AN-643
APPLICATION NOTE

One Technology Way • P.O. Box 9106 • Norwood, MA 02062-9106 • Tel: 781/329-4700 • Fax: 781/326-8703 • www.analog.com

Closed-Loop Control Circuit Implementation of the ADuC832 MicroConverter® IC and the AD8305 Logarithmic Converter in a Digital Variable Optical Attenuator

By Mark Malaeb

INTRODUCTION

Today's optical market may not seem very promising; this could be due mainly to the cyclical nature of the optical networking infrastructure. However, the major advancements of the recent past in the optical space cannot be ignored. Such advancements allowed for complete signal processing in the optical domain without the need to convert to the electrical domain. Also, because of its wide bandwidth and high density (DWDM) capabilities, optical fiber continues to be and will remain the medium of choice for data, voice, and video transport. The need to support such a medium was the reason behind the birth of countless optical devices. Optical attenuators, optical amplifiers (EDFA and Raman), laser diode drivers, and photodetectors are among these devices, just to name a few.

This application note focuses on the control circuitry, using the ADuC832 MicroConverter IC and the AD8305 logarithmic converter, for a MEMS based, silicon, optical wave-guide, digitally controlled variable optical attenuator (DVOA). Figure 1 shows the physical layout of such a module, the DVOA by GalayOr, Inc. Figure 2 shows how the control circuit is implemented in the DVOA module.

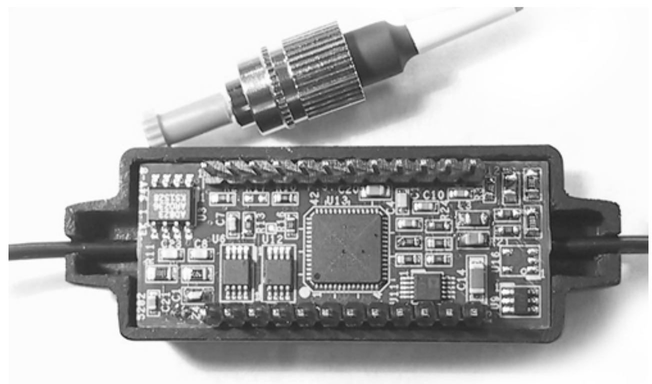

Figure 1. GalayOr DVOA

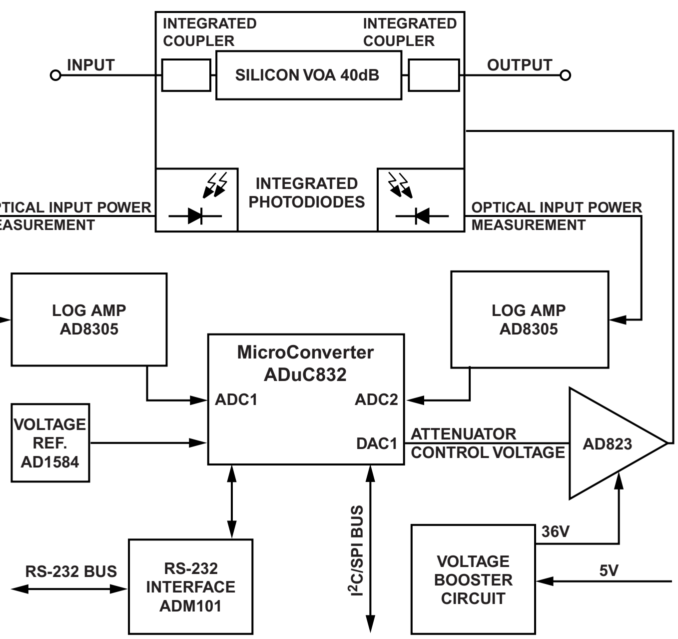

Figure 2. Overall DVOA Module Block Diagram

REV. 0

SYSTEM FUNCTIONAL DESCRIPTION

This DVOA is designed to attenuate optical signals up to 40 dB. The input and output optical power is measured using two integrated (1%) optical couplers and their corresponding photodiodes. The output currents from the photodiodes are fed into the log amps. The log amps convert the photodiode currents into a voltage proportional to the optical signal power level. These two voltages are then fed into two different ADC channels, on board the MicroConverter IC, for processing.

