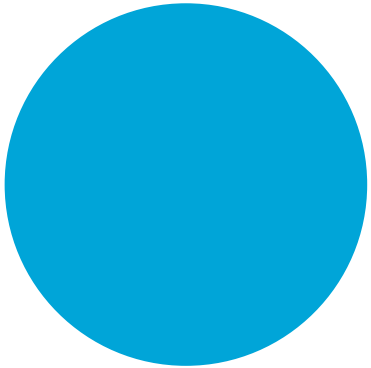

iXblue solutions for high power lasers based on beam combining technique

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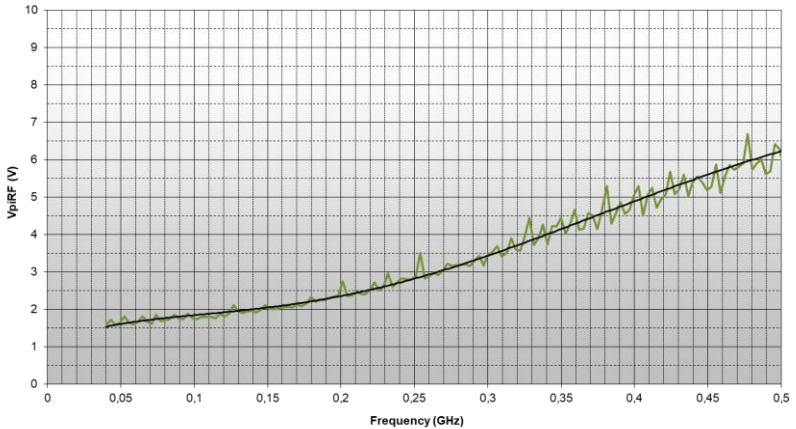
NIR-MPX-LN-0.1-MPX-LN-0.1: a low frequencies phase modulator

- **High input impedance:**
  - for efficient RF generator signal transmission transfer to the modulator.
  - To avoid thermal effect and signal degradation due to phase drift.
    - ⇒ High impedance modulator and purely capacitive electrodes vanish thermal effect and phase drift. This ensures stable operating performance over a large temperature range.

Application Note: *"iXblue: Use of $LiNb0_3$ modulators at low frequencies"*



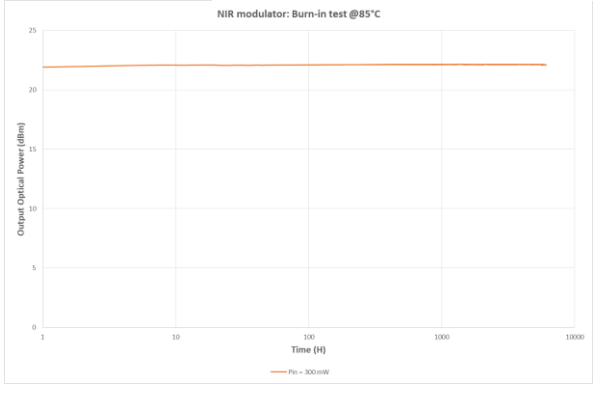
- **Very low Vπ:**
  - Modulator Vπ is proportional to the Electro-Optical bandwidth
  - The (NIR-)MPX-LN-0,1 features a Vπ of only 1,5 V @ 50 MHz
    - ⇒ Low Vπ at low frequencies minimizes RF power consumption

- **High packaging quality:**
  - Telcordia and space qualifications (TRL9 with NASA)
    - ⇒ Packaging and specific mechanical housing for harsh environmental conditions.

iXblue solutions for high power lasers based on beam combining technique

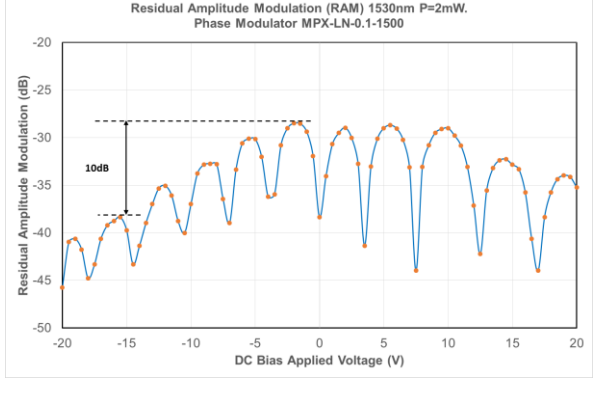
NIR-MPX-LN-0.1 a low frequencies phase modulator

