Lookup tables

Look up tables can be a very useful tool for data analysis. Once mastered, look up tables can allow engineers to visualise many more aspects of car performance that might otherwise go unnoticed. It allows data which is collected off-track, or from an external source, to be integrated with the on track data for direct comparison.

Lookup tables are often used to visualise engine parameters dependant on more than one variable. These parameters can be very difficult to express as an equation and require expensive modelling software to calculate. Lookup tables offer a very effective way of expressing the channel using numerical methods without the need for advanced surface analysis. The data analysis software uses the raw data points in the lookup table and interpolates between them generating a full surface. There is also the possibility to extrapolate from or snap to the raw data values depending on the requirement.

Any good data analysis package will have the capability to use data from 1D and/or 2D lookup tables from a spreadsheet and generate channels. This generated channel can then be used in all of the functions and displays just as any other logged channel.

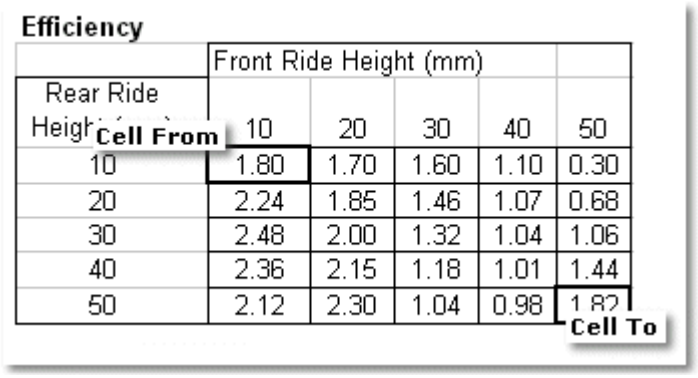
After the data has been gathered for use in the lookup table, the first step is to format thespreadsheet into a style which can be interpreted by the analysis software. Often the axis points need to be set in ascending order, and for 1D lookup tables, the axes may need to be aligned horizontally instead of vertically. Once the spreadsheet is in the correct formatit normally needs to be saved in a fixed location as if the file is moved, the analysis software will no longer be able to find it.

Once this is completed, the lookup table can be referenced in the data analysis software. A definition string is used to define the location and filename of the spreadsheet, the sheet name and the cells which contain the lookup values.

table #name = path\filename\sheet!cellfrom:cellto;

Where:

table - keyword is used for defining lookup tables.
name - is the lookup tables name. It must always start with a '#' symbol.
path - is the directory path of the Excel file. Relative network paths can also be used. See the examples below.
sheet - is the Excel sheet name.
Cellfrom - the lookup table's top/top left value cell.
Cellto - the lookup table's bottom/bottom left value cell.
Cellto and **Cellfrom** arguments can be specified using the Excel Cell syntax, e.g. cell A3 would be A3.



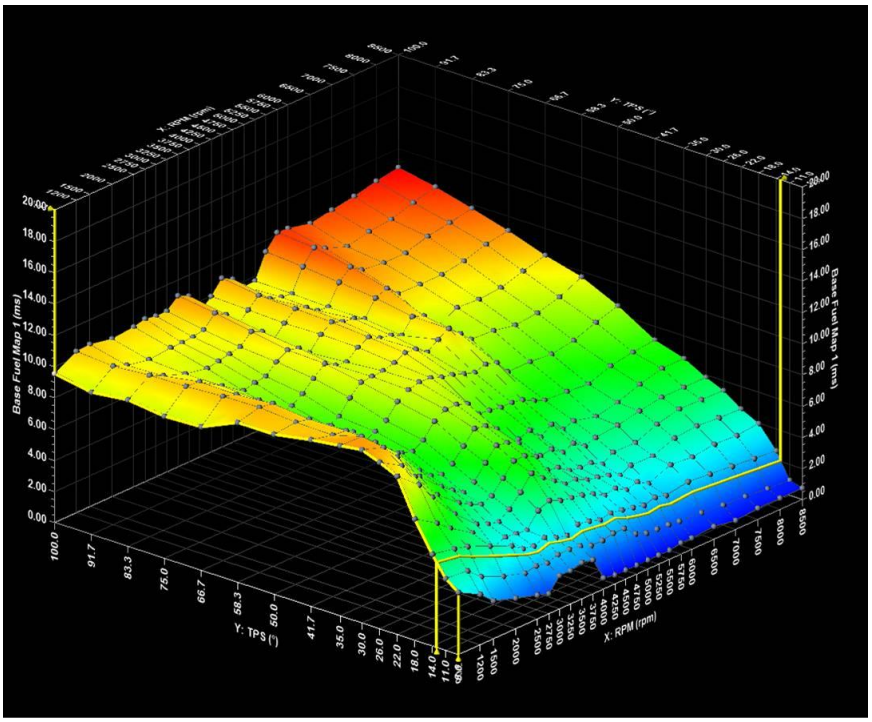
Examples
table #local = C:\Lookup Tables\My Tables.xls\Sheet1!B4:B8
table #srv = \\server\c\Lookup Tables\Server Tables.xls\Sheet1!B4:B8

