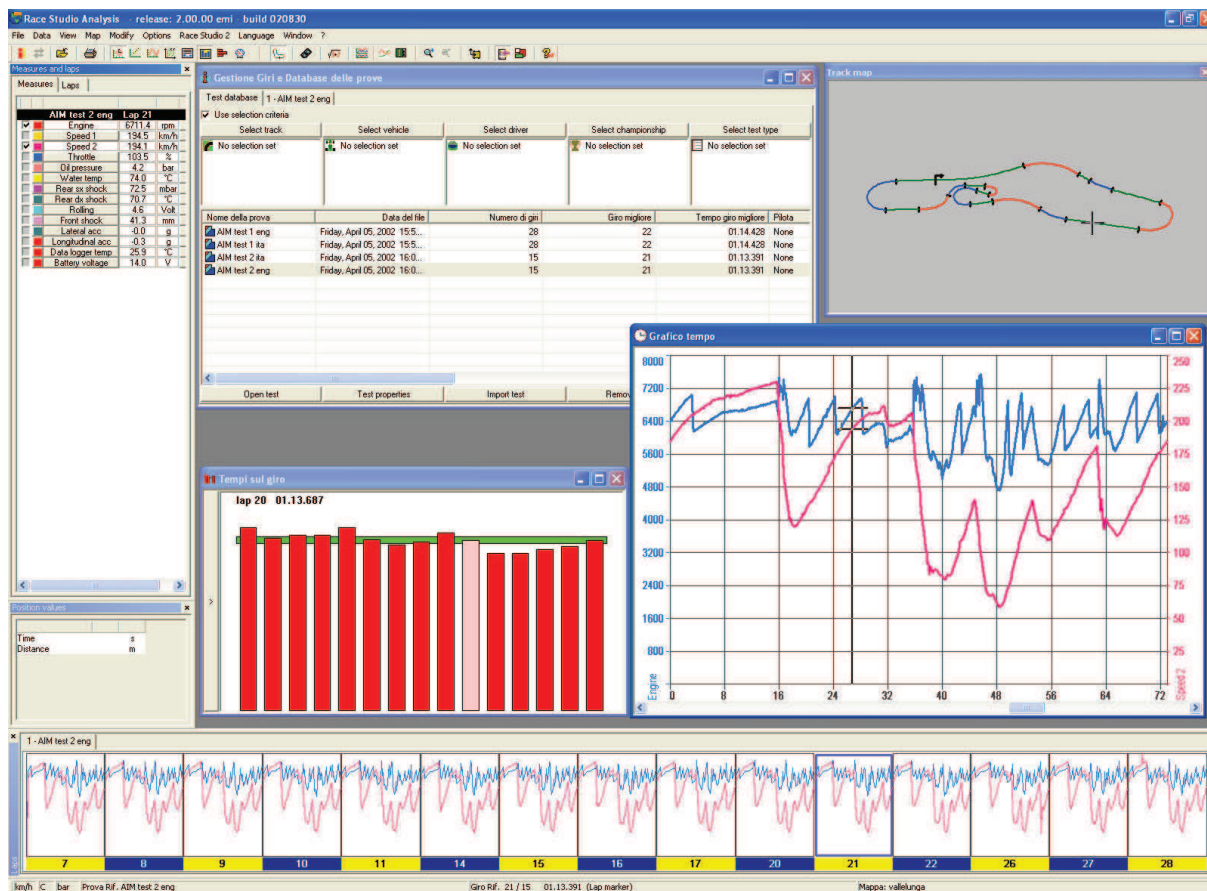


Race Studio 2



Race Studio 2 Analysis

User's manual

Version 1.00.10 – 9th June 2003

Chapter 8 – “How to use the Math channels”

8.1 – Introduction to Math channels

Race Studio Analysis allows analysing two different kinds of measures: Input channels and Math channels.

