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Cyclic Athermal AWG λ Router for Super-PON

Daisuke Ogawa

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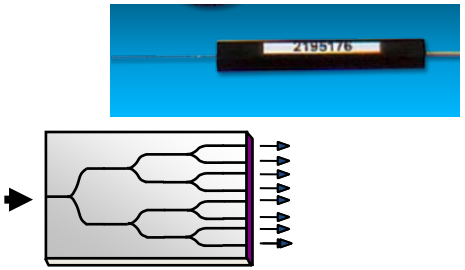
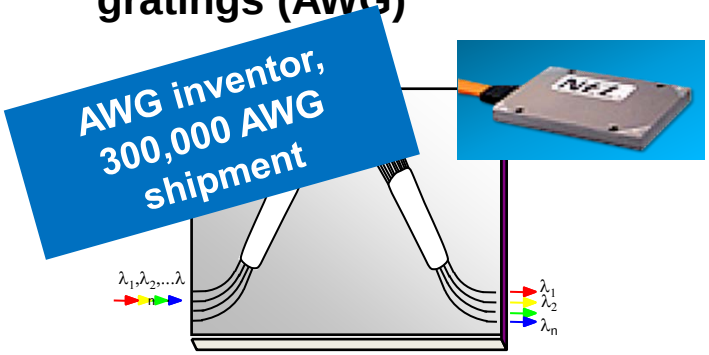
Silica-based PLC technologies

- Precisely controlled wafer processing, mass-producible
- No mechanical moving parts enables high reliability and robustness component
- A large variety of Products: Basic “single function” components (splitter/coupler, MUX/DEMUX[AWG], switch, attenuators, etc.) as well modules integrating multiple functionalities for ROADM such as MultiCast Switch

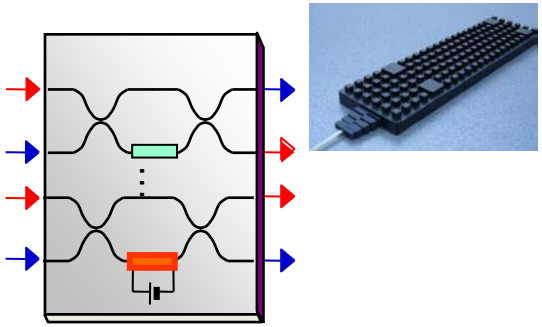
Splitters



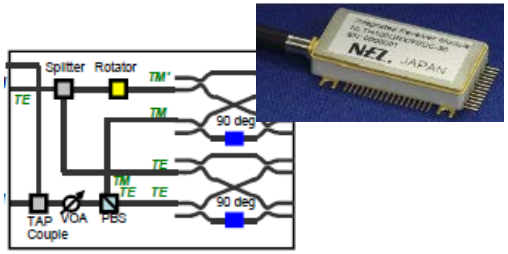
Arrayed-waveguide gratings (AWG)



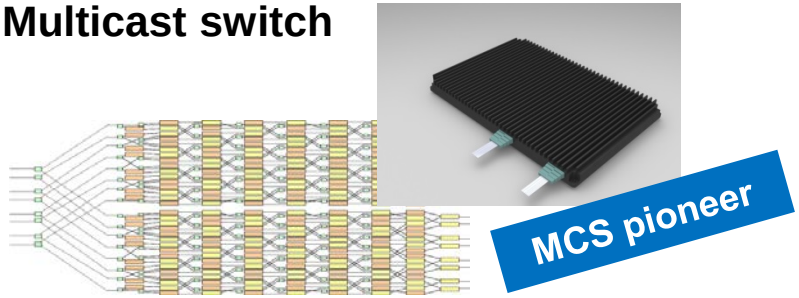
Thermo-optic (TO) switches



μICR



Multicast switch



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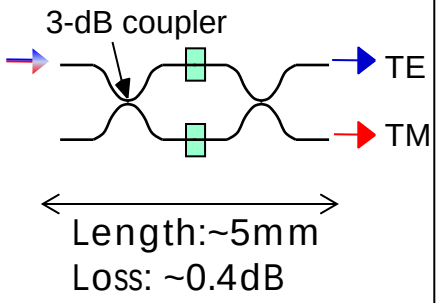
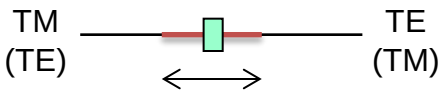
Functional PLC

