Projeto de Circuitos Fotônicos Integrados

Projeto de Filtro CDWM Baseado em MZI

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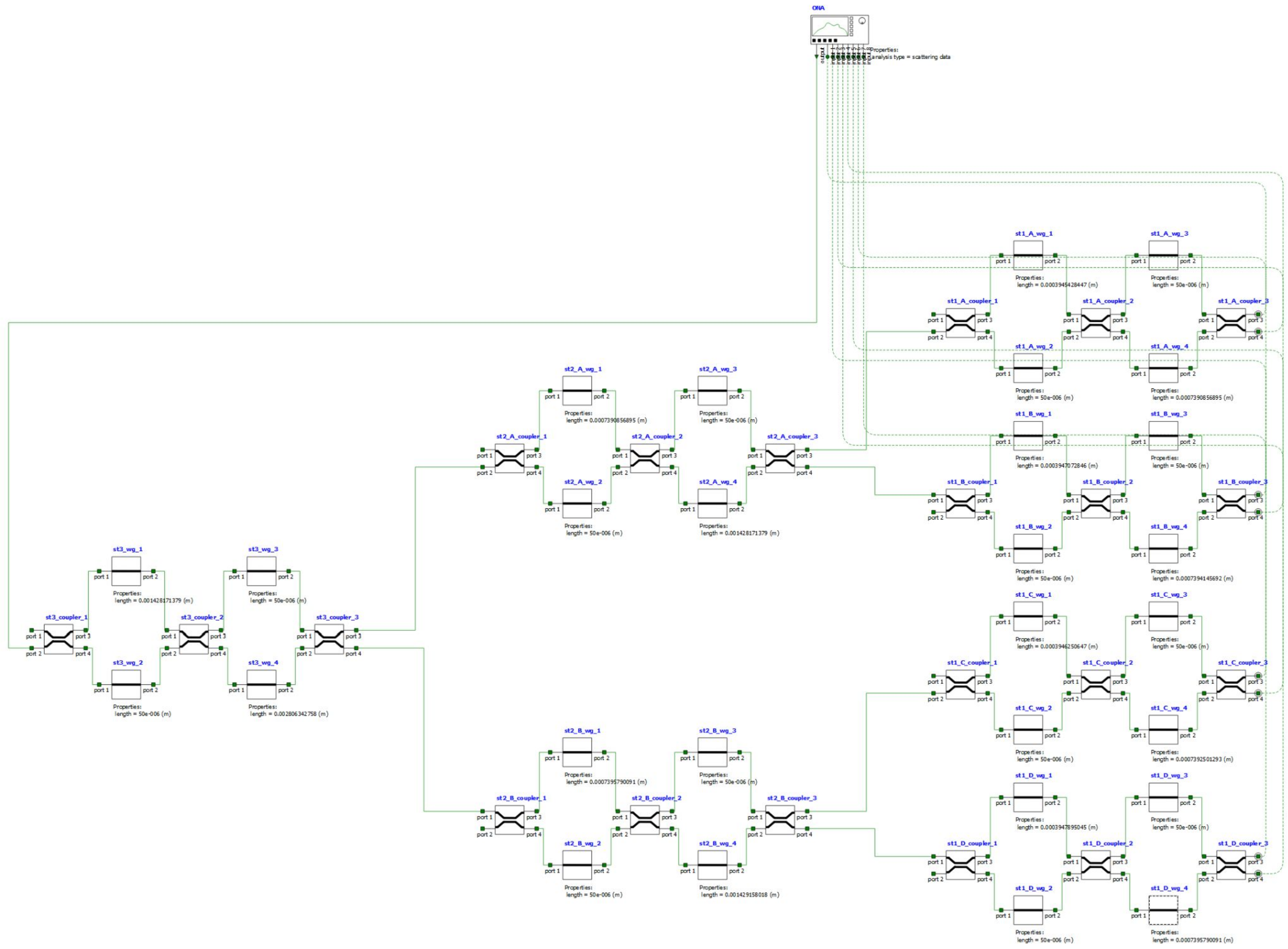
CURSOS, CAPACITAÇÃO E TREINAMENTOS

EMBRAPII
Empresa Brasileira de Pesquisa e Inovação Industrial

Layout Interconnect



Pré-requisitos

1. Número de entradas: 1;
2. Número de saídas: 8;
3. Espaçamento entre canais: 50, 100 e 200 GHz;
4. Banda de operação: banca C (1530 - 1565 nm);
5. O filtro deve estar alinhado com os canais definidos pelo padrão ITU da banda C (https://www.fiberdyne.com/products/pdf/Fiberdyne-ITU-Grid-C-Band-100GHz.pdf);
6. Uso de filtros de, no mínimo, segunda ordem;
7. Use acopladores de grade;
8. Tamanho máximo do circuito: 500 x 400 um;
9. PDK SiePIC (https://github.com/SiEPIC)

