ADI Dual Beam Spectrophotometer Solution

Application Introduction

A spectrophotometer is a photometer that can measure intensity as a function of the light source wavelength. A spectrophotometer is commonly used for the measurement of transmittance or reflectance of solutions and transparent or opaque solids or gases. The use of spectrophotometers spans various scientific fields, such as physics, materials science, chemistry, biochemistry, and molecular biology. Spectrophotometers are widely used in many industries including semiconductors, laser and optical manufacturing, printing, and forensic examination, as well as in laboratories for the study of chemical substances.

The most common spectrophotometers are used in the UV and visible (UV/VIS) region of the spectrum, with some of these instruments operating in the near-infrared region as well. This article will introduce a general spectrophotometer with a simplified optical system as an example. The signal chain will also be referenced in UV/VIS, along with other spectrophotometers.

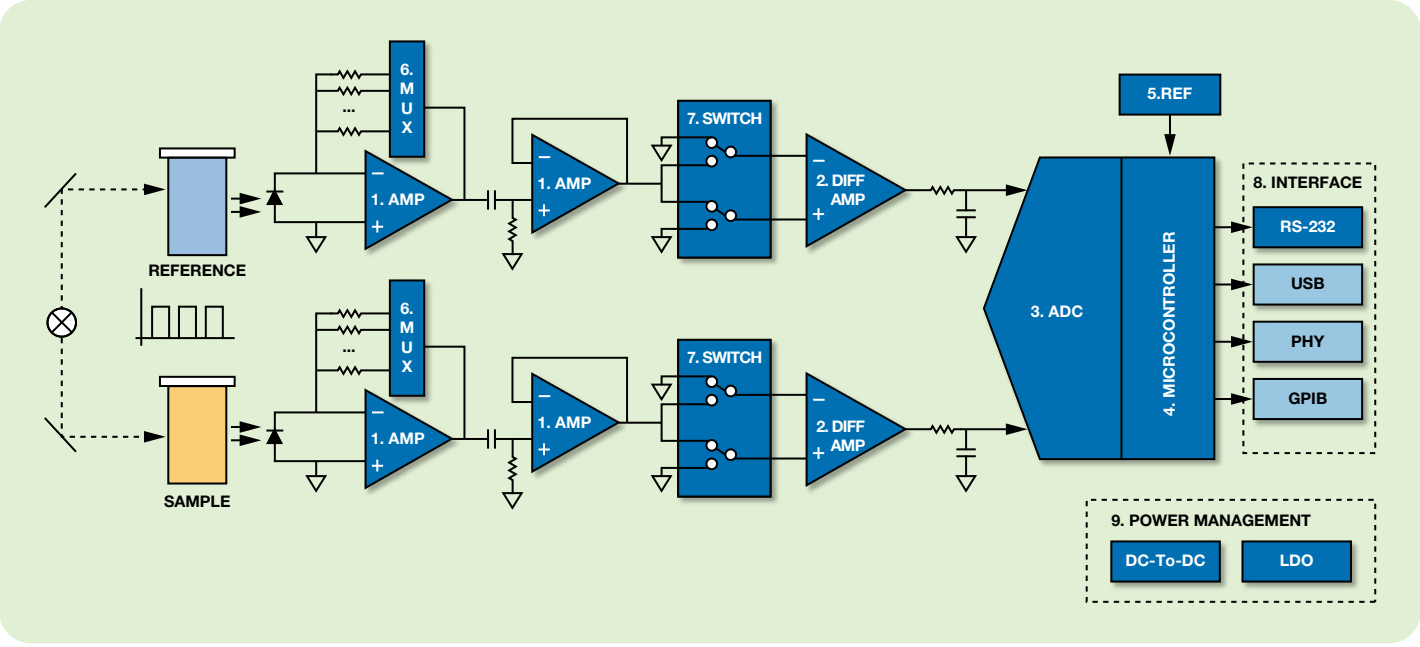
Stability

Drift with time and drift with temperature are very important factors during spectrophotometer design. To achieve this objective, low drift and an accurate signal chain are required, which can best be accomplished by using ADI products. Besides the components, dual beam architecture is another key point.

Solutions from ADI

System Block Diagram

Below is the system block diagram of a general spectrophotometer including a simplified optical system, sample and reference cells, a dual channel signal conditioning circuit, a microcontroller (ADC integrated), a communication interface, and power management.