MZI based PBS

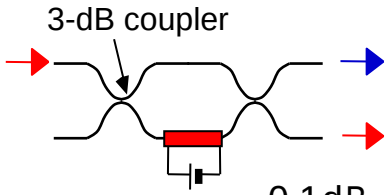


Polarization rotator

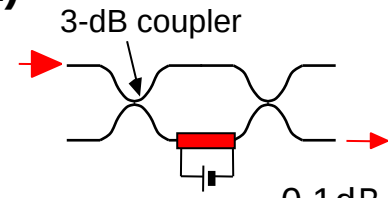


Length: ~0.5mm
Loss: ~0.4dB

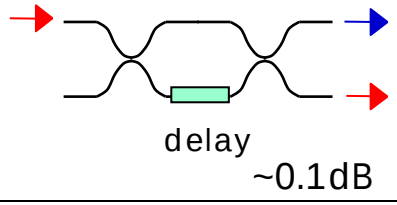
Thermo-optic switches (TOS)



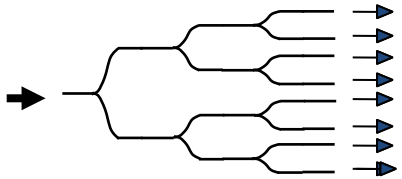
Variable optical attenuator (VOA)



Mach-Zehnder Interferometer

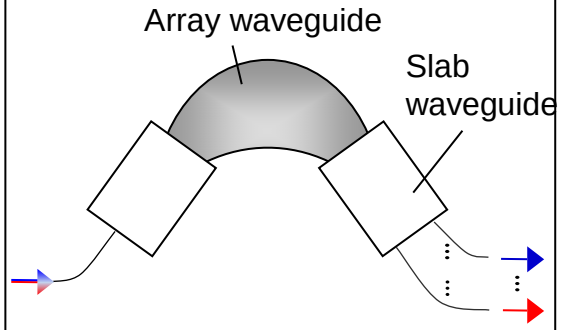


1xN Splitter
Tap coupler



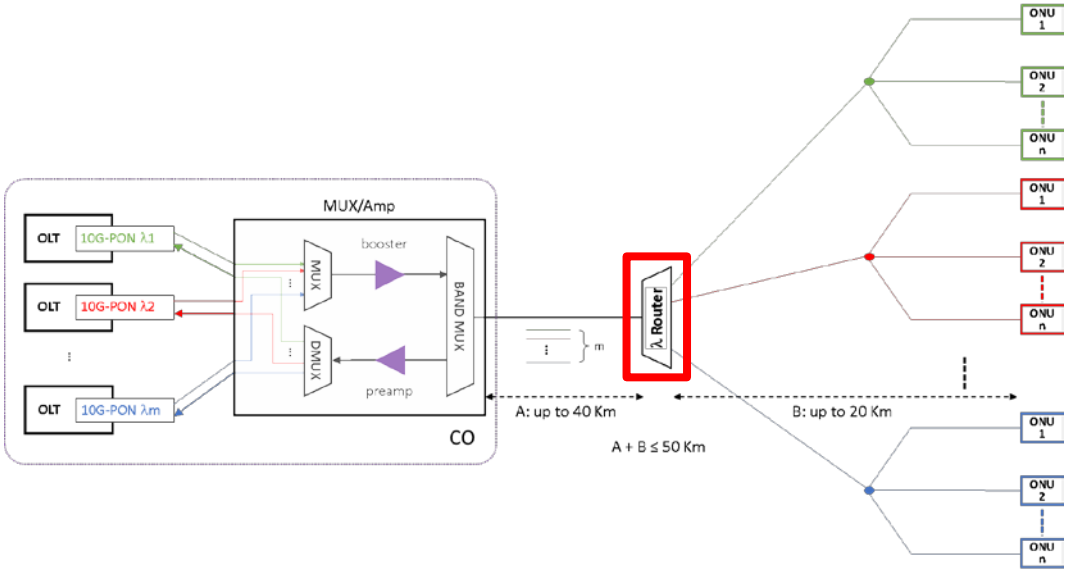
~0.1dB
for each1x2 splitter

Arrayed Waveguide Grating (AWG)



λ Router for Super-PON

- λ Router is passive wavelength router
- Cyclic AWG is suitable for λ Router
  - Cyclic fundamental nature and Bi-Directional functionality enables UpStream/DownStream operation
  - Completely Passive operation by Athermalization



