Accurately Controlled Counter-Phased RF Modulation Scheme for Fiber Optic Parametric Amplifiers

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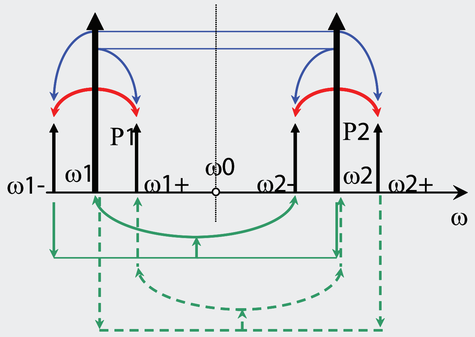
Introduction:

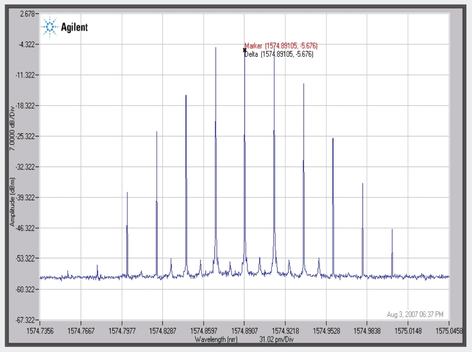
- Fiber Optic Parametric Amplifiers (FOPA) provide unprecidented gain with very low noise characteristic.
- The gain in FOPA is attained via four wave mixing and is thus proportional to the power of the strong laser pumps.
- A primary obstacle in FOPA is Stimulated Brillouin Scattering (SBS) which limits the power level that can be coupled into fiber, thus limiting the gain efficiency of the amplifier.



Four Wave Mixing in FOPA with two pumps

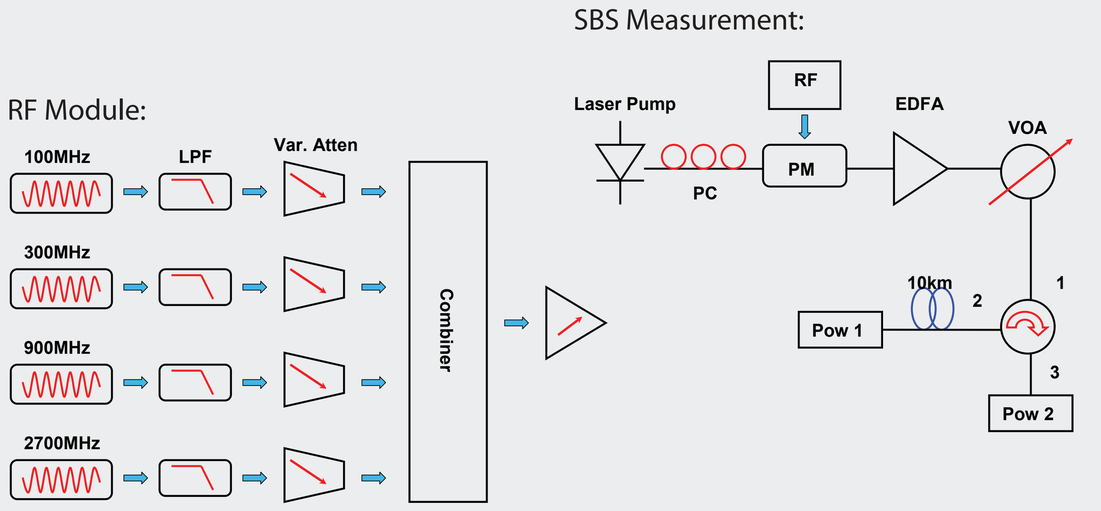
Experiment:

- We begin by observing and characterizing the SBS behavior of a 10km spool of fiber.
- By introducing phase modulation to the pumps, we alleviate the SBS problem by spectrally broadening the pumps, effectively raising the SBS threshold level.
- Phase modulating the pumps also imparts noise on the idler compromising signal integrity.
- We conclude by reducing the noise by counter-phasing the pumps of a two pump FOPA and comparing the results to those of existing SBS suppression methods.