Fluxo de Atividades

Definição dos Parâmetros

- FSR(λ)
- L
- ΔL
- ΔL_{fs}

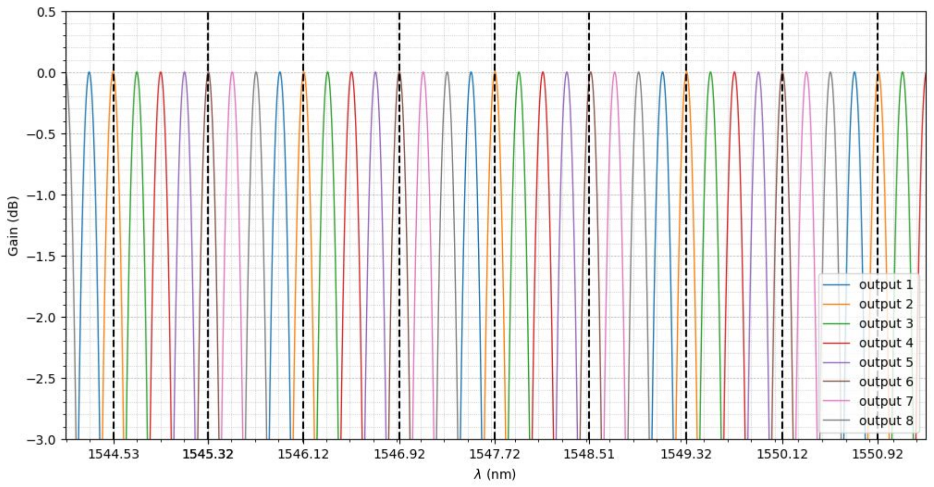
Montagem dos Circuitos via API

Simulação Caso Ideal

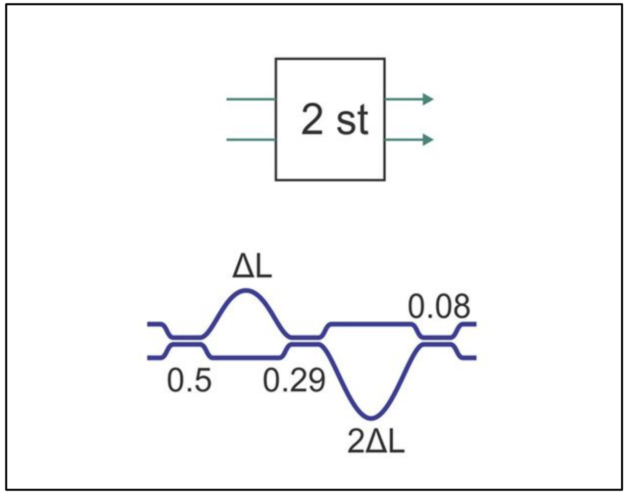
Simulação PDK SiEPIC

CDWM - Filtros de 1 estágio (Caso Ideal)

- Picos significativamente menos planos em comparação aos os resultados de para os filtros de 2 e 3 estágios.

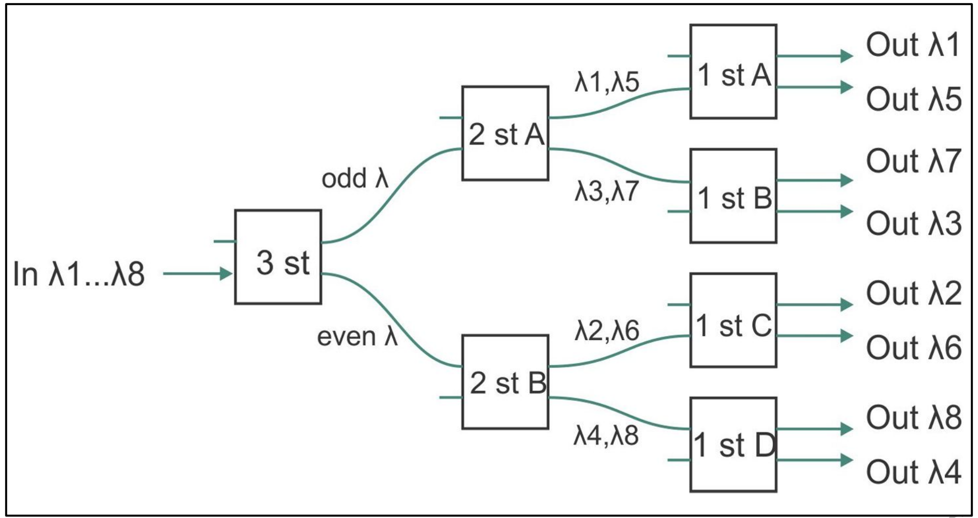


CDWM - Filtros de 2 estágios (Caso Ideal)



Fonte: [1]

- Parâmetros de Simulação:
  - $FSR = \lambda / n_{gr}.\Delta L_{FSR}$
  - $\Delta L_{FS} = \lambda^2 / n_{eff}$
  - $\Delta L = \Delta L_{FSR} + \Delta L_{shift}$

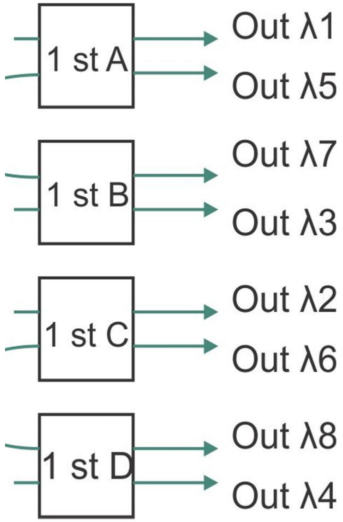


Fonte: [1]

