772B-MIR

LASER SPECTRUM ANALYZER

Provides high-resolution spectral characterization of pulsed and CW infrared and mid-infrared lasers.

BRISTOL INSTRUMENTS

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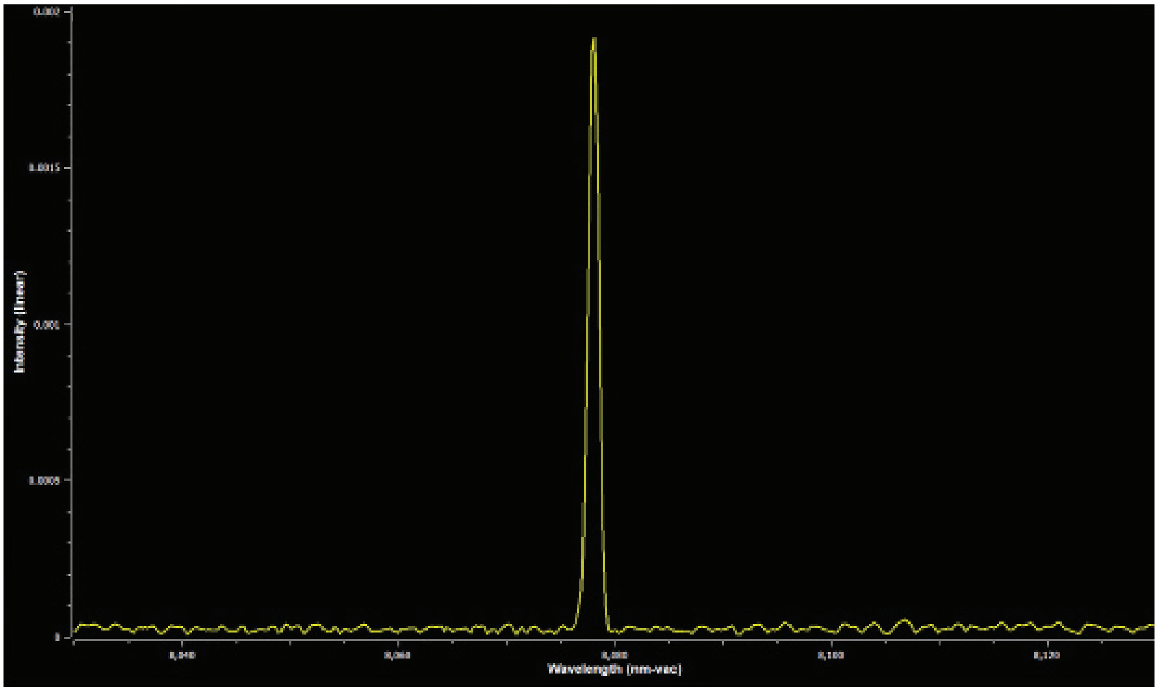
The **772B-MIR Laser Spectrum Analyzer** combines proven Michelson interferometer technology with fast Fourier transform analysis to characterize the spectral properties of pulsed and CW lasers that operate from 1 to 12 µm. When used with CW lasers, the model 772B-MIR operates and performs just like Bristol's 771B-MIR Laser Spectrum Analyzer. What makes the 772B-MIR system unique is that it employs a sophisticated algorithm to enable the spectral measurement of pulsed lasers that have a repetition rate as low as 50 Hz.

PULSED LASER MODE

The 772B-MIR Laser Spectrum Analyzer, when used in Pulsed Mode, determines the spectral features of pulsed lasers with a repetition rate as low as 50 Hz. The spectrum shown below is that of a quantum cascade laser operating at a pulse rate of 10 kHz and a pulse length of 50 ns.



Performance

The 772B-MIR Laser Spectrum Analyzer offers the following specifications when used with pulsed lasers.

- ***Spectral resolution of 4 GHz***
  Spectral resolution is defined as the measured full width at half maximum intensity (FWHM) of an infinitely narrow optical signal.

Performance (continued)

- ***Wavelength accuracy of ± 10 parts per million (± 0.08 nm at 8 μm)***
  Wavelength accuracy is defined as the measurement uncertainty, or maximum wavelength error, with a confidence level of ≥ 99.7%. This specification is guaranteed by continuous calibration with a built-in HeNe laser, which is an ideal reference source because its wavelength is well-known and fixed by fundamental atomic structure.

- ***Optical rejection ratio as high as 20 dB***
  The Optical Rejection Ratio (ORR) of a laser spectrum analyzer defines its ability to measure a low intensity signal near a higher intensity peak. It is the ratio between the measured noise level at a given distance from the peak and the intensity of the peak.

Technology

The 772B-MIR Laser Spectrum Analyzer uses a scanning Michelson interferometer to generate an interferogram that is converted to a spectrum using fast Fourier transform analysis. However, with pulsed lasers, a single scan of the Michelson interferometer does not generate an interferogram that is sufficient to convert to a spectrum. Therefore, data from multiple scans of the interferometer must be collected to "build" such an interferogram.

The model 772B-MIR uses a special analysis algorithm to capture data only when a laser pulse is detected. By collecting data from a number of pulses, a more complete interferogram can be generated and used to compute the spectrum of the laser under test.

