

Rad-icon Imaging Corp.

3193 Belick Street, Unit 1
Santa Clara, CA 95054-2404

tel 408-486-0886
fax 408-486-0882

AN01: Interfacing the RadEye1 Image Sensor to the National Instruments PCI-6111E Data Acquisition Board

Introduction

This application note describes a simple method to acquire images from the RadEye1 large-area image sensor into a PC for display, storage and analysis. The system makes use of the PCI-6111E data acquisition board from National Instruments for digitizing the analog output from the RadEye sensor. A custom adapter board matches up the signals from the RadEye connector to the input connector on the PCI-6111E board. The programs for acquiring, displaying and storing images are written using National Instruments' LabVIEW graphical programming language. Please refer to the RadEye1 datasheet or the National Instruments catalogue for more detailed technical information on these instruments.

RadEye1 to PCI-6111E Interface

The RadEye image sensor requires 5 V power, two control signals and a reference voltage to operate. It returns an analog differential video signal as well as digital horizontal and vertical sync signals. The PCI-6111E board supplies the control signals through its two counter/timer outputs. It can supply the 5 V power and the analog reference voltage as well, although we chose to use a separate, clean power supply and regulator in order to improve the noise performance. One of the differential analog input channels on the PCI-6111E board is used to digitize the RadEye video signal to 12 bit resolution at a maximum sampling rate of 5 MS/s.

The PCI-6111E board plugs into the PCI bus on a standard Pentium-class PC. Note that the four-channel PCI-6110E board may be used instead, although this application only requires one analog input channel. Due to the large datasets involved in this application (each RadEye image occupies one megabyte), we recommend that at minimum a 300 MHz Pentium-II with 64 MB RAM should be used. The LabVIEW software that was used to control the image acquisition runs on either Windows 95, 98 or NT. The complete system is shown in Figure 1. A close-up of the adapter board is pictured in Figure 2.



Figure 1 – RadEye Imaging System

Adapter Board

The adapter board schematic is shown in Figure 3. The main function of the adapter board is to map the signals from the 15-pin RadEye header to the 68-pin connector on the PCI-6111E board. The video lines are buffered with unity-gain opamps that are capable of driving the 100 pF input impedance of the PCI-6111E. We chose the Elantec EL2044C for this function, although any unity-gain-stable opamp that can drive a large capacitive load with reasonable slew rate and bandwidth can do the job.

The PCI-6111E board has several input ranges that can be used with the RadEye sensor. The typical output signal range from the RadEye is 0-1 V, which we have mapped into the ± 1 V input range of the PCI-6111E. The ± 0.5 V range provides additional resolution but saturates at only 50% of the full-scale signal. All of the input range settings available on the PCI-6111E are bipolar, meaning that the data acquisition effectively uses only 11 bits unless additional circuitry is added to offset the differential output lines of the RadEye from each other.

In addition to the signal lines, the adapter board also contains a voltage divider for setting the analog reference voltage VD, and a regulator to supply power to the RadEye and the EL2044C's. As was mentioned above, the PCI-6111E does have a 5 V output that could be used to power the RadEye device, as well as two DACs that could be used to set VD remotely from the PC. However, PC power tends to be quite noisy, so we chose to use a separate power supply instead.

Also on the adapter board are a few pull-up and pull-down resistors to set the RadEye control inputs to the default continuous mode. This allows the RadEye to be operated without the PC by supplying only 5 V power and a master clock signal from a function generator. This mode may be useful for debugging purposes or when the PC with the PCI-6111E board is unavailable. The additional RadEye timing modes that are accessible via the BIN, RESET and NDR control signals can be connected to the PCI-6111E digital I/O ports. Please refer to the RadEye data sheet for information regarding these timing modes.

LabVIEW Program

The block diagram for the LabVIEW program is shown in Figure 4. The main program consists of a sequence frame which initializes the PCI-6111E board, programs the on-board counters and digital I/O lines, and then acquires a specified number of frames from the RadEye sensor. After the data acquisition is complete, the data array is reformatted, displayed, and saved to disk.

The PCI-6111E board contains two programmable on-board counters. CTR0 is used for the master clock that controls the RadEye readout timing as well as the A/D conversion on the PCI-6111E. The frequency and duty cycle can be adjusted from the front panel prior to running the program. CTR1 sets the frame rate for the RadEye sensor. It is programmed to produce a start pulse that signals the beginning of a new readout cycle. The frame period as well as the width of the pulse can be adjusted from the front panel. The width of the start pulse has to be shorter than the readout period of the sensor (i.e. $t_{\text{start}} \leq 1024 \cdot 538 \cdot t_{\text{clock}}$) since the control circuitry on the RadEye sensor begins a new frame readout as soon as it sees a high level on the start input. Similarly, the period of the start pulse has to be longer than the frame period to ensure that the entire frame is scanned before the next readout begins.

