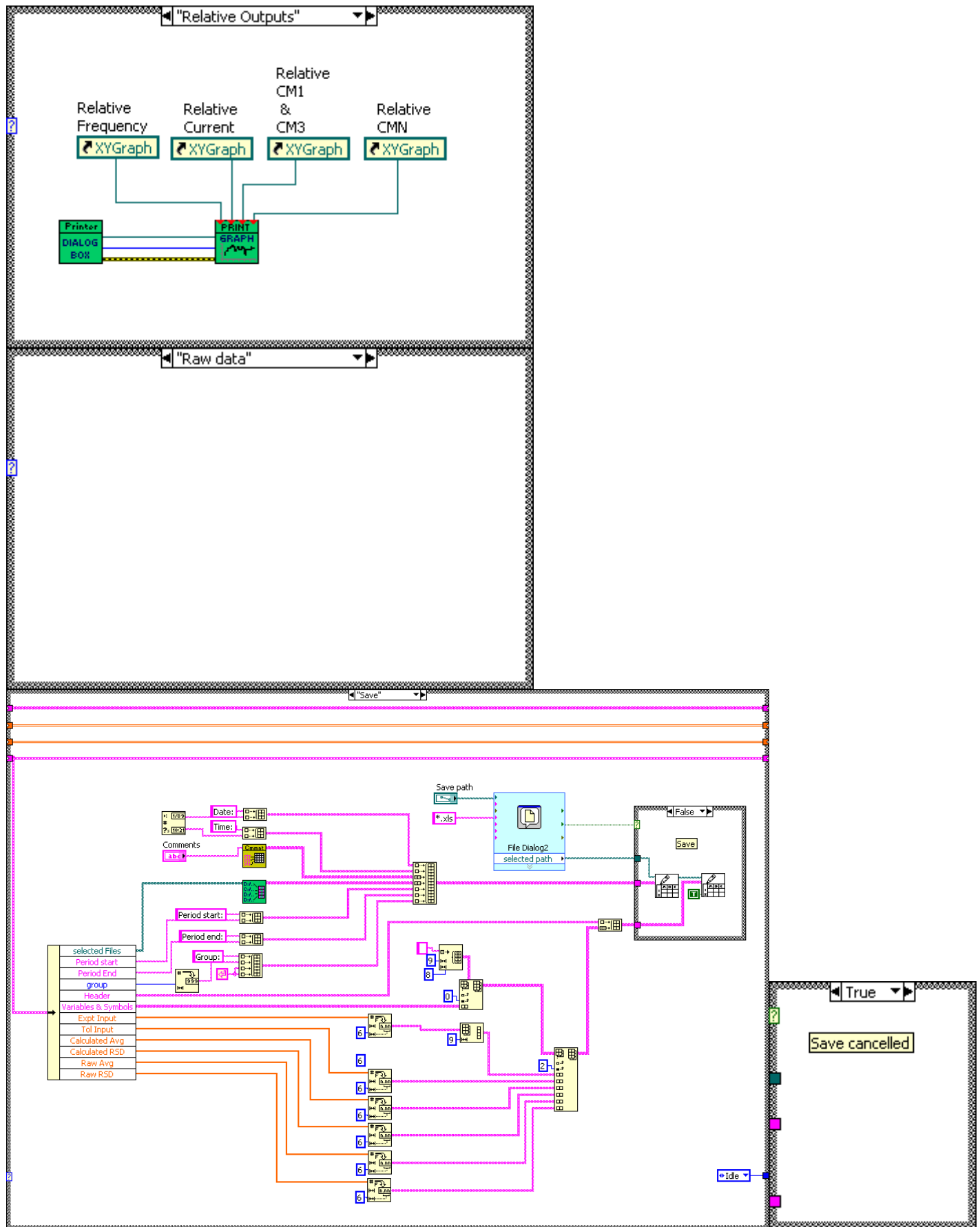
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