WIDE RANGE DIGITIZER FOR CHEM-BIO LIDAR

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ABSTRACT

The Frequency Agile Laser (FAL) Sensor is an active standoff chemical detector, developed at The Edgewood Chemical Biological Center (ECBC), for the purpose of remotely sensing chemical warfare agents. The Laser Standoff Chemical and Biological Detection (LSCBD) program is quite successful, however, one major limitation of the LSCBD system has been data acquisition and processing capability. The received analog signal, in a LIDAR system, is detected, amplified and digitized for subsequent computer processing. Typically, receiver amplifier gain is adjusted from time-to-time so that signal amplitude applied to the digitizer is not too large, resulting in signal clipping, nor too small, resulting in poor digitizer resolution. In LIDAR applications, the received signal amplitude changes rapidly, and proper gain adjustment, in real-time, is difficult. The Laser Standoff Detection group has addressed this problem by the design of a unique, high resolution, wide range digitizer. Four A/D converters, each with a progressively higher voltage range, are configured in a circuit in which the input signal is applied simultaneously to all A/D converters. Digital output signals are selected from the A/D converter having the lowest voltage range, which is not exceeded by the input signal. These data comprise 16 bit data words, which are sent to a digital signal processor (DSP). The DSP processes the LIDAR signal and sends data via a high-speed serial link to the LIDAR computer.

This design eliminates the need for manual or automatic gain control amplifiers in the LIDAR data acquisition system. Digital signal resolution is maintained for small signals, yet large amplitude signals are not distorted due to signal clipping.

1. INTRODUCTION

The Frequency Agile Laser (FAL) LIDAR is an active standoff chemical detector developed at The Edgewood Chemical Biological Center (ECBC), for the purpose of remotely sensing chemical warfare agents. The FAL LIDAR operates by transmitting pulses of light at various infrared wavelengths into the atmosphere and measuring the returned energy as it is scattered back to the sensor from a hard target and/or an aerosol cloud. One major limitation of the FAL system has been data acquisition and processing capability. The received analog signal, in a LIDAR system, is detected, amplified, and digitized for subsequent computer processing. Typically, receiver amplifier gain is adjusted, from time-to-time, so that signal amplitude applied to the digitizer is not too large, resulting in signal clipping, nor too small, resulting in poor digitizer resolution. In LIDAR applications, the received signal amplitude changes rapidly, and proper gain adjustment, in real-time, is difficult. This program addresses the problem, by the design of a unique, high resolution, wide range digitizer.

2. DESIGN APPROACH

Four A/D converters, each with a progressively higher voltage range, are configured in a circuit in which the input signal is applied simultaneously to all A/D converters. A/D voltage ranges are, ± 0.55 volts, ± 1.1 volts, 0 to 2 volt, and 0 to 4 volts. Digital output signals are selected from the A/D converter having the lowest voltage range, which is not exceeded by the input signal. These data comprise 16 bit data words, which are sent to a digital signal processor (DSP). Two A/D converters are 14-bit, 2's compliment and two are 12-bit straight binary. The two most significant bits comprise an A/D identifier, which provides DSP instructions from a look-up table. The DSP processes the LIDAR signal and sends data via a high-speed serial link to the LIDAR computer.

Figure 1 is a block diagram of the digitizer configuration.