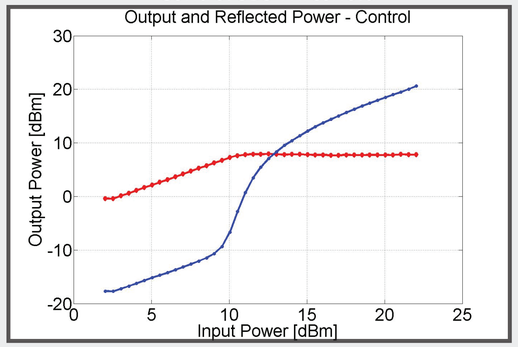
Spectral Broadening of a Pump by 2700MHz Modulation

Experimental Setup:

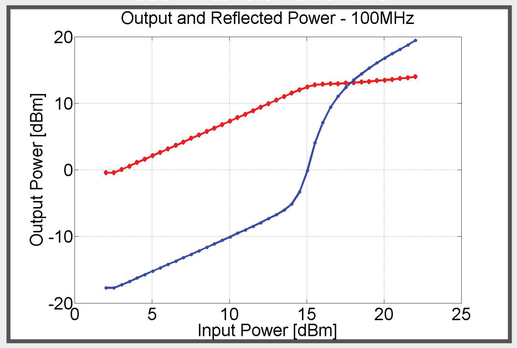


Experimental Results:

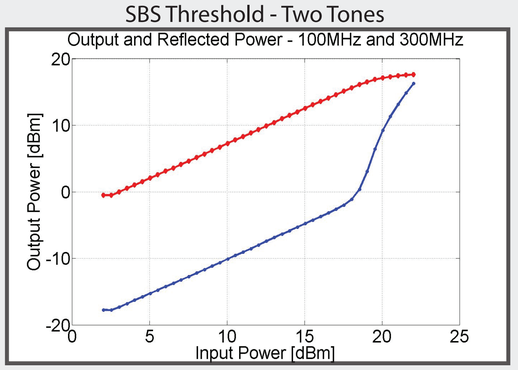
Control SBS Threshold



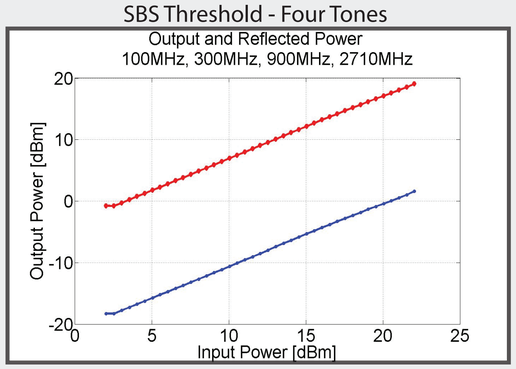
SBS Threshold - One Tone



SBS Threshold - Two Tones

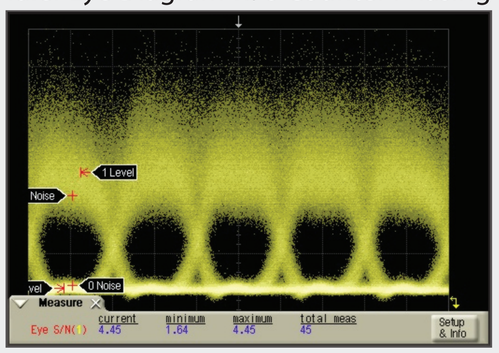


SBS Threshold - Four Tones



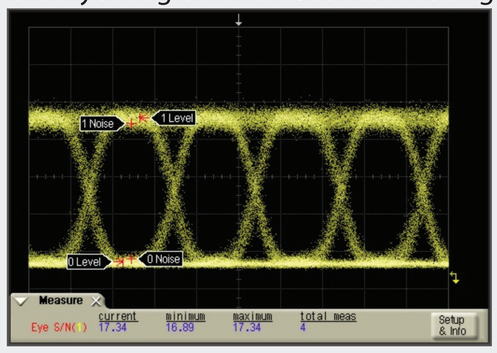
Counter-Phased Results:

Idler Eye Diagram w/o Counter Phasing



Phased by PRBS; Q = 4.45

Idler Eye Diagram with Counter Phasing



Modulated by counter-phased tones; Q = 17.34

Conclusion:

- We have successfully demonstrated an effective workaround to SBS in highly non-linear fibers by phase modulating the pump laser with multiple tones, achieving an effective increase of greater than 14dB of the SBS threshold when modulating with four tones.
- Additionally, we have successfully demonstrated the viability of a FOPA with two counter-phased pumps by observing an extremely low noise idler.

UCSD Calit2 Summer Undergraduate Research Scholarship 2007