CDWM - Filtros de 2 estágios (Caso Ideal)

Splitter	ΔL_{FSR}	ΔL_{Shift}
3 st	ΔL_{Base}	0
2 st A	$\Delta L_{Base}/2$	0
2 st B	$\Delta L_{Base}/2$	$0.75\ \Delta L_{FS}$
1 st A	$\Delta L_{Base}/4$	0
1 st B	$\Delta L_{Base}/4$	$0.25\ \Delta L_{FS}$
1 st C	$\Delta L_{Base}/4$	$0.125\ \Delta L_{FS}$
1 st D	$\Delta L_{Base}/4$	$0.375\ \Delta L_{FS}$

Fonte: [1]



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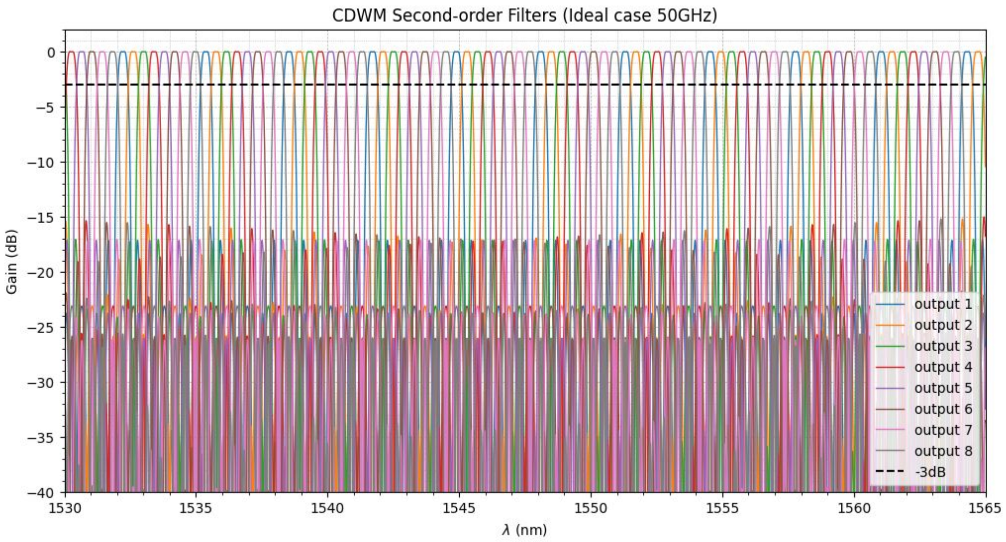
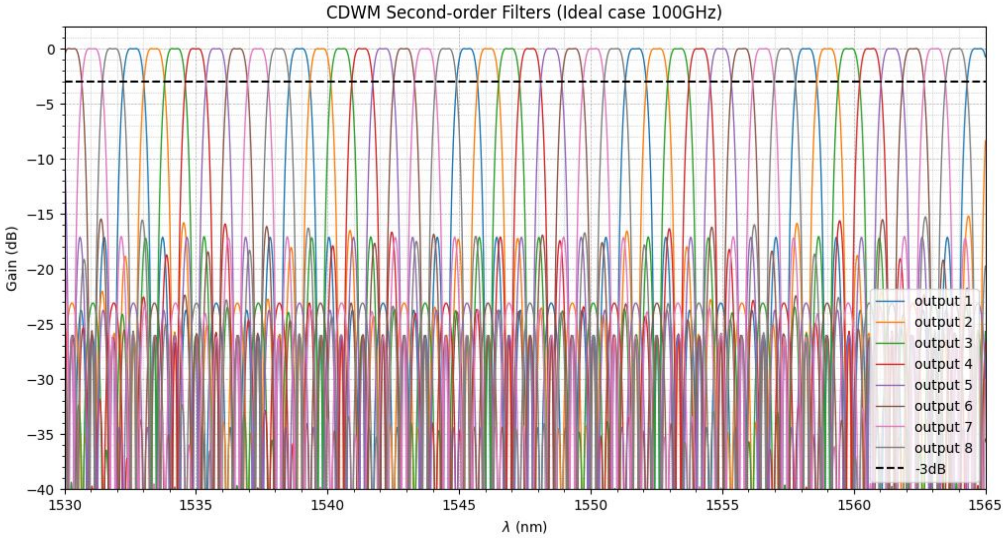
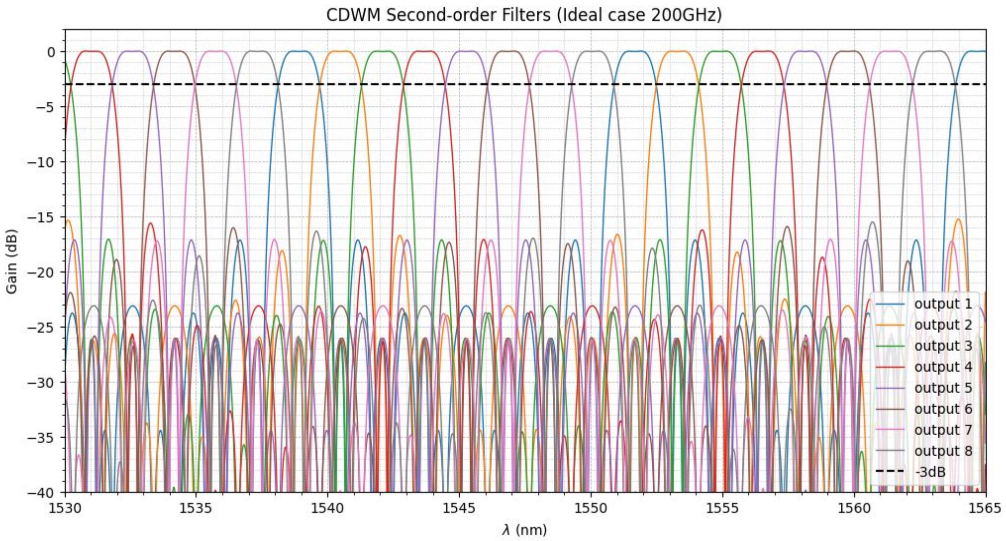






