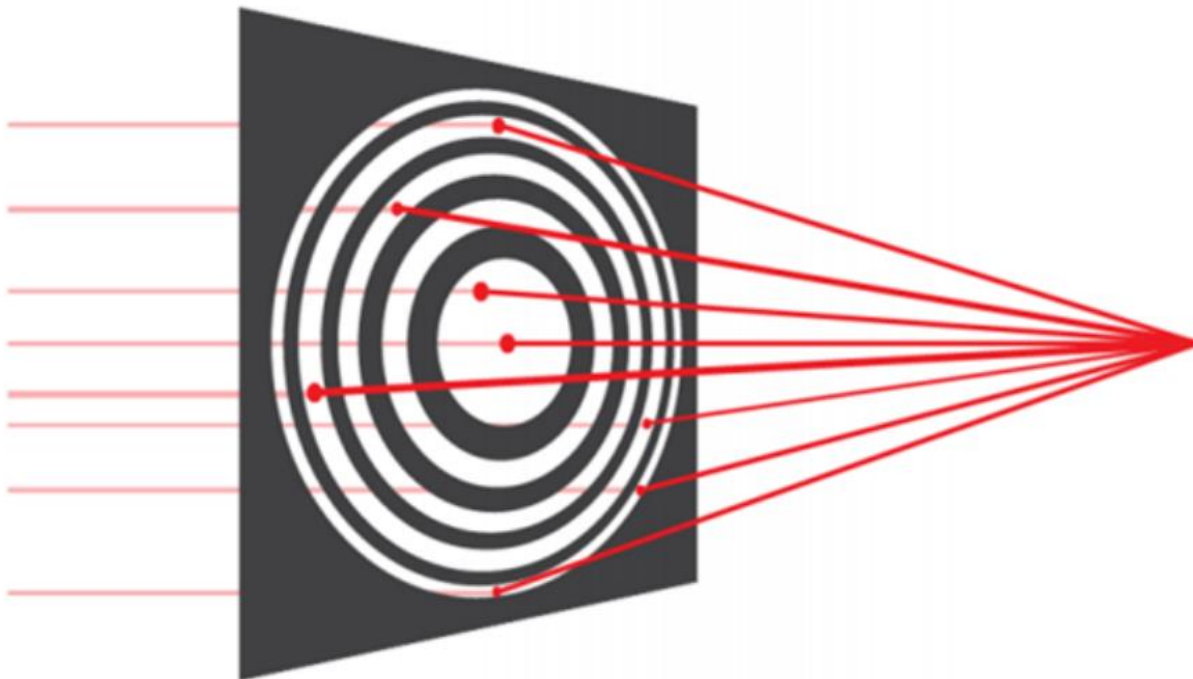


Using Formulas in Modules

In this application we wish to demonstrate how to use formulas in BEAMER modules. The formula will be used in the TRANSFORM module