- **Incomparable optical waveguide and the key optical performances reached:**
  - Annealed Proton Exchange process on a selected $LiNbO_3$ doped wafer.
  - Polarizing waveguide : PER > 20 dB, and > 25 dB with option PER.
  - Very low insertion loss : IL < 3 dB. Gaussian distribution with a 2 dB typical mean.
  - High optical power handling capability of up to 300 mW.
  - High resistance to refractive index effect changes and Pyro-electric effect.
    - ⇒ iXblue offers the best $LiNbO_3$ phase modulator optical performance.
    - ⇒ High optical performance is stable over the temperature range and over time



Application Note: *"iXblue; Introducing the iXblue NIR-MPX-LN-0.1"*

- **Mitigate the RAM effect:**
  - The (NIR-)MPX-LN-0.1 is a DC coupled device: a permanent DC signal can be applied w/o modulator damages
  - Applying a constant DC voltage allows to reduce the RAM from typically 30dB to near 40dB (patented technique)
    - ⇒ Residual amplitude modulation can be strongly reduced thanks to a permanent DC voltage



Application Note: *"Residual Amplitude Modulation of optical phase modulators"*

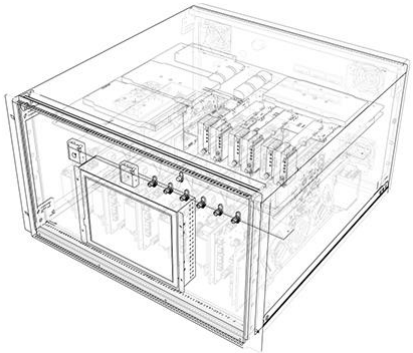
iXblue solutions for high power lasers based on beam combining technique

DR-VE-0.1-MO a RF amplifier to match the (NIR-)MPX-LN-0.1 phase modulator

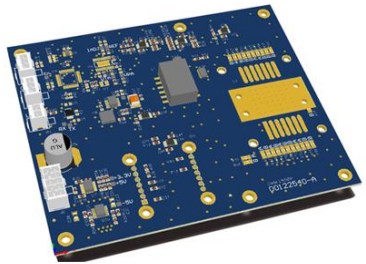
- **Perfect matching between the modulator and the RF generator:**
  - High impedance for efficient RF signal amplification from the generator to the modulator,
  - Adapted bandwidth
  - Mechanical matching
  - DC coupled amplifier
    - ⇒ Simple and inexpensive, the DR-VE-0.1-MO is a DC-coupled voltage amplifier that operates over a DC to 200 MHz bandwidth.
    - ⇒ Draws very little current.

iXblue solutions for high power lasers based on beam combining technique

Custom component integration designs based on Customer specification: the ModBox



- **Custom Optical Systems & Instruments**
  - The ModBox systems are Optical Transmitter solutions based on external $LiNbO_3$ modulation means.
  - iXblue has the inter-disciplinary expertise to integrate simple to complex electro-optical systems and sub-systems.
  - In-depth knowledge in Photonics, RF and hyper-frequency, electronics and interfacing.
  - ModBox addresses the Telecom, Communication and lasers markets, from 780 nm to 2 500 nm.
  - Strong background and High competences in the high energetics and powerful lasers field.
    - ⇒ Who knows better than the EOM manufacturer on how to use their own products ?