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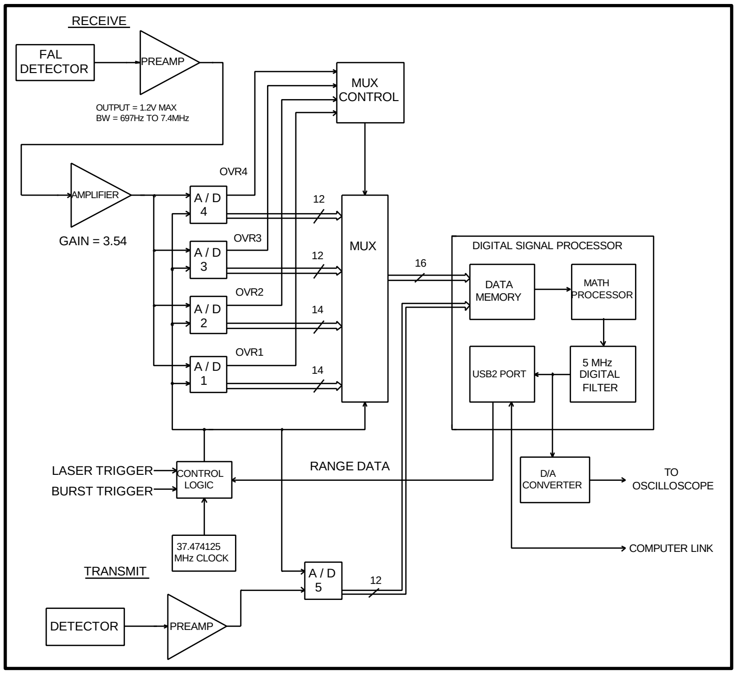

Figure 1. Digitizer block diagram

3. ANALOG-TO-DIGITAL CONVERTERS

This digitizer configuration requires multiple A/D circuits, with progressively higher input voltage ranges. Although the voltage ranges differ, many A/D characteristics must match to insure proper seamless operation over the entire input voltage range. These matching characteristics include operating frequency and pipeline delay (latency) of both output and OTR (out-of-range) signals. For circuit design simplification, it is desirable that digital output levels and power supply requirements match. A/D voltage ranges were dictated by the FAL preamplifier characteristics as well as specifications of the A/D integrated circuits. Although most FAL preamplifier output signals are positive, the circuit is AC coupled and produces some small negative signals. Maximum preamplifier output voltage is + 1.2 volts For compatibility with the present FAL signal, the digitizer will accommodate bipolar input signals.

The Analog Devices AD6645, 14-bit A/D, was selected for the two lowest voltage digitizer stages. This is a 14-bit 2's complement A/D, which satisfies the bipolar signal requirement with adequate signal resolution. The most sensitive digitizer stage includes a preamplifier with gain of 2, to extend the input voltage range from ± 1.1 volts to ± 0.55 volts. The second stage utilizes the AD6645 without pre-amplification to provide an input voltage range of ± 1.1 volts. The two higher voltage stages use the AD9224. Output coding is straight binary, since large bipolar signals are not encountered. The third stage voltage range is 0 to 2 volts and the fourth stage range is 0 to 4 volts. Input voltage range of the AD9224 is changed from 2 volts to 4 volts by a reference voltage modification.

To take advantage of the four-volt range of the AD9224, an analog amplifier with gain of 3.54 is interposed before the A/D converters.

4. DIGITAL SIGNAL PROCESSOR

Design of the DSP circuits and software are ongoing. The preliminary DSP selection is Analog Devices Corporation Part ADSP-21262. A possible candidate for the serial interface is the Cypress CY7C68001 universal serial bus integrated circuit. The DSP will implement the following functions.

1. Perform programmed calibration procedure upon system turn-on.
2. Within a 5- millisecond period, perform the following functions:
   - A. Store 2500, 16 bit words from receive A/D's and 1000, 16 bit words from transmit A/D.
   - B. Check the two most significant bits in each word to determine functions to be performed.
   - C. Perform indicated operation on each binary word, i .e. subtract offset voltage, change 2's complement data to binary, and multiply by a function of the least significant bit to determine voltage.
   - D. Apply 5 MHz low-pass digital filter to data.
   - E. Put data into 32 bit floating point format.
3. Transmit data to computer via high speed USB serial interface.

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CONCLUSIONS

This design eliminates the need for manual or automatic gain control amplifiers in the LIDAR data acquisition system. Digital signal resolution is maintained for small signals, yet large amplitude signals are not distorted due to signal clipping.