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COST-AWARE SOLUTION (HARDWARE AND SOFTWARE) FOR MONITORING APPLICATIONS

DEAKY, B[ogdan] - A[lexandru]

Abstract: *As part of the author's research work in the telemanufacturing field, a couple of solutions for remotely monitoring manufacturing machines are being developed. This paper introduces a low-cost data acquisition solution (including hardware and software), in an advanced development stage.*
Key words: *teleengineering, telemanufacturing, remote monitoring*

1. INTRODUCTION

During the next years, the author will be engaged in research in the telemanufacturing field, in order to design and develop new solutions. While several solutions might be researched, a good part of the efforts are and will be directed towards the ones that prove to be well-performing and also cost-aware. The solutions concern the remote monitoring of fabrication machines (involving both hardware and software) as well as the customer orders and production management (involving mostly software).

One of the problems that arose right at the beginning was to achieve the sensor data acquisition and the transmission of this data to a PC. It is an essential part of any monitoring problem, no matter whether one needs to achieve local monitoring or to have a real-time situation report regarding a factory, let's say, on a mobile phone.

2. SHORT STATE-OF-THE-ART

Of course, there are available state-of-the-art solutions. The reader might be aware of the high-quality hardware platforms offered by National Instruments and their versatility, like Compact RIO. In the beginning of this year, the author found himself very pleasantly surprised to discover the advancement level achieved by the tools (both hardware and software) they provide. NI is certainly following the new trends and now their tools can be used even for developing remote monitoring applications (there is a special browser plugin that helps display and use a LabView application over the Internet and, for some time now, outputting applications to some mobile platforms has also been made possible). A very good example of such an application is presented in (Le Roux, 2010) and concerns cooperative remote learning in chemical engineering. Tag4M is also worth mentioning: a new device which "digitizes the data to send it on to Access Points, where the data is routed to the Internet and a Server IP" (Tag4M, 2010), thus creating an instrumentation cloud. (Ursutiu et al., 2010) discusses its use in predictive maintenance and machine control.

Although it is true that they also offer very good quality and performance and a large number of features, most of the state-of-the-art solutions have a high price. The cheapest LabView license costs over 1000 Euros (does not output .exe files) and a Compact RIO module can easily reach 1000 Euros (NI, 2010). Small manufacturing centres and researchers form a niche that requires a smaller number of these features and might not afford to pay the prices involved with the full set. In Tag4Ms case, the prices are affordable, but only a few institutions have access to firmware development tools (fortunately, the author might get access in the future and will experiment with these tags).

3. OWN SOLUTION

Because of the reasons enumerated above, the author decided to get involved in electronics and develop a couple solutions of his own (including both hardware and software). This paper is about the first PCB (fig.1) and software that he developed to learn and experiment. By the time that this paper is being written, the board already turned out to be a performing, promising and low-cost solution. The author wants to thank Dr. Mihai Manescu, who is the designer of the circuit on which the initial board is based and personally assisted the author to get a fast start in the field.

At the boards core lays a high-performance, low-power AVR ATMega8 microcontroller (8-bit), manufactured by Atmel. It features an advanced RISC architecture and high endurance non-volatile memory segments (including 8KB Flash program memory, 512 Bytes of EEPROM and 1KB of SRAM) and has up to 16 MIPS throughput at 16 MHz (with external oscillator).

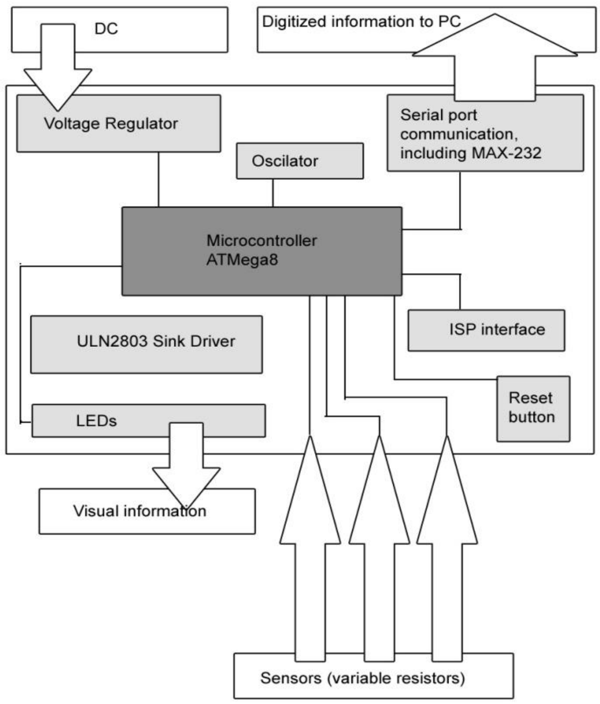

Fig. 1.The PCB with adjustable resistors as sensors

For more information one can refer to the datasheet; the author only wants to add an important fact: the ATMEga8 includes a 6-channel Analog Digital Converter in PDIP package (8 channels in TQFP) which allows reading the data from 6 input lines. All these values might seem small when compared to high-end microcontrollers, but one can rest assured that they are more than sufficient for a monitoring problem that includes the mentioned number of inputs. These numbers also mean to lower costs.