Note: The signal chains above are representative of a system block diagram. The technical requirements of the blocks vary, but the products listed in the following the table are representative of ADI's solutions that meet some of those requirements.

1.Amp	2. Difference Amplifier	3. ADC	4. MCU	5. Reference	6. Mux	7. Switch	8. Interface	9. Power Management
AD8615/ AD8605/ AD8626	AD8271/ AD8278	AD7798/ AD7799	ADuCM361/ ADuC7061	ADR4525/ ADR3425/ ADR291	ADG704/ ADG708/ ADG1609	ADG733/ ADG1636	ADM3251E	ADP2441/ ADP2370/ ADP160/ ADP7102/ ADP7182

Theory of Operation

The simplified optical system delivers modulated light which passes through both reference and sample cells. The light sensor, such as a photodiode, transfers the beam energy of the reference and sample channels to current. The following signal chain transfers the current to voltage and demodulates the signal to dc voltage. It is finally presented to the Σ-Δ ADC, which can be independent or integrated in the microcontroller. The ADC gets the voltage amplitude of the reference and sample channels, whose ratio is related to the quantity of the sample.

The dual beam system helps to get stable results under the condition of the fluctuation of the lamp and also makes the operation easy when compared to a single beam system. The modulated light method helps to get away from the affection of ambient light and other noise sources that are not in phase with the modulating clock.

Main Products

Part Number	Description	Benefits
Operational Amplifier		
AD8615	1 pA max @ 25°C, low offset voltage: 80 μV typ, 24 MHz bandwidth, 12 V/μs slew rate, low noise 8 nV/√Hz, 5 V power supply, rail-to-rail input/output	Low bias current at room temperature, high speed, low noise, low offset opamp
AD8605	1 pA max @ 25°C, low offset voltage: 65 μV max, 10 MHz bandwidth, low noise 8 nV/√Hz, rail-to-rail input/output	Low bias current at room temperature, high speed, low noise, low offset opamp
AD8626	0.25 pA bias current @ typ room temperature, less than 2 pA bias current @ typ 50°C, low offset drift 2 μV/°C, up to ±13 V power supply, high bandwidth 5 MHz, rail-to-rail output	Wider power supply range, low bias current @ 0 °C to 50 °C, low offset drift
Difference amplifier		
AD8271	Gain = ½, 1, 2, gain drift 10 ppm/°C, 15 MHz and 30 V/μs slew rate	Low gain drift and high speed, suitable for the drive ADC
AD8278	Low power consumption 100 μA, G = ½ or 2, bandwidth 1 MHz,	Low power consumption, enough bandwidth
ADC		
AD7798	380 μA quiescent current, 3-channel 16-bit peak to peak resolution, up to 470 Hz output update rate	Low power consumption and high integrated Σ-Δ ADC, high resolution and high accuracy
AD7799	380 μA quiescent current, 3-channel 24-bit Σ-Δ ADC, up to 470 Hz output update rate	Low power consumption and high integrated Σ-Δ ADC, high resolution and high accuracy
Microcontroller		
ADuCM361	Precision analog microcontrollers, ARM Cortex™-M3 32-bit processor, 6 differential channels, single (24-bit) ADCs, single 12 bit DAC, power consumption 1.0 mA, 290 μA / MHz, 19-Pin GPIO, 128k bytes flash/EE memory, 8k bytes SRAM. Small package, low drift internal reference 5 ppm typical, integrated programmable current source	Low power consumption, high precision 24-bit Σ-Δ ADC, 4 mA to 20 mA loop applications, small package
ADuC7061	A precision analog microcontroller based on a 10 MHz ARM7 and a highly precise dual Σ-Δ ADC front-end, 24 bit of resolution and 16-bit ENOB and sub-100 Hz output rates; the memory footprint includes a 32 kB flash and 4 kB SRAM; other key specs include sub-3 mA operation (with MCU core at 1 MHz) making the part suitable for 4 mA to 20 mA loop applications, a 12-bit DAC and small packaging, 5 mm × 5 mm 32-Pin LFCSP	Low power consumption, low cost 24-bit Σ-Δ ADC, 4m A to 20 mA loop applications, small package
Reference		
ADR4525	2.5 V reference, very low drift: 2 ppm/°C (max), low noise: 1.25 μV pp @ 0.1 Hz to 10 Hz, long time stability: 25 ppm/√1000hr, hysteresis: 50 ppm	Low drift, very good stability and low noise reference, low hysteresis, and many other choices for output voltage in the ADR45xx family
ADR3425	2.5 V reference, low drift 8 ppm/°C (max), long time stability 30 ppm/√1000hr, 100 μA max quiescent current, small size SOT23-6 package	Low drift, good stability, and many other choices for output voltage in the ADR34xx family
ADR291	2.5 V reference, 12 μA quiescent current	Low power consumption, pretty good drift and stability

