A LOW COST CAN NODE FOR A/D MEASUREMENTS IN ATLAS

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ABSTRACT

We have developed a CAN node suitable for A/D measurements and data I/O in the Muon Spectrometer for ATLAS. It is based on commercial hardware and software from Phytec Corporation [1] and programming software from Keil Software[2] and DAvE [3]. The advantages besides very low cost are commercial design and ease of programming and debugging. Phytec provides a CAN node based on the Siemens' C515C 8 bit microprocessor [4] and provides tools for downloading programs. Keil Software supplies an integrated development environment for programming the C515CC. The CAN node along with 48 channels of TMP37 [5] temperature sensors has been radiation tested to 1 10^{12} neutrons/cm^2 [6] and 3 10^{12} neutrons/cm^2 [7] at two sites.

DESIGN CONSIDERATIONS

The ATLAS Muon spectrometer may have on the order of 100,000 voltages to monitor, perhaps on the order of 50,000 temperature generated voltages and low voltages on the MDTs (Monitored Drift Tubes) alone. ATLAS Muon also requires the downloading of chamber constants and the ability to refresh or change programs operating on the CAN nodes over the CAN bus. The ATLAS philosophy for electronics is to use suitable commercial products where available and CAN is the standard for detector control. Hence this development was predicated on finding what might be available in the CAN commercial market upon which to base a design for A/D measurements and data I/O. The most challenging part of the CAN node was the CAN node itself and software for downloading programs. Within ATLAS Muon there are varying needs of functionality for the CAN nodes as well. Hence the design approach adopted was to find a commercial node with the required computer functionality and memory and to which a daughter board could be easily attached and provide the specific functionality required of the node. The Phytec KitCon 515C meets these requirements. All computer ports are available on a header to which a daughter board can be attached just by plugging it on.

One reason for choosing the Phytec KitCon 515C (www.phytec.com) besides low cost were the availability of software tools for ease of programming. Phytec has on board software tools that allow the downloading of software my means of a built in RS232 port and more recently over the CAN bus itself. Keil Software (www.keil.com) provides tools for writing software and debugging it both in emulation mode and run time mode. DAvE provides many programming examples for the C515C. Other reasons were the large number of multifunctional I/O ports (six), optically isolated CAN bus, 256K flash ROM and the availability of CANOpen protocol.

HARDWARE DESCRIPTION

The Phytec KitCon 515C is full 2.0B CAN compliant. It is optically isolated from the CAN bus using HCPL-0601 optical isolators. This enables the ATLAS grounding rules to be maintained as the power for the front end transceiver and optical isolator front end is supplied from the bus while all the local functionality power is supplied from a locally grounded source.

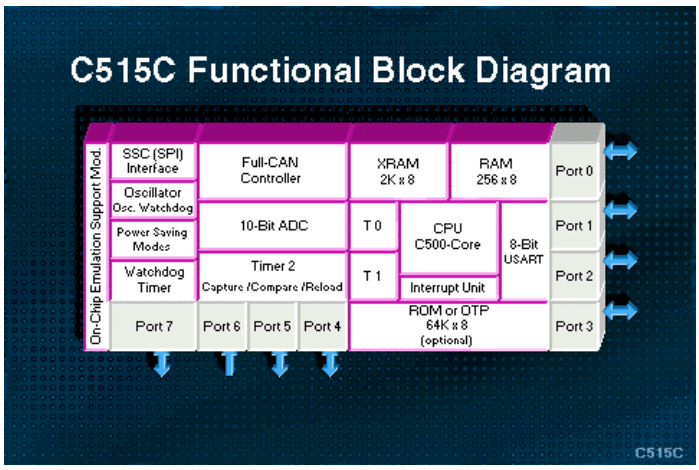

Figure 1. Shows a block diagram of the C515C processor.

The Siemens C515C microprocessor (see Figure 1.) provides many different internal peripherals including;

- SSC (Synchronous Serial Channel) - serial port compatible with the common SPI interface.

