ETHERNET DATA ACQUISITION SYSTEM

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Abstract: Ethernet Data Acquisition System allow remote monitoring and control via Ethernet local area network (LAN), using open architecture and industry-standard TCP-IP. The user not only has local access to EDAS through sockets, it also has access to the system through the web page hosted on EDAS. A larger data acquisition system can be formed with several EDA Systems connected to the same network. The system has been made even more flexible through the connectors that allow user to connect his own signal interfaces.

Key Words: data acquisition, analog / digital converter, eCos operating system, Ethernet communication, embedded system.

1. INTRODUCTION

This purpose of this paper is to present the results of a research work for National Instruments, USA. The block diagram of the device developed during this research session is shown in Figure 1.

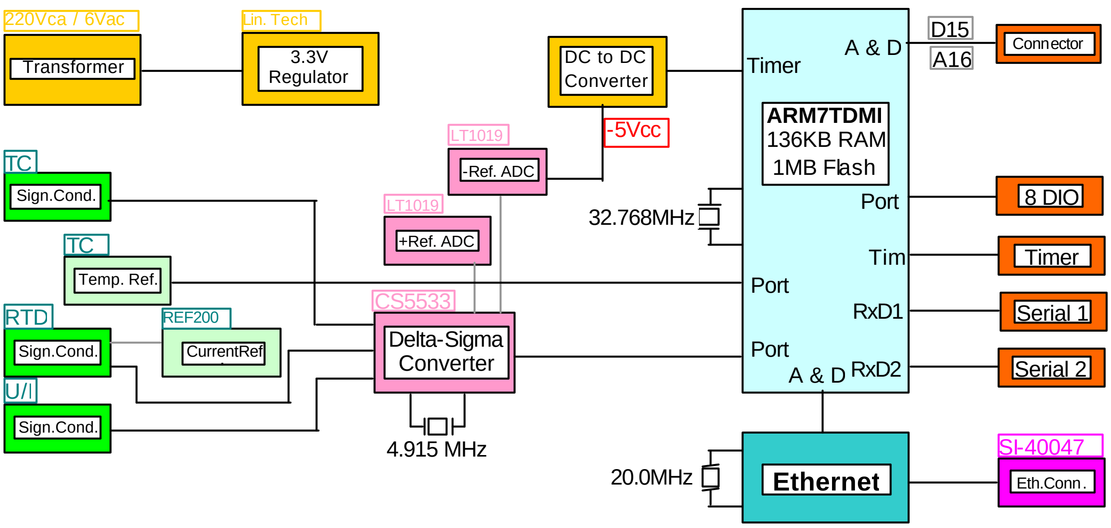

Figure 1 – Block diagram

The Ethernet Data Acquisition System (EDAS) has the following features:

- -1 analog input for thermocouple (TC) and temperature sensor for the cold junction of the thermocouple, with I2C interface (TCN75);
- -1 analog input for thermal resistors (RTD) and internal constant current source for 3-wire RTD configuration (REF200);

-2 analog inputs for voltage and current;
-8 digital input/output lines (DIO);
-1 PWM digital line and 1 counter/timer line;
-2 serial ports;
-1 Ethernet 10BASE-T port (CS8900A);
-AC and DC power supply ready.

2. HARDWARE

The AT91FR is a member of the Atmel AT91 16/32-bit Microcontroller family, which is based on the ARM7TDMI processor core. The processor has a high-performance 32-bit RISC architecture with a high-density 16-bit instruction set and very low power consumption. In addition, a large number of internally banked registers result in very fast exception handling, making the device ideal for real-time control applications. [1]

The eight-level priority-vectored interrupt controller together with the Peripheral Data Controller, significantly enhance real-time device performance. By combining the microcontroller, featuring more than 1 Mbit of on-chip SRAM and a wide range of peripheral functions, with 8 Mbits of Flash memory in a single compact 120-ball BGA package, the Atmel AT91FR provides a powerful, flexible and cost effective solution to many compute-intensive embedded control applications and offers significant board size and system cost reductions.

The Flash memory may be programmed via the JTAG/ICE interface using a single device supply, making the AT91FR ideal for in-system programmable applications.

