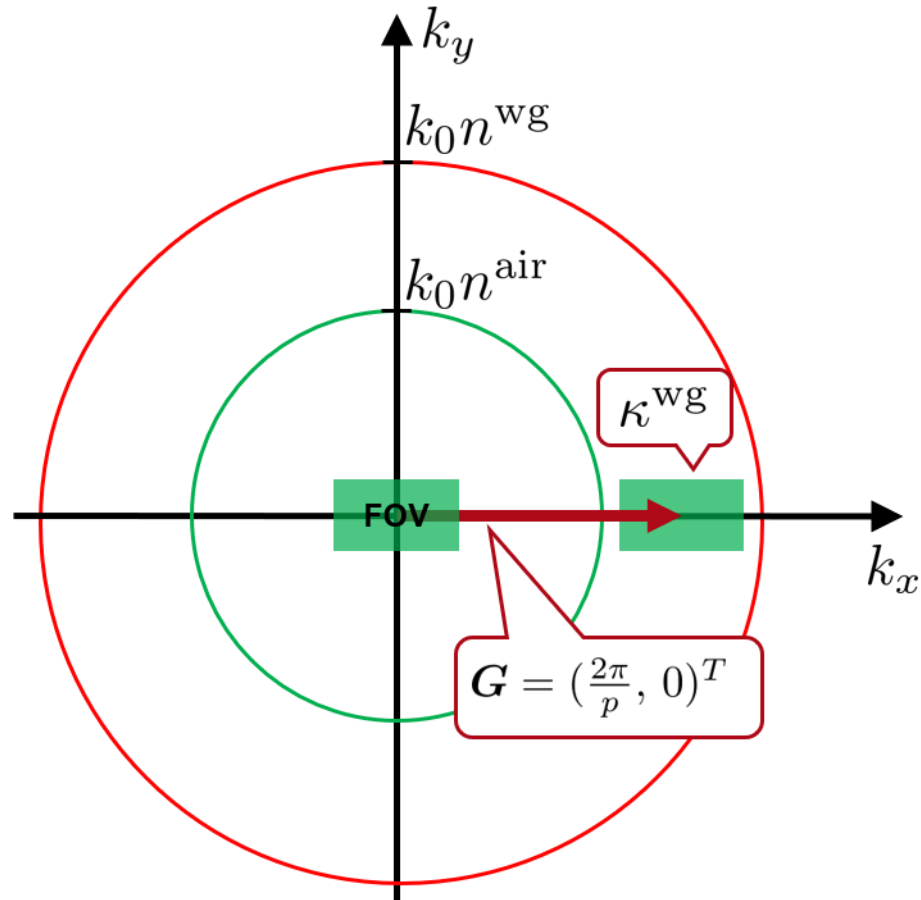


Customized Module: Grating Period Calculation According to the Guiding Condition of Lightguides