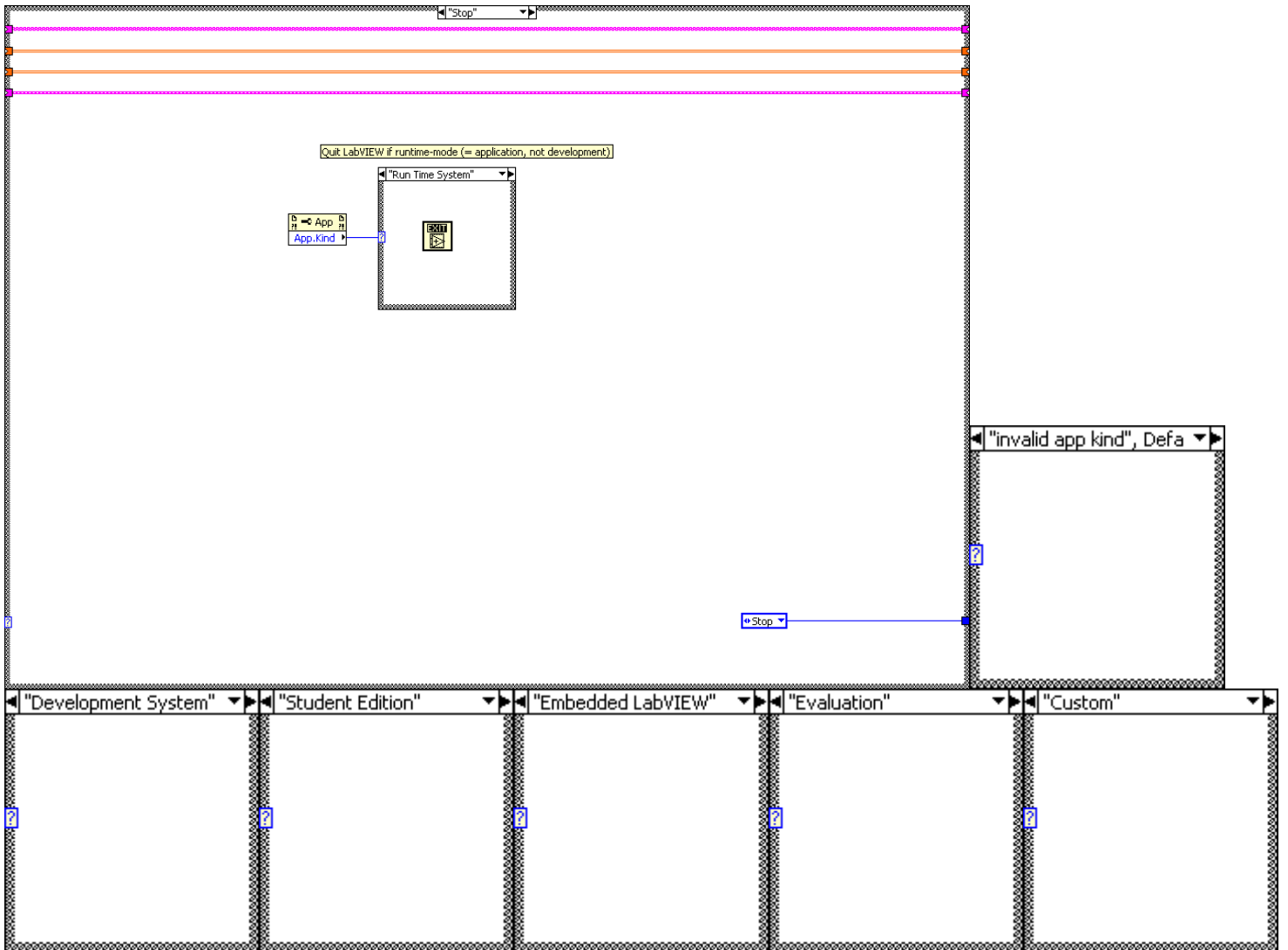
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