Graphical Application Development Environment for Analog Microcontrollers

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Abstract – **Analog microcontrollers' development is one of the fastest growing segments of engineering, and will continue to be for the foreseeable future as consumers demand smarter cars, appliances, intelligent sensors, and so on. The evolution of these commercial technologies will propel virtual instrumentation into being more applicable to a growing number of applications. In present paper the approach of integrating these advanced technologies in one environment is proposed.**

Keywords – **Analog Microcontrollers, Embedded Systems, Virtual Instrumentation, Graphical ADE, LabVIEW.**

I. Introduction

The analog microcontrollers combine precision analog functions, such as high resolution ADCs, DACs, voltage and current references, with an industry-standard microcontroller and embedded flash memory. With theirs mixed-signal IC architecture, they delivers on the needs of today's sensor and measurement systems designers. Using their functionality it is possible to significantly increase the performance and dramatically cut the development time of data acquisition systems.

The base building blocks of typical analog microcontroller (Analog Devices ΣΔ MicroConverter ADuC834Products) are shown in fig.1.

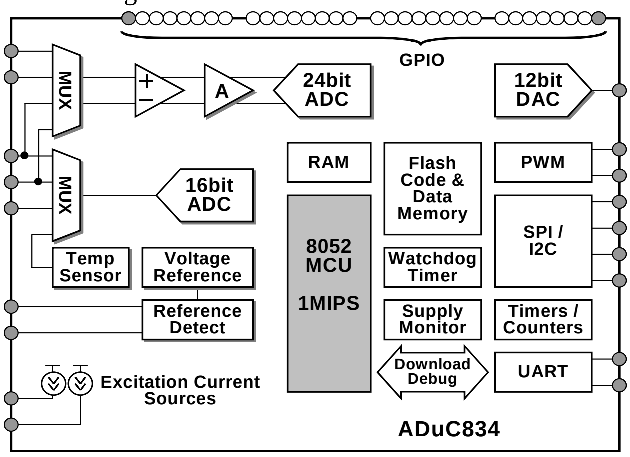

Figure 1 The building blocks of analog microcontroller

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As can be considered by reconfigurations and reprogramming of these blocks the developer can compose a multitude of measurement configurations.

One of the features of the more of the analog microcontroller's product is the ability of the device to download code to its on-chip program memory [1]. This in-circuit code download feature is usually conducted over the device serial port. Serial download capability allows developers to re-program the part while it is soldered directly onto the target system avoiding the need for an external device programmer. Serial download also opens up the possibility of system upgrades in the field. This means that users can upgrade system firmware in the field without having to swap out the device.

The great disadvantage of such system firmware upgrading is the necessity of low-level programming. Although there is library of ANCI-C functions, currently targeted at the Keil environment [2], the lack of integrated software framework for microcontrollers is obviously. This framework must decrease the complexities of integrating multiple measurement devices into a single system by providing standard interfaces to all I/O devices, and must provide development tools to rapidly configure, build, deploy, maintain, and modify high-performance measurement and control solutions.

In last few yeas Application Development Environments (ADEs) play a critical role in a measurement and automation software framework. With these tools, the system developers design and integrate the system that takes measurements, controls processes, implements calibration and linearization routines, displays information to the end user or connects with other applications. In addition it is imperative that the ADE provide high-level, intuitive development paradigms so that a wide variety of users can rapidly build measurement and control systems. Obviously, the ADEs used to develop such measurement solutions should provide an easy-to-use design model, compiled performance, and application-level programming flexibility for a complete range of applications.

For maximum development productivity, the ADE should include comprehensive statistical and numerical analysis functions, as well as high-performance signal processing and control algorithms common in measurement applications including functions such logic control, noise reduction, spectral measurements, digital filtering, signal detection, numerical integration and differentiation, curve fitting, fractional-octave analysis, and order analysis.

It is well known that National Instruments LabVIEW is one of an industry-leading ADE for designing test, measurement and control systems [5]. It provides an easy-to-use application development environment designed specifically for the needs of engineers and scientists. LabVIEW offers powerful features that make is easy to connect to a wide variety of hardware and other software.

One of the most powerful features that LabVIEW offers is its graphical programming environment. With LabVIEW, it is easy to design custom virtual instruments by creating a graphical user interface on the computer screen through which the user can:

- Operate the instrumentation program;
- Control selected hardware;
- Manipulate and analyze acquired data;
- Display and publish results.

In addition the benefits offered by Lab VIEW and concerning concretely the analog microcontrollers are:

- Visualize the microcontroller's configuration;
- Ability of fast reconfiguration for acquires various measurement data;
- Easy to implement calibration and linearization techniques.