Abstract

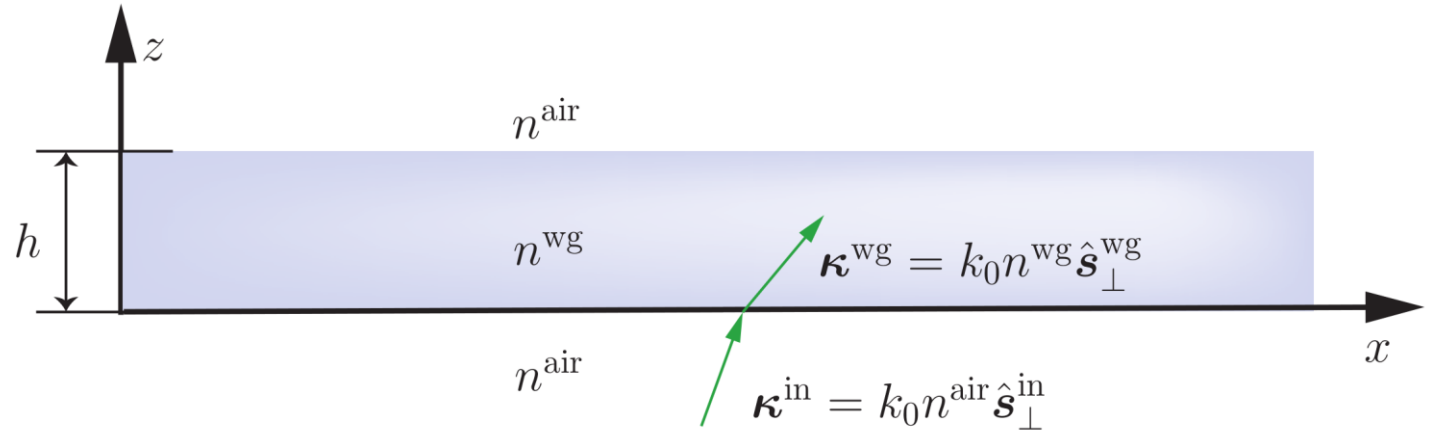


A module in VirtualLab Fusion is generated to calculate the range of the period of a coupling grating, so to fulfil the guiding condition of lightguides. To aid the design waveguide-based display devices, a certain field of view (FOV) is given as the desired input parameter. In the module, both the total internal reflection limit and the propagating light limit of the lightguide are used to compute the possible grating period range.

Programming Task: Definition of Field of View in k-Domain

Task:

Generate a module to calculate the range of the period of a coupling grating to fulfil the guiding condition of planar lightguides.



sketch of a planar lightguide to illustrate the coupling procedure

The x - and y -component of the spatial frequency vector for the incident light is defined as

$$\boldsymbol{\kappa} = k_0 n (\hat{s}_x, \hat{s}_y)^T,$$

whereas the Cartesian angles α and β are used to define a specific field of view (FOV) directions for a set of incident directions. The relation between angles and directions is described as follows

$$\hat{\boldsymbol{s}}_{\perp}^{\text{in}} = \frac{(\tan \alpha, \tan \beta)^T}{\sqrt{\tan^2 \alpha + \tan^2 \beta + 1}}.$$

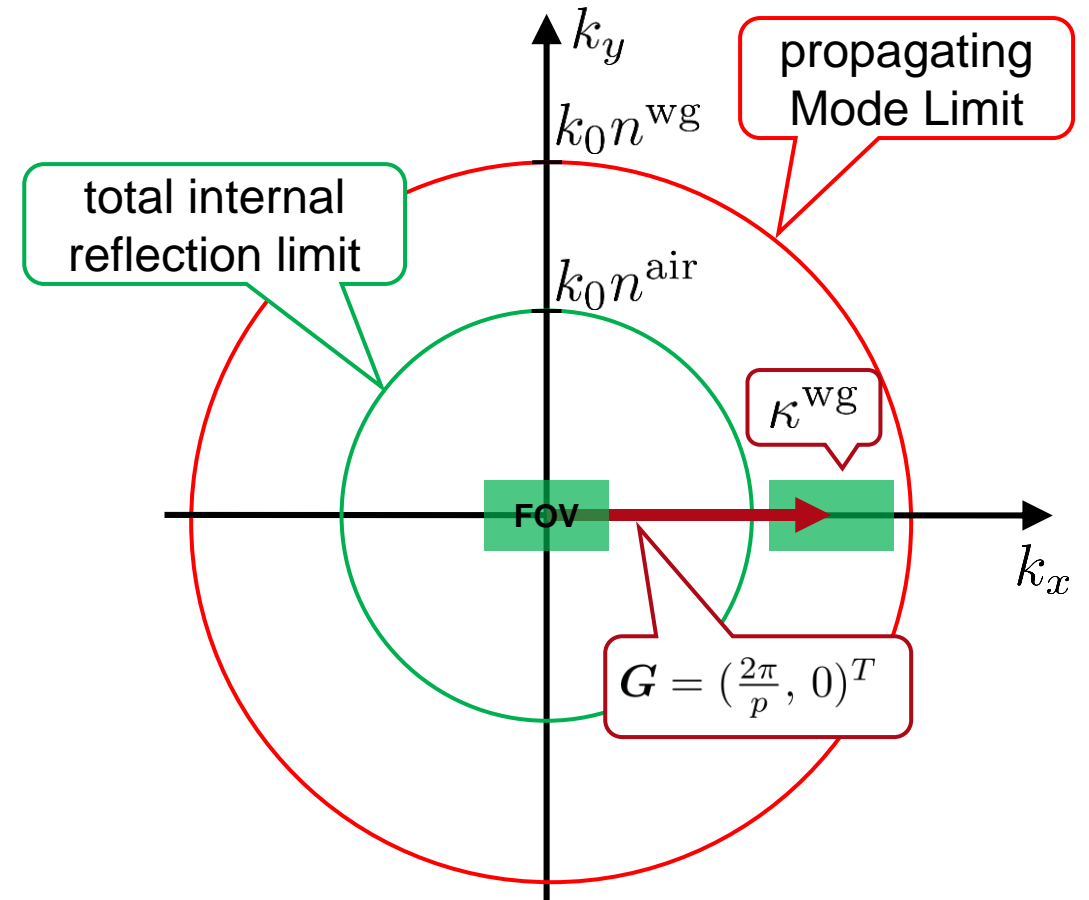
Programming Task: Definition of the Guiding Condition