The data logger acquires the Input channels (for example speed or oil pressure), while the user defines the Math channels and the program calculates them on the PC using the Input channels or the Math channels themselves

Examples of math channels are “gear number”, “Wheel-power”, “Slip factor” etc...

These channels are intended for **expert users** only.

8.2 – Math channels window’s description

Race Studio Analysis math formula interpreter is a general-purpose, full featured interpreter that works with the natural math language syntax.

Each formula may include **identifiers**, **constants**, **functions**, **symbols** and **operators**:

- The **identifiers** are the input or the math channels;
- The **constants** are symbolic constant values user-defined. For example, the acceleration of gravity $ACCGRAV = 9.81 \text{ m/s}^2$ is a constant;
- The **symbols** and the **operators** allow the user to create a math formula;
- The **functions** are predefined math formulas: the user has to set the argument of the functions.

To run this function, you may click the  Math channels command, located inside the Modify toolbar, you may use the proper button  in the buttons toolbar or you may use the shortcut “ALT+F8”.

The Math channel window is shown in Figure 8.1 and described below.

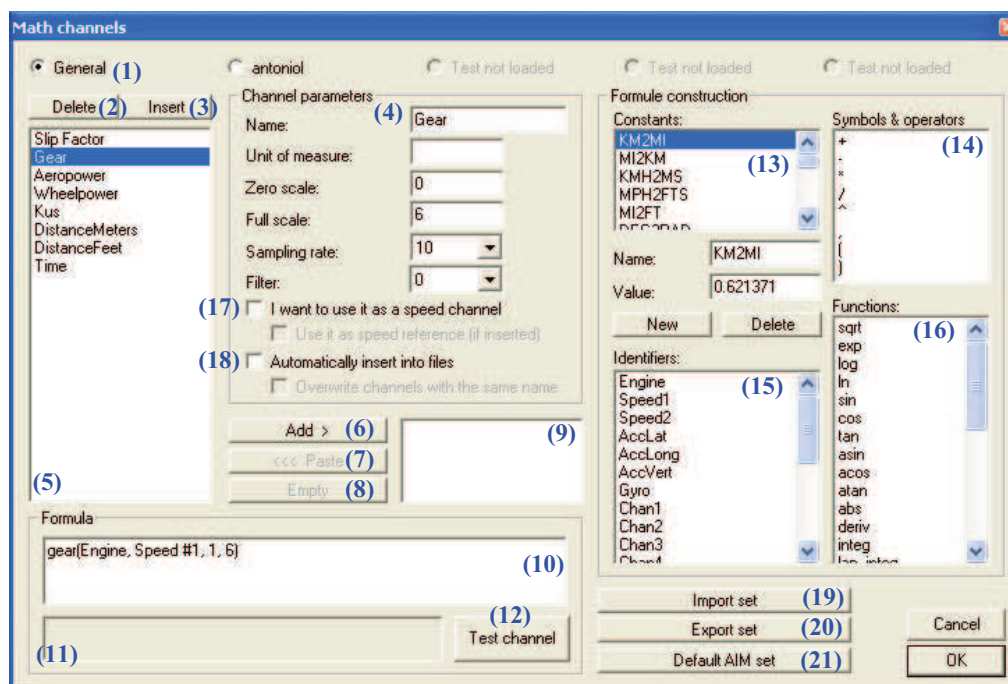


Fig. 8.1– Math channels window

In the window's upper side it is shown 5 checkboxes (1): the "General" one is always enabled, while the other ones are enabled if the corresponding test has been loaded (in Figure 8.1 it has been loaded one test only). The selected checkbox will start blinking.

When the "General" box is checked, the predefined math channels are shown in (5). When you click over a math channel, you can see its properties in the "channel parameters" panel (4), and its associated math formula in the "Formula" panel (10).

With the buttons "Insert" (3) and Delete (2) you may insert or delete channels; if you need to modify an existing math channel, you have to select it and change the parameters (4) and/or the math formula. To change the formula, you may either manually edit the string (10) or use the four panels "Constants" (13), "Symbols & operators" (14), "Identifiers" (15) and "Functions" (16) to automatically build-up the formula. If you double click on an item of these four panels, the corresponding item is automatically copied inside the "formula" panel (10).