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Cyclic nature of AWG

- Cyclic wavelength phenomenon is realized by fundamental nature of AWG
- Multiple bands are provided with solo AWG

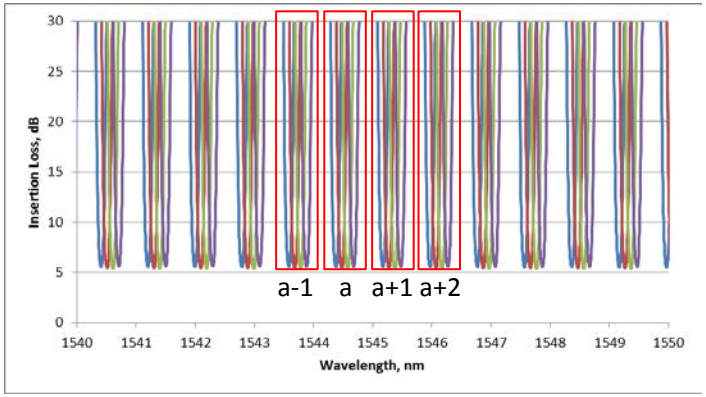
$$\lambda_c = \frac{n_c \times \Delta L}{m}$$

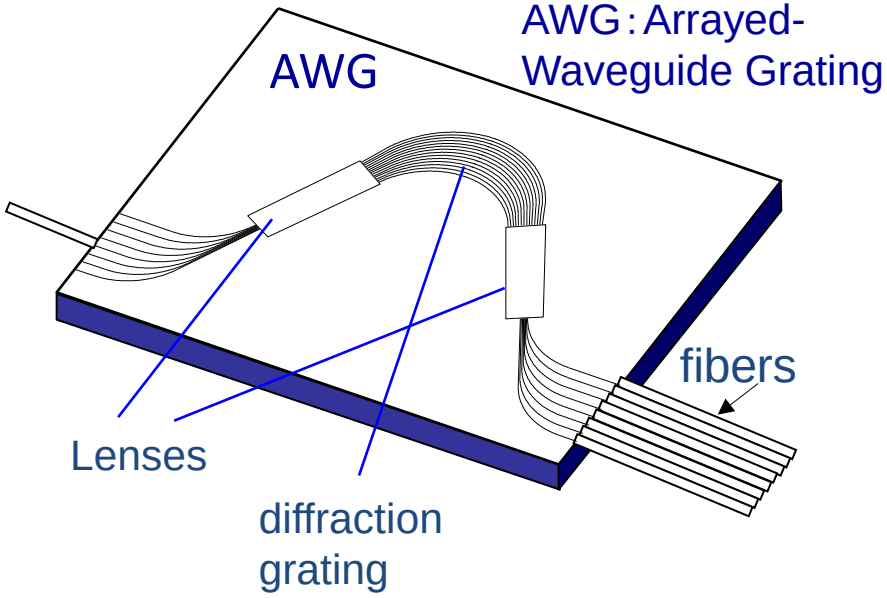
$$m = a-1, \quad a, \quad a+1, \quad a+2 \cdots$$

ΔL: Waveguide path length difference
m: Diffraction order
FSR: Free Spectral Range