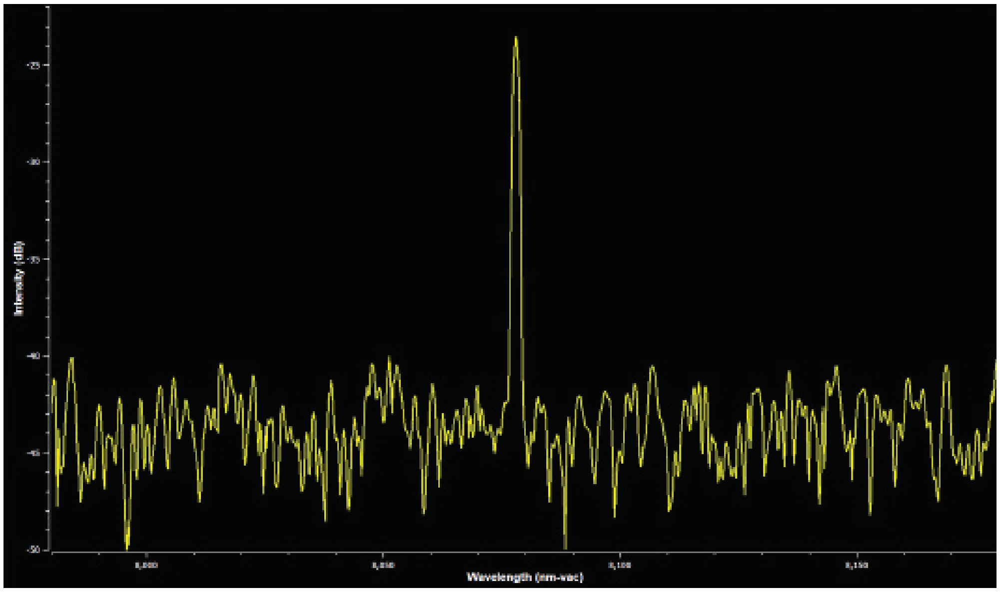
- ***Laser Pulses***
  The quality of the measured spectrum is dependent on the number of laser pulses used to "build" an interferogram. This number can be from 4,000 to 140,000 and is defined by the user. Data from a higher number of pulses will result in the generation of a more precise spectrum with a better optical signal-to-noise ratio (OSNR). For example, collecting data from at least 30,000 laser pulses will generate a spectrum with an OSNR of about 15-20 dB.

- ***Measurement Time***
  The 772B-MIR system computes a spectrum after data from a specified number of pulses is collected. Therefore, the measurement time will depend on the total number of pulses specified and the pulse rate of the laser under test. While data collection using more pulses will result in a higher quality spectrum, it will also take longer to generate the spectrum.

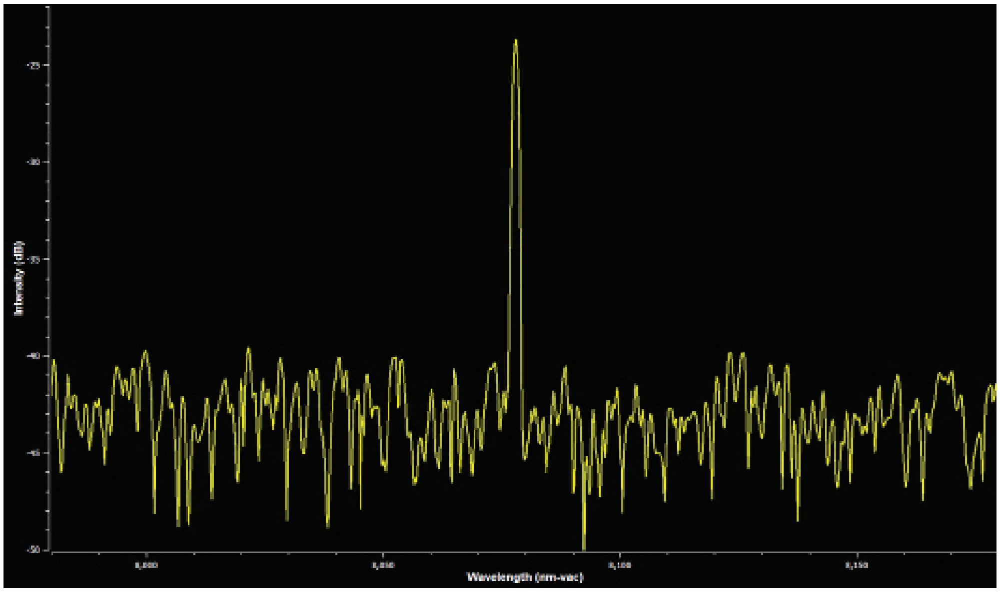
  The time required to generate a spectrum is approximately two times the time required to collect the chosen number of pulses, but not less than about 10 seconds. For example, when measuring 30,000 pulses from a laser with a pulse rate of 1 kHz, the measurement time will be about 60 seconds.

Sample Spectra

The 772 B-MIR Laser Spectrum Analyzer was used to generate spectra of an 8 µm QCL operating at a variety of pulse rates and a pulse length of 50 ns. These spectra are shown below.