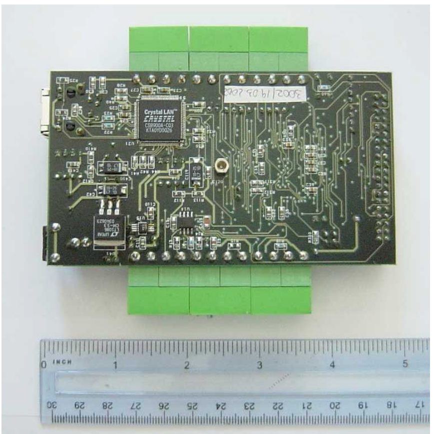

Figure 2 – Rear view of the first solution

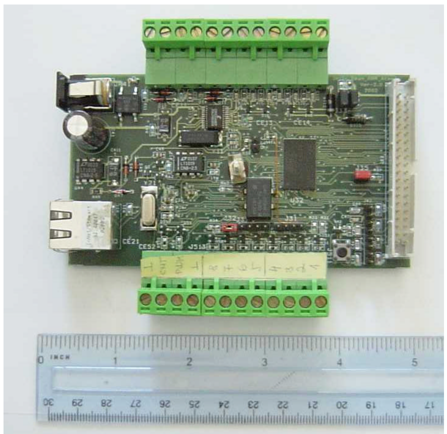

Figure 3 – Front view

The CS8900A is a low-cost Ethernet LAN Controller optimized for Industry Standard Architecture (ISA) Personal Computers. Its highly-integrated design eliminates the need for costly external components required by other Ethernet controllers. The CS8900A includes on-chip RAM, 10BASE-T transmit and receive filters, and a direct ISA-Bus interface with 24 mA Drivers.

In addition to high integration, the CS8900A offers a broad range of performance features and configuration options. Its unique Packet Page architecture automatically adapts to changing network traffic patterns and available system resources. The result is increased system efficiency. [2]

2.1. Analog inputs board

The CS5533 are highly integrated DS Analog to-Digital Converters (ADCs) which use charge-balance techniques to achieve 16-bit performance. The ADCs are optimized for measuring low-level unipolar or bipolar signals in weigh scale, process control, scientific, and medical applications. [3]

To accommodate these applications, the ADCs come as four-channel devices and include a very low noise chopper-stabilized instrumentation amplifier (6 nV/vHz @ 0.1Hz) with selectable gains of 1×, 2×, 4×, 8×, 16×, 32×, and 64×. These ADCs also include a fourth order DS modulator followed by a digital filter which provides ten selectable output word rates of 7.5 Hz, 15 Hz, 30 Hz, 60 Hz, 120 Hz, 240 Hz, 480 Hz, 960 Hz, 1.92 kHz, and 3.84 kHz (for an input clock MCLK = 4.9152 MHz).

The REF200 combines three circuit building-blocks on a single monolithic chip two 100µA current sources and a current mirror. The sections are dielectrically isolated, making them completely independent. Also, since the current sources are two terminal devices, they can be used equally well as current sinks. The performance of each section is individually measured and laser-trimmed to achieve high accuracy at low cost. [4]

The sections can be pin-strapped for currents of 50µA, 100µA, 200µA, 300µA or 400µA. External circuitry can be used to obtain virtually any current.

Features: The REF200 is available in plastic 8-pin mini-DIP; completely floating, no power supply or ground connections; high accuracy: 100µA ±0.5%; low temperature coefficient: ±25ppm/°C; wide voltage compliance: 2.5V to 40V; also includes current mirror.

The LT1019 is a third generation band gap voltage reference utilizing thin film technology and a greatly improved curvature correction technique. Wafer level trimming of both reference and output voltage combines to produce units with high yields to very low TC and tight initial tolerance of output voltage. [5]

The LT1019 can both sink and source up to 10mA and can be used in either the series or shunt mode. This allows the reference to be used for both positive and negative output voltages without external components. Minimum input/ output voltage is less than 1V in the series mode, providing improved tolerance of low line conditions.

Features: tight initial output voltage: <0.05%; ultra low drift: 3ppm/°C typical; series or shunt operation; curvature corrected; ultrahigh line rejection: ˜ 0.5ppm/V; low output impedance: ˜ 0.02O; plug-in replacement for present references; available at 2.5V, 4.5V, 5V, and 10V; 100% noise tested; industrial temperature range in SO-8.

The TCN75 is a serially programmable temperature sensor that notifies the host controller when ambient temperature exceeds a user-programmed setpoint. Hysteresis is also programmable. The INT/CMPTR output is programmable as either a simple comparator for thermostat operation or as a temperature event interrupt. Communication with the TCN75 is accomplished via a two-wire bus that is compatible with industry standard protocols. This permits reading the current temperature, programming the setpoint and hysteresis, and configuring the device. [6]

The TCN75 powers up in Comparator Mode with a default setpoint of 80°C with 5°C hysteresis. Defaults allow independent operation as a stand-alone thermostat. A shutdown command may be sent via the 2-wire bus to activate the low-power standby mode. Address selection inputs allow up to eight TCN75's to share the same 2-wire bus for multizone monitoring.

