Lightvision

A publication of Lightwaves2020 Dec. 6, 2010

# New Tunable Laser Source
## Low-Cost and High-Power

*Lightwaves2020 combines the capability and robustness of the available high-powered flat-top amplified spontaneous emission (ASE) source with the high-speed tunable filter (HS-TF) device to produce the new low-cost and high-power tunable laser source.*

*Tunable laser sources are highly demanded in a variety of fields and applications, such as defense, communications, instrumentation, and medical imaging. In addition to low cost and high power, Lightwaves2020's tunable laser source has more characteristics to offer to a variety of customers:*

- *Fast scan-speed*
- *Uniform response*
- *Very high finesse*
- *Very high signal to noise ratio*
- *Small physical size*


*As an alternative to large equipments with cumbersome functions, this new tunable laser source is compactly designed with only high-performance key components, allowing it to be low-cost and very effective. While tuning speed is the fastest available as opposed to fiber grating based tunable devices, the high-power addition completes the functionality of the new tunable laser source. With very high finesse, very low noise, and very high signal to noise ratios, this new tunable laser source becomes the premier performing device available in the market.*

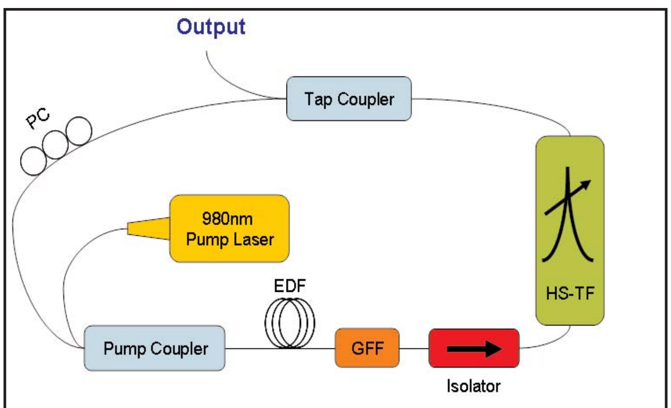



*Fig. 1: General schematic of Lightwaves2020's new tunable laser source.*

*A general schematic of Lightwaves2020's new tunable laser source is illustrated in Fig. 1, where the unique and patent-pending HS-TF device plays an important part in the overall performance of the laser system.*

*With proper erbium doped fiber selection and a matching gain flattening filter, a stable and uniform laser response with high power can be achieved. Aside from the ability to tune the device at high speeds, the HS-TF also maximizes noise reduction, tuning range, signal to noise ratio, and sharpness of the laser output.*

*Typical performance of the tunable laser source is illustrated in Fig. 2, where the output power can be greater than 15dBm with the capability of achieving powers greater than 20dBm or 100mW. In Fig. 3, stability of the laser source is illustrated after idling for one hour at 23$^{o}$C and the results are excellent.*