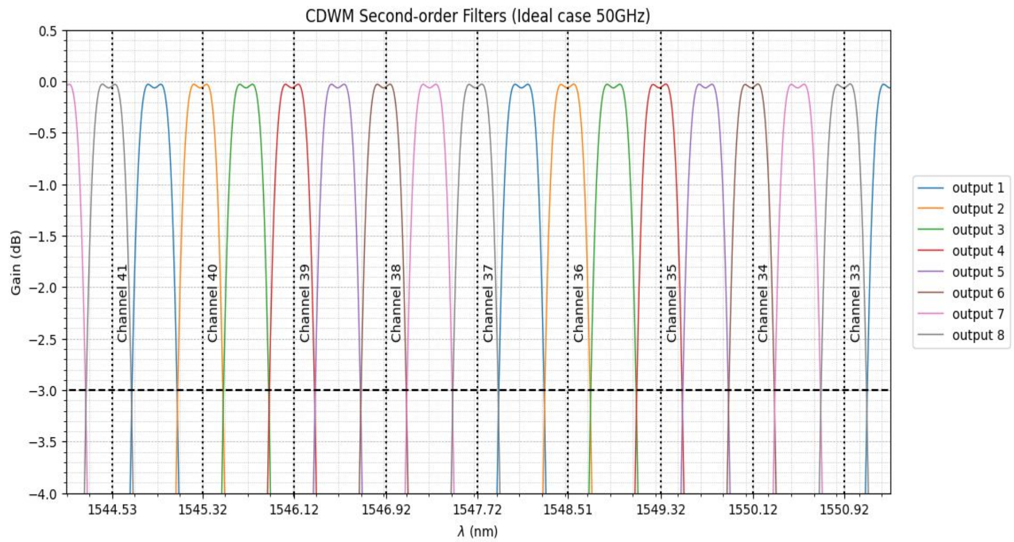
CDWM - Filtros de 2 estágios (Caso Ideal)

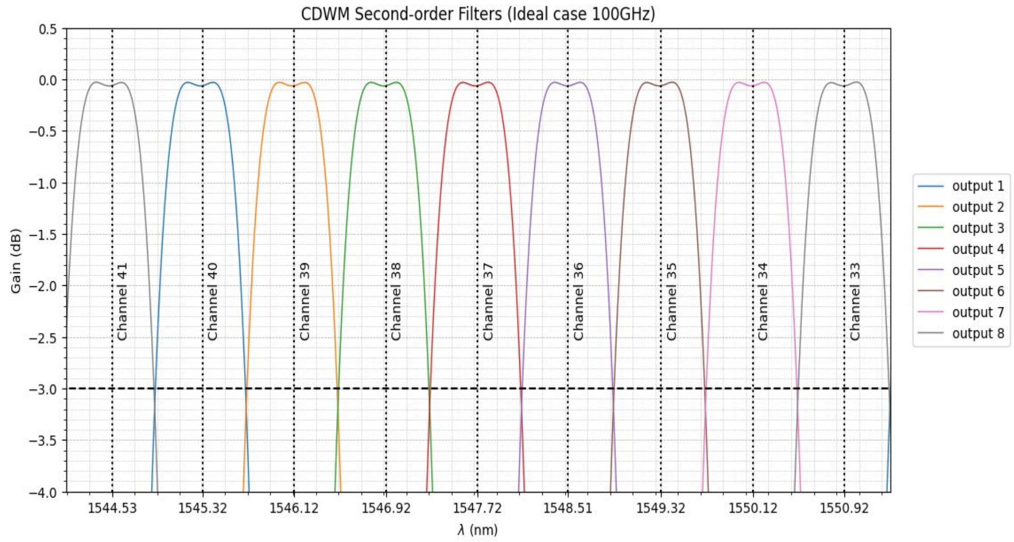
- Alinhamento dos canais definidos pelo padrão ITU para C

