



The need of LiNbO_3 modulators
dedicated to low frequencies

Introduction

LiNbO_3 modulators are widely used for their wide bandwidth performances up to 70 GHz that make them favoured devices for high data rate optical communications and high frequency analog transmissions.

However, they are also often used at low frequencies under 1 GHz. These LiNbO_3 phase modulators also have strong benefits at low frequencies (compactness, ease of use, low drive voltage) compared to devices based on alternative technologies. They are thus components to be considered even for few Hz to MHz frequency range applications:

- > to lock a frequency laser by a Pound Drever Hall technique, see our [e-learning page](#)
- > to combine several coherent beams, see our e-learning pages on [Coherent Beam Combining](#) and [Spectral Beam Combining](#)
- > to broaden a spectrum and create side bands, ask for our Technical Note on Spectral Analysis of an Optical Phase Modulator if needed
- > to frequency stabilize a large fiber interferometer,
- > etc...

Low frequency behavior

Users searching to implement LiNbO_3 phase modulators with modulation signals showing low and high frequency components - the typical case is a pulse signal with sharp rising and fall edges and a low repetition rate or a long pulse duration - must be very cautious. A “high bandwidth” phase modulator, and here “high bandwidth” means > 1 GHz typically, is not performing extremely well with such a modulation signal.

The reason is that to get a good high bandwidth performance, the impedance of the microwave line of the modulator is matched near to 50 Ω and a load resistance termination is connected at the end of the RF line to reduce or avoid any electrical RF reflection. Thus, a significant level of current is traveling in the RF electrodes, leading to local temperature increases by Joule effect. Heating and thermal dissipation becomes a problem when the repetition period or the pulse duration becomes longer than the time constant of the thermal effects (in the range of 1 kHz or below). Then the physical properties of the electrodes and waveguide are changing during the heat-on and cool-down periods, leading to unwanted phase drifts.

The figures below show the modulation obtained when a rectangular modulation signal is applied to a high frequency phase modulator (MPZ-LN-20 type) at 50 Hz and at 50 kHz.

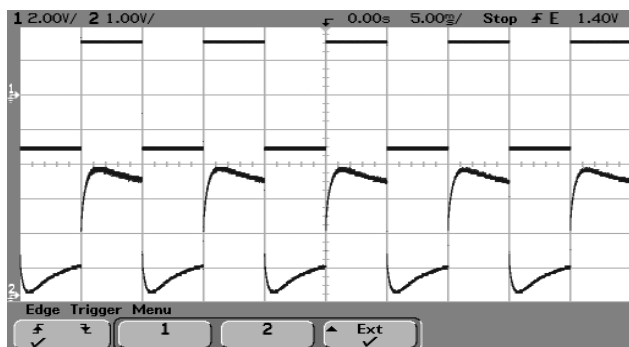


Figure 1:
up: modulation signal at 50 Hz
down: resulting intensity signal

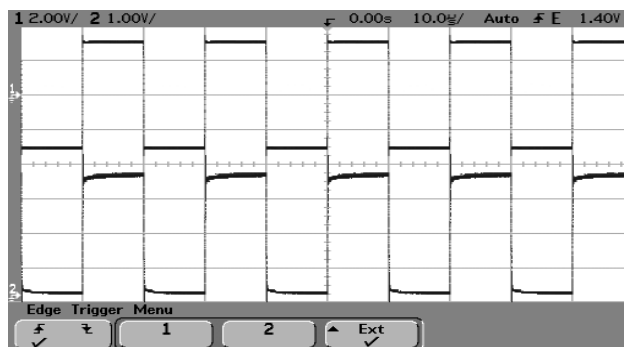


Figure 2:
up: modulation signal at 50 kHz
down: resulting intensity signal

The thermal effect is clearly visible at the very low frequencies (see figure 1 at 50 Hz). We can see transients at the sharp edges. At 50 kHz the phase transients disappeared: the thermal effect completely vanishes (see figure 2).

Standard 5, 10 or 20 GHz phase modulators are not suitable for such applications involving a very low repetition rate.

To suppress that phenomenon, a solution is to use a modulator with a high input impedance load (typically 10 k Ω) or directly an opened electrode line (M Ω). The thermal effects are then significantly reduced since the Joule effect becomes negligible. However the useful electro-optic bandwidth is also reduced to several hundred MHz which is still sufficient for a large range of applications (sensors). Exail has developed a family of phase modulators whose performances are optimized for low repetition rate modulation signals: the MPX-LN-0.1 series.

The figures below show the same modulation signal applied than before to a NIR-MPX-LN-0.1 phase modulator. The modulation is obtained with purely capacitive electrodes involving no thermal effect.