Although LabVIEW provides the tools required for most applications, LabVIEW also is an open development environment. This mean that the developers can easy upgrade or create new applications without discontinue the working programs.

The underlying idea promoted in this presentation is to create measurement system based on analog microcontroller in such way that the hardware only to converts the incoming signals into digital signals that is sent to the computer. The microcontroller device does not compute or calculates the final measurement. That task is left to the software that resides in the computer. The same devices can perform a multitude of measurements by simply changing the software application that is reading the data. So in addition to controlling, measuring and displaying the data the user application for an ADE based microcontroller system also play the role of the firmware that would exist inside in special purpose measurement system.

The principal approach to integrate the Analog Devices family of precision analog microcontrollers in LabVIEW ADE is described in next section.

II. Including Analog Microcontrollers in LabVIEW

As with LabVIEW, engineers interface with real-world signals, analyze data for meaningful information, and share results and applications, than the environment can be observed as be composed of three base parts. The first one is for data acquisition, second for data manipulation and analyzing, and the last one for data presentation and publishing. Following this division the developed ADE for analog microcontrollers just like is divided in three parts:

- Downloader consisting of number of programs and functions that controls data acquisition;
- Library consisting of created and build-in Virtual Instruments (VI) and subVI for data manipulation and
- Number of top level VI for data representation.

As has been mentioned the serial download capability of ADuC family microcontrollers allows users to re-program the device while it is assembled onto the target system. The core of presented graphical ADE is so called downloader created in LabVIEW. The downloader consists of number of Virtual Instruments (VIs) witch hierarchy is shown in fig.2. The brief description of each VI purpose follows:

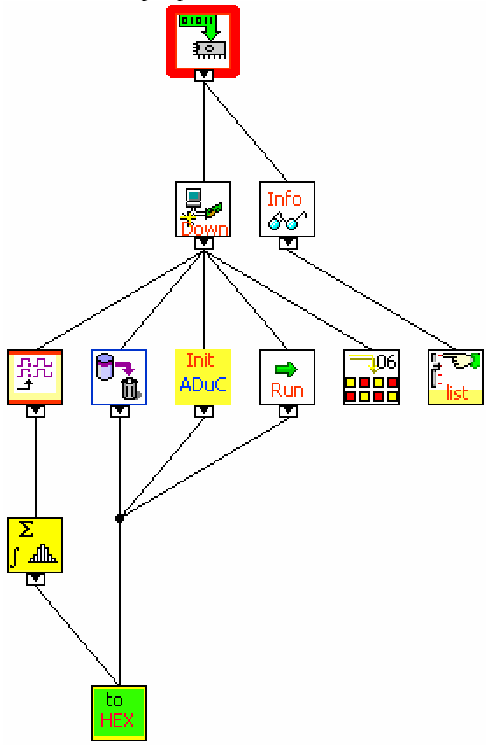
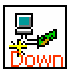


Figure 2 The downloader's hierarchy

ADuC_Program Select.vi This is a subVI that shows the files in Intel HEX format available in library (folder HEX Application). The folder HEX Application has been done specially for developers to keep the created downloadable programs (in HEX format), their descriptions (in txt format), and configuration of MicroConverter for each program (in jpg format).



ADuC_Downloader.vi By this subVI the user can select the appropriate program in Intel HEX format ant download it in the processor embedded in ADuC3xx family Analog Microcontrollers (8052 core).

ADuC_Create Application List.vi The subVI reads the application directory. Any HEX and TEX file which are contained in the directory (HEX Application) are listed. If the files are available and are successfully opened the Title of the files window is read and placed in a list which will be used to create a selection list.

ADuC_Initialise.vi The subVI send the data package via Serial VI to interrogate the ADuC3xx connected in serial port. It performs a VISA's Serial Port Write and Serial Port Read. If the communication is realized the ADuC must return the interrogation data <name> and version of embedded downloader.