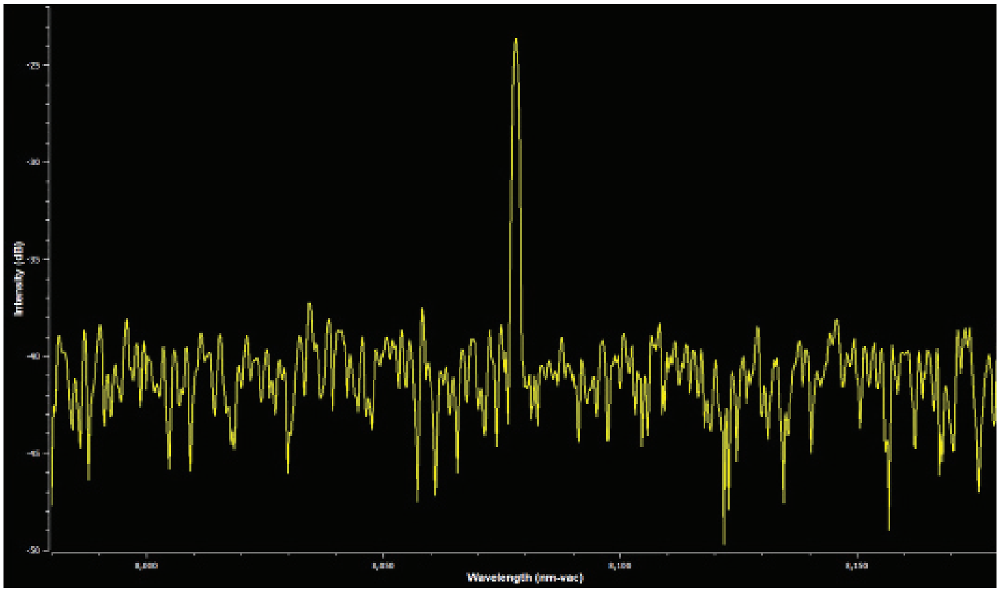


100 kHz Pulse Rate
100,000 pulses collected
OSNR ~ 20 dB
Measurement Time ~ 10 seconds

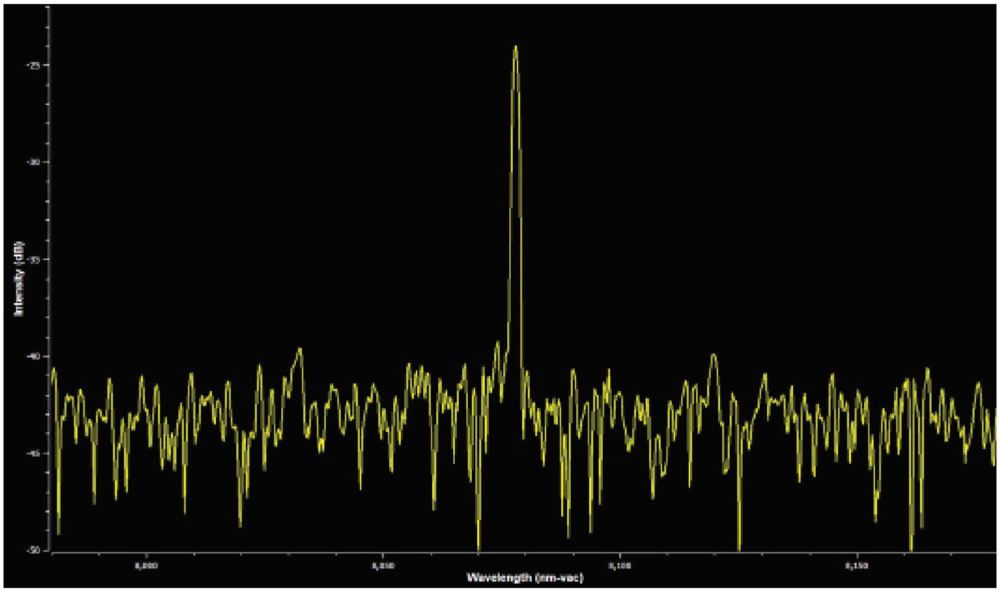


50 kHz Pulse Rate
100,000 pulses collected
OSNR ~ 20 dB
Measurement Time ~ 10 seconds

Sample Spectra (continued)

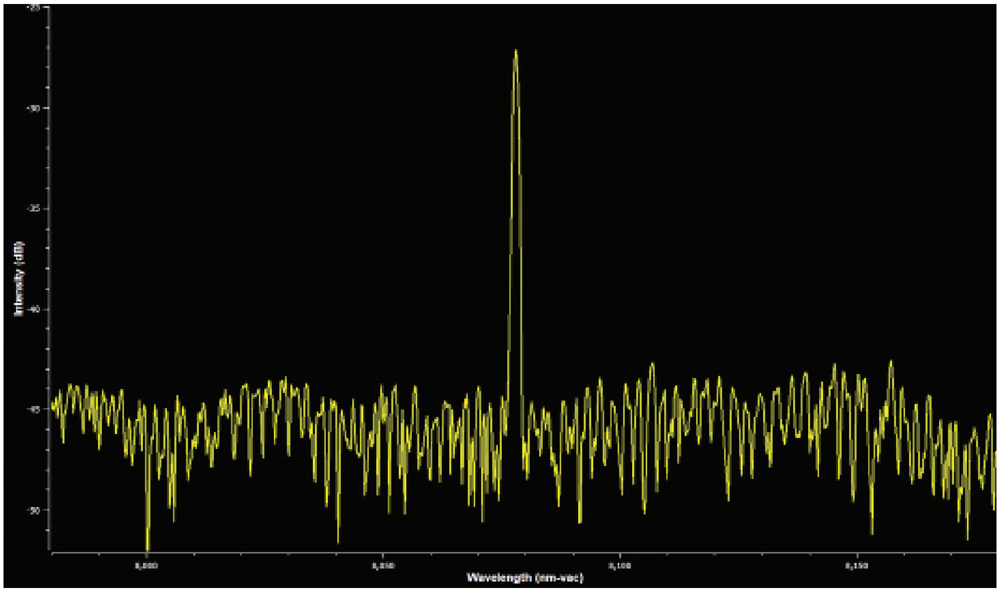


30 kHz Pulse Rate
30,000 pulses collected
OSNR ~ 16 dB
Measurement Time ~ 10 seconds