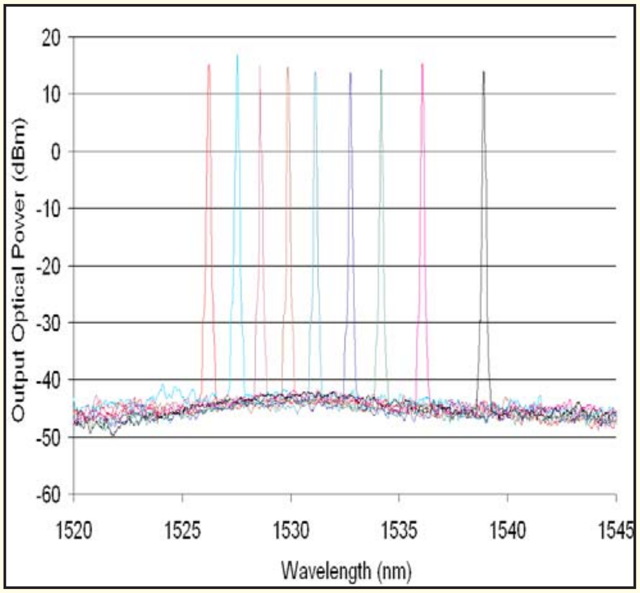



*Fig. 2: Example spectral performance of the new tunable laser source*

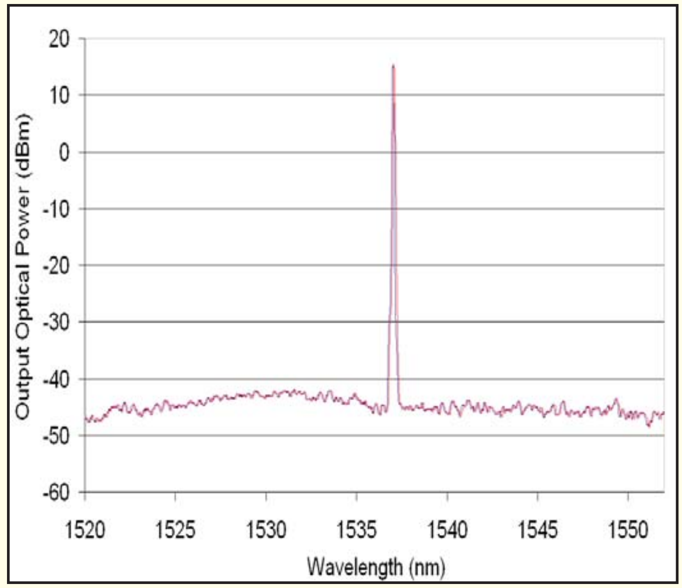



*Fig. 3: Stability of the new tunable laser source after idling for one hour at 23$^{o}$C*

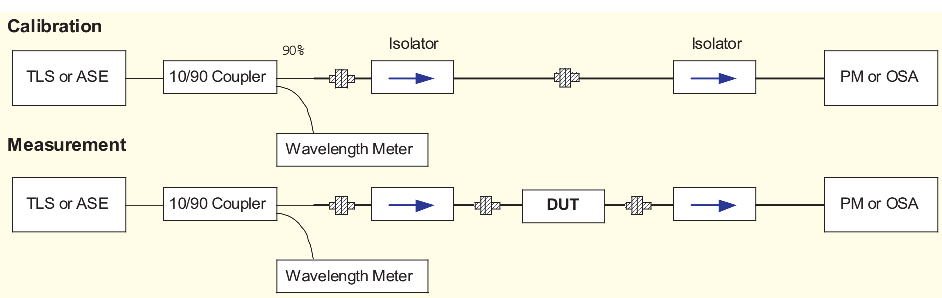
*Lightwaves2020's new tunable laser source is the premier performing fiber based laser source incorporating robust and proven Lightwaves2020 components in the ASE source and HS-TF. The combined high performing capabilities of the new tunable laser source provide the best solution to customers seeking compact, low-cost, and reliable tunable sources.*

*This is another great example of Lightwaves2020 having been offering exceptional solutions by combining the innovative technical expertise, established product quality, and friendly service for over a decade.*

# Testing Methods for High-Speed Tunable Filter

*Tunable Filter plays an important role in various applications. Typically, certain key parameters are used to evaluate the performance of a variety of tunable filters, namely insertion loss, 3dB bandwidth, free spectrum range (FSR), wavelength tuning range, and tuning speed. Lightwaves2020's Fabry-Perot based High-Speed Tunable Filter focuses on the specialty of narrow 3dB bandwidth and high tuning speed.*

*Figure 1 shows the block diagram of the testing method for the High-Speed Tunable Filter.*




*ASE: HP 83437A Broadband Lightsource*
*TLS: HP 8168F Tunable Laser Source*
*PM: HP 8153A Lightwave Multimeter*
*OSA: Agilent 86142B Optical Spectrum Analyzer*

*Note:*
*(1) Insertion Loss & Bandwidth & Side-band Suppresion Ratio ==> tested by TLS + PM*
*(2) Free Spectrum Range & Tuning Range ==> tested by ASE + OSA*

*Fig. 1 Diagram of Testing Method*

*Optical isolators are recommended at the front and back of the device to prevent light reflections from both the tunable filter and the optical path behind the device. Reflected light will induce power and wavelength instabilities to the light source and the device itself. The function of the wavelength meter is to ensure wavelength stability of the input laser source. In addition, the High-Speed Tunable Filter is equipped with Thermal Electric Cooler (TEC) control to prevent influences from environment temperature variations. Once the testing system is stable, all optical performances of the filter itself can be measured accurately.*

## *(1) Transmission Spectrum*

*The transmission spectrum of the filter can be presented by the following equations:*

$$T = \left[1 + \frac{4R}{\left(1-R^2\right)}\sin^2\left(\frac{\phi}{2}\right)\right]^{-1} \qquad (1)$$

$$\phi = \frac{2\pi}{\lambda}\cdot 2nd\cdot\cos\theta \qquad (2)$$

*where d is the gap between mirrors, theta is the incidence angle (=0$^{O}$), and R is the reflectivity of the mirrors.*

*Figure 2 shows the typical transmission spectrum of the High-Speed Tunable Filter.*

