How to Work with the Programmable Material and Example (Linear Dependence)
 Providing maximum versatility is one of our most fundamental objectives. A key aspect of this aim is to provide a flexible-enough definition mechanism of the refractive index, in order to achieve a realistic characterization of the matter which composes an optical system. In VirtualLab Fusion this role is left to Materials and Media: the first deal with the dependence of the refractive index on wavelength (dispersion), the second group take care of the dependence on position. In what follows we present a tutorial that guides the user in the task of programming their own custom materials.
Where to Find the Programmable Material: Catalog (1)

Note that the Programmable Material is also accessible at any point during the construction of a system when a material must be entered for the configuration!
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Snippet to define the imaginary part of the refractive index
The refractive index is in general a complex value. This snippet defines its real part.

The panel on the right shows a list of available independent parameters.

MinimumWavelength and MaximumWavelength refer to the boundary values of the range in which this particular function is defined.

Wavelength represents each of the points at which the programmed function is sampled.

Temperature and GasPressure retrieve these values from the configuration dialogue, and they can be used in the code, in case the final value of the refractive index depends on them.

The code must output a double value, representing the value of the real part of the refractive index at the wavelength Wavelength and for the given values of Temperature and GasPressure.

**Hint:** the Global Parameters, Snippet Help, Advanced Settings tabs and other aspects of the interface work equivalently to those of other programmable elements in VirtualLab.
Writing the Code: Absorption Coefficient

- The refractive index is in general a complex value. This snippet defines the absorption coefficient $\alpha$, which is related to the imaginary part of $n$ via Eq. (1).
- The panel on the right shows a list of available independent parameters.
- `MinimumWavelength` and `MaximumWavelength` refer to the boundary values of the range in which this particular function is defined.
- `Wavelength` represents each of the points at which the programmed function is sampled.
- The code must output a `double` value, representing the value of the imaginary part of the refractive index at the wavelength `Wavelength`.

$$\tilde{n} = n + i n'$$

$$\alpha = \frac{4\pi n'}{\lambda_0}$$  \hspace{1cm} (1)

**Hint:** The Global Parameters, Snippet Help, Advanced Settings tabs and other aspects of the interface work equivalently to those of other programmable elements in VirtualLab.
Wavelength Range

If you wish the final value of the refractive index of your custom material to be defined with respect to another material, tick this option and select the reference material accordingly.

Enter here the wavelength range for which your custom function will be valid.

Check the graphical representation of your custom material here!

It is possible to combine a programmable real refractive index with, for instance, a constant absorption coefficient. Their snippets are defined independently (except for the user-defined global parameters).

Enter here the wavelength range for which your custom function will be valid.
Programming a Material with Linear Behaviour
Linear Dependence of Refractive Index

Let us denote the complex-valued refractive index of our material with

$$\tilde{n}(\lambda) = n(\lambda) + i n'(\lambda)$$

$$\alpha = \frac{4\pi n'}{\lambda_0}$$

(1)

and let us assume that both the real refractive index and the absorption coefficient exhibit a linear dependence on the wavelength

$$n(\lambda) = n_0 + b\lambda$$

$$\alpha(\lambda) = \alpha_0 + b_\alpha\lambda$$

(2)

with

$$n_0 \rightarrow \text{Offset}$$

$$b \rightarrow \text{Slope}$$

$$\alpha_0 \rightarrow \text{Offset}$$

$$b_\alpha \rightarrow \text{Slope}$$

(3)
Where to Find the Programmable Material: Catalog (1)

Snippet to define the real part of the refractive index
Once you have triggered open the Edit dialogue, go to the Global Parameters tab.

There, Add and Edit four global parameters:

- `double OffsetRefractiveIndex = 1A.U.:` the offset for the linear dependence of the real part of the refractive index.
- `double OffsetAbsorptionCoefficient = 0A.U:` the offset for the linear dependence of the absorption coefficient.
- `double SlopeRefractiveIndex = 9e4A.U.:` the slope for the linear dependence of the real part of the refractive index.
- `double SlopeAbsorptionCoefficient = -1e4A.U.:` the slope for the linear dependence of the absorption coefficient.

Use the button with the small “notes” icon to add some explanation to your custom global parameters.
• **Optional:** you can use the Snippet Help tab to write instructions, clarifications, and some metadata associated to your snippet.

• This option is very helpful to keep track of your progress with a programmable element.

• It is especially useful when the programmable element is later disseminated to be handled by other users!
Programmable Material: Snippet Help

Custom Material with Linear Behaviour

Version: 1.0
Last Modified: Tuesday, November 20, 2018

This snippet defines a material whose refractive index depends linearly on the wavelength.

<table>
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<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
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<tr>
<td>OffsetRefractiveIndex</td>
<td>Offset for the linear dependence of the refractive index.</td>
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<tr>
<td>SlopeAbsorptionCoefficient</td>
<td>The slope of the linear dependence of the absorption coefficient.</td>
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Programmable Material: Writing the Code (1)

```
double RefractiveIndex = 1.0;
RefractiveIndex = OffsetRefractiveIndex + SlopeRefractiveIndex * Wavelength;
return RefractiveIndex;
```

Eq. (2)

Default global parameters/variables
Global parameters defined by user in Global Parameters tab

Declare output

Export Snippet to save your work!

Are there errors in your code?

Snippet to define the real part of the refractive index
Programmable Material: Writing the Code (2)

* Declare output *

* Export Snippet to save your work! *

* Are there errors in your code? *

* Eq. (2) *

* Default global parameters/variables *

* Global parameters defined by user in Global Parameters tab *

* Snippet to define the absorption coefficient $\alpha$ *
Save the Custom Material to the Catalog

**Hint:** if you used the Catalog to define your custom material, you will be automatically prompted to save your work to the catalog.
Note the different functional dependence of \( \alpha \) and \( \kappa (n^2) \)!
Test the Code!

Main Function (Refractive Index)

// Declare output:
double RefractiveIndex = 1.0;

// Apply equation for linear dependence:
RefractiveIndex = OffsetRefractiveIndex + SlopeRefractiveIndex * Wavelength;

// Return output:
return RefractiveIndex;
// Declare output:
double AbsorptionCoefficient = 0.0;

// Apply equation for linear dependence:
AbsorptionCoefficient = OffsetAbsorptionCoefficient + SlopeAbsorptionCoefficient * Wavelength;

// Return output:
return AbsorptionCoefficient;
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