Features: solid state temperature sensing; 0.5°C accuracy; operates from – 55°C to +125°C; operating range 2.7V - 5.5V; programmable trip point and hysteresis with power-up defaults; standard 2-wire serial interface; thermal event alarm output functions as interrupt or comparator / thermostat output; up to 8 TCN75's may share the same bus; shutdown mode for low standby power consumption; 5V tolerant I/O at VDD = 3V; low power 250µA, operating; 1µA in shutdown mode; 8-Pin SOIC, and MSOP packaging.

2.2. System extension

A second solution of the board eliminated the converter chip and made place for 2 extension boards with functions like: analog input / output, digital input / output, connected through 15 pin connectors (allowing SPI data connection with converters). The system has also been improved by adding a real time clock (RTC).

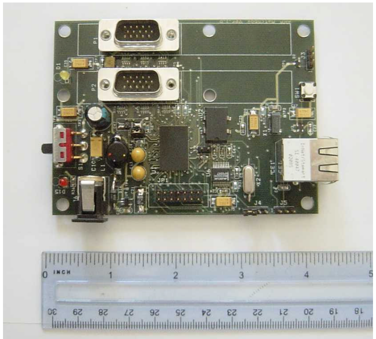

Figure 4 – Front view of the second solution

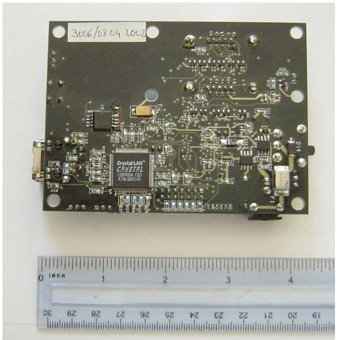

Figure 5 – Rear view

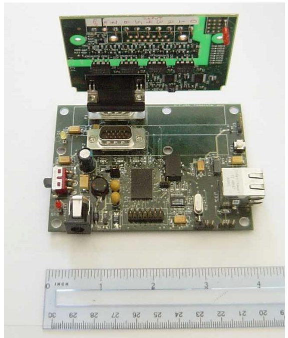

Figure 6 – Functional view

The PCF8583 is a clock/calendar circuit based on a 2048-bit static CMOS RAM organized as 256 words by 8 bits. Addresses and data are transferred serially via the two-line bidirectional I2C-bus. The built-in word address register is incremented automatically after each written or read data byte. Address pin A0 is used for programming the hardware address, allowing the connection of two devices to the bus without additional hardware. [7]

The built-in 32.768 kHz oscillator circuit and the first 8 bytes of the RAM are used for the clock/calendar and counter functions. The next 8 bytes may be programmed as alarm registers or used as free RAM space. The remaining 240 bytes are free RAM locations.

Features: I2C-bus interface operating supply voltage: 2.5 V to 6 V; clock operating supply voltage (0 to +70 °C): 1.0 V to 6.0 V; 240x8-bit low-voltage RAM; data retention voltage: 1.0 V to 6 V; operating current (at f_{SCL} = 0 Hz): max. 50µA; clock function with four year calendar; universal timer with alarm and overflow indication; 24 or 12 hour format; 32.768 kHz or 50 Hz time base; serial input/output bus (I2C); automatic word address incrementing; programmable alarm, timer and interrupt function.

3. SOFTWARE

We are dealing with embedded system with low resources compared to a PC. Therefore we need a flexible operating system that uses low resources maintaining the functionality of a normal PC operating system. We decided to work with eCos [8], which is an open source, royalty-free, real-time operating system intended for embedded applications.

The highly configurable nature of eCos allows the operating system to be customized to precise application requirements, delivering the best possible run-time performance and an optimized hardware resource footprint. It has support for our processor and due to its open source nature we were able to integrate all the support we needed for building an Ethernet data acquisition system.

Keeping in mind that we are dealing with low memory resources we had to use the Light Weight Internet Protocol stack (lwIP), who's focus is to reduce the RAM usage while still having a full scale TCP, making it suitable for use in embedded systems with tens of kilobytes of free RAM and room for around 40 kilobytes of code ROM.