If you wish to add to currently loaded test a predefined math channel, please select it from the channel list (5) and press button "Add" (6): the test name will appear in (9). Then select the currently loaded test from the checkboxes (1) and click button "Paste" (7). The math channel, now, will appear in the channel list (5) of the current test.

To delete a math channel from (9), please use button "Empty" (8).

Once the formula has been defined, you should use the button "Test channel" (12) to check if the formula has been correctly interpreted. You can find the result of this check in the grey line (11) below the formula string. If there is something wrong you can see the offending item highlighted in the formula string (10). It is suggested to try to misspell some identifiers or constants to see how the "Test channel" function works.

The *Math channels* window also allows the user to set the new channel as a "speed" one (17). If checkbox (17) is enabled, the user is also allowed to set this channel as "Reference speed" (see paragraph 5.4 "How to modify the reference speed").

Moreover, the new *Math channels* graphical interface also allows the user to "Automatically insert the channel into the DRK file" each time a DRK file is opened. Moreover, if you enable the checkbox "Overwrite channels with the same name", each channel labelled as the one you are going to insert will be overwritten.

The new *Math channels* window also allows the user to import (19) or export (20) the math channels set. Moreover, you may load a "Default math channels set" by pressing button *Default AIM set* (21).

For further information and examples concerning the insertion of a predefined/new math channel, please refer to chapters 8.3 and 8.4.

8.2.1 – The predefined math channels

Race Studio Analysis provides a list of predefined math channels shown in (5). Each customer may both use these channels and create his own predefined math channels.

User defined math channels will not be removed or deleted when upgrading the software.

The predefined math channels list is described here below.

Name	Description	Needed channels	Parameters
Wheel Power	The available engine power.	Reference speed.	Vehicle weight.

Slip Factor	The ratio between the reference speed and the engine rpm.	Reference speed and engine rpm.	None.
Gear no.	Calculates the current gear number.	Reference speed and engine RPM.	The maximum and minimum really used gear number.
Time	For every lap is calculated the elapsed time from the start of the lap	None.	None.
Calculated speed	The maximum, the minimum or the average between Speed #1 and Speed #2. This channel can be selected as <i>reference speed</i> .	Two speeds input channels.	The algorithm for the calculation
Kus	A representation of understeer/oversteer.	Speed, lateral acceleration and steering angle.	The wheel base of the vehicle and the threshold value for the lateral acceleration.
DistanceMeters	For every lap is calculated the travelled distance in meters	Reference speed.	None.
DistanceFeet	For every lap is calculated the travelled distance in Feet	Reference speed.	None.

8.2.2 – The “Channel parameters” panel

The “Channel parameters” panel **(4)** allows changing the math channel name, the unit of measure, the minimum and maximum plotting scale values and the sampling rate.

It is also possible to “filter” the math channel if data are very noisy (for further information on filters, refer to chapter 4.6.4).

The “Channel parameters” panel also allows the user to define a math channel as a “speed channel”. For instance, if you have two speed sensors installed on the vehicle, you may create a math channel

called “average speed” with the following equation $\frac{Speed1 + Speed2}{2}$ and use this channel as reference speed (for further information on changing the reference speed, please see chapter 5.4).

8.2.3 – The “Formula” box

In the “Formula” box **(10)** it is shown the math formula used to calculate the math channel.

This formula is totally modifiable: to change the formula you may either use the “Formula construction” tools or manually edit the string.

8.2.4 – The “constants” table

The “Constants” table **(13)** shows a list of predefined constants: these constants load some common numbers (such as the acceleration of gravity, the mass of the vehicle, etc...). These values may be used in the formulas.