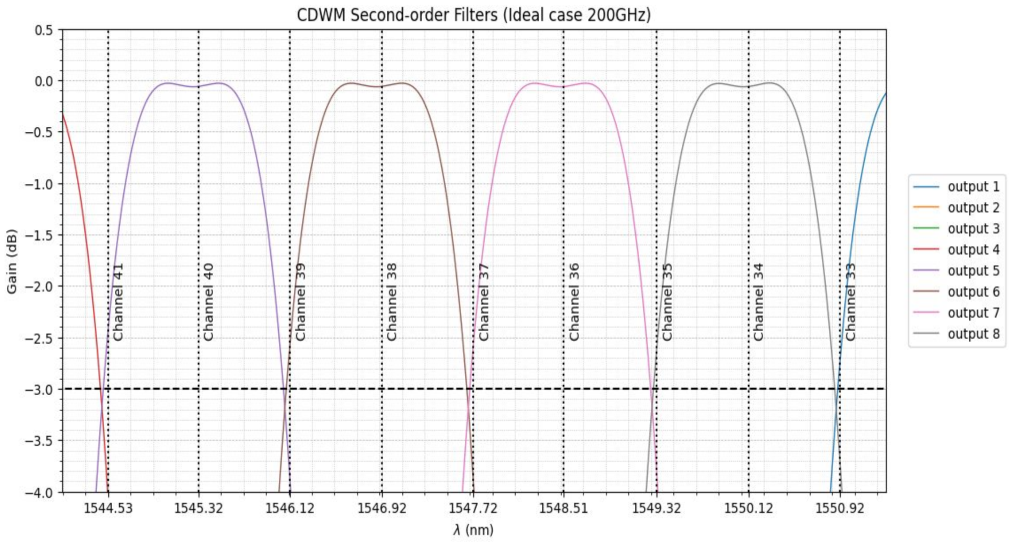
Channel (#)	Frequency (GHz)	Wavelength (nm)		Channel (#)	Frequency (GHz)	Wavelength (nm)
1	190100	1577.03		37	193700	1547.72
2	190200	1576.03		38	193800	1546.92
3	190300	1575.37		39	193900	1546.12
4	190400	1574.54		40	194000	1545.32
5	190500	1573.71		41	194100	1544.53
6	190600	1572.89		42	194200	1543.73
7	190700	1572.06		43	194300	1542.94
8	190800	1571.24		44	194400	1542.14
9	190900	1570.42		45	194500	1541.35
10	191000	1569.59		46	194600	1540.56
11	191100	1568.77		47	194700	1539.77
12	191200	1567.95		48	194800	1538.98
13	191300	1567.13		49	194900	1538.19
14	191400	1566.31		50	195000	1537.40
15	191500	1565.50		51	195100	1536.61
16	191600	1564.68		52	195200	1535.82
17	191700	1563.86		53	195300	1535.04
18	191800	1563.05		54	195400	1534.25
19	191900	1562.23		55	195500	1533.47
20	192000	1561.41		56	195600	1532.68
21	192100	1560.61		57	195700	1531.90
22	192200	1559.79		58	195800	1531.12
23	192300	1558.98		59	195900	1530.33
24	192400	1558.17		60	196000	1529.55
25	192500	1557.36		61	196100	1528.77
26	192600	1556.55		62	196200	1527.99
27	192700	1555.75		63	196300	1527.22
28	192800	1554.94		64	196400	1526.44
29	192900	1554.13		65	196500	1525.66
30	19300	1553.33		66	196600	1524.89
31	193100	1552.52		67	196700	1524.11
32	193200	1551.72		68	196800	1523.34
33	193300	1550.92		69	196900	1522.56
34	193400	1550.12		70	197000	1521.79
35	193500	1549.32		71	197100	1521.02
36	193600	1548.51		72	197200	1520.25

Note: For 200GHz spacing use either odd or even numbered channels.

CDWM - Filtros de 2 estágios (Caso Ideal)







CDWM - Filtros de 2 estágios (PDK SiEPIC)

- Atualização dos dados
  - n_{eff}
  - n_{gr}
- Parâmetros de Simulação:
  - $FSR = \lambda / n_{gr}.\Delta L_{FSR}$
  - $\Delta L_{FS} = \lambda^2 / n_{eff}$
  - $\Delta L = \Delta L_{FSR} + \Delta L_{shift}$

CDWM - Filtros de 2 estágios (PDK SiEPIC)