A guided mode must fulfill the guiding condition, which includes the total internal reflection condition and the propagating mode condition

$$k_0 n^{\text{wg}} \geq \kappa^{\text{wg}} \geq k_0 n^{\text{air}}$$

A grating is an elegant component for the coupling because the FOV is shifted in the k-domain under consideration of the grating vector \mathbf{G} . Then the guiding condition can be extended to

$$k_0 n^{\text{wg}} \geq |\boldsymbol{\kappa}^{\text{in}} + \mathbf{G}| \geq k_0 n^{\text{air}}$$



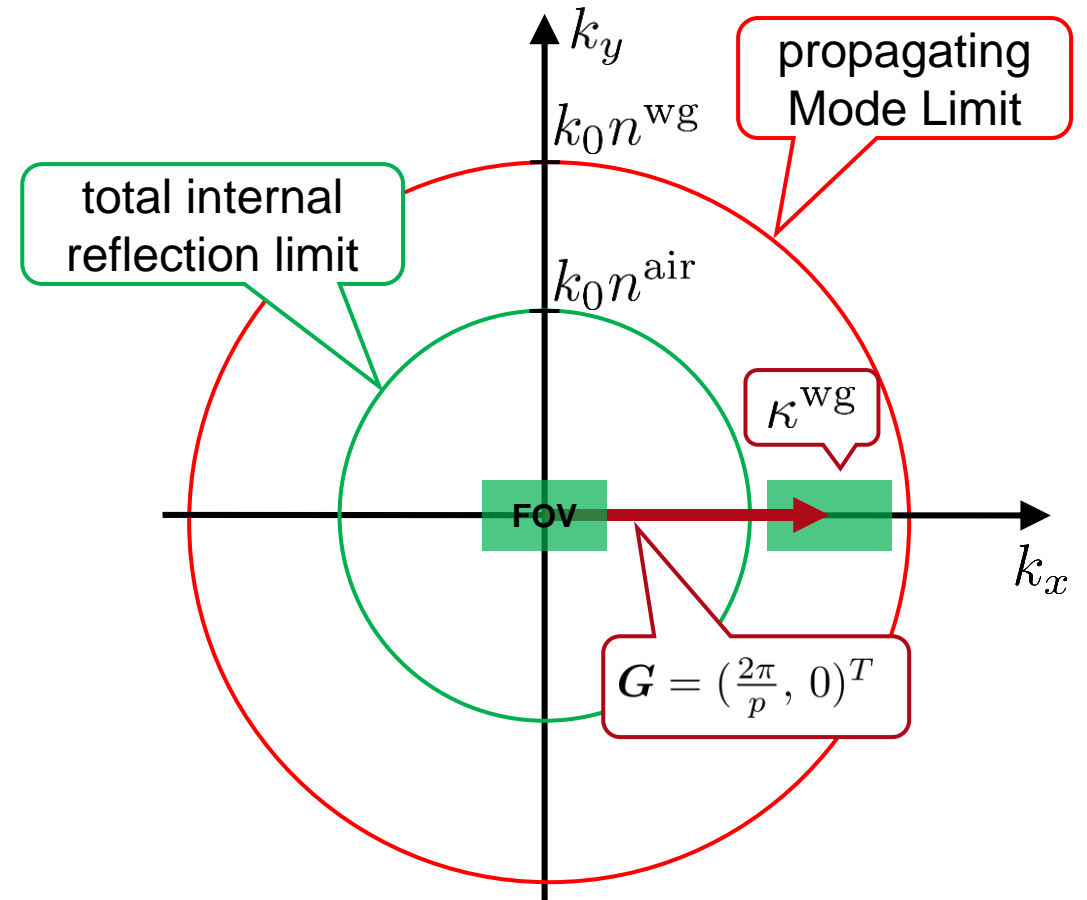
k-domain diagram to illustrate the guiding condition

