

Create an AWG PDK from Device to Circuit

Products: RSoft BeamPROP, ADS Photonic Designer
Applications: PICs

Introduction

Arrayed Waveguide Gratings (AWGs) are key building blocks in photonic integrated circuits, widely used for wavelength multiplexing and demultiplexing in optical communication and sensing applications. The design of A WG devices requires a seamless workflow that bridges device-level electromagnetic modeling with circuit-level simulation and layout generation.

This application note presents an integrated design methodology combining **RSof t BeamPROP BPM** for accurate device-level analysis with **ADS Photonic Designer** for circuit simulation and layout implementation. This workflow enables a smooth transition from detailed waveguide and slab modeling to system-level verification and mask-ready layout generation.

The process leverages:

- RSoft A WG Utility for geometry generation and simulation
- Custom-PDK Generation Utility for S-matrix extraction
- ADS Photonic Designer for circuit simulation and layout generation

This unified approach accelerates A WG development, ensures consistency across design stages, and supports scalable PIC design.

Workflow Description

The combined use of RSoft utilities and ADS Photonic Designer enables automated creation of custom device libraries and PDK components, effectively bridging device-level simulation and circuit-level design.

Using RSoft tools, users can:

- Automatically generate and simulate a 3D A WG model
- Extract S-matrix data from device simulations
- Create reusable IP blocks and custom PDK for PIC design workflows

When ADS Photonic Designer is selected as the target platform, the utility generates complete S-matrix-based components, including:

- Simulation data
- Schematic symbols
- Layout views

These components can be used directly within the ADS Photonic Designer environment. Figure 1 illustrates the overall workflow for custom PDK generation using a Silicon 4x4 A WG device as an example.

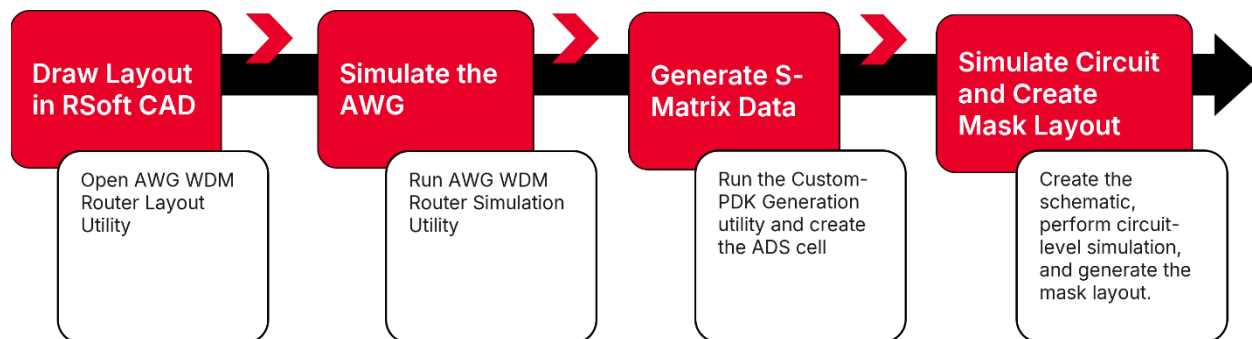


Figure 1. Process flow for custom PDK generation, illustrated using a Silicon 4x4 AWG example.

1: Use AWG Utility in RSoft CAD Layout

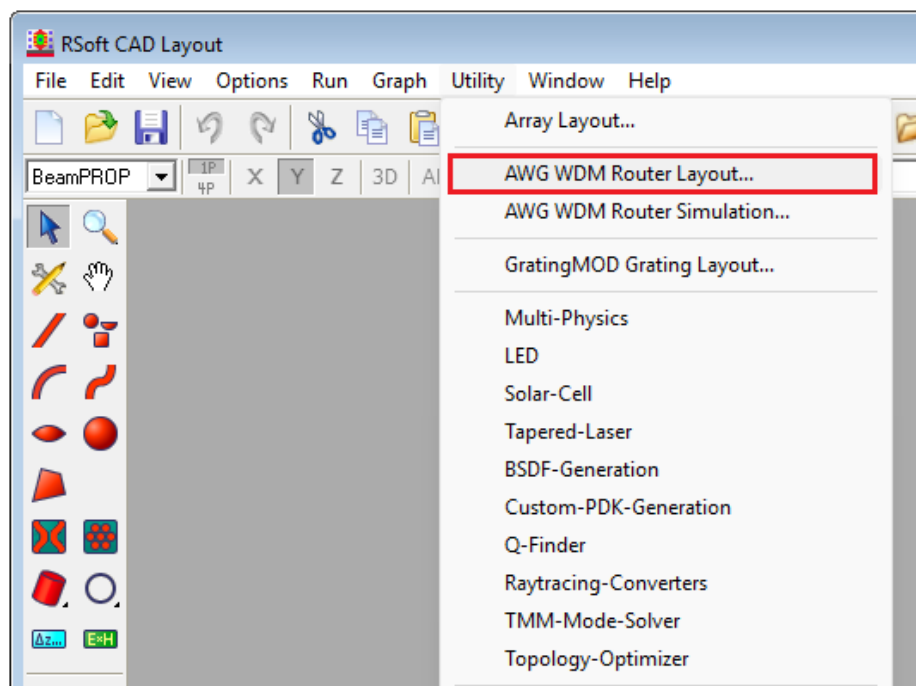


Figure 2. The access method for the AWG WDM Router Layout Utility from RSoft CAD environment.