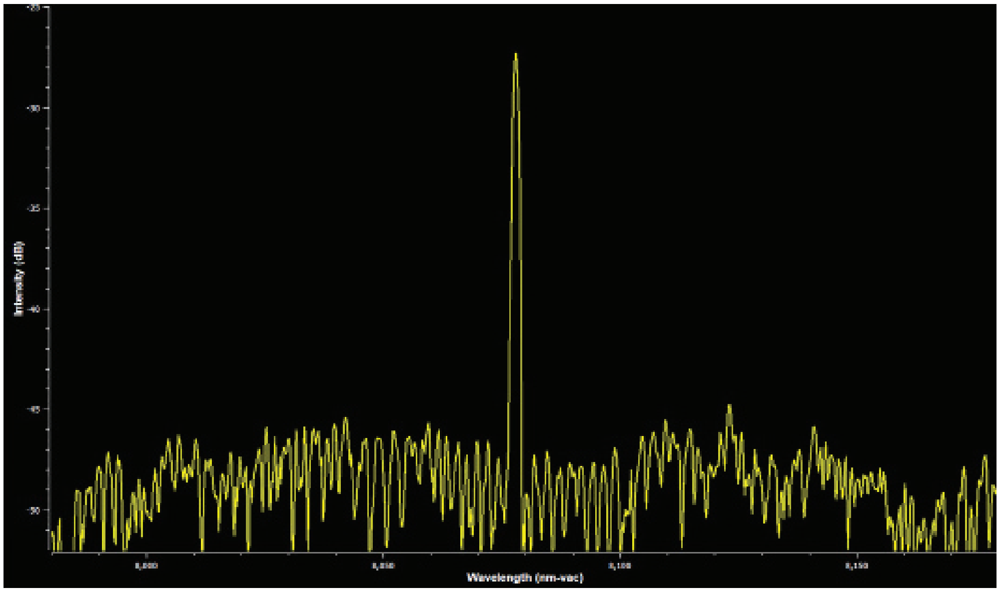


30 kHz Pulse Rate
100,000 pulses collected
OSNR ~ 20 dB
Measurement Time ~ 10 seconds

Sample Spectra (continued)

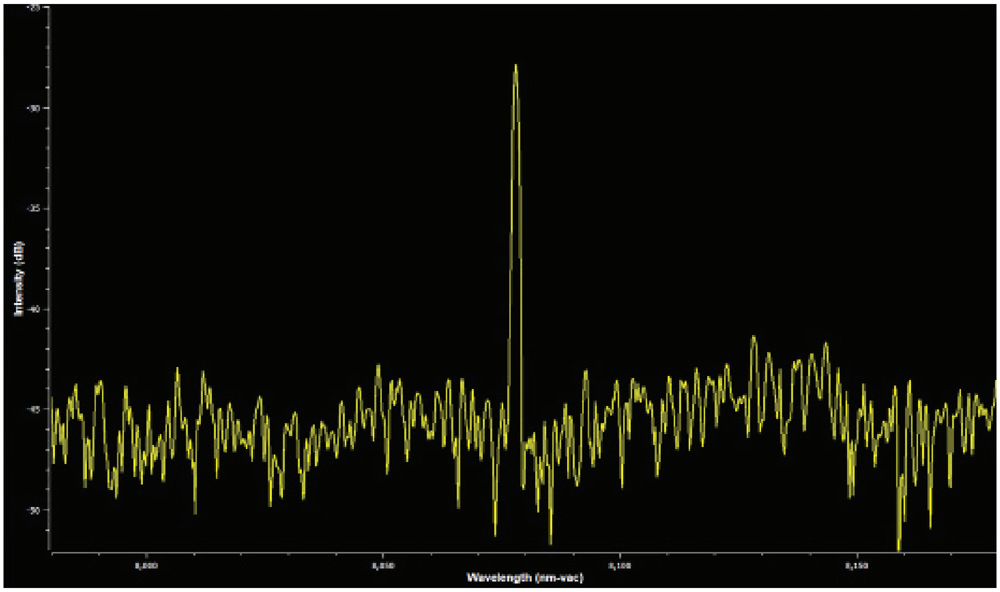


10 kHz Pulse Rate
30,000 pulses collected
OSNR ~ 16 dB
Measurement Time ~ 10 seconds



10 kHz Pulse Rate
100,000 pulses collected
OSNR ~ 20 dB
Measurement Time ~ 20 seconds

Sample Spectra (continued)