Programming Task: Calculation of the Period Range

In case of 1D-periodic gratings one component of the grating vector becomes zero and the FOV can always be rotated into the internal coordinate system of the grating, so that $G_y = 0$ without loss of generality.

The range of the period of a 1D-periodic grating to couple a certain FOV into a lightguide, following the guiding condition, can be calculated by

$$\frac{2\pi}{\sqrt{(k_0 n^{\text{air}})^2 - (k_y^{\text{in}})^2 - k_x^{\text{in}}}} \geq p \geq \frac{2\pi}{\sqrt{(k_0 n^{\text{wg}})^2 - (k_y^{\text{in}})^2 - k_x^{\text{in}}}}$$



k-domain diagram to illustrate the guiding condition

Input to the VirtualLab Module

C# Module: Header

```
using System;

using VirtualLabAPI.Core.Common;
using VirtualLabAPI.Core.Modules;
using VirtualLabAPI.Core.Numerics;
using VirtualLabAPI.Core.SupportFunctions;

namespace OwnCode {
    public class VLModule : IVLModule {
        //define wavelength for evaluations
        double wavelength = 532e-9;
        //define refractive index of surrounding medium
        double refractiveIndexSurrounding = 1;
        //define refractive index of substrate
        double refractiveIndexSubstrate = 2;
        //define FOV rectangle (cartesian angles)
        VectorD FOV_CartesianAngles = new VectorD(30, 20);
    }
}
```

Output of the VirtualLab Module

C# Module: Output

```
public void Run() {  
    [...]  
  
    //output of results  
    if(minimumPeriod >= maximumPeriod){  
        //log maximum period  
        Globals.DataDisplay.LogMessage("The specified field of view can not be handled (completely coupled into the  
            substrate) by the current media configuration.");  
    }else{  
        //log maximum period  
        Globals.DataDisplay.LogMessage("Maximum Period = " + PhysicalUnits.FormatPhysicalUnit(maximumPeriod,  
            PhysicalProperty.Length));  
  
        //log minimum period  
        Globals.DataDisplay.LogMessage("Minimum Period = " + PhysicalUnits.FormatPhysicalUnit(minimumPeriod,  
            PhysicalProperty.Length));  
    }  
}
```



Messages

[11/22/2018 12:17:18] Compile successful
[11/22/2018 12:17:18] Module started
[11/22/2018 12:17:18] Maximum Period = 422.6183 nm
[11/22/2018 12:17:18] Minimum Period = 306.1351 nm
[11/22/2018 12:17:18] Thread finished normally

Messages Detector Results

Number of Used Cores (also for Parameter Run): 8

Document Information

title	Customized Module: Grating Period Calculation According to the Guiding Condition of Lightguides
document code	CZT.0108
version	1.0
toolbox(es)	Starter Toolbox
VL version used for simulations	7.4.0.49
category	Feature Use Case
further reading	<ul style="list-style-type: none">– <u>Optimization of Lightguide Coupling Grating for Single Incidence Direction</u>– <u>Optimization of Binary Grating for Lightguide Coupling over Desired FOV</u>– <u>Optimization of Slanted Grating for Lightguide Coupling over Desired FOV</u>