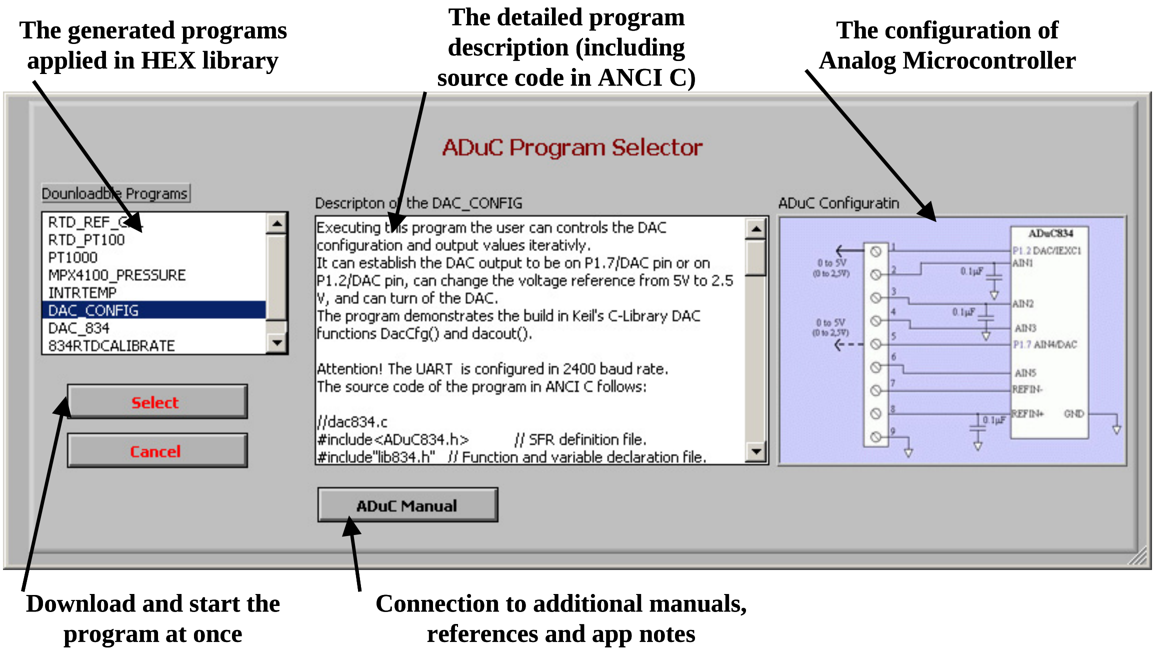
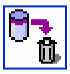
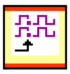


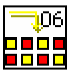
Figure 3 The initial user interface



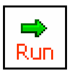
ADuC_Erase_Memory.vi The subVI erases memory before downloading a program.



ADuC_Download.vi This subVI is the core of downloader. It gets the HEX data and sent it to ADuC3xx program memory.

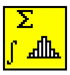


ADuC_Run_ACK.vi This subVI performs diagnostic function. It is used to read ACK when the HEX program running successfully.



ADuC_Run.vi The subVI starts the program execution.

ADuC_Convert to Hex String.vi This VI Converts download Data packets from decimal string to hexadesimal string.



ADuC_Check Sum.vi This subVI check sum for Intel HEX format and append check sum value to HEX string.

An example demonstrating the benefits of graphical ADE is shown in figure 3. The initial user interface that appears when the user executes the graphical downloader consists from three main dialog windows.

The available programs in folder HEX Application are listed in left upper corner of the user interface. It is necessary to note that only HEX files that have appended description files with same name would be appeared in the list.

In the center of the user interface the detailed description of programs is positioned. This description includes the base functionality of program, the serial poll baud rate, and if is possible the source code in ANCI C.

The image suggesting the user how to make external connections for properly operation of measurement system is located in the right part of the user interface. This removes the necessity of weary searching the information in additional documentations for pin names, connector numbers, types, ets.

When the user choose the appropriate program he has opportunity to interrogate, erase memory, download and run the program at once by simple pushing the button “Select”. All mentioned activities are left invisible for the developer.

In order to add new application in the folder HEX Applications the developer must fulfill the following steps:

- Create or acquire the program code in standard Intel HEX format.
- Wright or take some available documentation describing the program’s functionality and characteristic.
- Save the documentation in plain text format.
- Draw the configuration of analog microcontroller and save the schematics in JPEG format.

The developer must keep in mind that for propriety recognition the names of these three files must be equal.

The second part of suggested ADE consists of various VIs and subVIs for data manipulation. Some of these VIs are buid-in LabVIEW libraries of functions and some for their particularity are created additionally.

LabVIEW has more than four hundred build-in function designing specifically for extracting useful information from set of acquired data. Examples include mathematics, frequency analyses, peak detection, curve fitting, statistics, and many more. It is obvious that developer after acquiring data from analog microcontroller as decimal (or hexadecimal) digits has a great number of opportunities to scale data as necessity. He can be involve calibration coefficients, make linearization by polynomial curve fitting, establish optimization procedures, etc.

The third piece of the introduced graphical environment is presentation, which encompasses data visualization, user interface design, web-publishing, report generation and data management. Because LabVIEW was designed specifically for engineers and scientists, the user can take advantage of measurement-specific interface design tools.

III. Putting the Environment into Practice

Executing graphical ADE for analog microcontrollers a number of application was created and stored in library. To accomplish experiments as acquisition hardware is used the Analog Devices MicroConvertor ADuC834 (fig.1). This analog microcontroller is a complete smart transducer front end, integrating two high resolution sigma-delta ADCs (24 and 16 bits), an 8-bit MCU, and program/data Flash/EE memory on a single chip.