Creating an AWG model is easy and efficient with the AWG WDM Router Layout Utility. This utility can be opened by selecting Utility/AWG-WDM-Router-Layout... from the CAD menu (Figure 2).

The tool allows users to:

- Define number of ports, channel spacing, center wavelength, etc.
- Define layout prefix
- Automatically generate a 3D AWG model

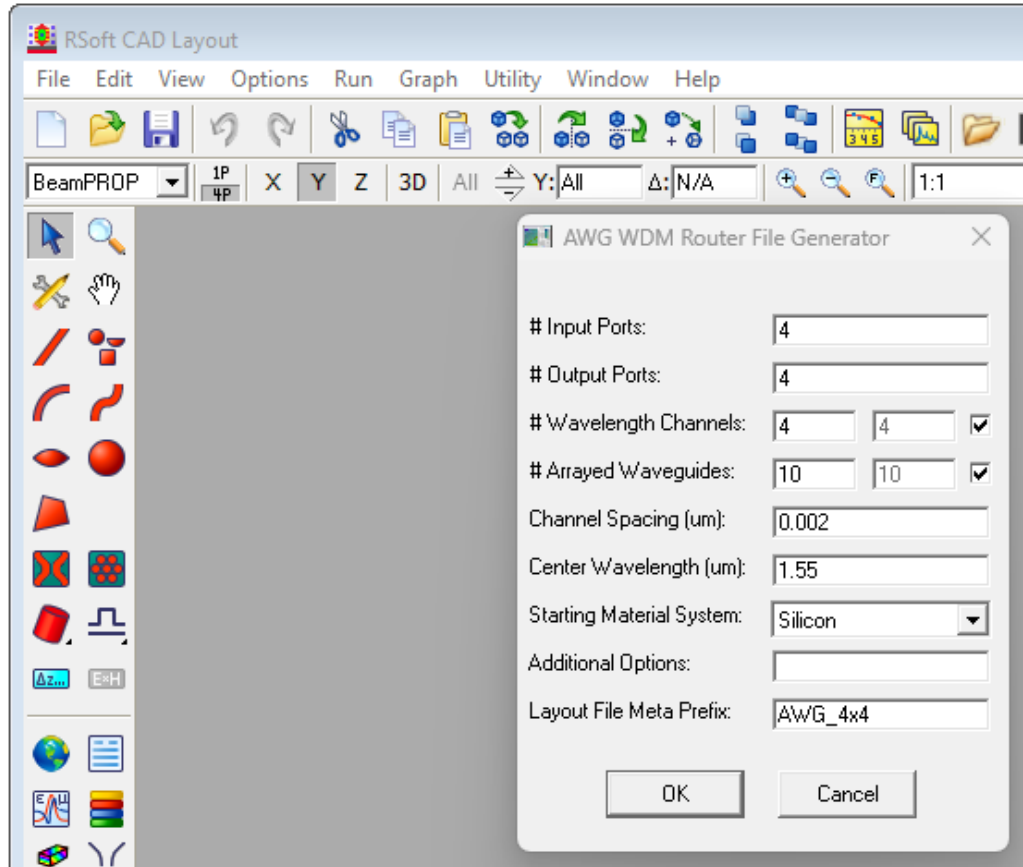


Figure 3. The AWG WDM Router Layout window showing the pre-set parameters for a Silicon 4x4 AWG device.

Based on the parameters shown in the AWG WDM Router Layout dialog, the Silicon 4x4 AWG with 4 channels centered at 1.55 μm wavelength is being designed (Figure 3). After clicking “OK” button, the layout of the input star coupler for the Silicon AWG is shown in RSoft CAD, having 4 input ports and 10 arrayed waveguides (Figure 4).