Once the table has been defined, the variables used to calculate the lookup value and the numerical method also need defining. This is done in a secondary line as below

#name (exp,mode)
#name (exp1, exp2,mode)

where:

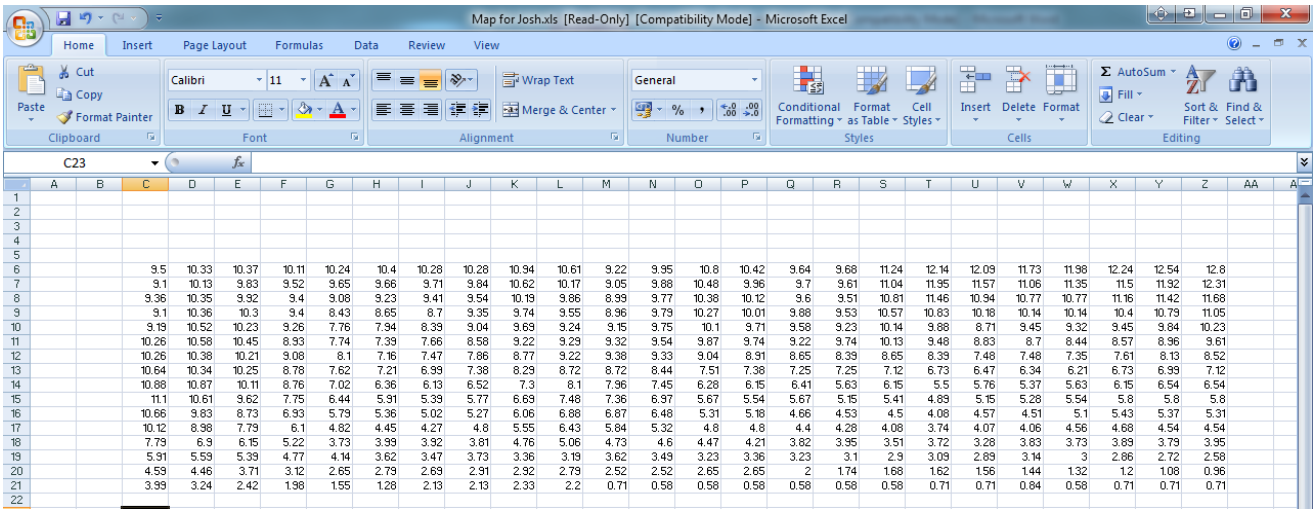
name - is the name of the table.
exp - is the input argument used in 1D lookup tables (Index Column)
exp1 and **exp2** - are input arguments used in 2D lookup tables. exp1 specifies the IndexColumn and exp2 the IndexRow.
mode - is optional parameter. It specifies modes of interpolation/extrapolation. If not specified explicitly, the **Snap** value will be assumed. It can have one of the following values
Interpolate - interpolation is performed
Extrapolate - extrapolation is performed.
Both - interpolation and extrapolation is performed.
Snap (default value) - neither interpolation or extrapolation is performed - the nearest value is returned.
Hold - as Snap mode but will use old value until new value is reached.



Engine Map Fuel injection timings against RPM and Throttle Position - Image courtesy of Pectel control systems, CalTool software.

Just by inspecting the shape of the surface, it is obvious how difficult it would be to devise an equation to describe it without the use of expensive modelling software.