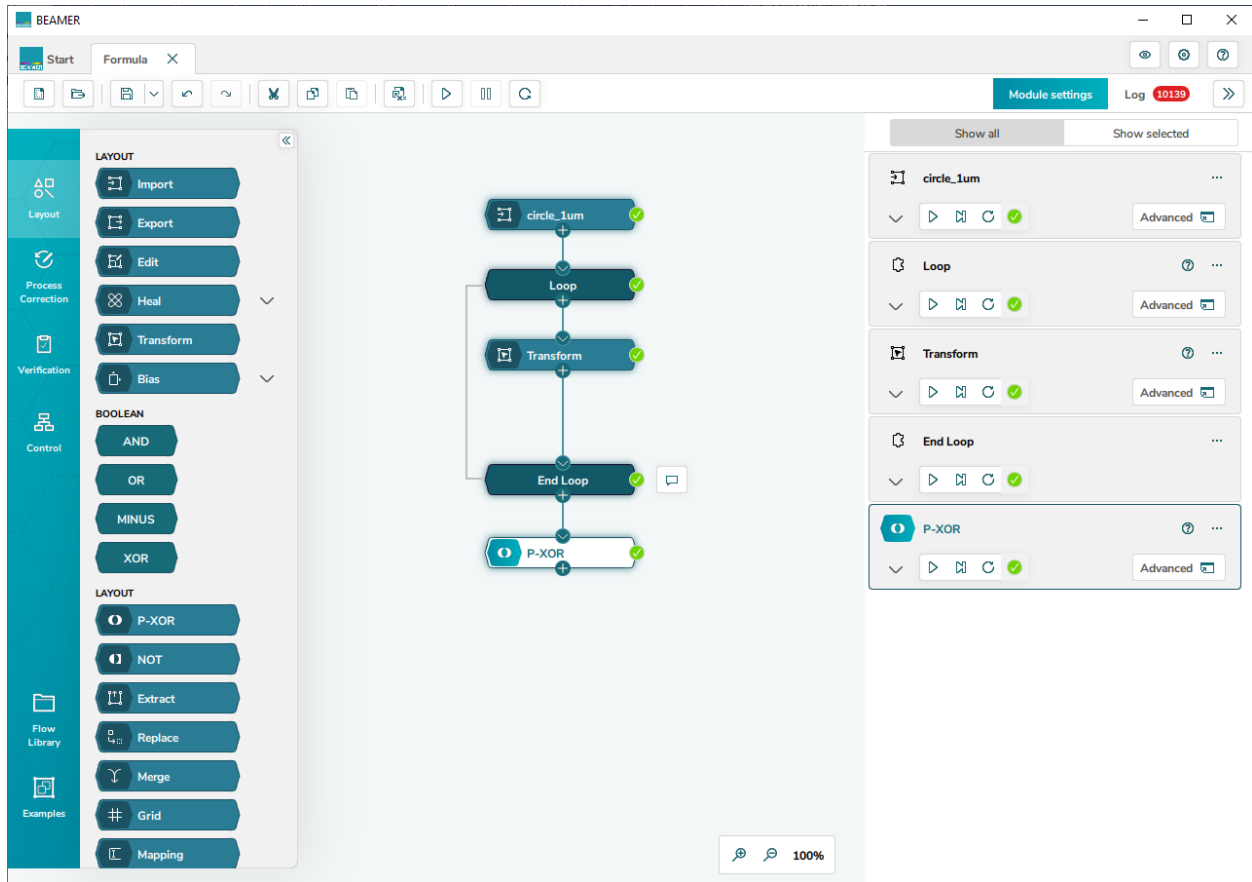
For the flow we will create a Fresnel zone plate pattern. For information on Fresnel zone plates see <http://zoneplate.lbl.gov/theory>

A zone plate is a diffractive optic that consists of several radially symmetric rings called zones. Zones alternate between opaque and transparent, and are spaced so that light transmitted by the transparent zones constructively interferes at the desired focus.