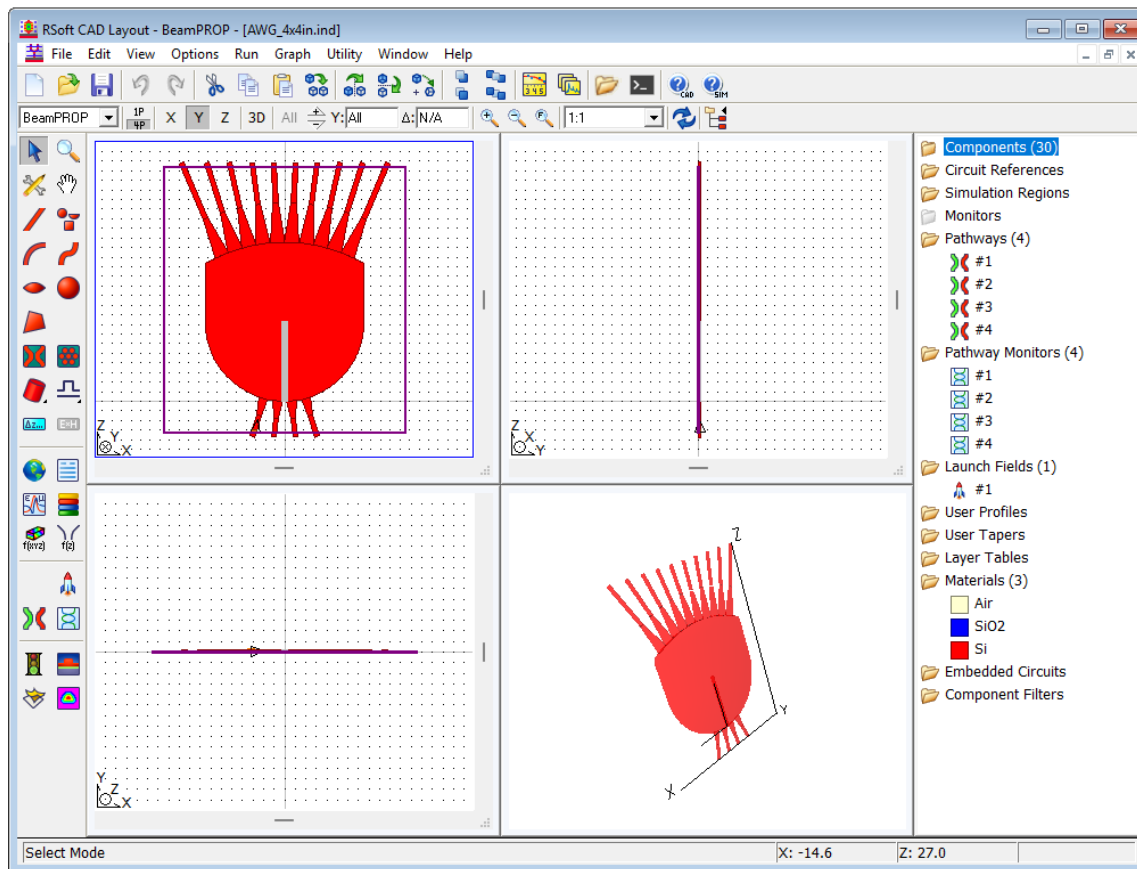


Figure 4. The input star coupler for the Silicon AWG, showing 4 input ports and 10 arrayed waveguides.

2: Simulate the AWG

Here is the overview of simulation methodology. The input star coupler is simulated with BeamPROP. The resulting field is decomposed into modes of the array waveguides. The modes are propagated through the array independently according to the geometry of the array and the properties of the waveguides in the array. The field at the end of the array is constructed from the modified mode amplitudes and phases, and launched into the output star coupler. The output star coupler is simulated with BeamPROP, and the power in the output arms is measured and stored in a data file containing the transmission spectrum of the device.

Note that the BeamPROP simulations may be performed in 2D, 3D, or 3D-EIM (effective index method). These are set in the Global Settings dialog. The EIM combines the speed of 2D with much accuracy of a 3D simulation, and is therefore the default method and recommended in this application note.