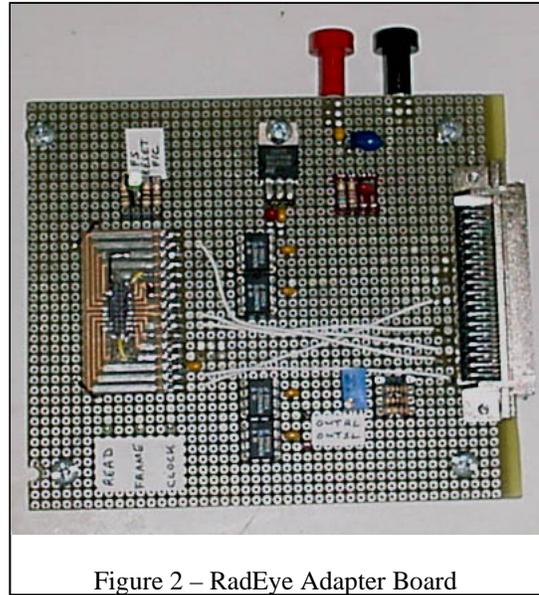


Figure 2 – RadEye Adapter Board

The program sets up the data acquisition function on the PCI-6111E board to acquire data from channel 0, using the differential, DC-coupled input mode, with a ± 1 V input range. Since the data flow is synchronous with the master clock generated by CTR0, the same clock is also used to sample the video signal on the PCI-6111E board. The video signal is delayed by a few gate propagation delays from the original CTR0 clock, which ensures that the signal is sampled just before the end of the “data valid” period. The program acquires a complete frame and then repeats the setup-and-acquire cycle based on the number of frames selected from the front panel control. The acquired frames are averaged on a pixel-by-pixel basis to allow for noise reduction, if desired.

After the data acquisition is complete the frame buffer has to be reformatted in order to remove the pixels acquired during the horizontal blanking interval. The final 1024 by 512 image is displayed on the front panel and optionally saved to disk.

LabVIEW saves these image files as an array of 16-bit signed integers. There is no image header. The default byte order used by LabVIEW is big-endian, or “Mac” byte-order (as opposed to the little-endian byte order used by “Intel” PCs). Image analysis software like Photoshop or NIH Image, which can read 16-bit “raw” image files, usually allows the user to specify the byte order. As a rule of thumb, if the image looks extremely noisy with lots of saturated pixels then you picked the wrong byte order. The program scales the averaged image by a factor of ten prior to saving to take advantage of the “extra” bits available in the integer file format.

Conclusion

We presented a simple data acquisition system that can be assembled quickly and relatively inexpensively for acquiring images from the RadEye1 sensor. The main purpose of this system is to provide a simple solution that allows a basic evaluation of the device. It is intended solely as an experimental laboratory-type setup. More sophisticated electronics and software that are optimized for a specific application are likely needed to use the RadEye sensor in a commercial or industrial environment.

For assistance with evaluating the RadEye sensor for a particular application, or to check whether the RadEye sensor is compatible with another data acquisition system, please contact us directly at 408-486-0886. More information about the Rad-Icon large-area imaging product lines is also available on-line at www.rad-icon.com.

RadEye is a trademark of Rad-Icon Imaging Corp. LabView is a trademark of National Instruments Corp. All other brand and product names are trademarks or registered trademarks of their respective companies.

Appendix A: Parts List for Adapter Board

J1	15-pin header, 0.040" pitch, Samtec P/N FC1-15-01-T-LC	1 ea.
	flex cable to connect to RadEye, Samtec P/N FJ-15-D-02.00-4	1 ea.
J2	68-pin male header, SCSI2, Nat. Inst. P/N 777600-01	1 ea.
U1,U2	IC, OpAmp, Elantec P/N EL2044CN	2 ea.
U5	IC, regulator, Nat. Semi. P/N LM317T	1 ea.
C1	Capacitor, 0.22 μ F, 25 V, ceramic	1 ea.
C2,C4,C6	Capacitor, 0.1 μ F, 25 V, ceramic (also for bypassing U1 & U2)	5 ea.
C3,C5,C7	Capacitor, 10 μ F, 25 V, tantalum	3 ea.
R2,R3,R4,R5	Resistor, 10 kOhm, 1/4 Watt	4 ea.
R9,R10	Resistor, 1 kOhm, 1/4 Watt	2 ea.
R6	Potentiometer, 10 kOhm	1 ea.
R7	Resistor, 220 Ohm, 1/4 Watt	1 ea.
R8	Resistor, 680 Ohm, 1/4 Watt	1 ea.
D1	Diode, 1N4002 or equivalent	1 ea.