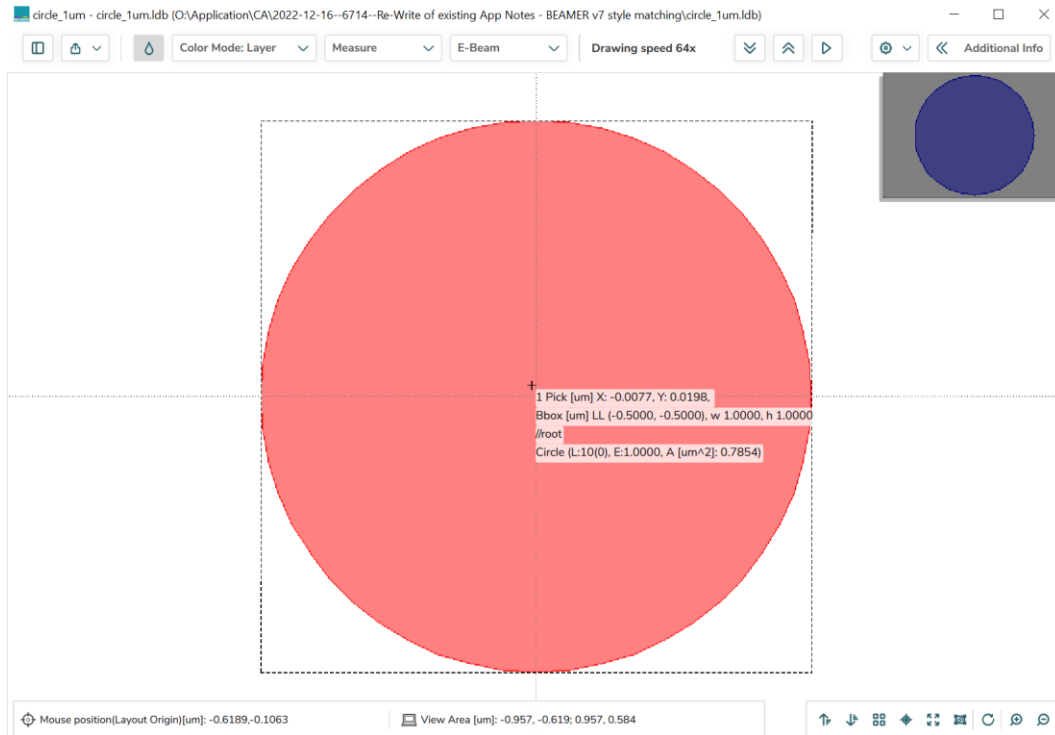
PROCESS FLOW

Shown below is the process Flow for example using formulas in modules.



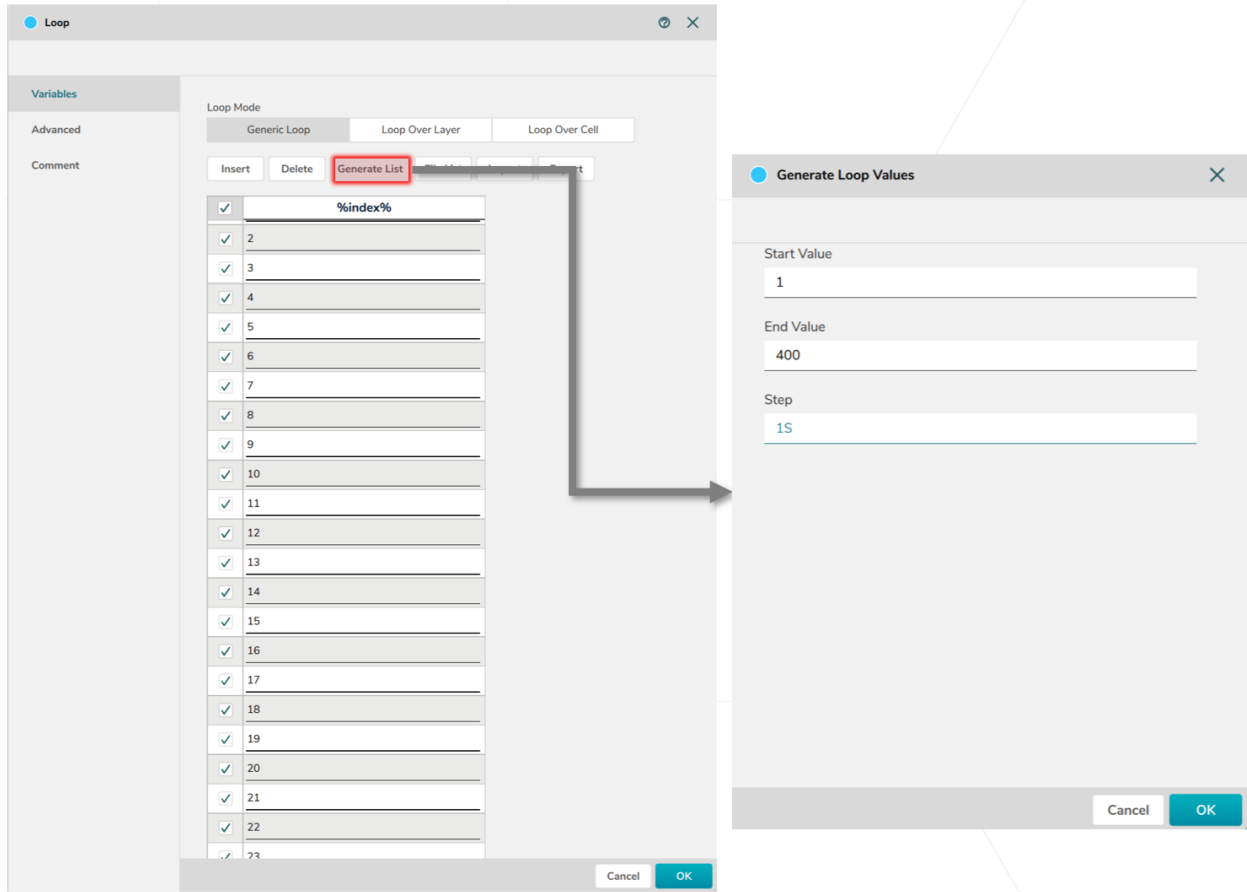
IMPORT

Here the file is imported. The input file is a circle of diameter 1 μ m.