Main Products (Continued)

Part Number	Description	Benefits
Mux		
ADG704	4-channel multiplexer, low on resistance 2.5 ohm @ typ, low leakage current 10 pA @ typ, low power consumption 1 μA	Low leakage and low on resistance help to build a highly accurate system
ADG708	8-channel multiplexer, low on resistance 3 ohm @ typ, low leakage current 10 pA @ typ, low power consumption 1 μA	Low leakage and low on resistance help to build a highly accurate system
ADG1609	4-channel multiplexer, ±8 V power supply, 1 μA low on resistance 4.5 ohm @ typ, low leakage current 20 pA @ typ, low power consumption	Wider power supply range, low leakage and low on resistance help to build a highly accurate system
Switch		
ADG733	Double SPDT switch, low on resistance 2.5 ohm @ typ, low leakage current 10 pA @ typ, low power consumption 1 μA	Low leakage and low on resistance help to build a highly accurate system
ADG1636	Double SPDT switch, ±8 V power supply, low on resistance 2.5 ohm @ typ, low leakage current 10 pA @ typ, low power consumption 1 μA	Wider power supply range, low leakage and low on resistance help to build a highly accurate system
Interface		
ADM3251E	Isolated RS232 transceiver, 460 kbps data rate, 5 V or 3.3 V operations, 15 kV ESD protection, 2.5 kV isolation	High integrated isolated RS-232 transceiver
Power Management		
ADP2441	4.5 V to 36 V input buck regulator, 1 A output current, high efficiency larger than 90%, adjustable switching frequency: 300 KHz to 1 MHz, current limit protection, external soft start, thermal shutdown	Small 3 mm × 3 mm LFCSP package, high efficiency
ADP2370	3.0 V to 15 V input buck regulator, 800 mA output current, 1.2 MHz or 600 K PWM frequency, low quiescent current 14 μA, high efficiency larger than 90%, current-mode control architecture	Small 3 mm × 3 mm LFCSP package, few peripheral components, and small solution size
ADP160	2.2 V to 5.5 V input LDO, 150 mA maximum output current, ultra-low quiescent current: 10 μA when output 10 mA, up to 15 fixed output voltage options available from 1.2 V to 4.2 V	Low power consumption, integrated output discharge resistor, small package with only two 1 μF external capacitor
ADP7102	20 V input LDO, 300 mA output current, low noise 15 μV rms, 7 fixed version and adjustable version	High input voltage, low noise LDO
ADP7182	–28 V input LDO, 200 mA output current, low noise 18 μV rms.	High input voltage, low noise negative LDO

Demo System

Below is the dual channel colorimeter demo system. Please refer to the reference circuit CN0312 in the Design Resources section for detailed information.

Design Resources

Reference Circuits

- Dual-Channel Colorimeter with Programmable Gain Transimpedance Amplifiers and Synchronous Detectors (CN0312)—*www.analog.com/CN0312*

Application Notes and Articles

- Programmable Gain Transimpedance Amplifiers Maximize Dynamic Range in Spectroscopy Systems—*www.analog.com/library/analogdialogue/archives/47-05/pgtia.pdf*

Design Tools and Forums

- ADuCM361 Design Tools—*ftp://ftp.analog.com/pub/MicroConverter*
- Analog Photodiode Wizard—*www.analog.com/en/content/photodiode_wizard/fca.html*
- ADIsimPower™: ADI Voltage Regulator Design Tool—*www.analog.com/adisimpower*
- ADIsimOpAmp™: ADI OpAmp Design Tool—*www.analog.com/adisimopamp*
- Engineer Zone™: Online Technical Support Community—*ez.analog.com*

To view additional resources, tools, and product information please visit: *instrumentation.analog.com*

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