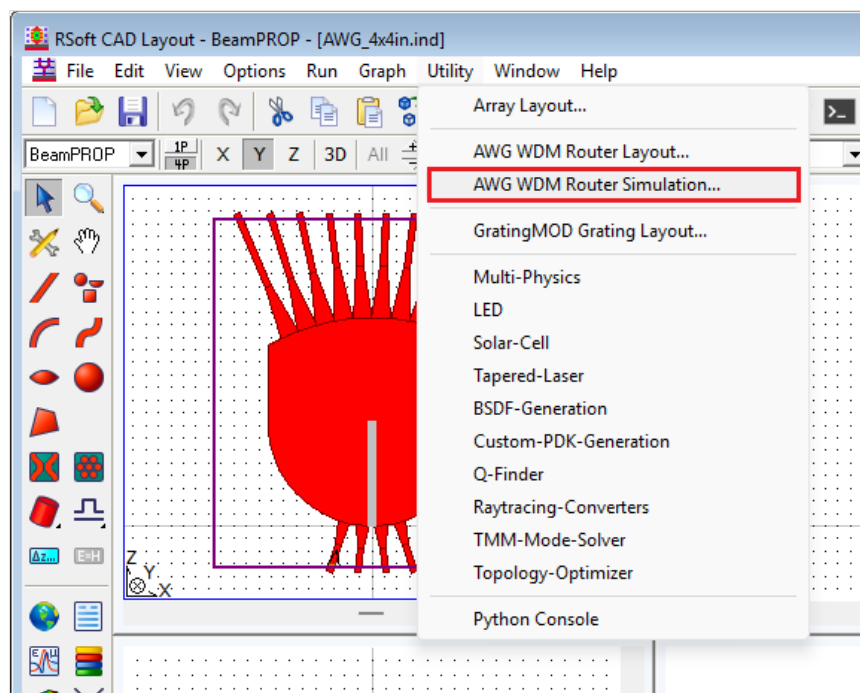


Figure 5. The access method for the AWG WDM Router Simulation Utility from RSoft CAD environment.



Figure 6. The AWG WDM Router Simulation Utility dialog, where two main sections are split including Port/Channel Parameters and Simulation Parameters.

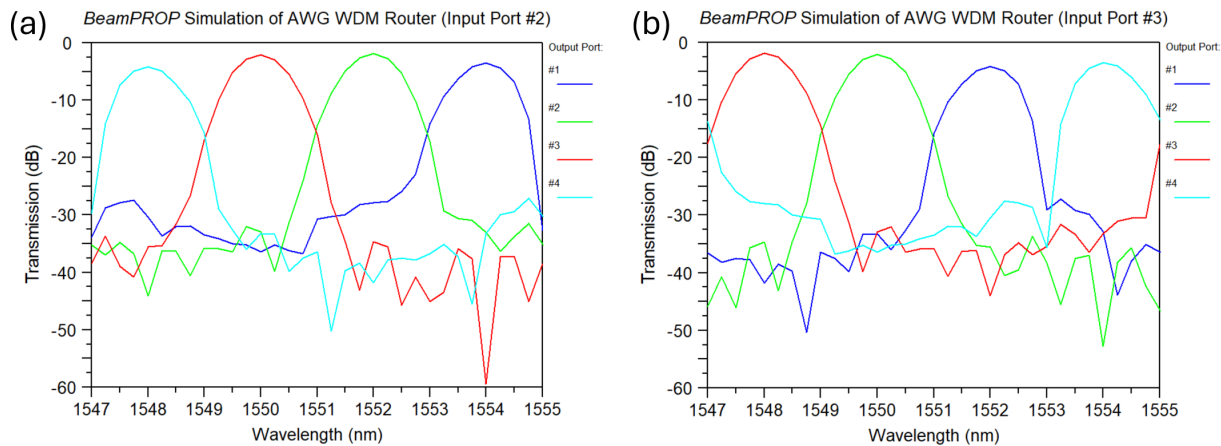


Figure 7. Simulated transmission spectra of the Silicon 4×4 AWG obtained using the 3D-EIM method, showing wavelength routing for (a) input port 2 and (b) input port 3.

After the model has been checked and revised, if necessary, run the simulation with the AWG WDM Router Simulation Utility (Figure 6). The simulation results demonstrate that the Silicon 4×4 AWG successfully performs wavelength division multiplexing with clear spectral separation across the output ports for 4 channels (Figure 7). Each output channel exhibits a well-defined transmission peak with approximately 2 nm channel spacing (i.e., design target), indicating that the path length difference and array configuration are properly designed.

The device exhibits insertion loss in the range of approximately –2 dB to –4 dB across the output channels, and channel crosstalk maintained at approximately –30 dB to –40 dB, demonstrating good isolation between adjacent wavelength channels.

The spectral response shows Gaussian-like passbands rather than flat-top profiles, suggesting that the design has not been optimized for bandwidth flattening. However, strong out-of-band suppression is observed, with transmission levels reaching below –40 dB and occasionally down to –50 dB, indicating good phase coherence and interference quality within the array.

The comparison between different input ports confirms the expected cyclic routing behavior of the AWG, where the wavelength-to-output mapping shifts systematically with the input port. This validates the proper phase progression and symmetry of the arrayed waveguide structure.

3: Export AWG Model as Custom PDK Component

Figure 8 shows how the Custom-PDK-Generation can be accessed through the Utility from the CAD menu. Figure 9 illustrates the configuration options for the RSoft Custom-PDK Generation Utility. For this example, the Output Mode is set to “Full PDK”, enabling the generation of both S-matrix data and a custom PDK model for use in a target PIC design platform. An extra design parameter of R_i is scanned to demonstrate the design flexibility, where R_i is the radius of lens at input/output port end of star coupler. You may refer to the AWG Utility user guide document for more information.