The board also includes a voltage regulator (5V DC), an external 16Mhz oscillator, MAX232 circuitry for serial port communications and an 8 channel Darlington Sink Driver, also called a Relay Driver to offer the possibility of driving external devices (not exploited yet in the current layout). Additional wiring has been protected with tubular cables and made versatile by attaching female connectors. To be able to conduct tests, adjustable resistors (attached to male connectors) were used as sensor input. The total cost of the materials was under 40 Euros.

An important cost-related aspect is that the development environment supplied by Atmel, AVR Studio, is free to download and use, without any restrictions (a clear advantage when compared to other IDEs, like CodeWarrior). Also, there is very good documentation for Atmel microcontrollers and a very supportive user community, which makes learning very easy.

A couple of firmware versions were developed with AVR Studio 4, of which the latest version displays the following features:

- MCU Port initialisation (input sand outputs definition).
- Initialisation of serial port communications, timers and ADC.
- Reading and converting sensor data.
- Bidirectional serial port communication (the MCU sends the sampled data at predefined intervals; the user can specify which sensors to query and the sampling interval, by pressing PC keyboard keys) (see fig.2).
- Turning the LEDs on and off to communicate also visually with the user.
- Saving user settings into EEPROM so that they can be read and reapplied after restarts (see fig.2).

It is important to mention that the current firmware version is based on interrupts and flag variable usage. This increases the overall performance and brings the software architecture close to a RTOS (Real Time Operating System).

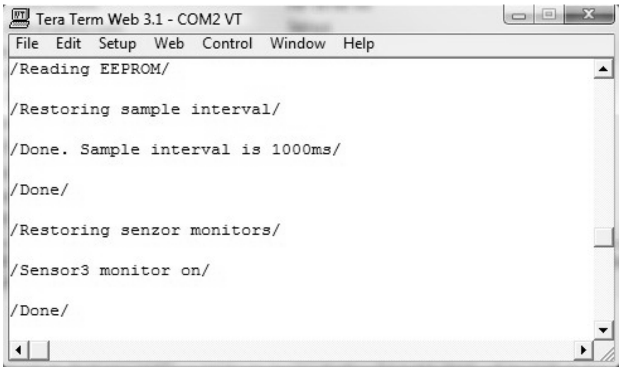

Fig. 2.Serial communication snapshot (on restart)

4. FUTURE RESEARCH

Regarding this specific research direction, the author intends to carry out the following activities in the near future:

- Decrease current consumption by modifying the software in order to use different power/sleep modes.
- Decrease the space occupied and the current consumption by prototyping a new circuit, using a Freescale prototyping board; create packaging.
- Make an alternative solution, based on Tag4M.
- Develop dedicated PC software for analytics and communication with the board, using C++ with QT and the optimization methods published in (Deaky, 2008).

Regarding general research directions, the author intends to achieve the following goals:

- An external simultaneous monitoring system of manufacturing machines, with data output to the Internet. The system will involve hardware and software components. The possibility to make the data accessible with mobile devices in planned as well. This paper is related to this objective.
- An online software system for client order and production management, dedicate to rapid manufacturing centres (with CNC and RP machines) based also on a study related to specific requirements of external cylindrical gears. There will be two main parts, one useful to the client and the other useful to the manufacturer. It will include user management, ordering and production planning (with alerts).
- A special online monitoring system that involves monitoring of the cutting process parameters and other internal parameters of a CNC mill with FANUC controller. The system will include communications with the machine, using protocols provided by the manufacturer.

5. CONCLUSION

The telemanufacturing field has speeded up its development in the last years, due to globalization and the development of the Internet. Research in this field has tough interdisciplinary requirements but can also be very rewarding. Its results can be brought also to smaller manufacturers in the form of specialised systems adapted to their logistical needs and also to their sometimes limited budget. During the following years, , the author will pursue the enumerated objectives to research and develop affordable and original hardware and software solutions for remote monitoring and rapid manufacturing factory management.

6. AKNOWLEDGEMENTS

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