Tunable Filter based Optical Add/Drop Technology (TOADM)

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Benefit of Tunability/Reconfig. network

- Faster and remote provisioning
- **Bandwidth-on-demand** — Better bandwidth utilization; transform bandwidth capacity to revenue generating services
- **Automated network reconfiguration and restoration** — Flexibility, security and cost-effectiveness
ROADM Optical Networks

Optical core switch

Intercity

Metro

Customers

ROADM

Source: AT&T
ROADM Technologies

- WB (wavelength blocker) + 2-port tunable filter
- WSS (wavelength selective switch)
- TOADM (tunable optical add/drop module)
- WSS+ TOADM
ROADM (1)
(WB + 2-port tunable filters)

In

1xM Couplers

TF Arrays

Drop

Add

Express Out

Loss > 12 dB

Loss > 10 dB
Application of TF and TOADM

In

Express Out

3-port TOADM

1xM Couplers

2-port TF Arrays

Drop

Add

Broadcast-and-Select ROADM
ROADM (2)  
Wavelength Selective Switch (WSS)

Add Channels
Drop Channels
Loss ~5 dB
Grating Demux + MEMS Switchs

Optoplex Confidential
ROADM (3)
3-Port Tunable filter (TOADM)

Add Channels
Loss < 4 dB

Drop Channels
Loss ~ 3 dB

In
Express Out

Optoplex Confidential
ROADM (4)
WSS + TOADM

WSS re-groups inputs signals into 4 sets
TOADM demux signals in each sub-set
# Tunable Filter Technology Comparison

<table>
<thead>
<tr>
<th>Technology</th>
<th>Passband Flat-top</th>
<th>High Ch. Isolation</th>
<th>Athermal</th>
<th>Latching</th>
<th>3-Port</th>
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<tbody>
<tr>
<td>Single cavity (MEMS Based)</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Multi-cavity (Thin-film based)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tbody>
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TOADM

Same size as a credit card
Filter Tuning Mechanism

$\lambda_{\text{drop}} = f(n, d, \theta)$
TOADM Performance (1)

Drop Channels (100 GHz 3-port, single channel)

Wavelength (nm)

Insertion Loss (dB)
TOADM Performance (2)

Express Channels (100 GHz 3-port, single channel)

Insertion Loss (dB)

Wavelength (nm)
100 GHz Tunable Filter Performance (3)

IL vs Channel Number

Insertion Loss (dB)

Channel Number

Drop Channel
(100 GHz 3-port, single channel)
100 GHz Tunable Filter Performance (4)

Bandwidth vs Channel Number

- PB @ 0.5dB
- SB @ 25dB

Drop Channel (100 GHz 3-port, single channel)
100 GHz Tunable Filter Performance (5)
flat top, high isolation

Express Channels

Drop Channels
TOADM Performance (6)

performance at various temperatures

![Graph showing TOADM performance at various temperatures.](image)
Band-drop TOADM
(Band drop TOADM + colorless demux)

Input

Tunable Filter
4 Skip 0

Drop

Colorless Demux

Demux

Express

4 Dropped Channels
Band drop TOADM Performance (1)

100 G, 4-skip-0, drop channels

Insertion Loss (dB)

Wavelength (nm)

Optoplex Confidential
Band drop TOADM Performance (2)

100G, 4-skip-0 express channels

Insertion Loss (dB)

Wavelength (nm)
Summary

- It has been proved that thin-film based tunable optical add/drop (TOADM) technologies provides a cost-effective, high performance, low technical risk solution for building a reconfigurable optical network.