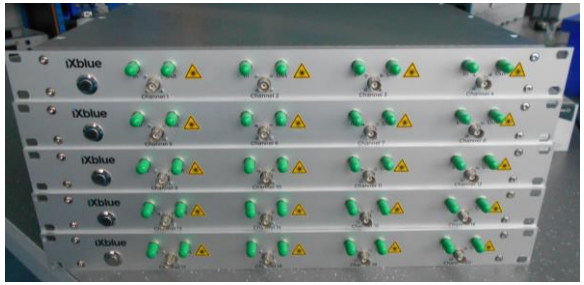
- **Turn-key ModBox is a dedicated product for customers needs**
  - From prototype base plates to modules, or racks,
  - to industrial and reproduceable module or rack solutions.
  - Prototype ModBox hardware will be accessible and re-configurable.
  - The ModBox system meets the European standards and are compliant with the EMC and optical norms EN61326-1 Ed. 2006 / NF EN 60825-1 & EN 60825-2 Ed.2014.

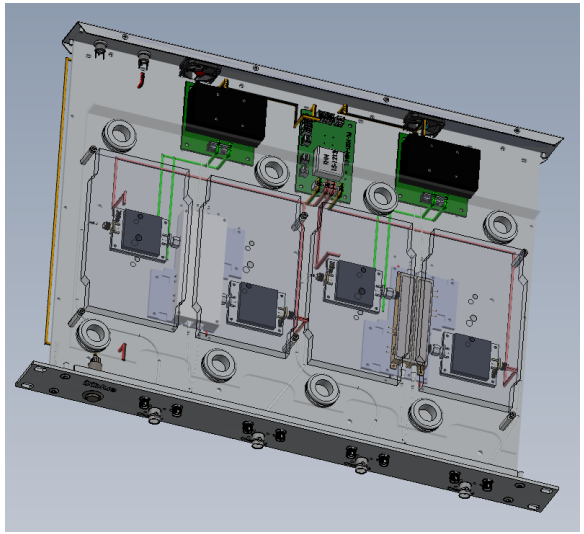
iXblue solutions for high power lasers based on beam combining technique

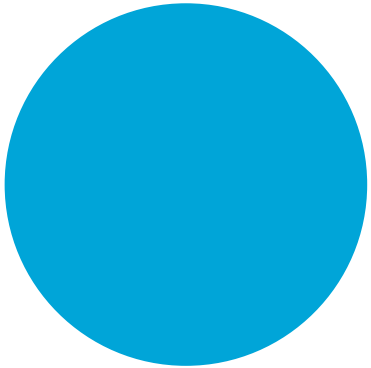
ModBox proposal for NIR-MPX-LN-0.1 and matching components integration

- **The Modbox integration scenarios**
  - The rack size depends on the number of components to integrate
  - One rack can embed several phase modulator channels, each constituted by:
    - a phase modulator (NIR-)MPX-LN-0.1 optimized for 300 mW CW power handling
    - an optional RF amplifier DR-VE-0.1-MO
    - an optional fix delay line
    - an optional tunable delay line for an adjustable delay up to 600 ps
    - an optional power supply (220 V) otherwise 12 V supply in

- **Example of integration into a rack**
  - 8x(NIR-)MPX-LN-0.1 + 8xDR-VE-0.1-MO + 8xTunable Delay Line
  - 2U rack with a 495 mm depth
  - USB connection and GUI for driver and delay line controls







Annex

iXblue solutions for high power lasers based on beam combining technique

Some formulas

- **Induced electro-optical phase variation**
  - Refractive index variation induced by the electro-optical effect when a DC voltage V is applied:

$$\Delta n(V) = \frac{1}{2} n_e^3 r_{33} \Gamma \frac{V}{g}$$

  - Relative phase variation:

$$\Delta\varphi(V) = \frac{2\pi}{\lambda}\Delta n(V)L = \frac{2\pi}{\lambda}\frac{1}{2} n_e^3 r_{33}\Gamma\frac{V}{g} = \pi\frac{V}{V_\pi}$$

  - Maximum RF phase variation with a sinusoidal peak to peak voltage V at a frequency f:

$$\Delta\varphi(V,f) = \pi\frac{V}{V_\pi(f)}$$

  - Exemple: using the maximal range of +/-20V and a Vπ=1,5V, a phase shift of 27π rads can be generated.

- **Equivalent time delay to the phase variation**

$$\Delta t(V) = \frac{\Delta n L}{c} = \frac{\lambda}{2c}\frac{V}{V_\pi}$$