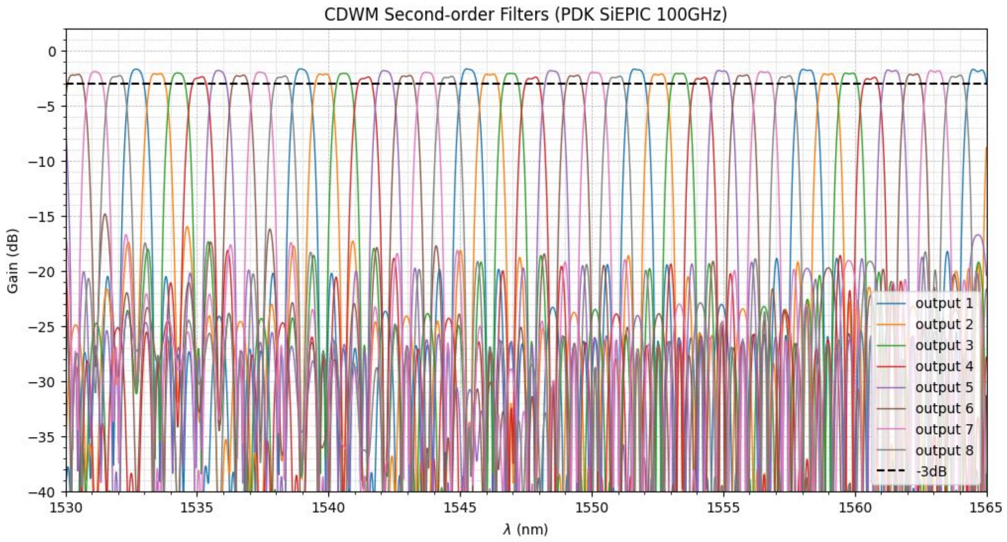
- Função para determinar o comprimento de acoplamento ideal

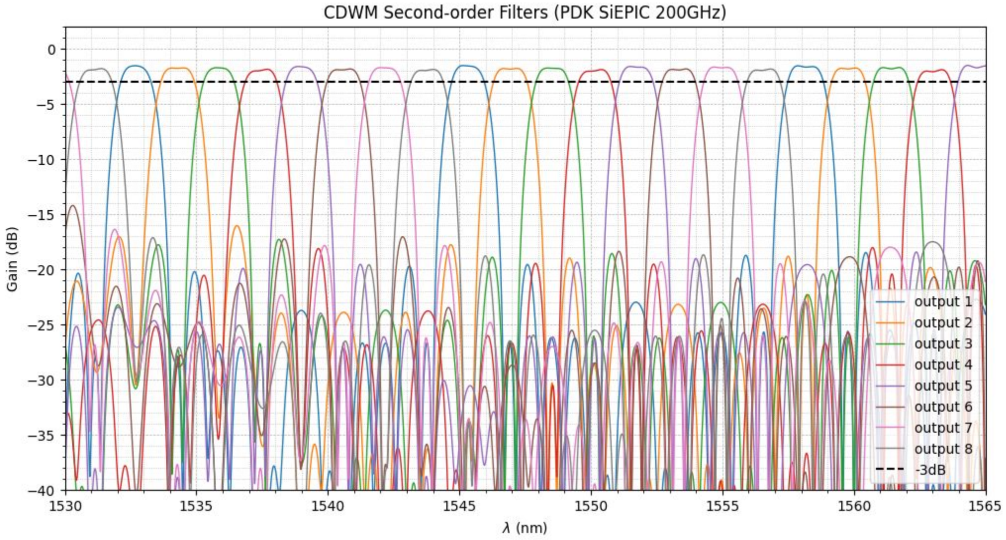
```python
# Function to determine the correct coupling lengths for each D.C.
def coupling(length):
    L_array = np.array([])
    dif_array_50 = np.array([])
    dif_array_29 = np.array([])
    dif_array_8 = np.array([])

    target_29 = 10*np.log10(0.29)
    target_8 = 10*np.log10(0.08)

    for L in length:
        interApi.switchtolayout()
        interApi.select('coupler')
        interApi.set('coupling_length', L)

        interApi.run()
        input_1 = interApi.getresult('ONA', 'input 1/mode 1/gain')
        input_2 = interApi.getresult('ONA', 'input 2/mode 1/gain')

        gain_1 = input_1["'TE' gain (dB)"]
        gain_2 = input_2["'TE' gain (dB)"]

        L_array = np.append(L_array, L)
        dif_array_50 = np.append(dif_array_50, np.mean(np.abs(gain_1-gain_2)))
        dif_array_29 = np.append(dif_array_29, np.mean(np.abs(gain_1-target_29)))
        dif_array_8 = np.append(dif_array_8, np.mean(np.abs(gain_1-target_8)))

    idx_50 = dif_array_50.argmin()
    idx_29 = dif_array_29.argmin()
    idx_8 = dif_array_8.argmin()

    print(f"Coupling length to 50% : {L_array[idx_50]/um}um\n"
          f"Coupling length to 29%: {L_array[idx_29]/um}um\n"
          f"Coupling length to 8%: {L_array[idx_8]/um}um")
```

```python
[11]
length = np.arange(0, 50, 2.5) * um
coupling(length)
```

```
Coupling length to 50% : 17.5um
Coupling length to 29%: 12.5um
Coupling length to 8%: 5.0um
```

CDWM - Filtros de 2 estágios (PDK SiEPIC)