The raw data points used to generate the map are put into a spreadsheet



1																										
2																										
3																										
4																										
5																										
6			9.5	10.33	10.37	10.11	10.24	10.4	10.28	10.28	10.94	10.61	9.22	9.95	10.8	10.42	9.64	9.68	11.24	12.14	12.09	11.73	11.98	12.24	12.54	12.8	
7			9.1	10.13	9.83	9.52	9.65	9.66	9.71	9.84	10.62	10.17	9.05	9.88	10.48	9.96	9.7	9.61	11.04	11.95	11.57	11.06	11.35	11.5	11.92	12.31	
8			9.36	10.35	9.92	9.4	9.08	9.23	9.41	9.54	10.19	9.86	8.99	9.77	10.38	10.12	9.6	9.51	10.81	11.46	10.94	10.77	10.77	11.16	11.42	11.68	
9			9.1	10.36	10.3	9.4	8.43	8.65	8.7	9.35	9.74	9.55	8.96	9.79	10.27	10.01	9.88	9.53	10.57	10.83	10.18	10.14	10.14	10.4	10.79	11.05	
10			9.19	10.52	10.23	9.26	7.76	7.94	8.39	9.04	9.69	9.24	9.15	9.75	10.1	9.71	9.58	9.23	10.14	9.88	8.71	9.45	9.32	9.45	9.84	10.23	
11			10.26	10.58	10.45	8.93	7.74	7.39	7.66	8.58	9.22	9.29	9.32	9.54	9.87	9.74	9.22	9.74	10.13	9.48	8.83	8.7	8.44	8.57	8.96	9.61	
12			10.26	10.38	10.21	9.08	8.1	7.16	7.47	7.86	8.77	9.22	9.38	9.33	9.04	8.91	8.65	8.39	8.65	8.39	7.48	7.48	7.35	7.61	8.13	8.52	
13			10.64	10.34	10.25	8.78	7.62	7.21	6.99	7.38	8.29	8.72	8.72	8.44	7.51	7.38	7.25	7.25	7.12	6.73	6.47	6.34	6.21	6.73	6.99	7.12	
14			10.88	10.87	10.11	8.76	7.02	6.36	6.13	6.52	7.3	8.1	7.96	7.45	6.28	6.15	6.41	5.63	6.15	5.5	5.76	5.37	5.63	6.15	6.54	6.54	
15			11.1	10.61	9.62	7.75	6.44	5.91	5.39	5.77	6.69	7.48	7.36	6.97	5.67	5.54	5.67	5.15	5.41	4.89	5.15	5.28	5.54	5.8	5.8	5.8	
16			10.66	9.83	8.73	6.93	5.79	5.36	5.02	5.27	6.06	6.88	6.87	6.48	5.31	5.18	4.66	4.53	4.5	4.08	4.57	4.51	5.1	5.43	5.37	5.31	
17			10.12	8.98	7.79	6.1	4.82	4.45	4.27	4.8	5.55	6.43	5.84	5.32	4.8	4.8	4.4	4.28	4.08	3.74	4.07	4.06	4.56	4.68	4.54	4.54	
18			7.79	6.9	6.15	5.22	3.73	3.99	3.92	3.81	4.76	5.06	4.73	4.6	4.47	4.21	3.82	3.95	3.51	3.72	3.28	3.83	3.73	3.89	3.79	3.95	
19			5.91	5.59	5.39	4.77	4.14	3.62	3.47	3.73	3.36	3.19	3.62	3.49	3.23	3.36	3.23	3.1	2.9	3.09	2.89	3.14	3	2.86	2.72	2.58	
20			4.59	4.46	3.71	3.12	2.65	2.79	2.69	2.91	2.92	2.79	2.52	2.52	2.65	2.65	2	1.74	1.68	1.62	1.56	1.44	1.32	1.2	1.08	0.96	
21			3.99	3.24	2.42	1.98	1.55	1.28	2.13	2.13	2.33	2.2	0.71	0.58	0.58	0.58	0.58	0.58	0.58	0.71	0.71	0.84	0.58	0.71	0.71	0.71	
22																										