$$FSR = N\frac{\lambda_c}{m}$$

Example Cyclic AWG Spectrum





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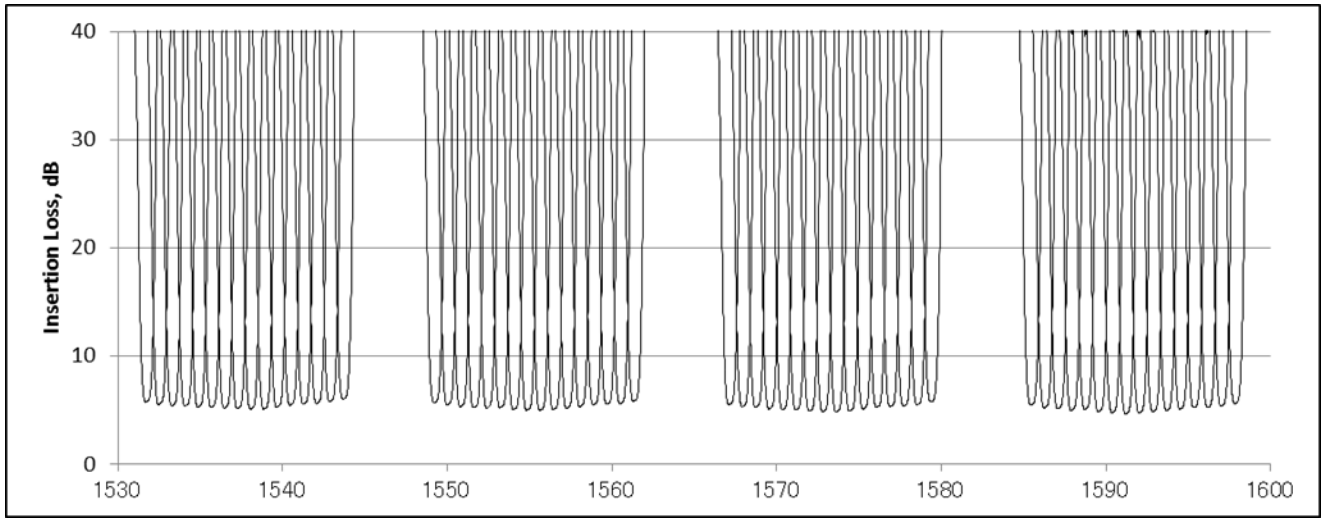
Channel plan in usable spectrum range for Super-PON

- Operating range: 1530-1600nm
- Number of channel in band:16 channels
- Available number of Bands: 4 bands with 100GHz channel frequency spacing



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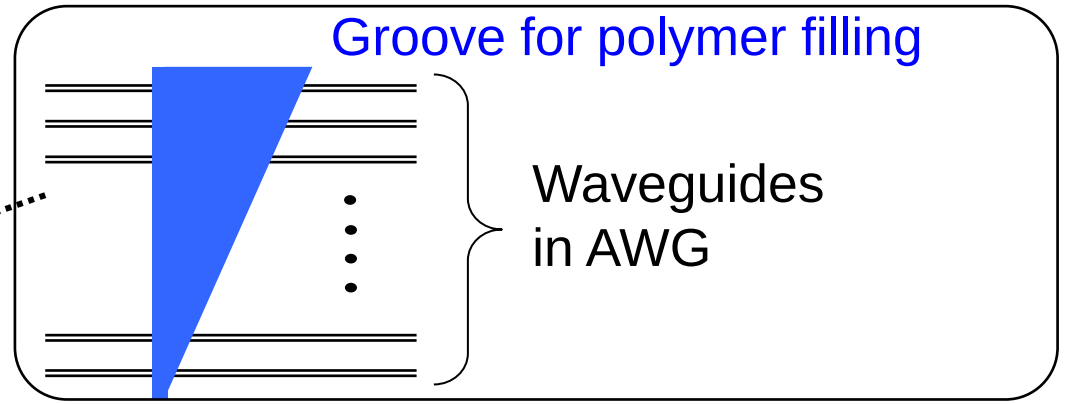
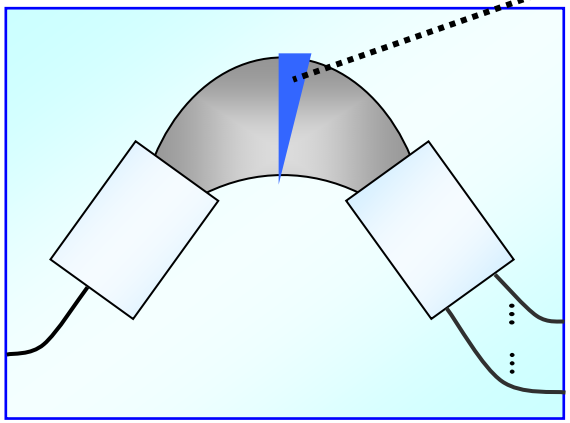
Proposal channel Plan