To illustrate the benefits of created environment some of typical examples would be applied in this section.

In Fig. 4 the graphical user interface for atmospheric pressure measurement is shown.

The measurement system is made up by simply connecting the pressure sensor MPX4100A to primary ADC inputs of microcontroller. The Motorola's MPX4100A series piezo-resistive transducer is a monolithic, signal conditioned, silicon pressure sensor [4]. This sensor provides an accurate, high-level analog output signal that is proportional to applied pressure. The ratiometric function of both the A/D converter and the pressure sensor device makes all voltage variations from the power supply rejected by the system.

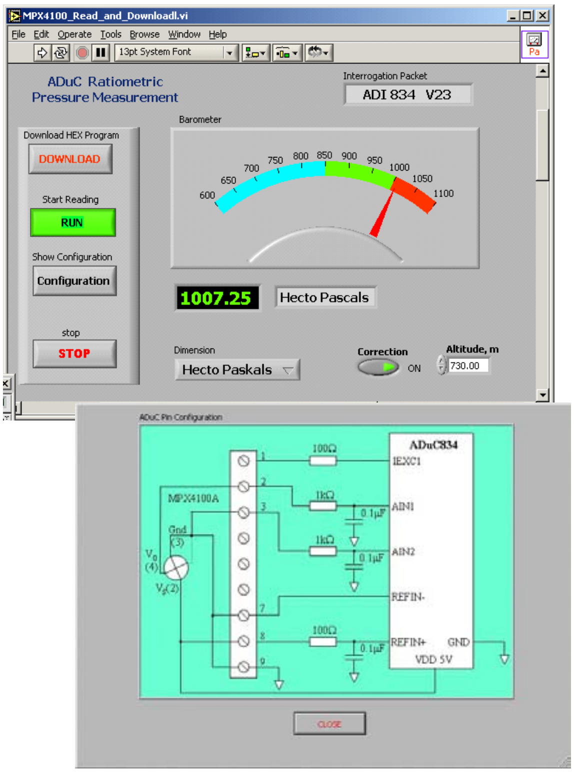


Figure 4 Atmospheric Pressure Measurement

Figure 5 shows graphical user interface for a typical analog measurement application of the ADuC834, namely an interface to an RTD (Resistive Temperature Device). The arrangement is commonly referred to as a 4 - wire RTD configuration [3]. Here, the on-chip excitation current sources are enabled to excite the sensor. The excitation current flows directly through the RTD generating a voltage across the RTD proportional to its resistance. This differential voltage is routed directly to the positive and negative inputs of the primary ADC. The same current that excited the RTD also flows through a series resistance R_{REF} generating a ratiometric voltage reference.

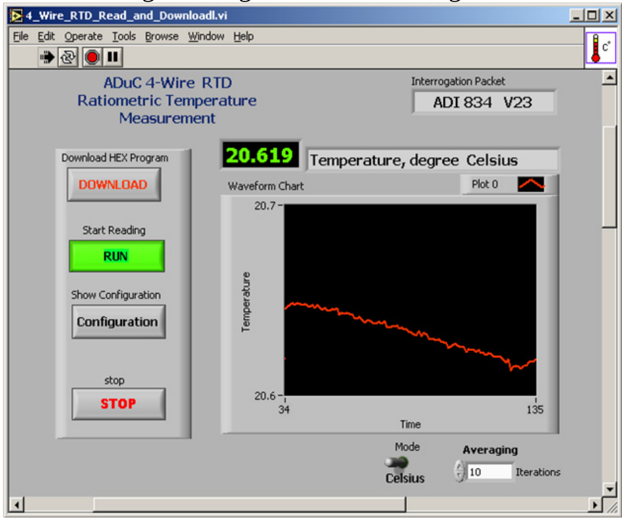


Figure 5 RTD Temperature measurement

As can be seen in the figures the user interface is designed to keep some similarity regardless of which type of physical phenomena is measured – pressure, temperature or any other.

In the left part of interface are positioned the controlling buttons. Button "Download" is used to download and start program. "Run" serves data acquisition and properly manipulation for desired result representation. The "Configuration" button pushes additional window with system configuration (fig.4). "Stop" breaks the program executing.

IV. Conclusion

In order to integrate the embedded systems or particularly analog microcontrollers and virtual instrumentation in one software framework, the appropriate graphical application development environment is created. For experimental work the Analog Devices MicroConvertor ADuC834 and National Instruments LabVIEW are maintained. With insignificant modifications, the presented approach can be used also for other similarly products. Since the author's conception is based in open architecture it is possible to include continuously new programs for various applications.

References

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