Cosworth Electronics Limited
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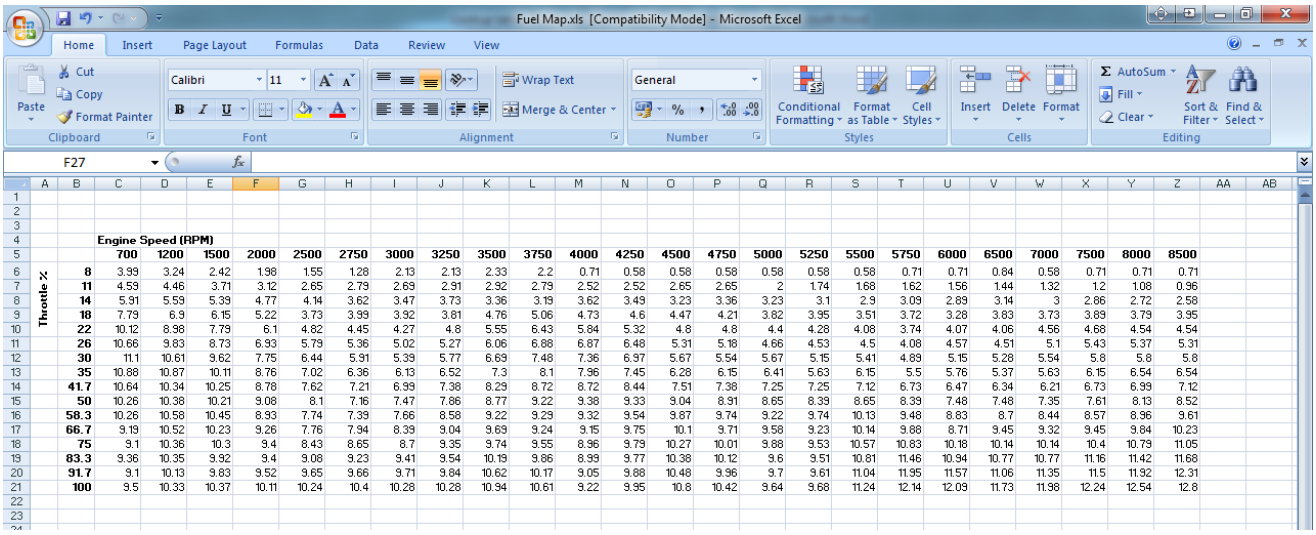
This is then put into the correct format



Throttle %	Engine Speed (RPM)																							
	700	1200	1500	2000	2500	2750	3000	3250	3500	3750	4000	4250	4500	4750	5000	5250	5500	5750	6000	6500	7000	7500	8000	8500
8	3.99	3.24	2.42	1.98	1.55	1.28	2.13	2.13	2.33	2.2	0.71	0.58	0.58	0.58	0.58	0.58	0.58	0.71	0.71	0.84	0.58	0.71	0.71	0.71
11	4.59	4.46	3.71	3.12	2.65	2.79	2.69	2.91	2.92	2.79	2.52	2.52	2.65	2.65	2	1.74	1.68	1.62	1.56	1.44	1.32	1.2	1.08	0.96
14	5.91	5.59	5.39	4.77	4.14	3.62	3.47	3.73	3.36	3.19	3.62	3.49	3.23	3.36	3.23	3.1	2.9	3.09	2.89	3.14	3	2.86	2.72	2.58
18	7.79	6.9	6.15	5.22	3.73	3.99	3.92	3.81	4.76	5.06	4.73	4.6	4.47	4.21	3.82	3.95	3.51	3.72	3.28	3.83	3.73	3.89	3.79	3.95
22	10.12	8.98	7.79	6.1	4.82	4.45	4.27	4.8	5.55	6.43	5.84	5.32	4.8	4.8	4.4	4.28	4.08	3.74	4.07	4.06	4.56	4.68	4.54	4.54
26	10.66	9.83	8.73	6.93	5.79	5.36	5.02	5.27	6.06	6.88	6.87	6.48	5.31	5.18	4.66	4.53	4.5	4.08	4.57	4.51	5.1	5.43	5.37	5.31
30	11.1	10.61	9.62	7.75	6.44	5.91	5.39	5.77	6.69	7.48	7.36	6.97	5.67	5.54	5.67	5.15	5.41	4.89	5.15	5.28	5.54	5.8	5.8	5.8
35	10.88	10.87	10.11	8.76	7.02	6.36	6.13	6.52	7.3	8.1	7.96	7.45	6.28	6.15	6.41	5.63	6.15	5.5	5.76	5.37	5.63	6.15	6.54	6.54
41.7	10.64	10.34	10.25	8.78	7.62	7.21	6.99	7.38	8.29	8.72	8.72	8.44	7.51	7.38	7.25	7.25	7.12	6.73	6.47	6.34	6.21	6.73	6.99	7.12
50	10.26	10.38	10.21	9.08	8.1	7.16	7.47	7.86	8.77	9.22	9.38	9.33	9.04	8.91	8.65	8.39	8.65	8.39	7.48	7.48	7.35	7.61	8.13	8.52
58.3	10.26	10.58	10.45	8.93	7.74	7.39	7.66	8.58	9.22	9.29	9.32	9.54	9.87	9.74	9.22	9.74	10.13	9.48	8.83	8.7	8.44	8.57	8.96	9.61
66.7	9.19	10.52	10.23	9.26	7.76	7.34	8.39	9.04	9.69	9.24	9.15	9.75	10.1	9.71	9.58	9.23	10.14	9.88	8.71	9.45	9.32	9.45	9.84	10.23
75	9.1	10.36	10.3	9.4	8.43	8.65	8.7	9.35	9.74	9.55	8.96	9.79	10.27	10.01	9.88	9.53	10.57	10.83	10.18	10.14	10.14	10.4	10.79	11.05
83.3	9.36	10.35	9.92	9.4	9.08	9.23	9.41	9.54	10.19	9.86	8.99	9.77	10.38	10.12	9.6	9.51	10.81	11.46	10.94	10.77	10.77	11.16	11.42	11.68
91.7	9.1	10.13	9.83	9.52	9.65	9.66	9.71	9.84	10.62	10.17	9.05	9.88	10.48	9.96	9.7	9.61	11.04	11.95	11.57	11.06	11.35	11.5	11.92	12.31
100	9.5	10.33	10.37	10.11	10.24	10.4	10.28	10.28	10.94	10.61	9.22	9.95	10.8	10.42	9.64	9.68	11.24	12.14	12.09	11.73	11.98	12.24	12.54	12.8