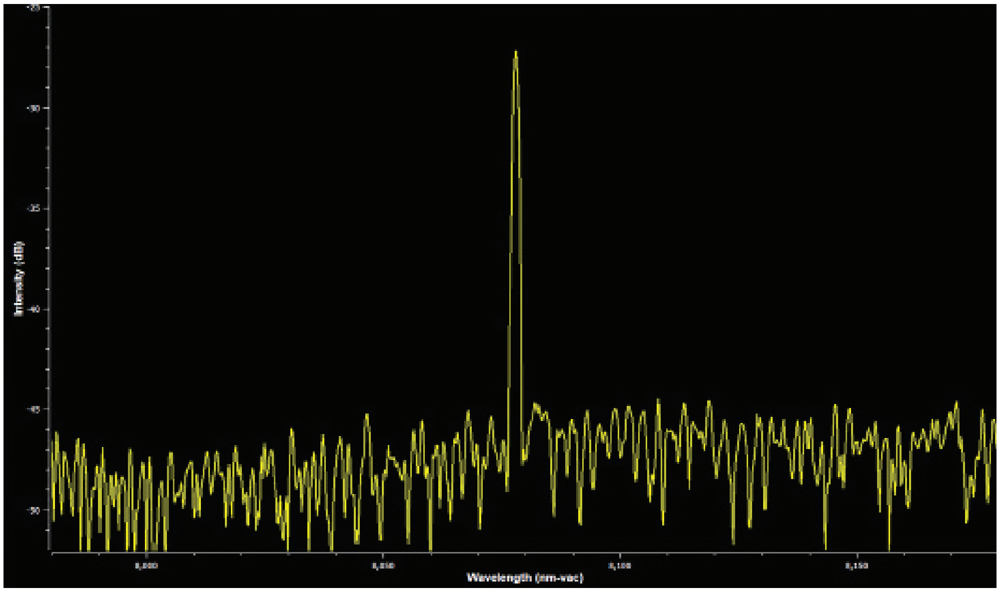


5 kHz Pulse Rate

30,000 pulses collected

OSNR ~ 16 dB

Measurement Time ~ 12 seconds



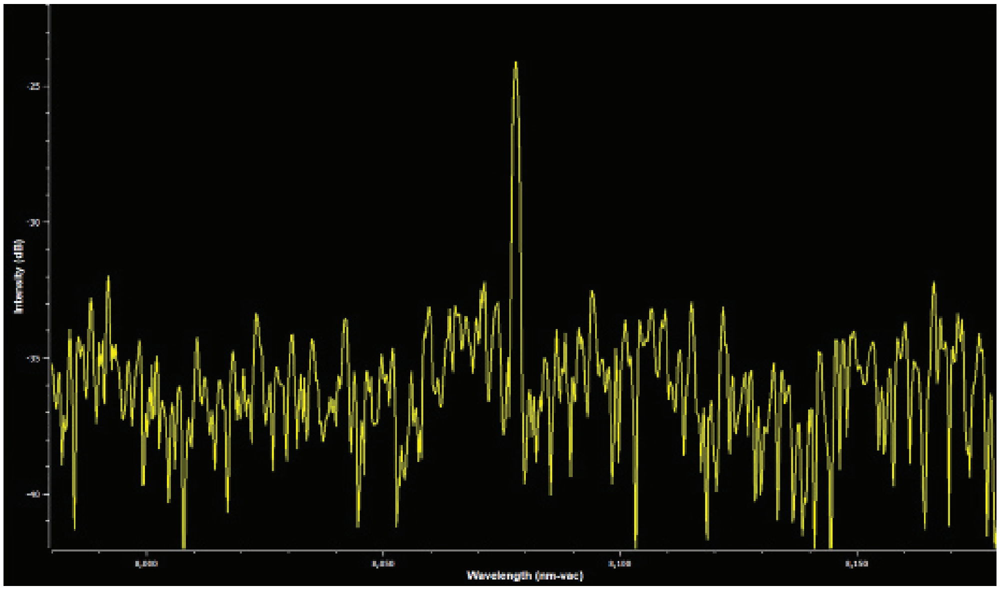
5 kHz Pulse Rate

100,000 pulses collected

OSNR ~ 20 dB

Measurement Time ~ 40 seconds

Sample Spectra (continued)

