AOTF ACOUSTO-OPTIC TUNABLE FILTER

AOTF technology can be applied/integrated in a photonics system from source through transmission, detection, and analysis, replacing current analytical instrumentation methods (e.g., monochromator, spectrometer, spectrophotometer, etc.). AOTF technology can, in most cases, be applied to industry applications currently served by the standard grating, prism, or scanning-diode type methods.

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AOTF technology virtually eliminates the negative aspects associated with grating and prism systems used to provide specific frequencies of light, and can provide narrow wavelength light transmission or reception from 200 nm to almost 20,000 nm in fast, discrete, and repeatable steps — all without any moving parts.

Although there are many methods/devices available that can scan a range of wavelengths, there are few that provide scanning without the limitations of mechanical systems. Current methods are capable of scanning various wavelengths "at will", but with jitter (here considered to include the hysteresis of the mechanical structure), and limiting overall structure (considered to include an ad-hoc optical bench to ensure proper optical alignment).

Since the 1960s, acousto-optic devices have been developed to selectively "tune" broad spectrum sources. AOTF devices outperform their mechanical counterparts, provide solid-state operation, and are a perfect candidate for on-line, real-time analysis applications and integration.

An AOTF device/system is comprised of the following (Figure 1):

1. A nonlinear, anisotropic crystal medium (e.g., TeO_2; where the RF/light interaction occurs).
2. An acoustic transducer to efficiently convert electrical to acoustic energy (e.g., piezoelectric).
3. An acoustic absorber (e.g., rubber or poly-filament material) that absorbs acousto-wave energy).
4. An RF generator that "injects" the acousto-wave into the crystal.
5. An RF controller/driver that precisely controls and drives the RF source. (Can be either manually controlled or automated via computer. The RF generator and controller/driver can be collocated on a PC card to conserve space).
6. A polarizer/analyzer set (input and output) selects the specific light for filtering and provides filtered light, respectively.

OPERATION

The transducer produces a standing wave in the anisotropic crystal medium. The specific wave produced is dependent upon the drive power (typically 1-4 watts) and frequency (50 to 300 MHz) of the RF source. One-half of a polarizer set is applied for input polarization of source light. The source light can be broadband or offer several lines, as in the case of a laser. The standing wave interacts with the input light, creating a nonlinear effect — in essence, creating a virtual grating. The filtered light, almost collocated with the original unaffected light component, emerges from the crystal and is filtered with the half of the polarizer set used as a coincident light filter and for output selection. The standing wave is then terminated/absorbed by the acoustic absorber

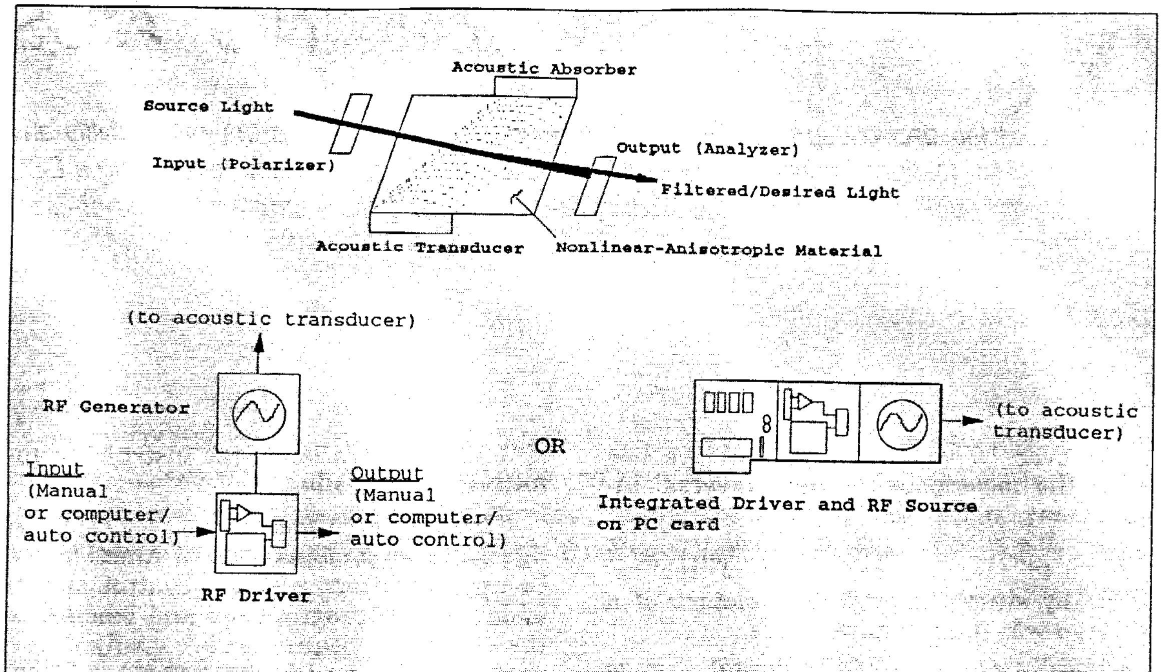

FIGURE 1. AOTF component diagram.

mounted to the crystal medium opposite the transducer.

The benefits of AOTF technology include:

1. Rapid scanning.
2. Accurate and precise selection of wavelengths.
3. Repeatable performance.
4. Inherent rugged design (solid-state).
5. Variety of application orientations.
6. Wide operational bandwidths (per material type).
7. Now uses standard materials and components that are off-the-shelf.

Additionally, through the combination of high-speed digital frequency synthesizers, digital signal processing, and fuzzy logic, it is now possible to scan 2000 nm in 25 milliseconds. Typical spectrum resolution of 105 Å at 1825 nm and related spectral efficiency of 55% at 2011 nm can be achieved.

The major alternatives to AOTF technology, and their drawbacks, include:

1. *Moving mirror and/or grating* — mechanical problems including repeatability, speed, and accuracy.
2. *Scanning-diode array* — can only be used in "detection" orientation; only part of an instrument.
3. *Tunable source* — most ideal, however, not practical and not available in most cases. □

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