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# Switching Characteristics of Optical Pulse Train by Weighted Collinear Acoustooptic Switches

重み付けコリニア音響光学スイッチにおける光パルス列スイッチング特性

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## 1. Introduction

In photonic network nodes, wavelength-selective optical switching or signal processing is expected to improve the processing speed with lower power consumption. Acoustooptic (AO) devices using collinear interaction between guided optical pulses and guided surface acoustic waves (SAWs) provide wavelength-selective processing capability though the switching speed is limited to an order of micro seconds. The AO device will be useful in switching at an order of micro seconds and packet processing.[1,2)]

When the pulse width becomes narrow, the switched pulse is distorted due to the wavelength selectivity of switching.[3)] In this report, we consider switching characteristics of pulse trains with collinear AO switches. Two types of collinear AO switches with weighted AO coupling along the interaction region are considered.

## 2. Weighted AO switches

A collinear AO device with a tapered SAW waveguide is shown in Fig.1, where sidelobe suppression is realized.[4)] Alternatives to achieve weighted AO interaction include employment of a tilted SAW waveguide[5)] and a SAW directional coupler[6)]. An AO filtering having Butterworth filtering characteristics was reported by employing a SAW directional coupler and a SAW absorption film as shown in Fig.2.[7)]

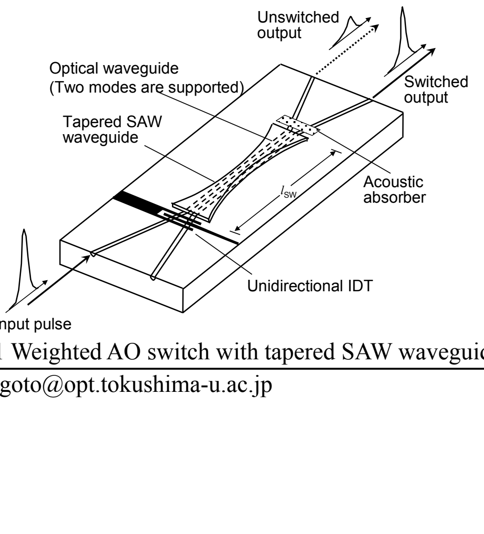


Fig.1 Weighted AO switch with tapered SAW waveguide.

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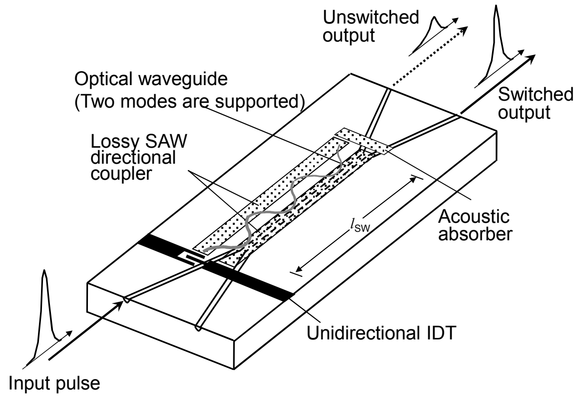



Fig.2 Weighted AO switch having Butterworth filtering characteristics.

The AO coupling $g(z)$ for the tapered SAW waveguide is assumed to be given by

$$g(z) = g_0\left[1-\alpha\cos\left(2\pi z/l_{SW}\right)\right] \quad (1)$$

where $\alpha$ is a parameter indicating the weighting strength, $l_{SW}$ is the interaction length. For complete switching, $g_0$ is set to be $g_0\ l_{SW} = \pi/2$. We assume $\alpha$=0 for the conventional coupling and $\alpha$=0.5 for a weighted one. It is noted that the sidelobe is decreased to -20dB for $\alpha$=0.5.

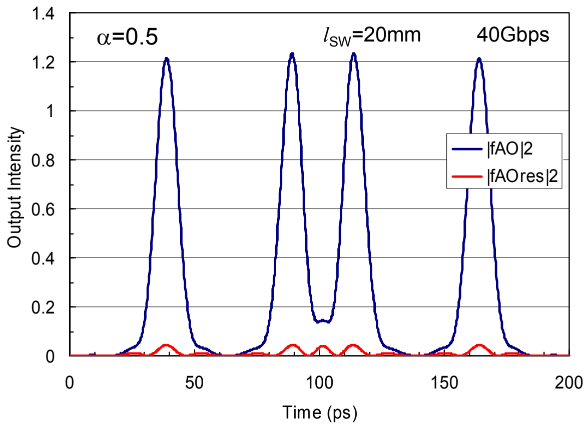
For the AO device having Butterworth filtering characteristics, we assume $g(z)$ given by

$$g(z) = g_0 \sin\left\{\kappa_\infty\left[z-\frac{\sqrt{\pi}}{2}z_t erf\left(\frac{z}{z_t}\right)\right]\right\}e^{-\beta_{im}z} \quad (2)$$