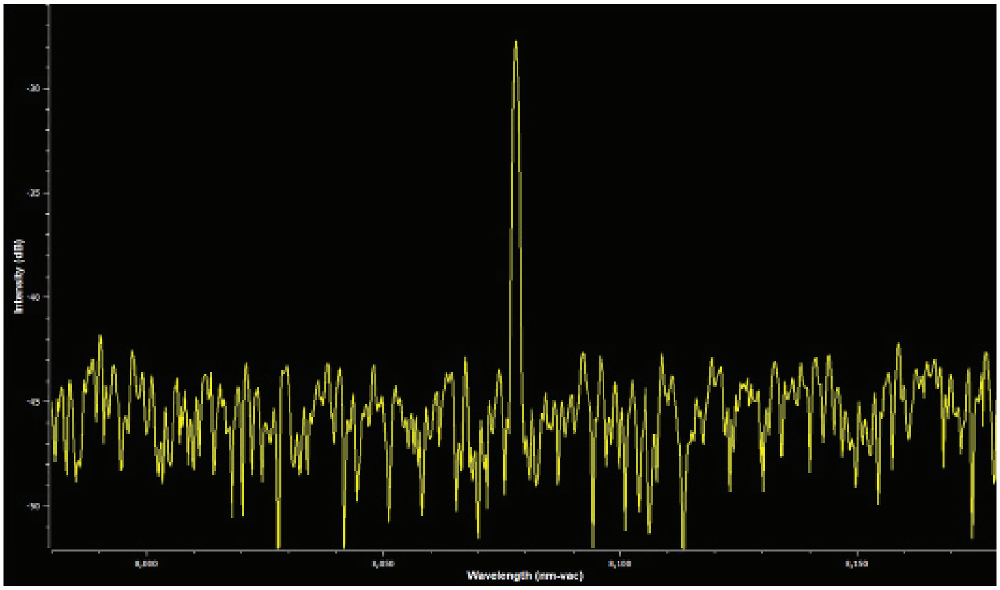


1 kHz Pulse Rate

5,000 pulses collected

OSNR ~ 10 dB

Measurement Time ~ 10 seconds



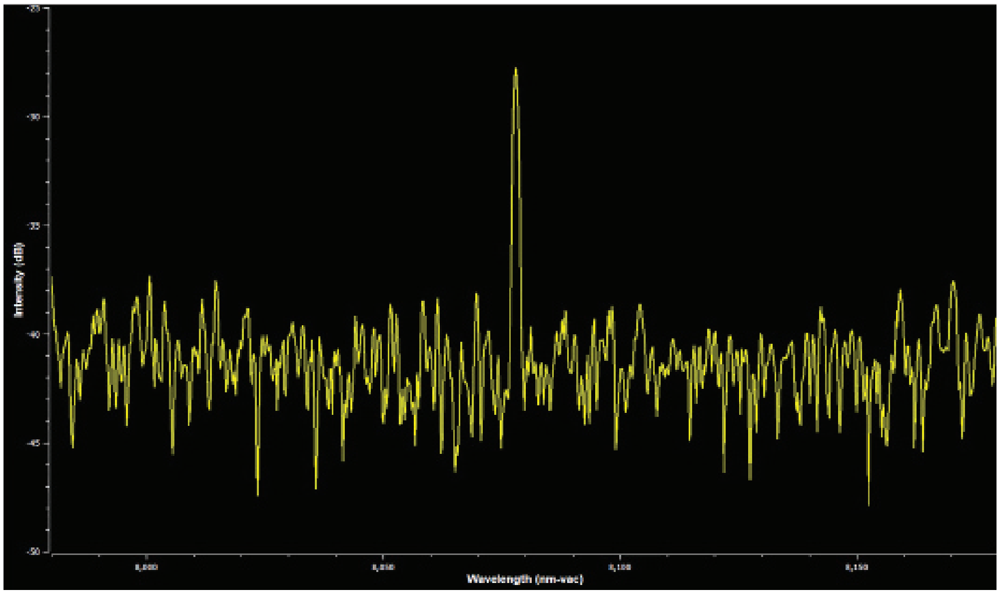
1 kHz Pulse Rate

30,000 pulses collected

OSNR ~ 16 dB

Measurement Time ~ 60 seconds

Sample Spectra (continued)