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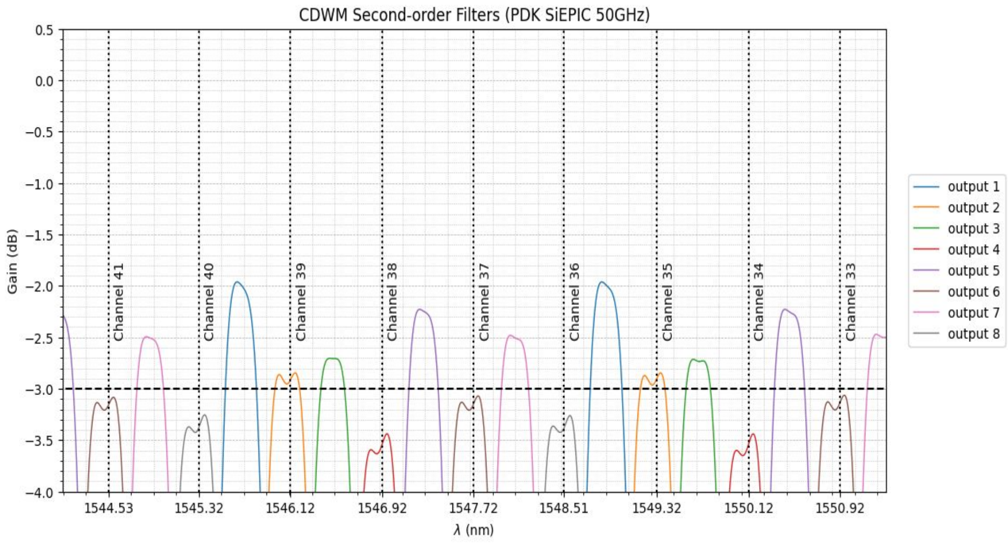
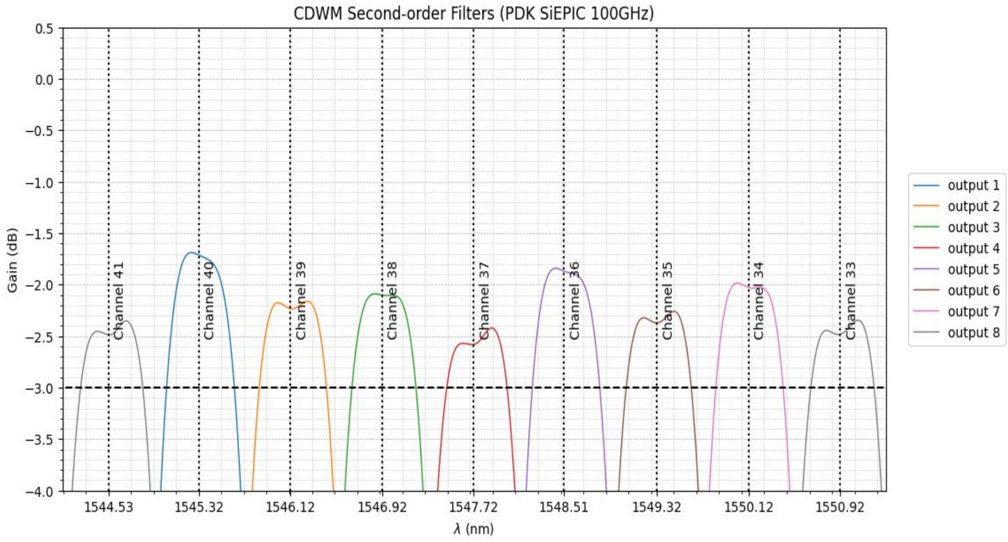
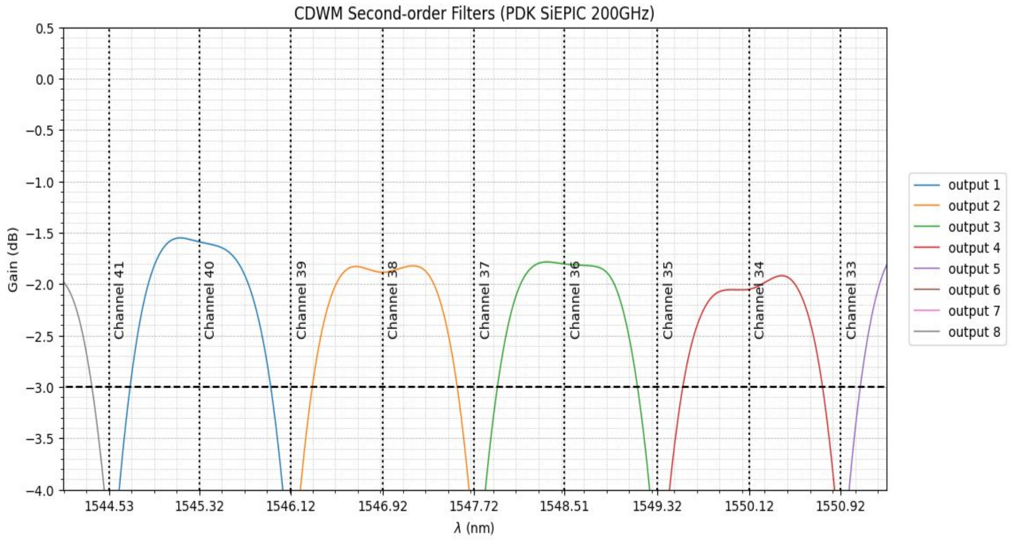
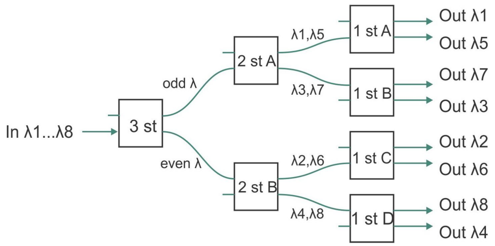
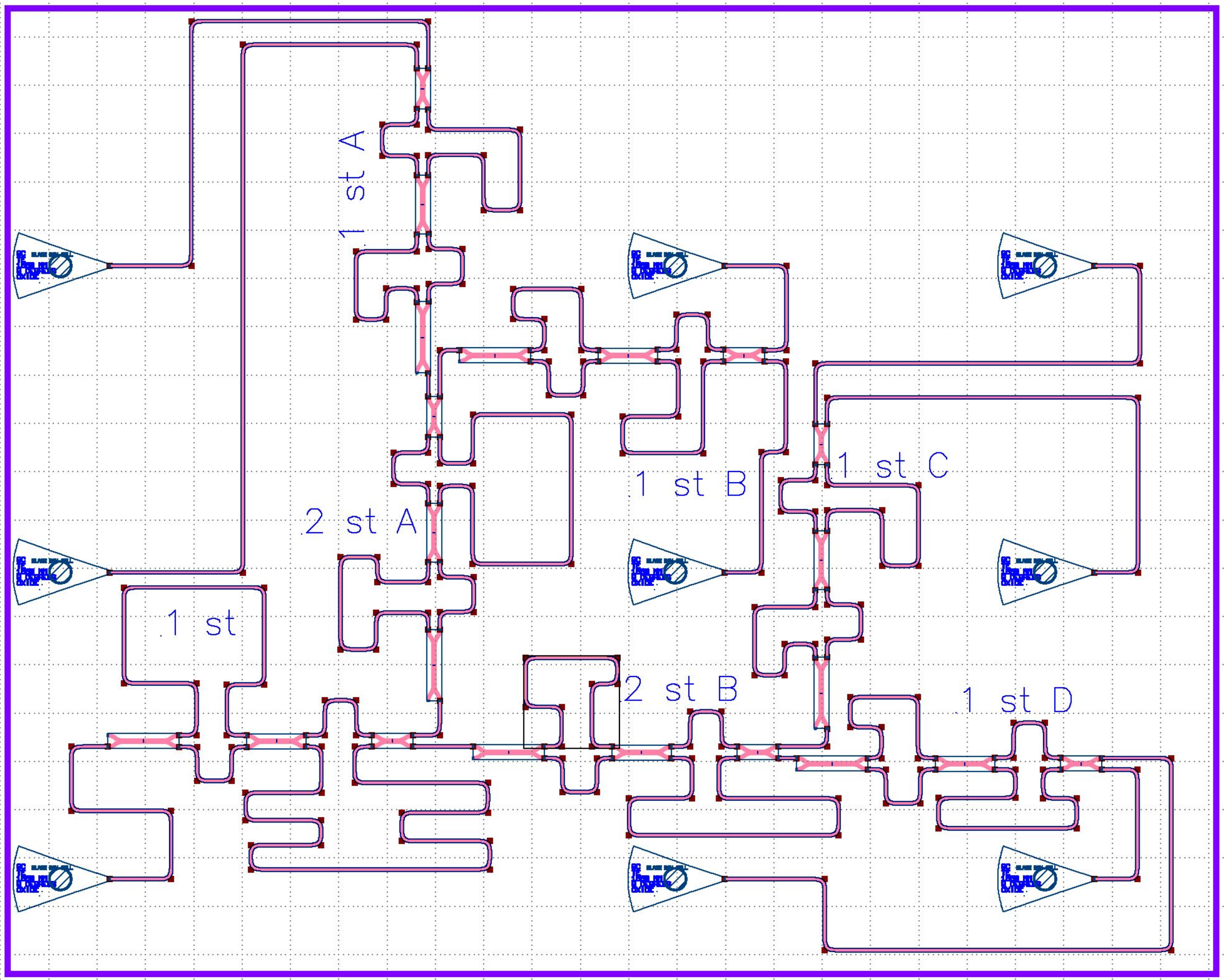








CDWM - KLayout (200 GHz)



Referências

[1] Folkert Horst, William M.J. Green, Solomon Assefa, Steven M. Shank, Yurii A. Vlasov, and Bert Jan Offrein, "**Cascaded Mach-Zehnder wavelength filters in silicon photonics for low loss and flat pass-band WDM (de-)multiplexing,**" Opt. Express 21, 11652-11658 (2013).

[2] Luceda Photonics. "**CWDM based on cascaded MZI lattice filters**". Link: *2. CWDM based on cascaded MZI lattice filters — Luceda Academy 2025.03 documentation*. Acessado em: 20/04/2025

[3] FiberDyne. "**Dense Wave Division Multiplexing (DWDM) ITU Grid: C-Band, 100 GHz Spacing**". Link: *Fiberdyne-ITU-Grid-C-Band-100GHz.pdf*. Acessado em: 20/04/2025

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