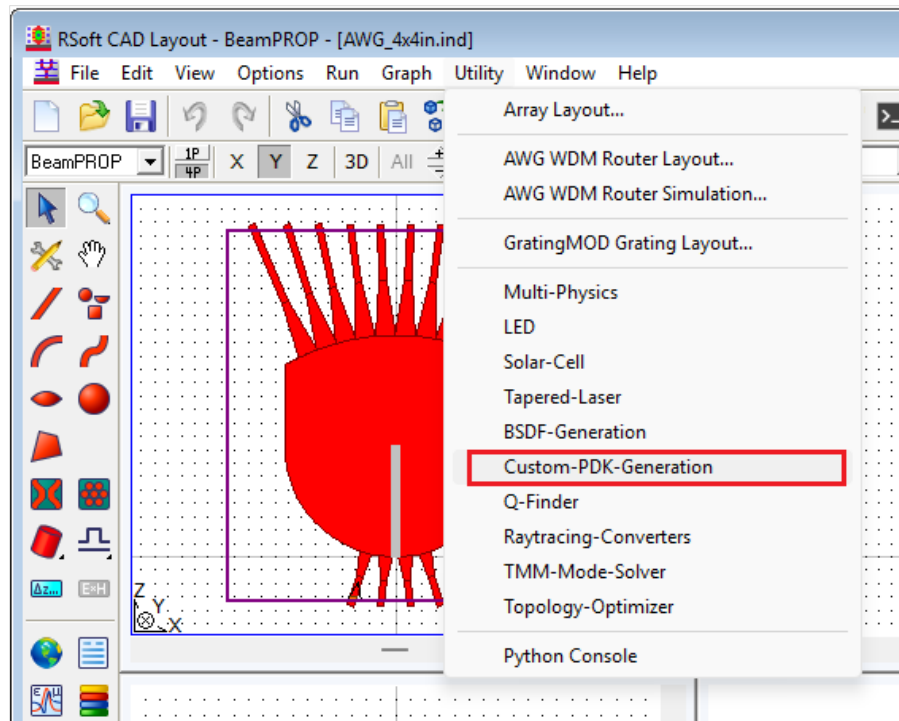


Figure 8. The access method for the Custom-PDK-Generation Utility from RSoft CAD environment.

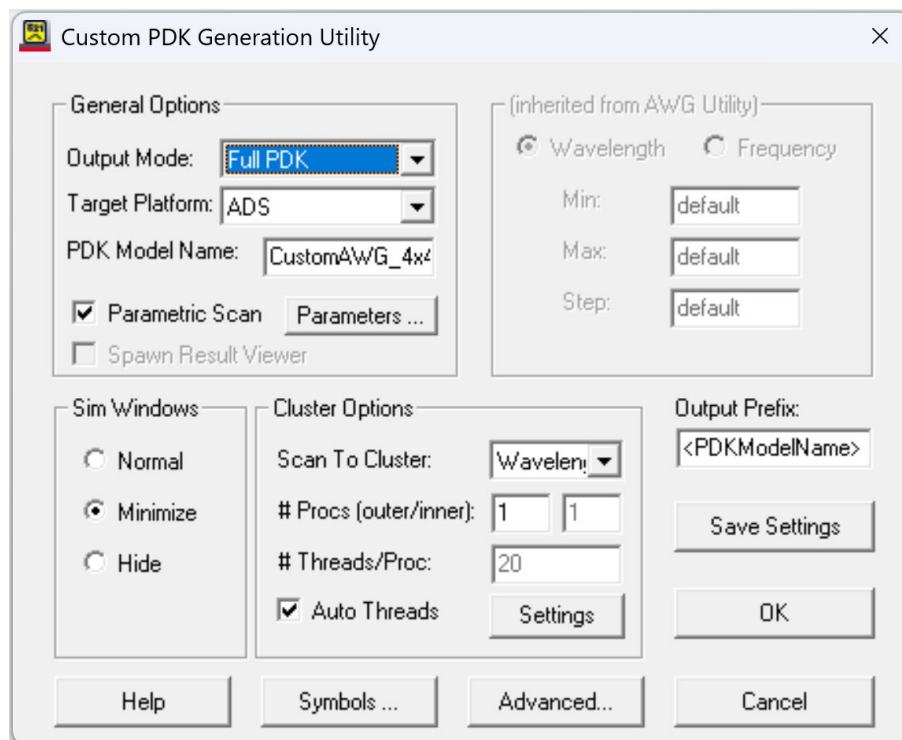


Figure 9. Configuration of the RSoft Custom-PDK-Generation Utility with ADS Photonic Designer selected as the target platform.