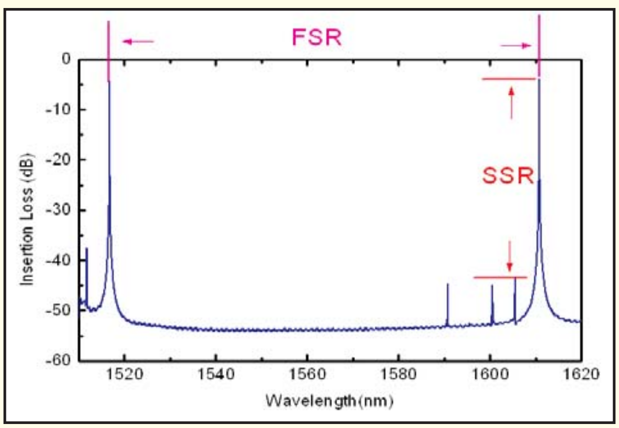



*Fig. 2 Transmission Spectrum*

*Wideband tunable laser source with <=1pm wavelength setting resolution is recommended for transmission spectrum measurement of narrow bandwidth filters. The Side-Lobe Suppression Ratio (SSR) is caused by the imperfection of the Fabry-Perot mirror pair. Typically, SSR is >20dB for the standard High-Speed Tunable Filter. High-Speed Tunable Filter with SSR >25dB is also available upon special request. The high-reflection coating on the mirrors is wavelength independent over a wide wavelength range. Therefore, the insertion loss and 3dB bandwidth will remain the same over the whole wavelength tuning range.*

## *(2) Tuning Speed Measurement*

*The tuning method of the High-Speed Tunable Filter is based on the control of the effective gap between a pair of mirrors with high-reflection coatings. The maximum operation speed for the device is defined as the shortest time to move the transmission spectrum peak from one wavelength to another without reducing the transmission power level.*

*Figure 3 shows the concept of tuning speed measurement.*

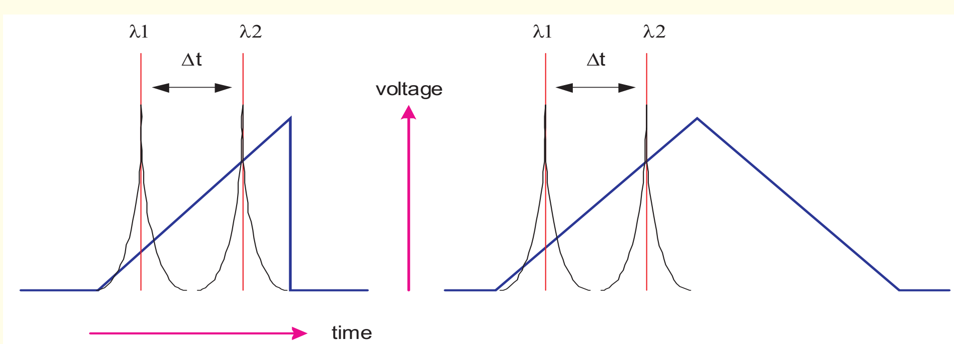



*Fig. 3 Concept of Tuning Speed Measurement*

*In general, (lambda 2)-(lambda 1) is >35nm for C-band operation, and is >80nm for C+L-band operation. Here, (delta)t is <1us for the standard High-Speed Tunable Filter product. High-Speed Tunable Filter with (delta)t <100us is also available upon special request.*

*Figure 4 shows the testing method for tuning speed measurement.*

*Thorlabs DC400FC high-speed photo detector is used for the optical signal analysis. The response bandwidth is >1GHz.*

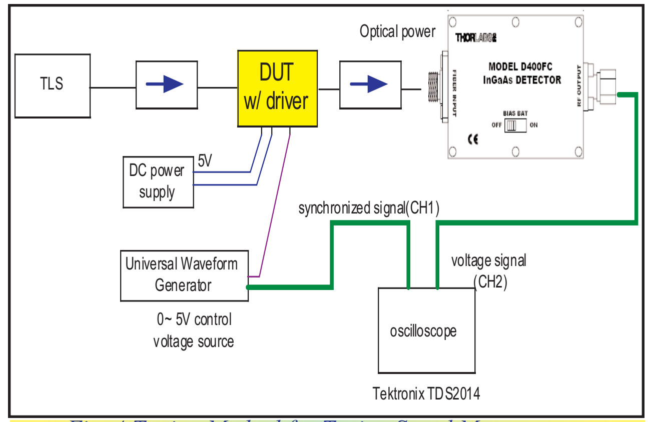



*Fig. 4 Testing Method for Tuning Speed Measurement*

*Figure 5 shows the typical curves for detected optical power vs. the frequency of the control voltage with a triangular waveform.*