Appendix B: National Instruments Part Numbers

PCI-6110E (NT/98/95)	777475-01
PCI-6111E (NT/98/95)	777530-01
Shielded cable (SH6868-EP, 2m)	184749-02
68-pin right-angle PCB connector (male)	777600-01
LabVIEW base package (NT/98/95)	776671-03

For more information visit the National Instruments website at www.natinst.com.

RadEye1 Adapter Board for PCI-6111E

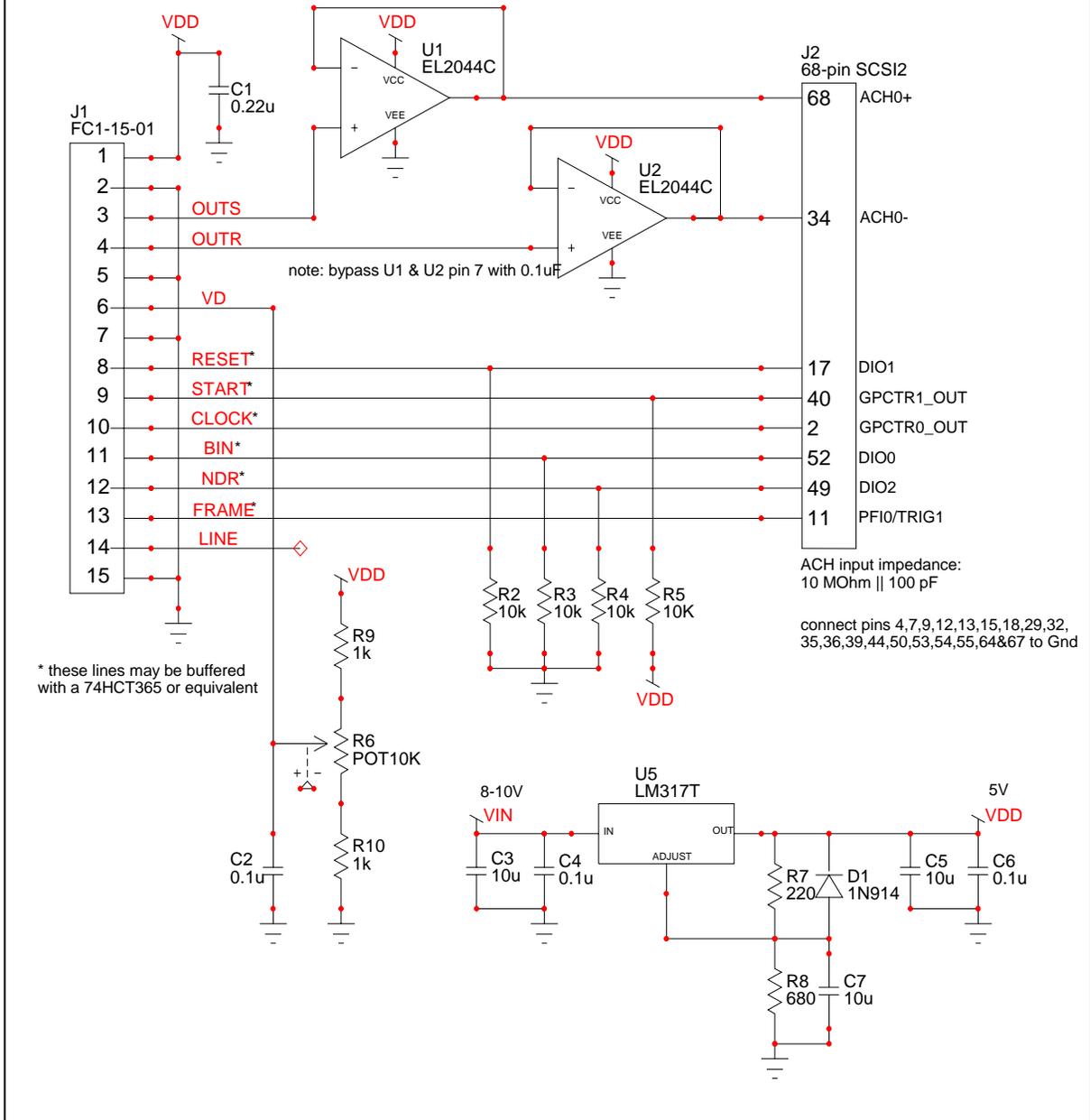


Figure 3 - Schematic

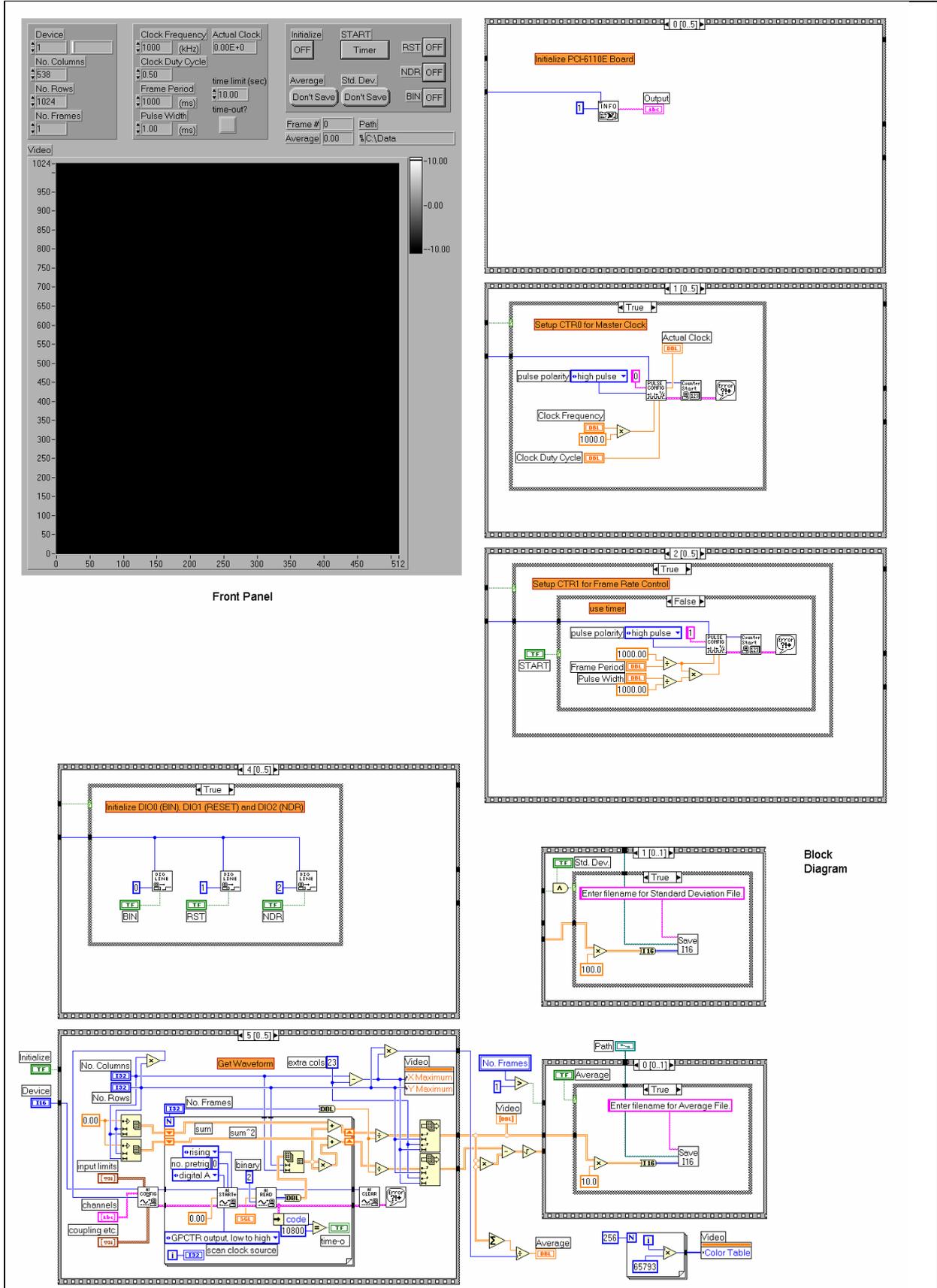


Figure 4 – LabVIEW Program