Pressing button “New” it is possible to create a new constant: the user has to define its value and the name. It is suggested to use a name which reminds the function of the constant: for instance, the constant MI2KM changes the distance’s unit of measure from Miles (MI) to Kilometres (km).

To add a new constant, please press button “New” and define the constant’s value and name. To delete a constant, please select it from the list and press button “Delete”.

8.2.5 – The “Symbols & operators” table

This panel **(14)** contains five formula operators (+ - * / ^), the commas (used as function parameters separator) and the brackets (used to define the precedence of operator and functions). Please, refer to next table to have a more detailed explanation of “Symbols and Operators”:

Operator	Parameters	Result
+ (sum)	A,B could be - Integer numbers - Decimal numbers - Identifiers - Constants	A+B
- (subtraction)	A,B could be - Integer numbers - Decimal numbers - Identifiers - Constants	A-B
* (product)	A,B could be - Integer numbers - Decimal numbers - Identifiers - Constants	A*B
/ (division)	A,B could be - Integer numbers - Decimal numbers - Identifiers - Constants	A/B
^ (integer power)	A could be - Integer number - Decimal number - Identifier - Constant B must be - integer number	A^B

Parentheses “()” and comma “,” Parentheses are used to include the argument of a function and to give the math formula a correct syntactic form.
Commas are used to separate the identifiers inside the functions.

8.2.6 – The “Identifiers” table

The “Identifiers” table (15) shows the names of both input and math channels already defined by the user.

These are the only channels the interpreter can use to compute a new math channel. If the channel name is misspell when testing the math formula (using button “Test channel”), the interpreter warns you, as shown in Figure 8.2.

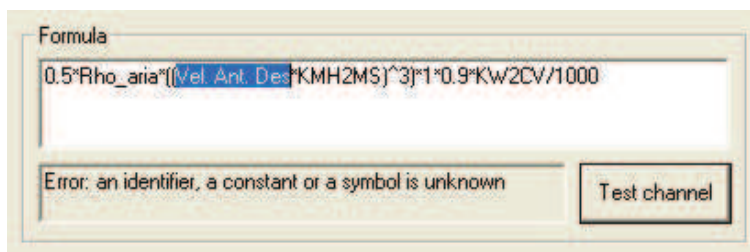


Fig. 8.2– The interpreter warns the user of an error concerning the identifier name

8.2.7 – The “Functions” table

This panel contains the list of functions supported by the interpreter. It is strongly recommended to use this panel to insert the function inside the formulas, because this way the software automatically inserts also the brackets and the commas needed, indicating also the number of parameters that each function uses.

Please, refer to next table to have a more detailed explanation of “Functions”:

Function	Argument(s)	Result
Sqrt(p1)	p1 = channel identifier	The square root of the argument
Exp(p1)	p1 = channel identifier	The exponential of the argument
Log(p1)	p1 = channel identifier	The base 10 logarithm of the argument
Ln(p1)	p1 = channel identifier	The natural logarithm (base e) of the argument
Sin(p1)	p1 = channel identifier	The trigonometric sine of the argument (argument in radians)
Cos(p1)	p1 = channel identifier	The trigonometric cosine of the argument (argument in radians)
Tan(p1)	p1 = channel identifier	The trigonometric tangent of the argument (argument in radians)
Asin(p1)	p1 = channel identifier	The arc, in radians, whose trigonometric sine is the argument
Acos(p1)	p1 = channel identifier	The arc, in radians, whose trigonometric cosine is the argument
Atan(p1)	p1 = channel identifier	The arc, in radians, whose trigonometric tangent is the argument
Abs(p1)	p1 = channel identifier	The absolute value of the argument