Once the VOA input and output power levels are known, an attenuation value is derived from the difference. The VOA attenuation value is set using an analog control voltage in the range of 5 V to 26 V. The attenuation increases with increasing voltage levels. This control voltage is generated from the DAC on board the MicroConverter IC. The voltage at the DAC output is amplified to the 5 V to 26 V levels using one of Analog Devices' high voltage op amps (AD823). A voltage booster, from 5 V to 36 V, is used to bias the AD823. Also, a high precision voltage reference (AD1584) is used by the ADC and DAC.

In the following paragraphs, a detailed description of the functions and features of the control loop's main components is presented.

ADuC832 MicroConverter IC

The ADuC832 MicroConverter IC, shown in Figure 3, is part of an 8052 based ADuC8xx controller family from Analog Devices. As shown in Figure 3, the MicroConverter IC integrates an 8-channel multiplexed 12-bit SAR analog-to-digital converter and two 12-bit digital-to-analog converters. Two channels are used to measure the output voltages from the AD8305 log amps, which correspond to the optical power levels present at the input and output of the VOA. One of the two on-board DACs is used to put out a voltage signal level proportional to the difference between the DVOA input and output ADC readings.

The MicroConverter IC control circuitry consists of an 8052 core with 62 Kbytes of program memory and 4 Kbytes of data memory. The preset VOA attenuation numbers, which are used to set the DAC, are stored in data memory. Two PWM outputs are also available on board in addition to the standard timers. To add to this high level of integration, the ADuC832 and all the ADuC8xx family include an on-board power-on reset circuit, a voltage reference, a temperature sensor, and a phase-locked loop (PLL). The PLL makes it possible to run the core with a small and inexpensive industry-standard 32 kHz watch crystal.

All these features plus all the standard peripherals that come with an 8052 based controller, i.e., RS-232 interface and I[2]C®/SPI®, are integrated in a 56-lead LFCSP space-saving package. This will make a perfect fit in the housing of this 47 mm × 17 mm × 10 mm DVOA module.