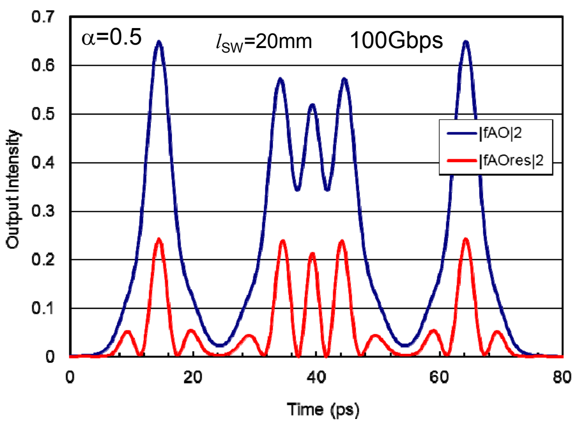
and

$$\kappa_\infty = \frac{N\pi}{l_{SW}-\frac{\sqrt{\pi}}{2}z_t erf\left(\frac{l_{SW}}{z_t}\right)} \quad (3)$$

where $N$ is the number of sections with alternating polarities and $z_t$ is an entrance taper length of the AO coupling. We set these parameters as $N$=3, $g_0$=26.228/$l_{SW}$ and $z_t$=0.19$l_{SW}$.[7)] The feature of this switch is that flat-top characteristics are obtained.

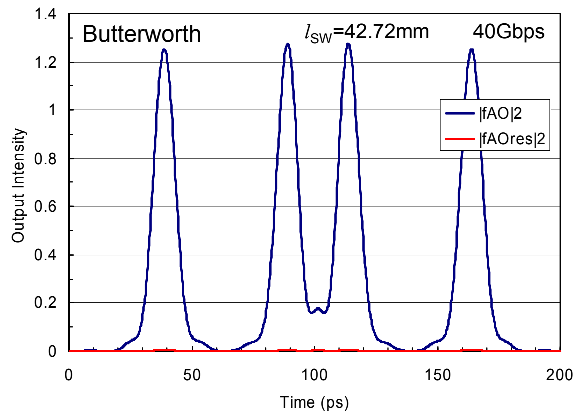



(a) 40Gbps

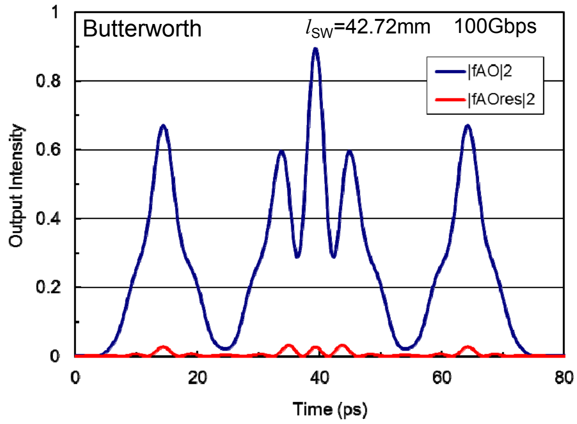



(b) 100Gbps

Fig.3 Switched output intensity with the weighted AO switch with tapered SAW waveguide (α=0.5).




(a) 40Gbps




(b) 100Gbps

Fig.4 Switched output intensity with the AO switch having Butterworth filtering characteristics.

## 3. Switching characteristics of pulse trains

We consider optical pulse trains at 40Gbps and 100Gbps. To conserve high-bit-rate pulse trains through switching, the filtering bandwidth in switching has to be enough wide to transmit all the frequency components.

We consider optical pulse train of on-off keying coded by 0101101. Fig.3 shows the simulated optical output from the switch with the tapered SAW waveguide of $\alpha$=0.5 for the input at 40Gbps and 100Gbps, where $f_{AO}$ and $f_{AO}^{res}$ denote switched and unswitched amplitude, respectively. The interaction length of the AO switch is assumed to be 20mm. It is clearly found that the pulse train at 100Gbps is distorted.

The output from the switch with Butterworth filtering characteristics is shown in Fig.4. The interaction length is assumed to be 42.72mm. Although the unswitched components are small, the pulse train is also distorted at 100Gbps. To switch optical pulse trains at 100Gbps, the AO interaction length has to be designed to be shorter.

## 4. Conclusion

Switching characteristics for high-bit-rate pulses with collinear AO devices were theoretically discussed. Design parameters of collinear AO switches for preserving the pulse trains will be further discussed. Wavelength-selective processing with integrated AO devices for use in photonic routers will also be investigated in future.

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