- Full CAN 2.0B controller - Controller Area Network .
- 2KB of XRAM
- 256Bytes of RAM
- 2 16-bit Counter/Timers
  –fully compatible with timer/counters 0 and 1 of the 80C51.
- 1 16-bit Counter/Timer with capture and compare
  – Compare : up to 4 PWM signals with 65535 steps at maximum, and 600 ns resolution.
  – Capture : up to 4 high speed capture inputs with 600 ns resolution.
  – Reload : modulation of timer 2 cycle time.
- 8-bit USART - can be used for RS-232 communications, includes it's own baud-rater generator.
- Watchdog timer - used to initiate a hardware reset incase of a software upset.
- 10-bit ADC - low impedance A/D converter with 8 multiplexed inputs. Requires an input buffer/amp.
- 64KB of ROM or OTP (optional)

The Siemens C515C microprocessor contains 7ports; six 8-bit multipurpose ports, and one 1-bit port

The C515C has the following port definitions:

- Port 0 is a bi-directional 8-bit digital port, alternatively it is used as an Address/Data bus for external memory accesses.

- Port 1 is a quasi-bidirectional 8-bit digital port with internal pull-up resistors; alternatively the pins of this port can be used for the inputs/outputs to the capture and compare unit, it can supply a system clock output, and it also has the Counter 2 input .

- Port 2 is a bi-directional 8-bit digital port, alternatively it is used to supply the high byte of a 16-bit address in association with Port 0.

- Port 3 is a quasi-bidirectional 8-bit digital port with internal pull-up resistors; alternatively the pins of this port can be used as an asynchronous serial port, counter/timer inputs, external interrupts, and the RD/WR control lines for external memory access.

- Port 4 is a quasi-bidirectional 8-bit digital port with internal pull-up resistors; alternatively the pins of this port can be used as the a CANBus serial interface, a Synchronous Serial Channel port, more external interrupts, and the A/D external start pin.

- Port 5 is a quasi-bidirectional 8-bit digital port with internal pull-up resistors; alternatively, Port 5 can also be made into a true bidirectional port which will provide CMOS levels.

- Port 6 is a unidirectional 8-bit port to the internal A/D converter; alternatively the port can be used as digital inputs if the voltage levels meet the high/low input voltages.

- Port 7 is a 1-bit port which can be used as a general digital input/output; alternatively this port can be used as an external interrupt line.

The Phytec KitCon 515C uses the Siemens C515C processors as the heart of its board. The Siemens C515C CPU can address the following:
– up to 64 Kbyte of internal/external program memory
– up to 64 Kbyte of external data memory
– 256 bytes of internal data memory
– 256 bytes CAN controller registers / data memory
– 2K bytes of internal XRAM data memory
– a 128 byte special function register area

Using the capabilities of the CPU to address larger amounts of memory than is currently available on the CPU, Phytec has added a 128KB Flash ROM, and a 32KB RAM chip. As well as an address decoder for accessing these chips. Phytec also provides three pre-decoded Chip Select (CS) lines for the user, to allow adding external devices to the memory bus. Phytec also provides both a RS-232 and CAN transceiver, as well as providing opto-isolation for the CANBus using Hewlett Packard HCPL-0601 opto-isolators. Phytec also includes a 10MHz oscillator crystal and a regulated power input for the CPU. This whole development system is contained on a 6U Eurocard, with half of the space left for a user development area. Phytec has divided the area with a 152 pin header, which contains all of the outputs/inputs of the CPU, and allows a user to attach external devices to it.