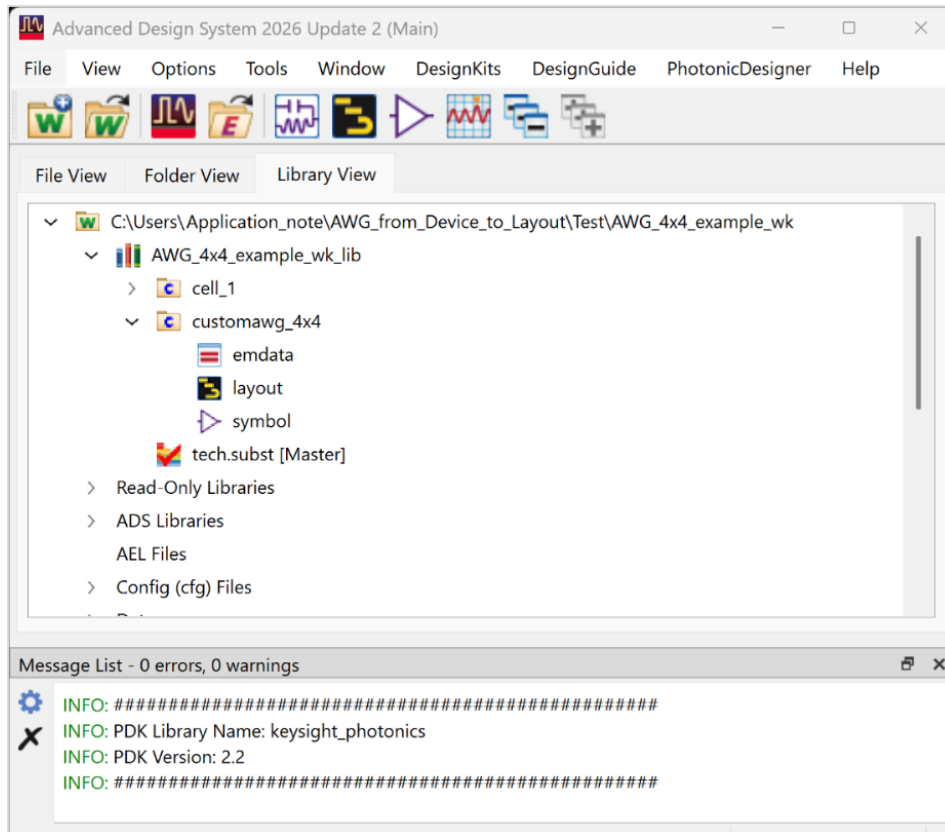


Figure 10. ADS Photonic Designer showing the custom AWG 4x4 component in a user-defined library.

In this application note, ADS Photonic Designer is selected as the target platform. For a detailed description of all available options, please refer to the Custom-PDK Generation Utility User Guide.

To convert the output of the utility into an ADS Photonic Designer component, run the following command: `adsgencell <cell-folder>`, within the directory to the library name. This command compiles an ADS cell along with its associated views, including symbol, layout, and emdata, as shown in Figure 10.

4: Load the AWG in ADS Circuit

The schematic of the Silicon 4x4 AWG element in ADS Photonic Designer uses the S-matrix data automatically generated by the Custom-PDK Generation Utility in BeamPROP BPM (Figure 11). The S-matrix data follows the standard ADS Photonic Designer format for bidirectional optical multiport device models.

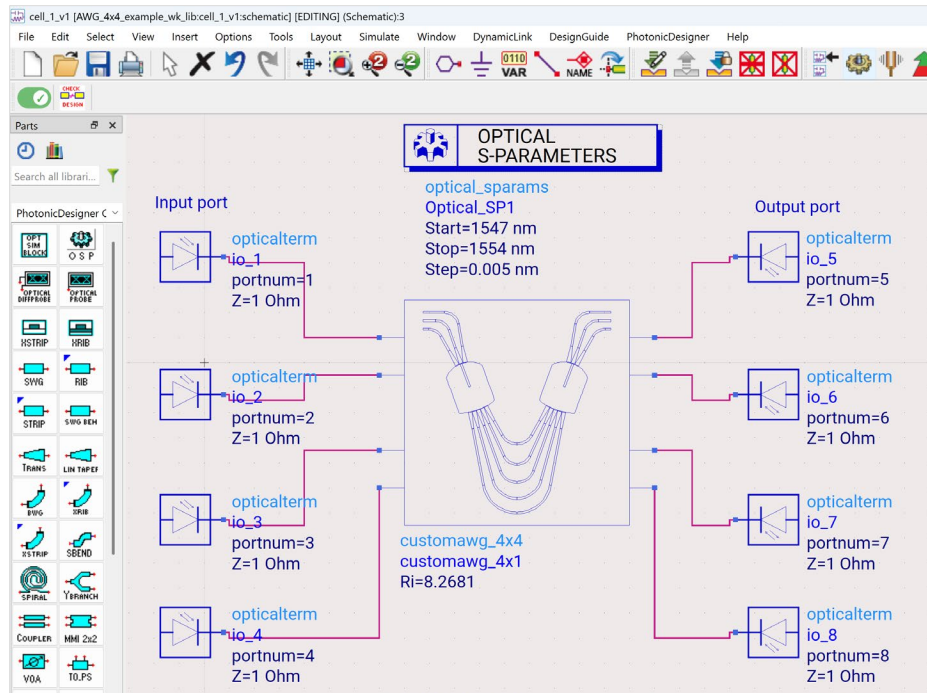


Figure 11. Schematic representation of the Silicon 4×4 AWG custom PDK component in ADS Photonic Designer.