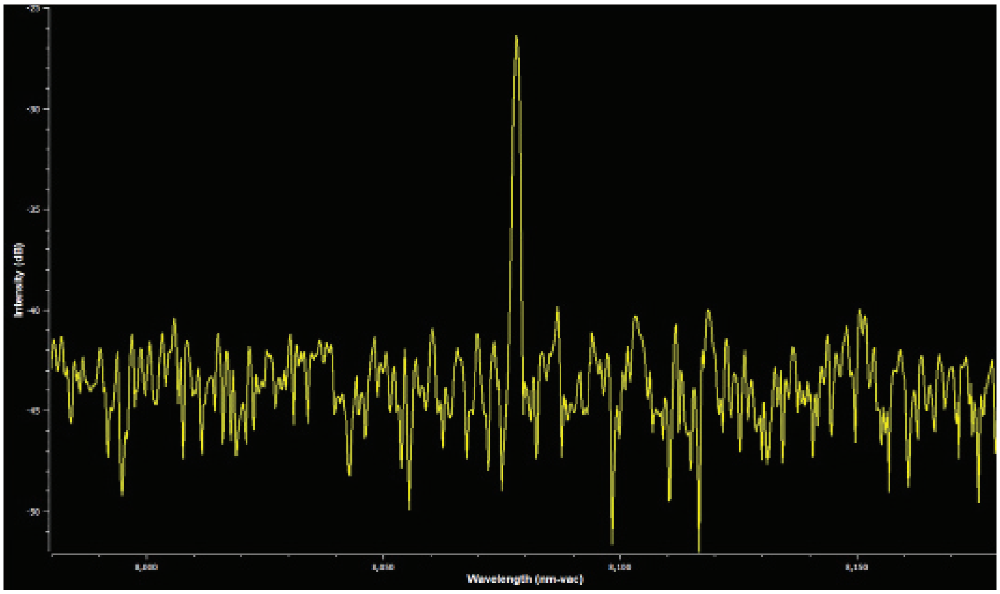


100 Hz Pulse Rate

5,000 pulses collected

OSNR ~ 10 dB

Measurement Time ~ 100 seconds



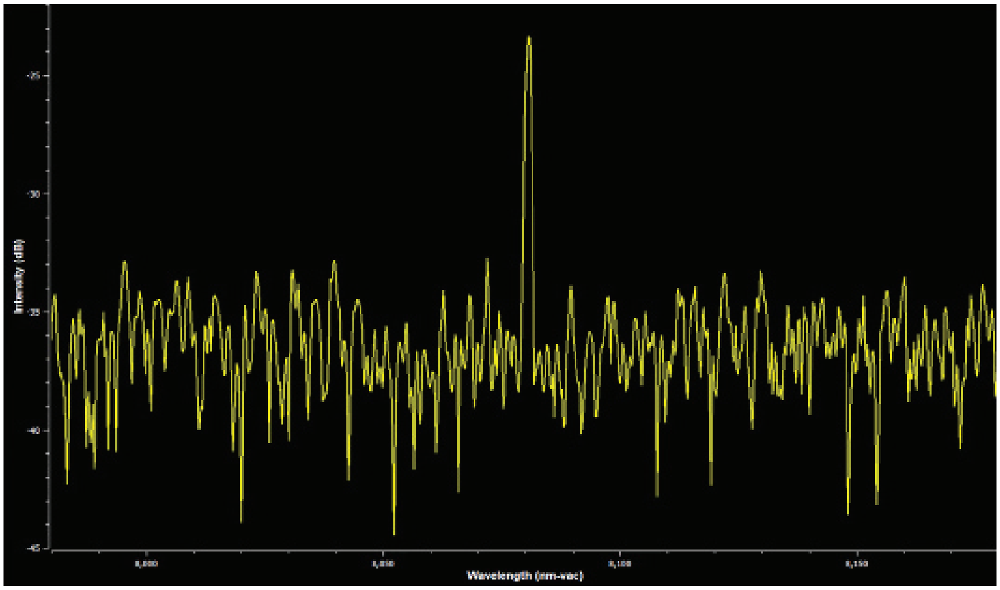
100 Hz Pulse Rate

30,000 pulses collected

OSNR ~ 16 dB

Measurement Time ~ 10 minutes

Sample Spectra (continued)



50 Hz Pulse Rate

5,000 pulses collected

OSNR ~ 10 dB

Measurement Time ~ 200 seconds

CW LASER MODE

The 772B-MIR Laser Spectrum Analyzer, when used in CW Mode, measures and displays the spectral features of CW and high-repetition rate pulsed lasers. With spectral resolution of 4 GHz, wavelength accuracy of ± 1 part per million (± 0.008 nm at 8 μm), and an optical rejection ratio of more than 30 dB, the model 772B-MIR provides the most detailed spectral information available.

For a complete description of the performance and operational features of the 772B-MIR system when used in CW Mode, please see the 771 Series Laser Spectrum Analyzer brochure.

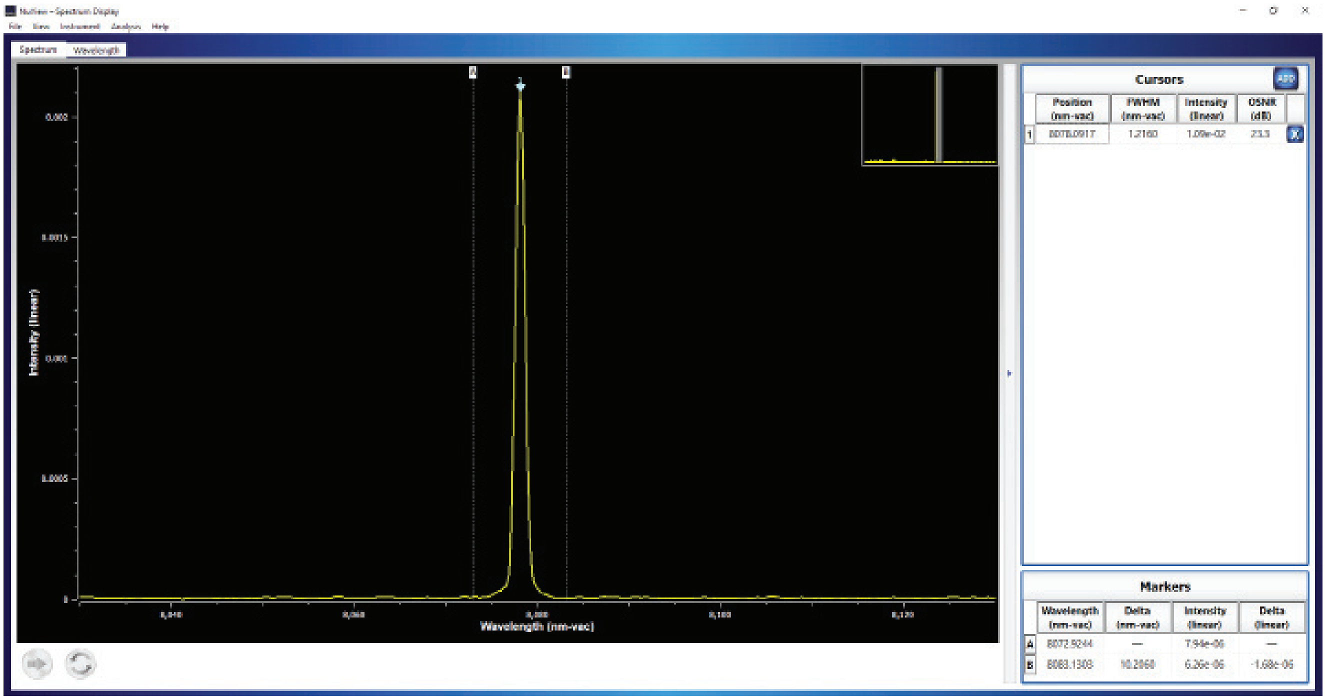
OPERATION

The 772B-MIR Laser Spectrum Analyzer is easy to use with a PC running under Windows. An on-board digital signal processor generates a laser's spectrum, automatically calculates various quantitative data, and then transfers the information to the PC using a USB or Ethernet interface. Bristol's *NuView*™ Software is provided to control measurement parameters and to display the spectrum and report data in a variety of formats.