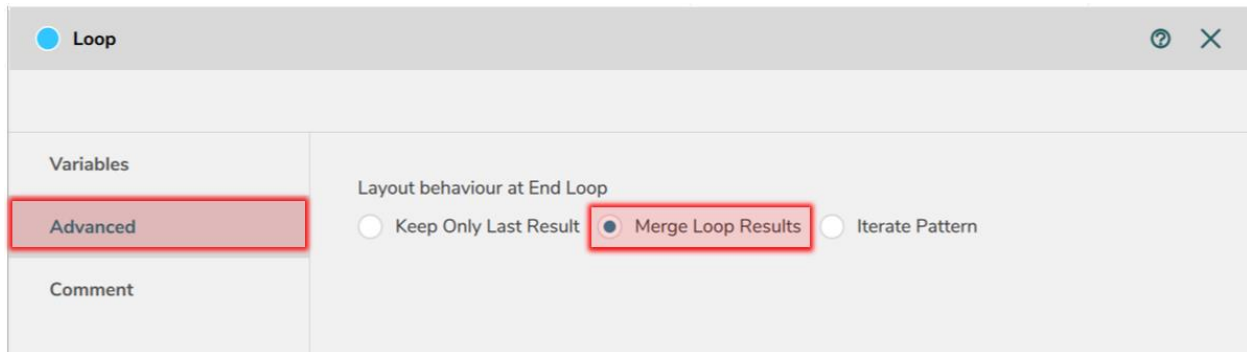


LOOP

As we wish to vary the TRANSFORM values in the simulation, the LOOP module is selected, a variable %index% defined, and using *Generate Values* starting with *Start Value 1*, *End Value 400* and *Steps of 1*, the required table is created as shown below.



In the **Advanced Tab** activate the *Merge Loop Results* button, see below:



TRANSFORM

Shown below is the TRANSFORM modules in which a formula is applies as the X- and Y- values.

Transformation

Configure Quick Access

General

Comment

Coordinate Origin

Layout Origin Center Bottom Left

Apply Centering To Axis

X and Y Only X Only Y

Reflect

X Y

Rotation [deg]

0.000000

Scale

X	Y
$139 * \text{\%index\%} * \text{\%index\%} / 4)^{0.5}$	$139 * \text{\%index\%} * \text{\%index\%} / 4)^{0.5}$

Shift [um]

X	Y
0.000000	0.000000

Cancel OK

For zone plates, the formula for the radius of the n^{th} ring is:

$$r_n = \sqrt{n\lambda f + \frac{n^2 \lambda^2}{4}}$$

The formula in the TRANSFORM module is thus:

$$2*(\%index%*0.0139*300+0.0139*0.0139*\%index%\%index%/4)^{0.5}$$

and is entered as the X and Y Scale values outlined in red above.