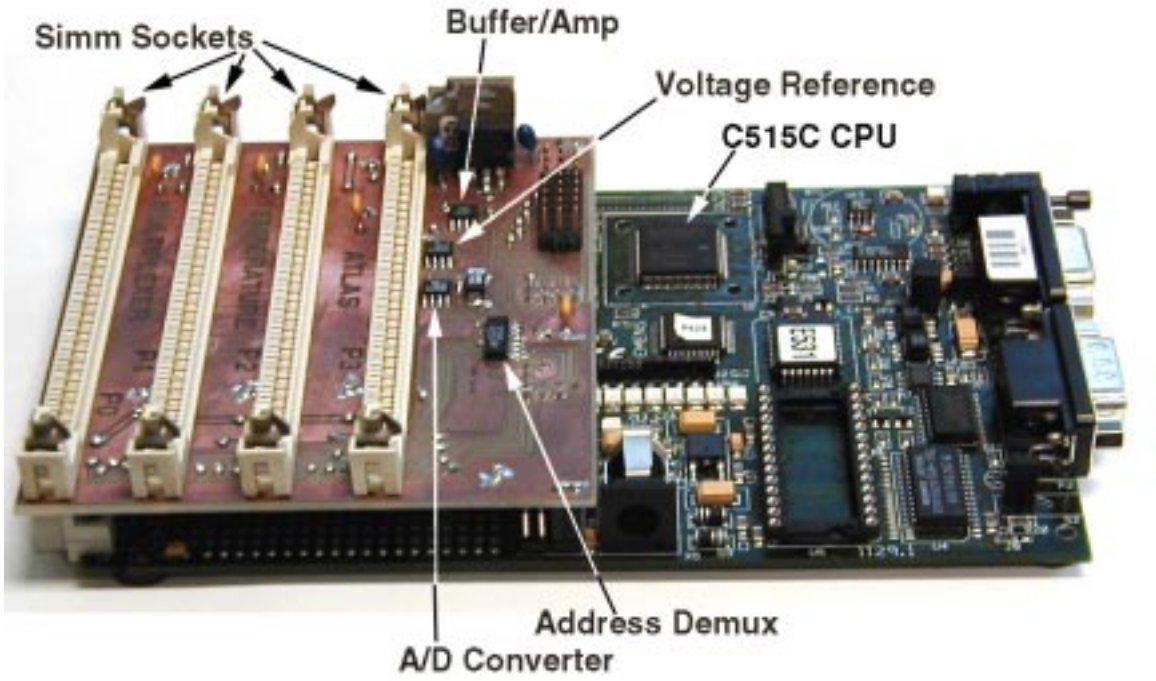

Figure 2. Photograph of the KitCon 515C with a 64 channel A/D daughter board mounted on it.

A version that we have built was designed for 64 12 bit A/D channels (see Figure 2.). A MAX1241 was chosen for the A/D and three MAX306 were selected for the analog multiplexing channels (www.maxim-ic.com). The MUX units were controlled from three I/O ports on the C515C and the A/D was read out achieved using one of the C515C serial ports. The A/D, MUX , MAX6225 voltage reference and sensor input connectors ware laid out on a daughter board that was then plugged into the KitCon.

For testing the 48 channel board we used Analog Devices TMP37 temperature sensors. These had the appropriate range of 0 to 125 °C with output voltage of 0 to 2.5 V or 20 mV/°C. Shielded twisted pair cables were used for the three wire hook up to the sensors. To minimize costs and provide secure connections the sensor cables were attached to a printed circuit board that plugged into SIM connectors mounted on the motherboard.

RESULTS

The noise level for the TMP37 on 6 meter cables was no more than a least count of 0.03 °C. The device was run while collecting 10^{12} fast neutrons/cm^2. No problems were observed during the approximately two hour run carried out at the University of Washington Hospital's cyclotron for neutron therapy. Approximately 99% of the neutrons had their energies between 100 KeV and 45 MeV. These high energy neutrons amounted to about three times the worst case dose for the MDT nodes over the expected 10 year running period. A second radiation test was carried out at the French Prospero facility where the dose was 3 10^{12} neutrons/cm^2.

The KitCon has also been set up to do data I/O using a counter timer chip (chip number) to provide clock signals stepping motors. Additional ports are used to control motor direction and gate off the stepping. The existing library of control software made this a very straight forward application to program.

REFERENCES

[1] PHYTEC Messtechnik GmbH
Robert-Koch-Str. 39
D-55129 Mainz, Germany
(www.phytec.com)

[2] Keil Elektronik GmbH
Bretonischer Ring 15
D-85630 Grasbrunn, Germany
(www.keil.com)

[3] DAvE, Infineon Digital Application Engineer, Version 1.0

[4] Siemens/Infineon: Infineon Technologies AG
P.O. Box 800949
D-81609 Munich, Germany
(www.infineon.com)

[5] Analog Devices
Corporate Headquarters
One Technology Way
P. O. Box 9106
Norwood, MA 02062-9106
(www.analog.com)

[6] University of Washington Hospital cyclotron

[7] Prospero, French Nuclear Facility