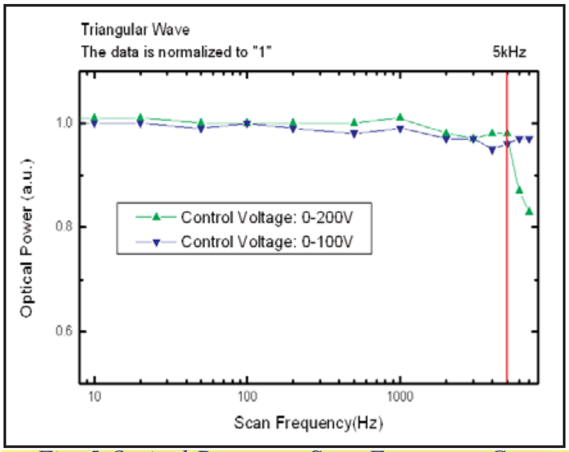



*Fig. 5 Optical Power vs. Scan Frequency Curves*

*The decrease in the transmission optical power represents the fact that the optical filter response cannot keep up with the control voltage variation. Therefore, Lightwaves2020's High-Speed Tuanble Filter can operate with >1kHz AC signal operation.*

*Fig. 6 shows the typical damping curve for Piezo material.*
*The tuning mechanism of the High-Speed Tunable Filter is based on the Piezo effect. Damping effect occurs when the displacement is changed by the control voltage.*

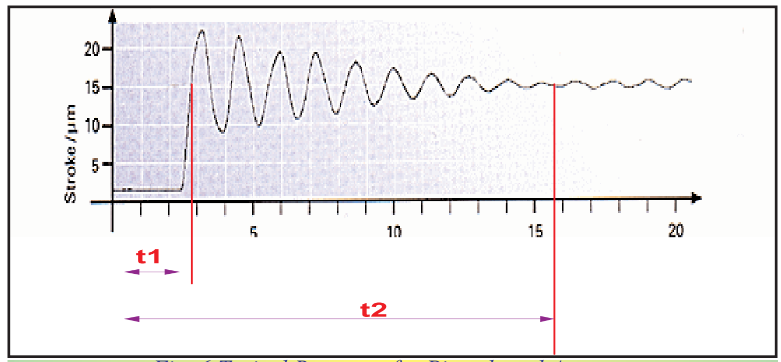



*Fig. 6 Typical Response for Piezo-based Actuator*

*Figure 7 shows the typical response curve while a square voltage waveform is applied to the device.*

*The damping phenomenon can be easily observed when a square voltage wave is applied. The square wave is used to switch the transmitted wavelengths. The main concerns in this application are the control voltage noise, input laser source stability, and the finesse of the device. All of these conditions need to be well-controlled in order to obtain the target performance.*

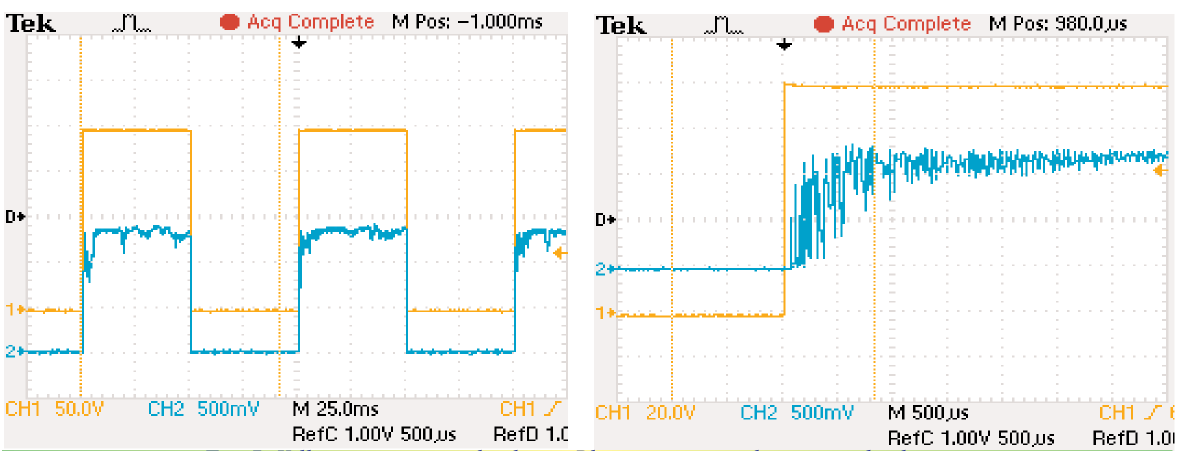



*Fig. 7: Yellow curve: control voltage; Blue curve: optical power to the detector*

*With the high-speed wavelength tuning characteristic and narrow 3dB bandwidth design capability for <10pm over a 35nm tuning range, Lightwaves2020's High-Speed Tunable Filter has many potential applications in different industry markets. We welcome you to contact us for future discussions regarding special application requirements.*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