Figure 7 presents a possible acquisition network with a PC acting as "supervisor" that can access any of the Ethernet Data Acquisition Systems (EDAS) acting as "slaves". Each of the boards has its own IP address in the master's subnet. The PC connects to a "slave" through a TCP socket and gives commands for configuration, acquisition and receives data from it.

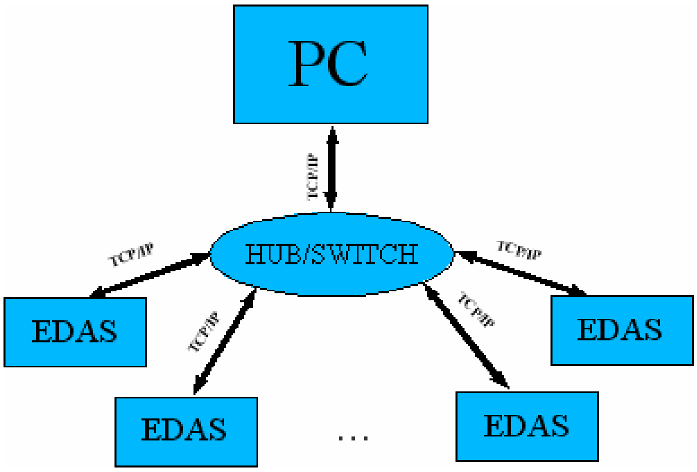

Figure 7 - Acquisition network example

Single point and continuous acquisition as well as analog output or digital input/output are possible. Once the real time clock synchronized with the system clock (PC), data can be time stamped for later processing on the PC. Without time stamps the PC reconstructed input waveform would not be the shadow of the real signal due to the fact that TCP/IP delays are unpredictable and variable.

EDAS' target was a TCP/IP enabled acquisition board for monitoring real life processes. Due to its powerful real-time operating system, EDAS can perform more than just monitoring tasks. It can also run local control loops with parameters and setpoint set through TCP/IP connection.

Figure 8 presents a temperature control demo application that uses one EDAS for measuring the temperature of the system and for turning on/off the heater (bipositional control algorithm).

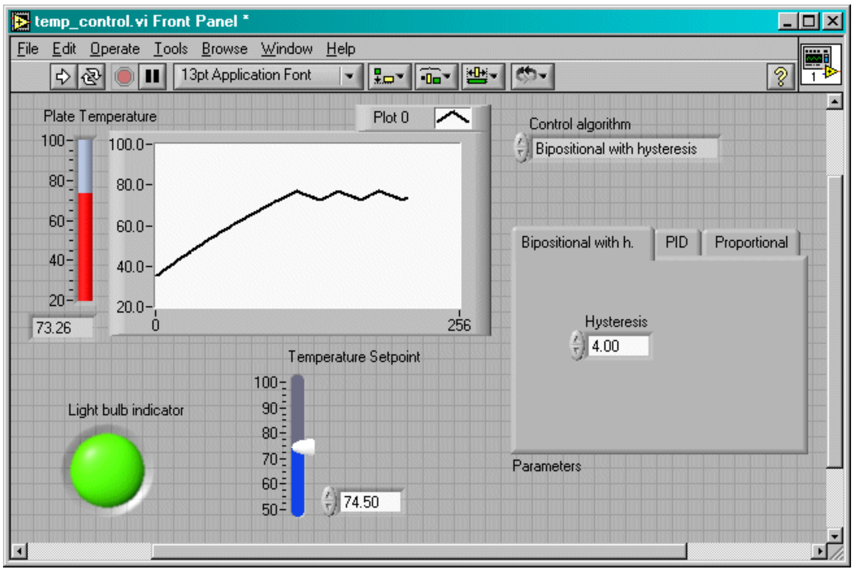

Figure 8 – LabVIEW test application

4. CONCLUSION

The Ethernet Data Acquisition System is an embedded powerful and intelligent data acquisition board enabling remote monitoring and local control of real life systems. It is TCP/IP ready and has an embedded real-time operating system that assures fast, parallel and prioritized task execution. As seen in figures 2 to 6 it has a small footprint, allowing easy integration into complex systems.

If connected directly to a computer (no collisions on the Ethernet) it can assure higher performance, similar to a dedicated acquisition board in a PC.

Voltage input domains are: ±2.5V, ±1.25V, ±625mV, ±312.5mV, ±156.25mV, ±78.125mV, ±39.0625mV.

The precision and stability of the measured values is excellent and guarantied by the converter (ADC) and the reference voltages but nevertheless by the quality of the PCB board.

Power consumption is 180mA at 3.3V while data acquisition is on and data is transferred through Ethernet interface.

5. REFERENCES

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