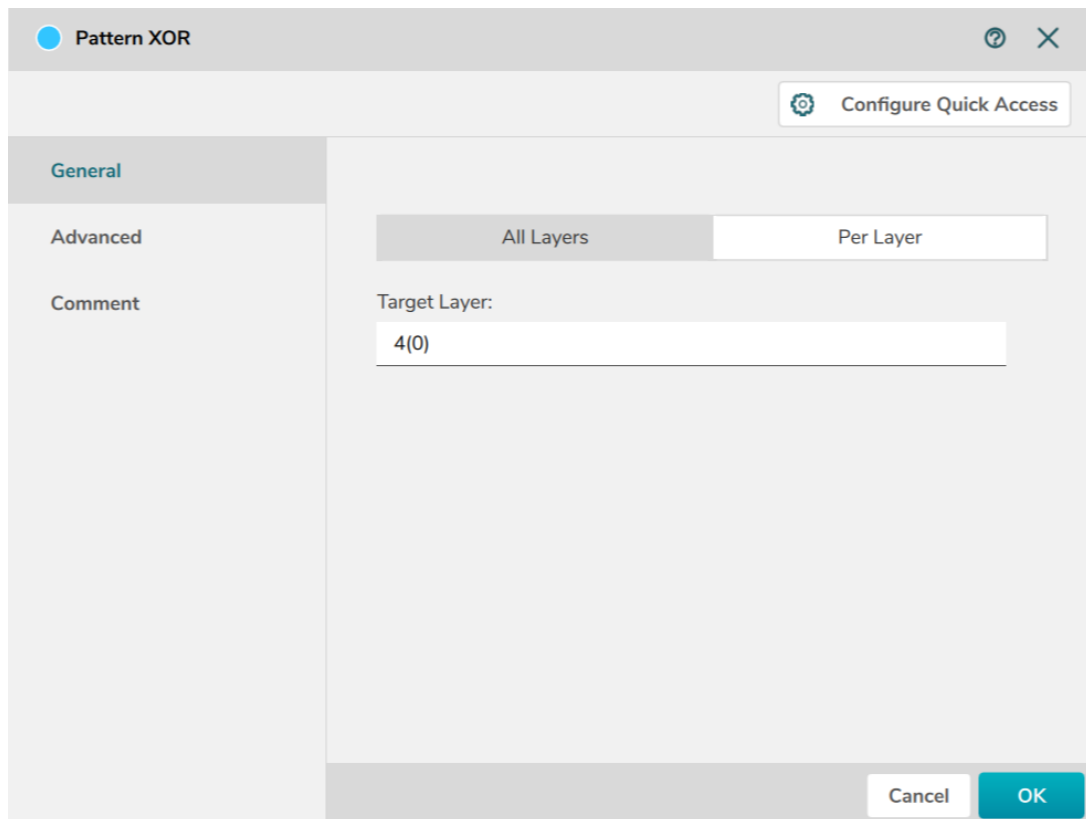
Notes:

- The initial factor 2 is due to the P-XOR module which deletes every second ring
- $2 * \text{index}$ gives the number of rings in the zone plate structure. The number of rings defines the resolution of the zone plate
- 0.0139 is the wavelength in μm of the illuminating light in this case
- 300 is related to the focal length and is used to obtain the required diameter of the innermost ring and therefore all successive rings

P-XOR

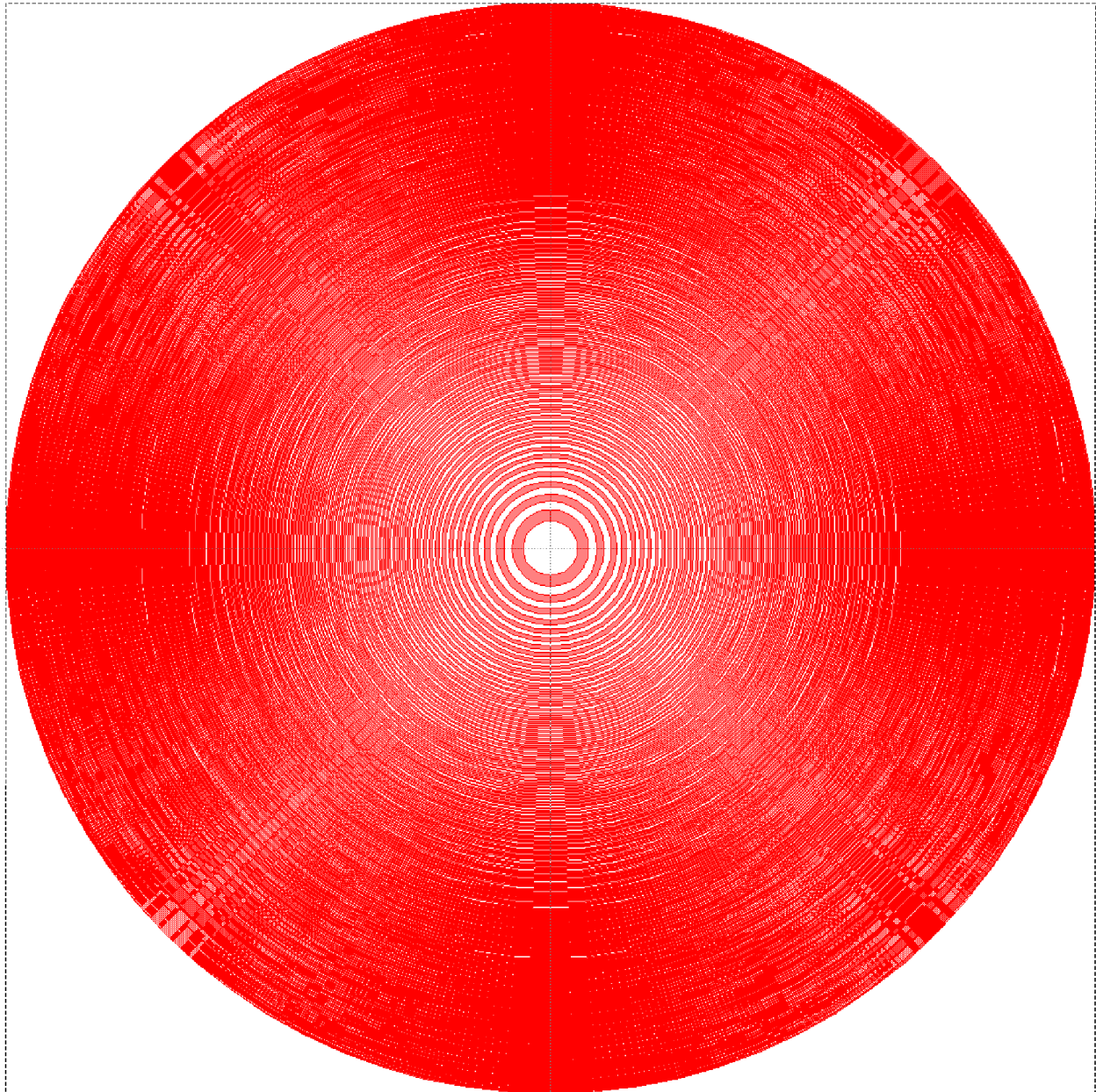
The P-XOR (Pattern-XOR) is a special Boolean operation that removes even overlaps and keeps odd overlaps. In this case this means that the inner ring and all alternate rings are removed resulting in the required zone plate structure.