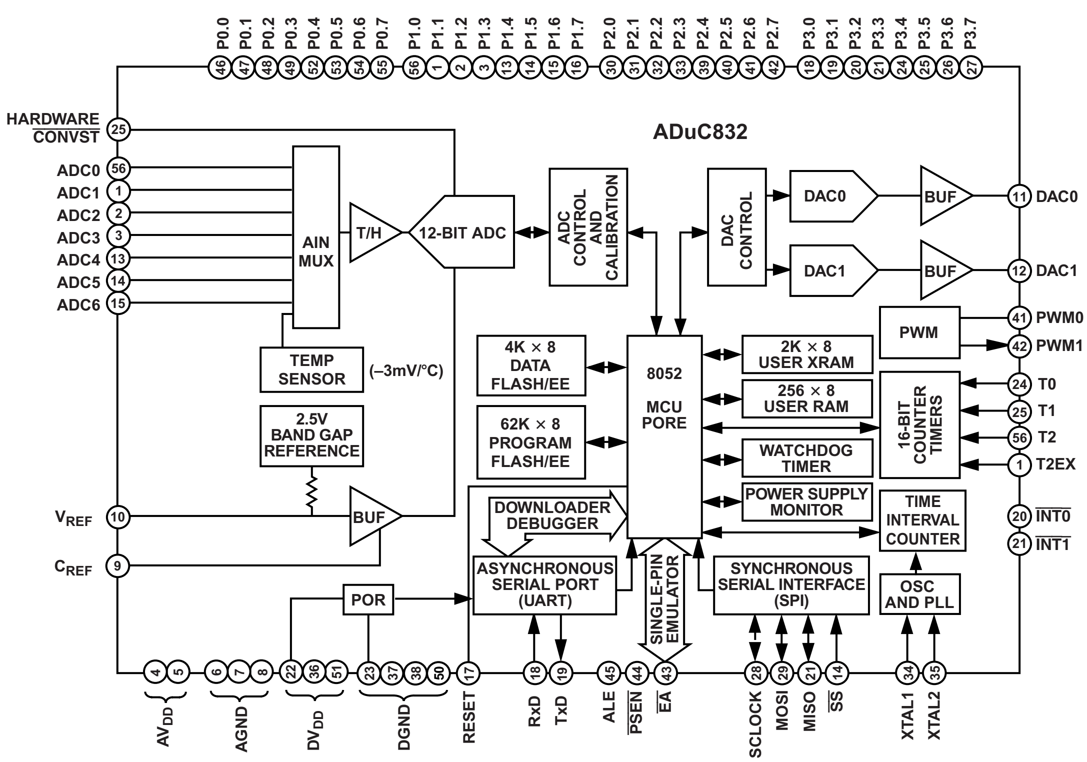

Figure 3. ADuC832 MicroConverter Block Diagram

AD8305 LOGARITHMIC AMP

The AD8305 logarithmic converter belongs to an Analog Devices family of converters optimized for converting optical power, measured as electrical current from a photodiode, into a voltage level. The AD8305's operation is based on a translinear technique to provide a wide dynamic range of power measurements (over five decades). The input current, from a photodiode, is applied to the collector of an NPN transistor, which in turn converts this current into a voltage (V_{BE}). The V_{BE} voltage is directly proportional to the logarithm of the input current establishing the basic logarithmic relationship. A second identical NPN transistor is used to generate a second V_{BE} to use as a fixed reference for the converter. The difference of the transistor V_{BE} provides an absolute measurement of the photodiode current and provides an output log-voltage that is proportional to the dB equivalent of the incident optical power.

Temperature compensation circuitry is employed to ensure good log conformity to within 0.1 dB over a wide range of temperatures. The device is designed to operate with a single positive supply. However, it can be run with dual supplies. This feature provides flexibility, especially where the anode on the photodiode has to be at the ground level. A functional block diagram of the AD8305 is shown in Figure 4.

The AD8305 includes an on-board amp to be used as a buffer or for amplification as required by the specific application. All these features are packaged in a space-saving 16-lead 3 mm × 3 mm LFCSP package. For more details on the AD8305, refer to its data sheet.

Two such log amps are implemented in the previously described DVOA. One is used to measure the current from the input photodiode and the other to measure the output. (A dual version of the AD8305 will be offered in the near future.) Through the use of the ADC on board the MicroConverter IC, these measurements are compared and processed to provide the corresponding digital value to the on-board DAC.

Communication, for calibration purposes, with the DVOA module is done through the serial communication port using the ADM101 from ADI. Communication is also done over the I^2C bus, which seems to have become the preferred choice for optical module designs.

These days, component suppliers must focus on simple and low cost optical components to be integrated in existing systems, resulting in short-term revenues. The Variable Optical Attenuator (VOA) is one of the most basic but essential optical building blocks in the evolution of optical networks. It exists in most optical subsystems and applications, such as optical amplifiers, optical add/drop modules, equalization modules, and testing elements. With its various applications and growing use in optical networking, the VOA component market is showing impressive growth and is expected to reach sales revenues of $400M to $600M in 2006 (KMI/RHK). With this promising VOA market forecast, Analog Devices is well positioned to supply the electronic control circuitry needed to support such a module.

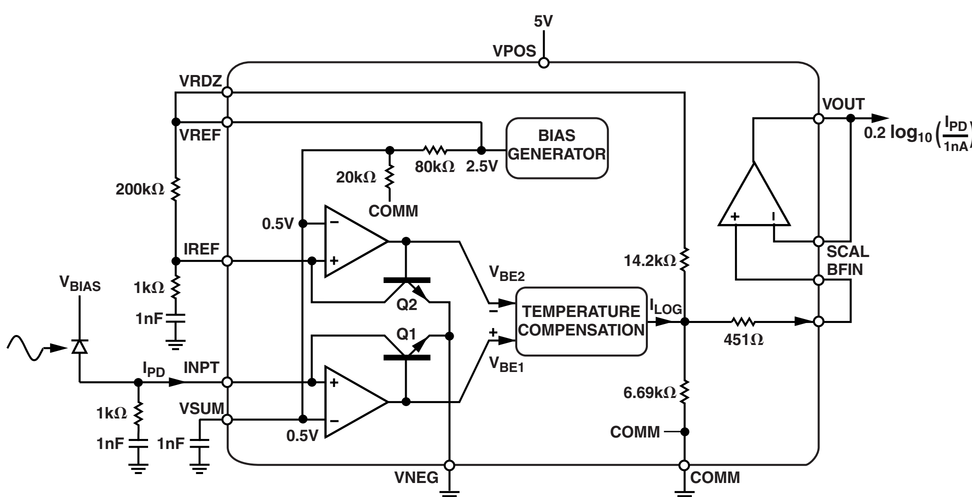

Figure 4. AD8305 Log Amp Block Diagram

E03644–.1–3/03(0)