Deriv(p1)	p1 = channel identifier	The first derivative function of the argument function over time, computed as $(F(t_0 + dt) - F(t_0)) / dt$
Integ(p1)	p1 = channel identifier	The integral function of the argument function, with $t_0 = 0$ as start integration point
Lap_integ(p1)	p1 = channel identifier	The integral function of the argument function, with $t_0 = \text{startlap}$ as start integration point for each lap
Min(p1, p2)	p1,p2 = channel identifier	The minimum value between the arguments
Med(p1, p2)	p1,p2 = channel identifier	The mean value between the arguments
Max(p1, p2)	p1,p2 = channel identifier	The maximum value between the arguments
High_pass(p1,p2)	p1 = channel identifier p2 = constant	If $p1(t) \geq p2 \rightarrow p1(t)$ If $p1(t) < p2 \rightarrow 0$
Low_pass(p1, p2)	p1 = channel identifier p2 = constant	If $p1(t) \leq p2 \rightarrow p1(t)$ If $p1(t) > p2 \rightarrow 0$
Band_pass(p1, p2, p3)	p1 = channel identifier p2,p3 = constant	If $p2 \leq p1(t) \leq p3 \rightarrow p1(t)$ Else $\rightarrow 0$
Bit_and(p1, p2)	p1 = raw channel identifier p2 = integer constant	The logical AND operation between the arguments The function is meaningless if applied to decimal numbers
Bit_or(p1, p2)	p1 = raw channel identifier p2 = integer constant	The logical OR operation between the arguments The function is meaningless if applied to decimal numbers
Bit_xor(p1, p2)	p1 = raw channel identifier p2 = integer constant	The logical XOR operation between the arguments The function is meaningless if applied to decimal numbers
Time()		It builds a function whose value for each t is the actual lap time, the time calculation is started at the beginning of each lap.
Bike_angle(p1, p2)	p1 = Vertical acceleration channel identifier p2 = Gyroscope channel identifier	The bike inclination angle (degrees)

Slip(p1,p2)	p1 = Engine RPM channel identifier p2 = Speed channel identifier	The slip factor
Gear(p1, p2, p3, p4)	p1 = Engine RPM channel identifier p2 = Speed channel identifier p3 = minimum gear used along the track (integer number) p4 = maximum gear used along the track (integer number)	The gear number (from p3 to p4)
Bike_acclat(p1,p2)	p1 = Speed channel identifier p2 = Gyroscope channel identifier	The bike's lateral acceleration
Bike_cornrad(p1,p2)	p1 = Speed channel identifier p2 = Gyroscope channel identifier	The bike's radius of corner

8.3 – How to add a predefined math channel

This chapter shows how to add a predefined math channel to the channels list. The different procedure steps are labelled with a progressive number starting from 1 to 9 (see also Figure 8.3). It is recommended to follow the procedure explained here below:

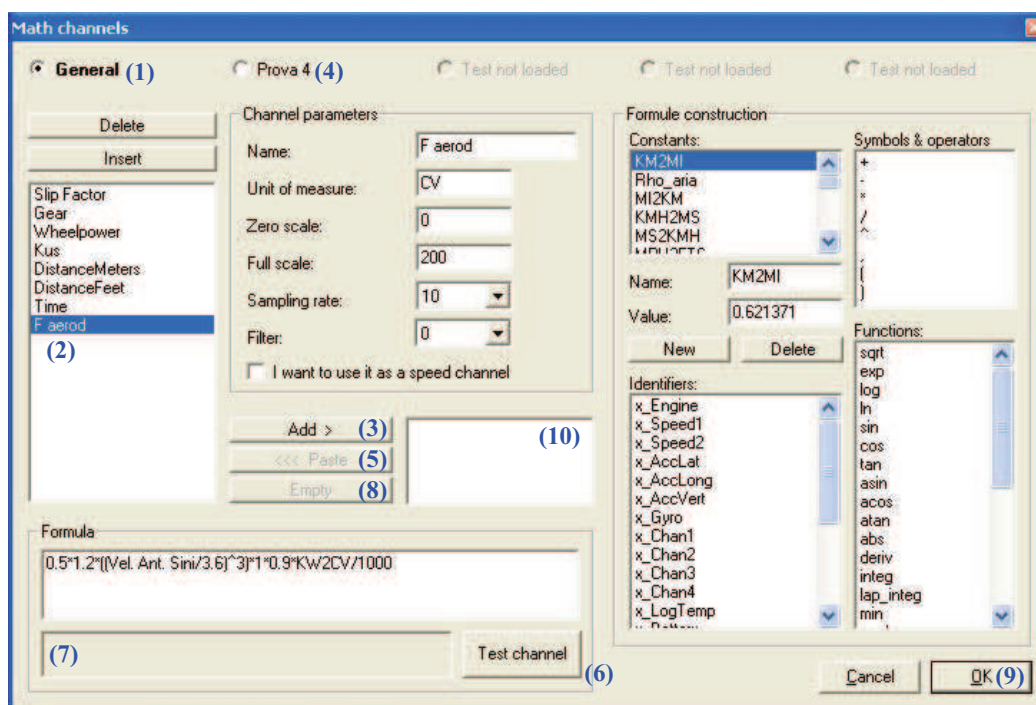


Fig. 8.3– *Math channels* window: adding a predefined math channel

1. Select the “General” checkbox; once selected, it will start blinking.
2. Select the desired predefined math channel: single click on the channel name.
3. Click the “Add” button.
4. Change the test from “General” to the currently loaded one by clicking on the corresponding checkbox.

5. Click the “Paste” button: this function copies the math channel from the general math channels list to the one corresponding to the loaded test.
6. Test the math formula using button “Test channel”. If there is no warning and it appears the text “OK, the formula has been correctly interpreted”, skip to point 9.
7. If it appears a warning message in (7), you have to fix the problem. The most common problem concerns misspell constant names or incorrect channel names: this last event is quite common because the predefined math channels use default channel names (such as “x_Engine”) while the user may have saved that channel with another name (such as “RPM” or “Engine_RPM”, etc...). The offending item is blue-highlighted: please, double-click on the correct channel (or constant) name to replace the incorrect parameter.
8. Click “Empty” to delete the pasted channel from (10).
9. Click button “OK” to apply the changes.

8.4 – How to add a new math channel

This chapter shows how to add a new channel to the math channel list.

For instance, the example reported here below shows how to add the math channel “average speed” to the currently loaded test channel list (in this example, it is supposed that two speed signals have been sampled).

1. Select the checkbox corresponding to the loaded test.
2. Click the “Insert” button.
3. Input the channel name in the corresponding box (located inside the “Channel parameters” panel): for instance, digit “avg_speed”.
4. Input the channel’s unit of measure: km/h, m/s, MPH, etc...
5. Set the plotting scale limits (i.e. the zero/full scale).
6. Do not modify the “Sampling frequency” menu: the correct sampling frequency is fixed by the program.
7. As this new math channel is a speed one, place a check besides the “I want to use it as a speed channel” box. This event will allow you choosing this new channel as “Reference speed”.
8. Now you are able to insert the math formula inside the “Formula” panel. It is strongly recommended to use the “Formula construction” panel to insert the formula, because this way the software automatically inserts the brackets and the commas needed.
9. Now select from the “Functions” list the “med” one and double click on it.
10. It is reminded that, as previously explained in chapter 8.2.7, the function “med” needs 2 identifiers, which are the first and the second speed channel
11. Once double-clicked on the function, it will appear in the “Formula” panel in the following way: **med(,)**
12. Now click with the mouse in the space between the open-bracket “(” and the comma “,” in order to set the **first** identifier and, then, select the correct first speed channel from the “Identifiers” list by double-clicking on it.
13. Now click with the mouse in the space between the comma “,” and the close-bracket “)” in order to set the **second** identifier and, then, select the correct second speed channel from the “Identifiers” list by double-clicking on it.
14. Now you may test the new math channel by pressing the “Test channel” function.
15. If the parameters/identifiers have been correctly set, it will appear the text “OK, the formula has been correctly interpreted”. Click “OK” to save the new channel inside the currently loaded test’s channel list.