5: Simulate Circuit and Create Mask Layout

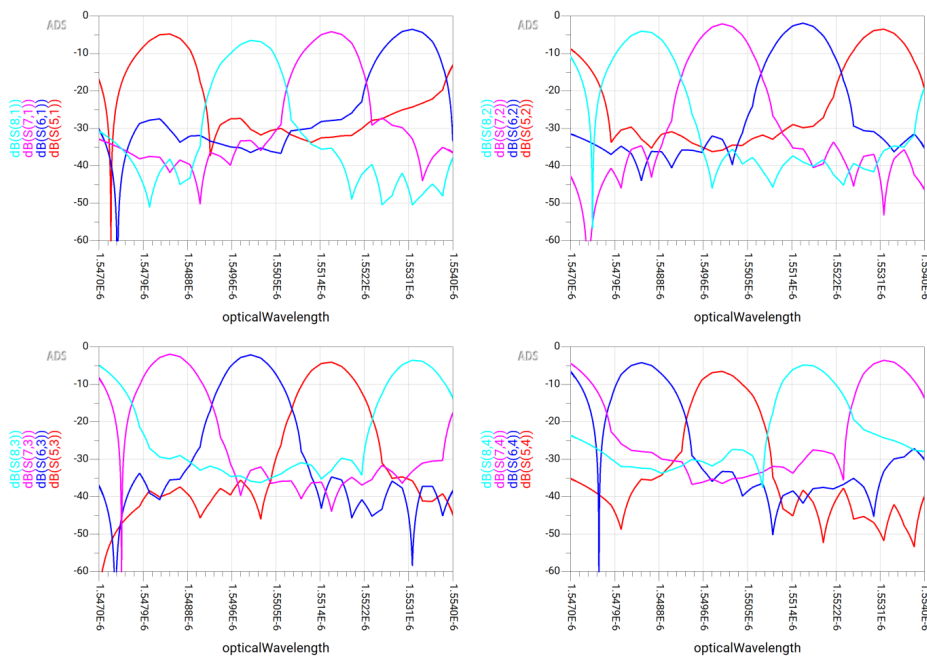


Figure 12. Transmission spectra of the Silicon 4×4 AWG PDK for input ports 1 through 4 with $R_i = 8.268 \mu\text{m}$.

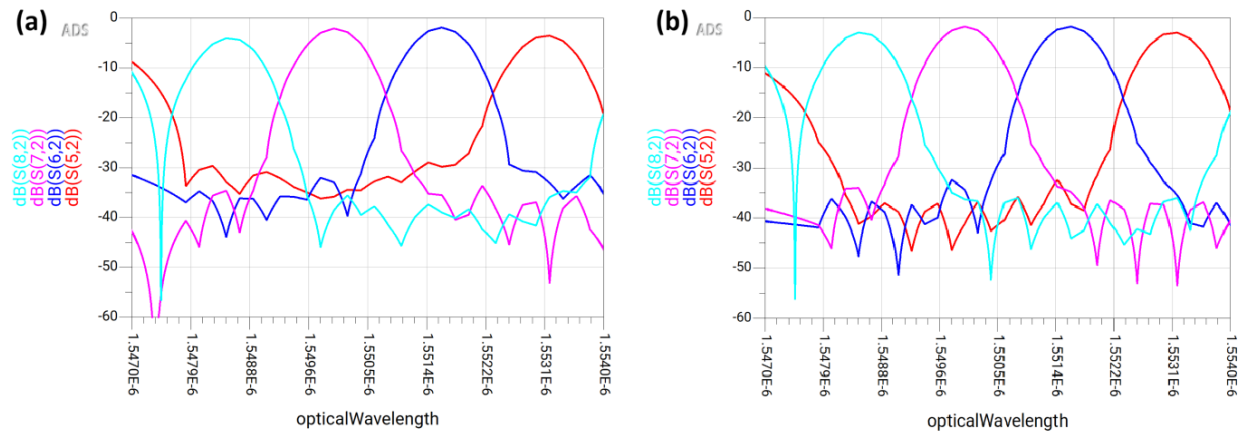


Figure 13. Comparison of transmission spectra at the same input port 2 for the Silicon 4x4 AWG PDK with (a) $R_i = 8.268 \mu\text{m}$, and (b) $R_i = 16.536 \mu\text{m}$.