Spectrum Display

The 772B-MIR Laser Spectrum Analyzer displays the measured spectrum as relative intensity versus wavelength (nm), wavenumber (cm^{-1}), or frequency (GHz). Relative intensity is displayed using a linear or log (dB) scale.

Convenient zoom and scroll functions are available to optimize the displayed spectrum. In order to keep track of any changes, a thumbnail shows a small representation of the entire measured spectrum with an indication of the portion that is currently being displayed.



The 772B-MIR Laser Spectrum Analyzer has the ability to analyze a spectrum quantitatively using up to 100 cursors and a pair of markers. Each cursor is used to identify a specific spectral feature for which absolute wavelength, relative intensity, bandwidth (FWHM), and optical signal-to-noise ratio (OSNR) is calculated. Cursors can be placed manually by selecting any peak in the spectrum or using a threshold to automatically select all peaks above the desired intensity. The markers provide absolute wavelength and relative intensity information about any single point of the spectrum. A marker is manually positioned to the point of interest. The data generated by the cursors and markers are reported in a table beside the spectrum.

Convenient Laser Input

The Laser Under Test (LUT) enters the model 772B-MIR through a 3 mm front panel aperture. To facilitate LUT alignment to the instrument, a portion of the internal HeNe reference laser is emitted from the input aperture to provide a visible visible tracer beam. Optimal alignment is achieved by superimposing the LUT to the tracer beam and utilizing the instrument's three adjustable height legs. (± 0.25").

Versatile Instrument Interface

The spectral information generated by the 772B-MIR Laser Spectrum Analyzer is transferred to a PC directly using a USB interface or via a Local Area Network using Ethernet. Analysis is done with the included *NuView™* Windows-based software. Relative intensity vs. wavelength data can be collected and saved to a file using a *.csv format for analysis with other graphing programs. Data can also be transferred using a convenient library of commands (SCPI) for LabVIEW or custom programming.

SPECIFICATIONS — 772B-MIR

LASER TYPE	Pulsed (repetition rate > 50 Hz, duration >20 ns)	CW (or quasi-CW with repetition rate > 50 kHz)
WAVELENGTH		
Range [1]	1 - 12 µm	
Accuracy [2, 3]	± 10 parts per million ± 0.08 nm @ 8 µm ± 0.0125 cm^{-1} @ 1250 cm^{-1} ± 375 MHz @ 37.5 THz	± 0.75 parts per million (1-5 µm) ± 1 parts per million (5-12 µm)
Spectral Resolution [4]	4 GHz	
Calibration	Continuous - built-in standard HeNe laser	
Display Resolution	8 digits	
Units [5]	nm, µm, cm^{-1}, GHz, THz	
OPTICAL REJECTION RATIO [6, 7]	10 - 20 dB (dependent on number of pulses acquired)	> 30 dB
MINIMUM INPUT POWER [7]	0.01 - 13 µW	
MAXIMUM INPUT POWER	100 nJ (10 ns duration)	10 mW
MEASUREMENT TIME [7, 8]	Approximately 2x time required to collect chosen number of pulses, but not less than about 10 s	< 2 s
INPUTS/OUTPUTS		
Optical Input [9]	Collimated beam, 3 mm diameter aperture, visible tracer beam to facilitate alignment	
Instrument Interface	USB and Ethernet with Windows-based display program Library of commands (SCPI) for custom and LabVIEW programming using any PC operating system	
COMPUTER REQUIREMENTS [10]	PC running Windows 10, 1 GB available RAM, USB 2.0 (or later) port, monitor, pointing device	
ENVIRONMENTAL [7]		
Warm-Up Time	None	
Temperature | Pressure | Humidity	+15°C to +30°C (-10°C to +70°C storage) | 500 – 900 mm Hg | ≤ 90% R.H. at + 40°C (no condensation)	
DIMENSIONS AND WEIGHT		
Dimensions (H x W x D) [11]	7.5” x 6.5” x 15.0” (191 mm x 165 mm x 381 mm)	
Weight	14 lbs (6.3 kg)	
POWER REQUIREMENTS	90 - 264 VAC, 47 - 63 Hz, 50 VA max	
WARRANTY	5 Years (parts and labor)	

(1) Capable of operation to 14 µm. Performance and specifications are not guaranteed beyond 12 µm.
(2) Defined as measurement uncertainty, or maximum wavelength error, with a confidence level of ≥ 99.7%.
(3) Wavelength axis is calibrated to system’s accuracy specification.
(4) Defined as the measured full width at half maximum intensity (FWHM) of an infinitely narrow optical signal.
(5) Data in units of nm, µm, and cm^{-1} are given as vacuum values.
(6) Acquisition of 30,000 pulses will result in an optical rejection ratio of about 15-20 dB.
(7) Characteristic performance, but non-warranted.
(8) For example, approximately 60 s for 30,000 pulses from a 1 kHz pulse rate laser.
(9) Required beam height is 5.4 ± 0.25”.
(10) For use with Windows-based display program. Interface with SCPI can be done using any PC operating system.
(11) Instrument height is adjustable (7.25 ± 0.25”) for alignment purposes.

CLASS 1 LASER PRODUCT
IEC 60825-1 (2014)

Bristol Instruments reserves the right to change the specifications as may be required to permit improvements in the design of its products.
Specifications are subject to change without notice.

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