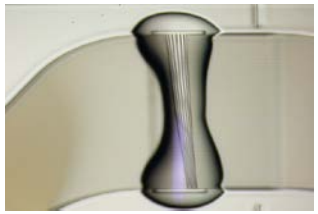
Channel	L-band 1		L-band 2		C-band 1		C-band 2	
	Frequency (THz)	Wavelength (nm)	Frequency (THz)	Wavelength (nm)	Frequency (THz)	Wavelength (nm)	Frequency (THz)	Wavelength (nm)
1	187.613	1597.93	189.807	1579.46	192.000	1561.42	194.193	1543.78
2	187.711	1597.10	189.906	1578.64	192.100	1560.61	194.294	1542.98
3	187.809	1596.27	190.004	1577.82	192.200	1559.79	194.396	1542.18
4	187.906	1595.44	190.103	1577.00	192.300	1558.98	194.497	1541.38
5	188.004	1594.61	190.202	1576.18	192.400	1558.17	194.598	1540.57
6	188.102	1593.78	190.301	1575.36	192.500	1557.36	194.699	1539.77
7	188.200	1592.95	190.400	1574.54	192.600	1556.56	194.800	1538.97
8	188.297	1592.12	190.499	1573.73	192.700	1555.75	194.901	1538.18
9	188.395	1591.30	190.597	1572.91	192.800	1554.94	195.003	1537.38
10	188.493	1590.47	190.696	1572.09	192.900	1554.13	195.104	1536.58
11	188.590	1589.65	190.795	1571.28	193.000	1553.33	195.205	1535.78
12	188.688	1588.83	190.894	1570.47	193.100	1552.52	195.306	1534.99
13	188.786	1588.00	190.993	1569.65	193.200	1551.72	195.407	1534.19
14	188.883	1587.18	191.092	1568.84	193.300	1550.92	195.508	1533.40
15	188.981	1586.36	191.191	1568.03	193.400	1550.12	195.609	1532.61
16	189.079	1585.54	191.289	1567.22	193.500	1549.32	195.711	1531.82

Athermalization

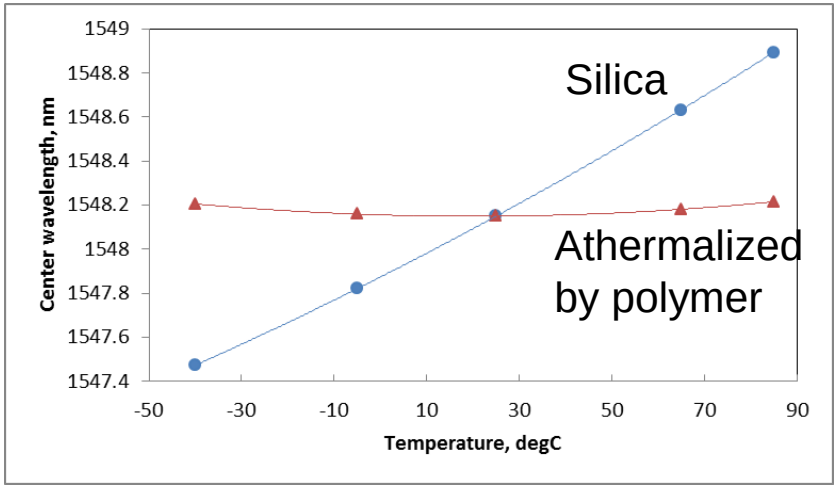
- Center wavelength compensation by polymer with negative thermal index coefficient against silica