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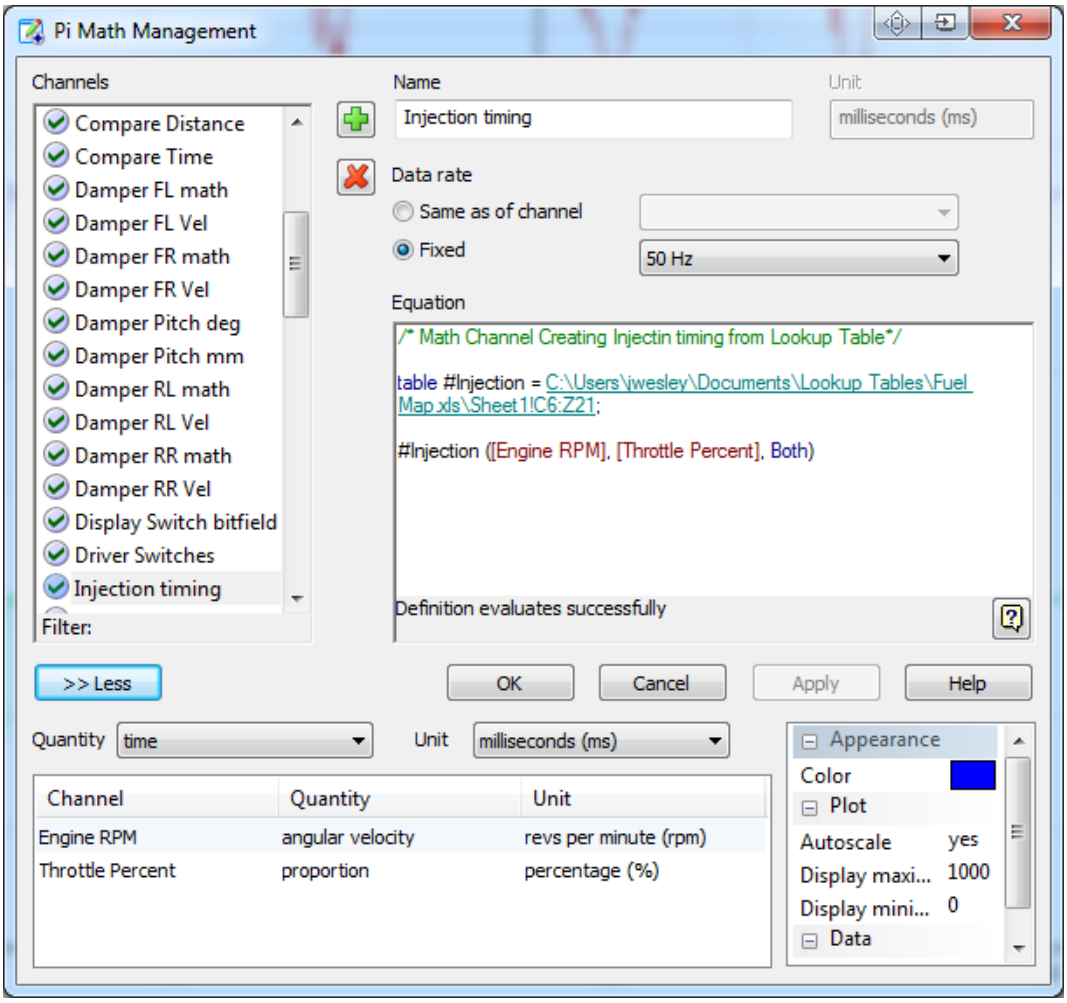
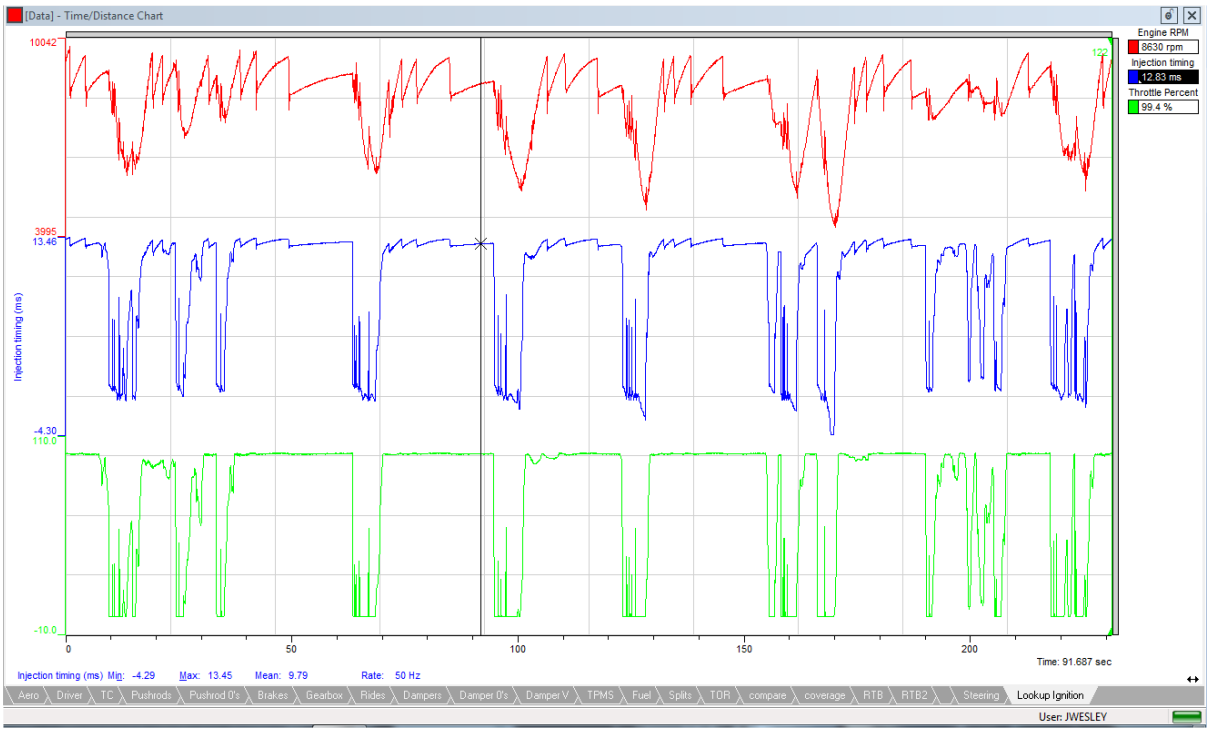


The Lookup Math channel is then created forming the new channel, Injection timing.



This channel can then be viewed alongside regular data channels.

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