The target layer and datatype in the result can be specified by opening the parameter window by double clicking the module.



RESULTS

Shown below is the output structure obtained.



The beauty and elegance of this example is that with just four basic BEAMER modules: INPUT, LOOP, TRANSFORM and P-XOR and using an appropriate formula in this case in the TRANSFORM modules, complex optical structures can be very simply and quickly produced.

USING VARIABLES

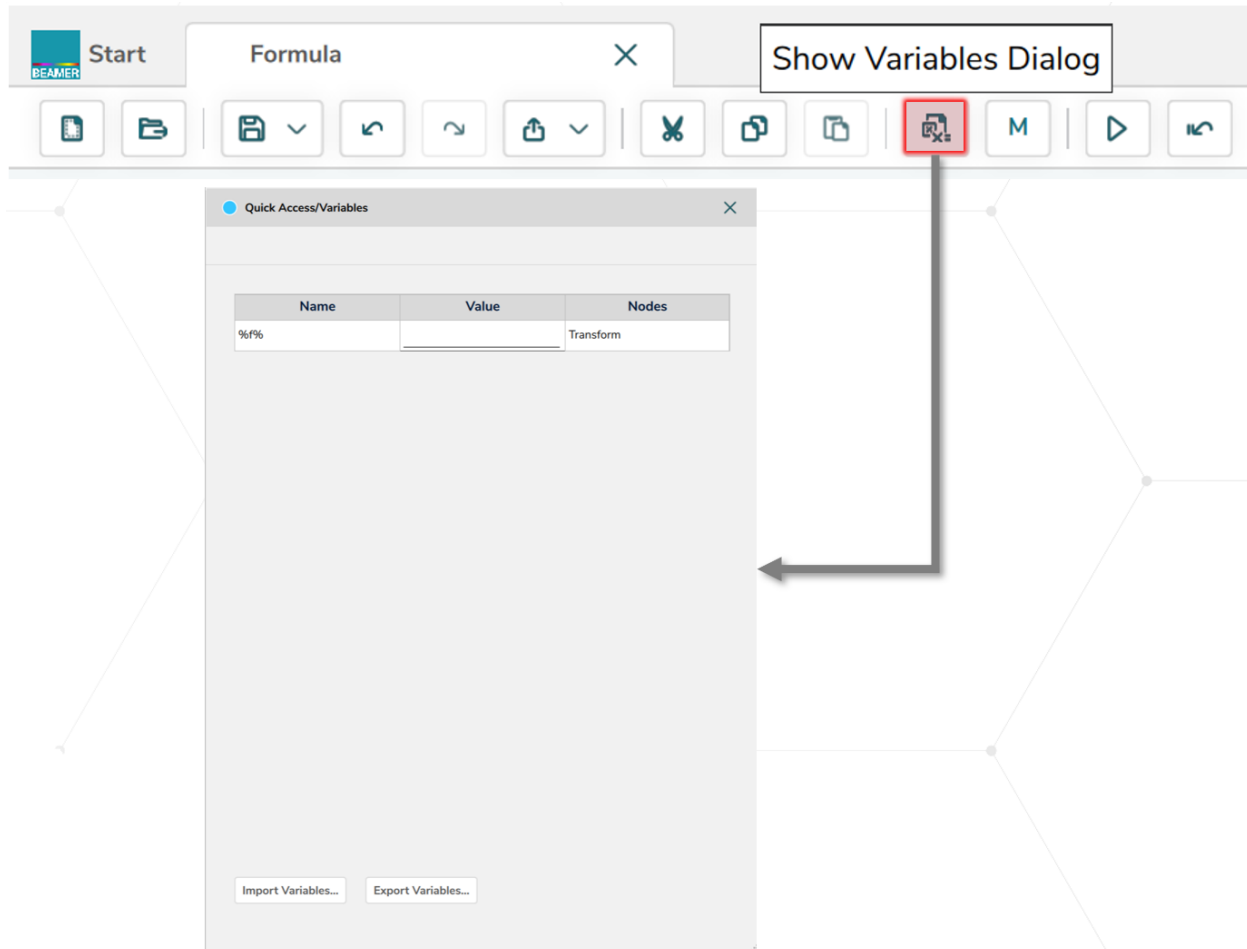
In the above example we used the formula:

$$2*(\%index%*0.0139*300+0.0139*0.0139*\%index%*\%index\%/4)^0.5$$

as the X - and Y - scaling factor in the TRANSFORM module. We could replace the fixed value of 300 for the focal length with the variable %f% as shown in red below:

$$2*(\%index\%*0.0139*\%f\%+0.0139*0.0139*\%index\%*\%index\%/4)^{0.5}$$

Using the *Variables* button on the tool bar opens a menu where the value for the focal length can be entered. Rerunning the flow then gives the desired results.



ADDITIONAL FUNCTIONS

Below is a list of additional functions that may be used in BEAMER modules:

- Basic mathematical operators : +, -, *, /, ^ (power function)
- Special functions:
 SINH,COSH,TANH,COTH,E,PI,LN,LOG,SIN,
 COS,TAN,COT,ASIN,ACOS,ATAN,ACOT,SQRT,INT

$$\begin{aligned} \text{SINH}(x) &= (\exp(x)-\exp(-x))/2 \\ \text{COSH}(x) &= (\exp(x)+\exp(-x))/2 \\ \text{TANH}(x) &= \text{SINH}(x)/\text{COSH}(x) \\ \text{COth}(x) &= \text{COSH}(x)/\text{SINH}(x) \end{aligned}$$

E: ~ 2.718

PI: π

LN: the natural logarithm

LOG: the common logarithm

SIN : sine function

COS : cosine function

TAN : tangent function $TAN(x) = SIN(x)/COS(x)$

COT: cotangent function $COT(x) = 1/TAN(x)$

ASIN: arcsine function

ACOS: arccosine function

ATAN: arctangent function

ACOT: arccotangent function

SQRT: square root function

INT: floor function

Functions for specific modules:

1. Extract
 - Math formula is accepted for region definition.
 - ASIN, ACOS, ATAN, ACOT are not accepted due to the data type.
2. Filter
 - Math formula is accepted for "value" assignment.
 - ASIN, ACOS, ATAN, ACOT are not accepted due to the data type.
3. Transform
 - Math formula is accepted for "scale", "shift" and "rotation".
 - ASIN, ACOS, ATAN, ACOT are not accepted due to the data type.
4. Grid
 - Math formula is accepted for "database grid" and "layout smoothing tolerance".
 - ASIN, ACOS, ATAN, ACOT are not accepted due to the data type.
5. Fracture
 - Math formula is accepted for "resolution" setting.
6. Heal, Not, P-Xor, And, Minus, Xor
 - Math formula is accepted for "Soft frame" setting.

For the present, the module "if" has a special parser which can be found by the link:

<http://www.partow.net/programming/exprtk/>