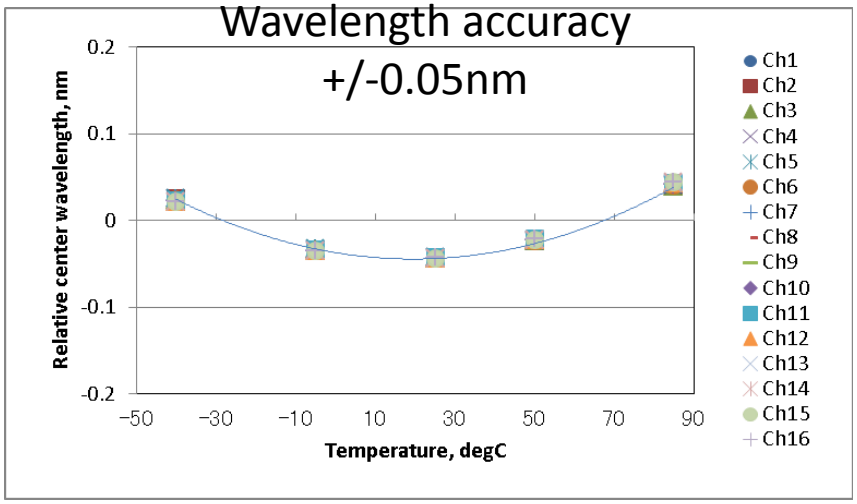


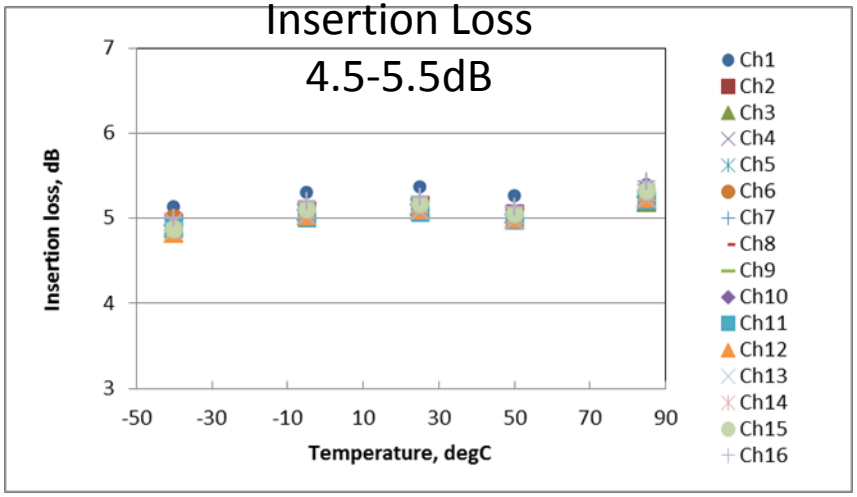


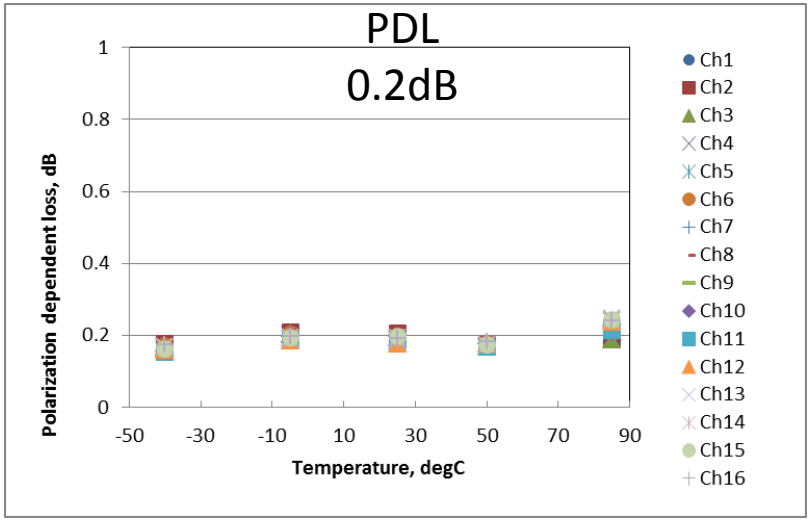
Y. Inoue et al.
Electron. Lett. 33, pp.1945 (1997)

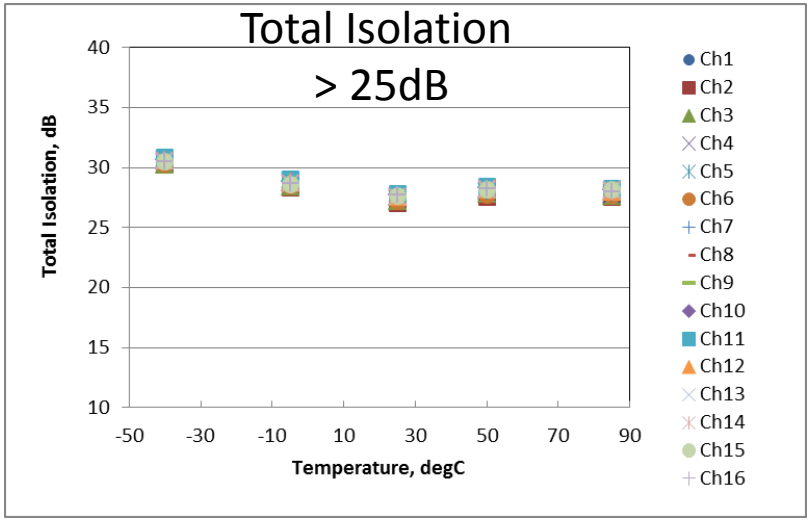


Optical performance over temperature









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Conclusion

- Cyclic AWG is the promising solution as the λ Router for Super-PON.
- Sufficient number of channel in the operating wavelength range is 16channel. 20 channels are also possible, but the edge channels would have worse insertion loss.
- Center wavelength shift is compensated by Athermalization. Athermal-AWG works -40 to 85degC of outside temperature range.

Thank you

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