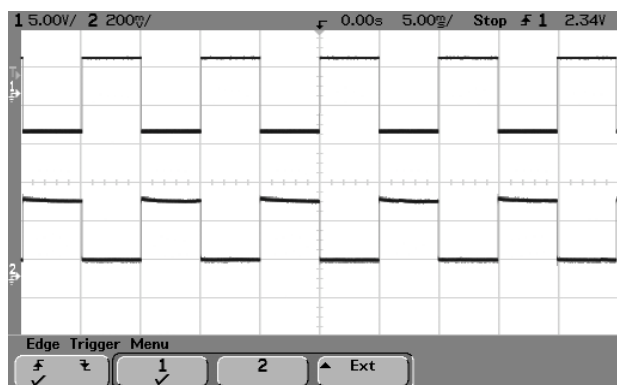


Figure 3:
up: modulation signal at 50 Hz
down: resulting intensity signal

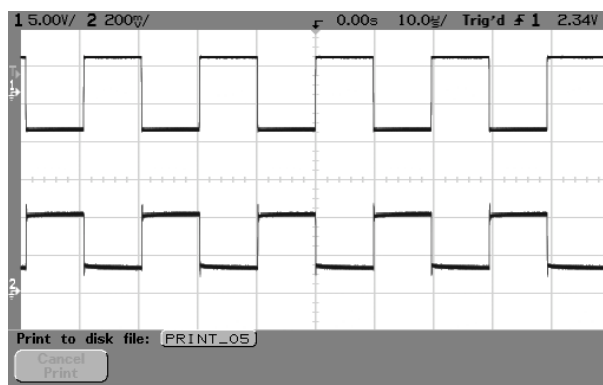


Figure 4:
up: modulation signal at 50 kHz
down: resulting intensity signal

There is no more thermal effect at the low frequency (see figure 3 at 50 Hz) thanks to the unloaded capacitive electrodes. At 50 kHz the fast edges are well transmitted (see figure 4).

Temperature stability

Considering the large range of environmental conditions under which Exail modulators can be used we evaluated their temperature dependance. MPX-LN-0.1 modulators have been tested in temperature over time (see figure 5). It shows that they keep their performances in operating conditions covering a large temperature range (-40°C to $+85^\circ\text{C}$) and during temperature variations.

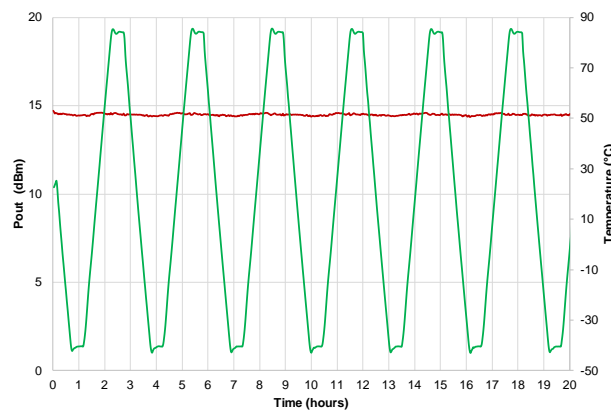


Figure 5: Output optical power stability over time with temperature variations

Conclusion

Exail provides phase and intensity modulators dedicated to low frequencies covering a wide range of wavelengths from 800 nm to 2 μm . We have succeeded in addressing the challenges for operation with modulation signals exhibiting low frequency components.

All the performances are listed in the datasheet of the corresponding modulators on our [webpage](#) and each application has its corresponding modulator depending on the desired wavelength.

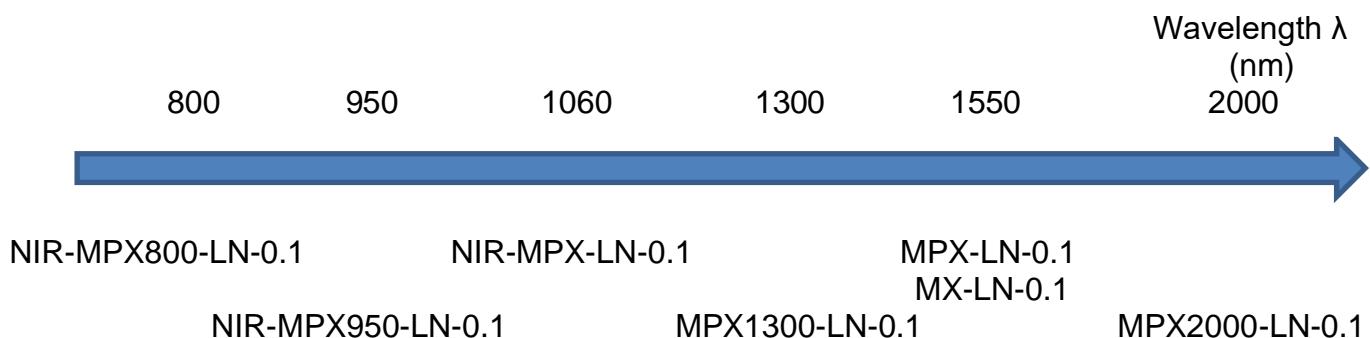




Figure 6: Picture of the MPX-LN-0.1 modulator