To perform circuit simulation, an Optical S-Parameter Simulation (OSP) component is added from the ADS Photonic Designer Components library. For this example, the wavelength sweep parameters are set to be Start: 1547 nm, Stop: 1554 nm, Step size: 0.005 nm, respectively (Figure 11).

Figure 12 shows the transmission spectra of the Silicon 4x4 AWG for four different input ports (1–4) with $R_i = 8.268 \mu\text{m}$. For each input, the device consistently routes the optical signal into four distinct wavelength channels, with similar channel spacing across all cases. The results are also in good agreement with the device-level simulations shown in Figure 7. A clear cyclic shift of the spectral responses is observed when the input port changes, which is a typical AWG behavior reflecting the phase front translation at the input slab. Despite the change in input position, the overall spectral shapes, insertion loss levels, and crosstalk performance remain comparable, indicating good uniformity and symmetry of the AWG design.

Figure 13 compares the transmission spectra of the 4x4 AWG for two different star coupler lens radii, $R_i = 8.268 \mu\text{m}$ and $R_i = 16.536 \mu\text{m}$. Both designs show similar channel positions and spacing, indicating that changing R_i does not significantly affect the wavelength routing function. However, increasing R_i leads to a noticeable improvement in spectral quality. The larger-radius case exhibits smoother passbands, reduced ripple, and slightly lower crosstalk, with deeper minima between channels. This improvement is attributed to reduced phase and wavefront distortion at the slab-array interface when using a larger lens radius, resulting in more uniform field coupling across the array waveguides.

A physical layout of the Silicon 4x4 AWG PDK can be generated directly from the schematic. From the schematic view (Figure 11), select Layout → Generate/Update Layout, and confirm the dialog. ADS Photonic Designer then generates and opens the layout view, as shown in Figure 14.

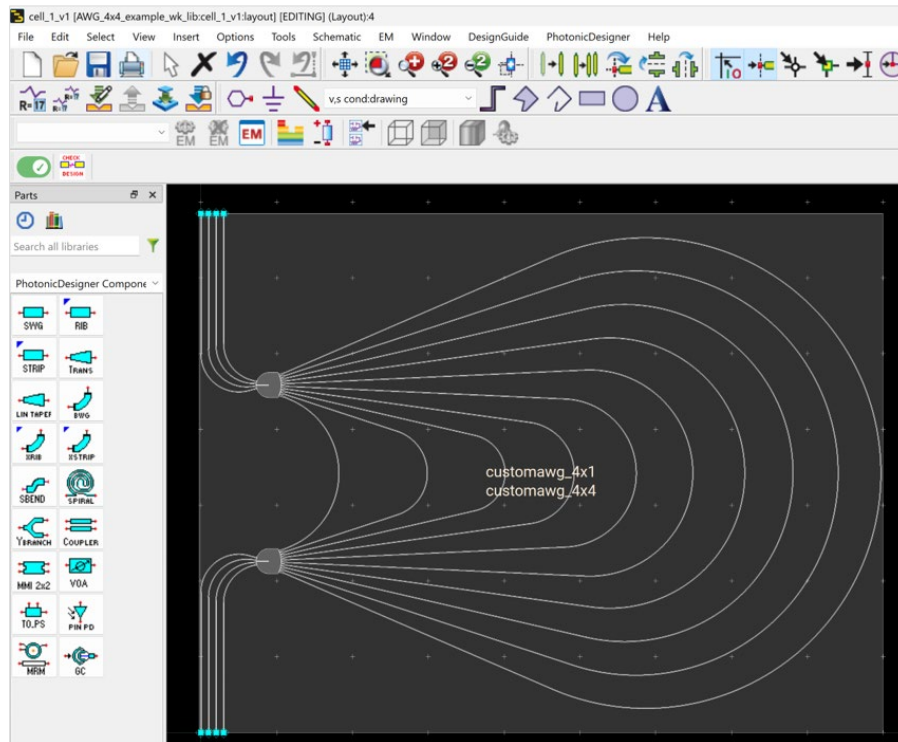


Figure 14. Physical layout of the Silicon 4x4 AWG PDK component generated directly from the schematic.

Conclusion

This application note demonstrates an efficient workflow for designing a Silicon 4x4 AWG using RSoft BeamPROP and ADS Photonic Designer. The process enables automated device modeling, S-matrix extraction, and seamless integration into circuit-level simulation and layout generation.

This approach is particularly well suited for passive photonic components that can be accurately described using S-parameters. The resulting AWG PDK can be directly applied in PIC designs such as WDM transceivers, optical routing networks, and multi-channel filtering systems, supporting scalable and compact multi-wavelength integration.

Example files

<https://support.keysight.com/KeysightdCX/s/knowledge-article-detail?keyid=Supporting-files-for-Create-an-AWG-from-Device-to-Circuit-and-Layout-Generation>

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