The Octagon™ embedded PCs and their Applications for Industrial Purposes

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Abstract - **The paper presents some practical results from the implementation of the Octagon™ high performance controller boards type 2060 PC/104 CPU. The industrial use of the board in study determines the special attention given to the reliability features of the module. The authors examine various exploitation factors that affect mostly the uninterrupted work of the module and hence devices based on it. A practical block diagram of a test device is presented and its work analyzed in the context of the 2060 features already outlined.**

Keywords - **Industrial controllers, Octagon, reliability**

I. INTRODUCTION

Industrial applications generally require except for high reliability, certain minimum compliance with power, repair and size requirements. Originally LS TTL technology was used in the design of the industrial computers. Because of the rapidly increasing number of components in the PCs, designers have turned sights to CMOS technology in order to satisfy very often contradicting needs. If we limit our study to the most important in our opinion characteristic of the industrial PCs – the reliability – we should examine in more detail the most common reasons for failures in the industrial embedded systems and in particular these built on CMOS technology. [1, 2, 3]

II. OCTAGON™ PCS RELIABILITY CHARACTERISTICS

The Octagon™ embedded industrial computers generally follow classic design pattern for implementation of CMOS circuits and hence they feature several most common reasons for failure – over voltage of the power supply, static dischargers and damage to the serial and parallel ports. The case with the random component failure is intentionally excluded from this list as the average MTBF of an Octagon card is greater than 11 years.

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The company reports [1] that in a seven year study is has never found a single case where multiple IC failures were not caused by misuse or accident. This result might mean that multiple component failures indicate that they were user induced.

Over voltage is perhaps most common reason for general or partial failures on these controllers. Same source [1] cites a figure of average 50% failures due to over voltage reasons

The company's study points to the following order of failure in the components mounted on the PC boards in cases of over voltage – programmable logic devices (PLCs), EPROMs and CPUs.

These results should be taken into account when diagnosing devices built with Octagon components.

Static discharges appear to be not as much serious as over voltage, but still essential enough to be considered, especially in industrial application. Usually failures from static discharges come from improper wiring and in particular open leads connected to I/O lines. In the case with the Octagon controller PCs this reason for device failure is almost completely excluded due to special measures taken by the designers to avoid static discharges. Though the company does not reveal its practices in this respect the overall effect of these failures are claimed to not exceed 3% of all registered cases of malfunction. Carried out tests at the laboratories of the Technical university of Varna indirectly confirmed such low figure as there was not a single case of PC board failure due to static discharge reasons during several months' intensive work with Octagon PCs and numerous cases of high voltage use close to or even in connection to the boards. No special measures were taken to prevent static charge induction in all instances [1].

More common reason for component failure appears to be improper power sequencing. As a rule of thumb, this refers to I/O lines connection when no special measures are taken either to avoid or to reduce negative effect of powering through I/O lines. If we apply +5 V to the input of a TTL chip with main power to the PCB off, there will be no visible effect. Applying +5V to a CMOS card however, at the same condition will cause current flow through this input and out the 5V power pin. This current attempts to power up the whole card. Most inputs are rated at 25 mA maximum and when this is exceeded, the chip may be damaged. A possible solution to avoid this and the previous case of failure threats is by introducing opto-couple isolation of the I/O lines on the Octagon controllers.

III. THE 2060 PC/104 CPU FEATURES

A 2060 PC/104 CPU card was used for both study and special design development. It integrates serial communications, IDE hard disk port, floppy disk port, CompactFlash socket, a multifunctional parallel port, digital I/O, two USB ports, keyboard, mouse and speaker ports and video. The 2060 CPU card can be used in a stand-alone mode or expanded through PC/104 interface. It should be noted however that 2060 as stand-alone CPU card cannot be used as an expansion one to another CPU card. The module comes with a BIOS loaded on a flash device for easy updates. Software wise it is fully compatible with most popular operating systems. Internal block structure is not revealed by the company, hence the whole unit is looked at as a black box with specified software features further implemented by the designers. [1, 2]

Following are the major hardware features of 2060 CPU Card.

A. CPU Procesor

The CPU is a high-performance. low-power AMD Geode GXI processor with clock speed of 233 or 300 MHz, jumper selectable. It uses CS5530A companion chip for some of the peripherals. The built-in ISA bus speed is 8.33 MHz.

SDRAM

Originally the card comes with 0 MB RAM. The memory socket can accept up to 256 MB capacity SO-DIMM modules type PC100 or PC133.

B. On-Board Flash

On board is a 512 kB SMT boot flash that contains the BIOS.

C. Compact Flash Soket

The CompactFlash socket accepts Type I and Type II CompactFlash cards. They appear as an IDE device to the system. It is implemented with ATA-4 compliant IDE controller and appears in Setup as primary IDE device.

D. Hard Disk and Floppy Disk Ports

A special 80-pin connector on the bottom side of the board is provided for connection of the hard disk. The IDE connector does not supply +5V to the hard drive. The hard drive is implemented with a second IDE controller. The BIOS supports up to two IDE drives in addition to the CompactFlash. The floppy drive is supported through the LPT port. Specific to the Card is that only LPT-to-floppy cable (part #6470) can be used to connect the external disk device. The option to use floppy with the LPT is selected from the LPT menu of BIOS Setup.

E. USB Port

The CS5530A companion chip supports two USB 1.0 channels, available when using an operating system that supports USB. There is no support from Octagon for DOS legacy USB. Both channels are HCI compliant.

F. Digital I/O

The 2060 has 16 digital I/O lines on the 80-pin connector and an additional 8 lines on a separate connector. All lines are 0-5V logic compatible, individually programmed as inputs or outputs.

G. ESD protected serial ports

The 2060 CPU Card has two serial ports. COM1 and COM2 provide RS-232C, COM2 also supports RS-422 and RS-485 interfaces. The latter are available through a separate connector. All serial I/O are ESD protected for discharge voltages of up to ± 8kV.

H. Multifunctional printer port

The 2060 CPU Card incorporates the latest enhanced parallel port and includes unidirectional, bi-directional, ECP, EPP and Floppy Drive modes.

K. Video

The board supports CRT monitors up to 1280 x 1024 x 8 resolution and flat panel displays with up to 1024 x 768 x 8 bpp resolution.

L. Setup EEPROM

Loss of Setup information is a serious issue in industrial application. Most PCs store their Setup information in battery-backed CMOS RAM. This however leads to the risk of loosing the information in a case of incidental discontinuing of CMOS powering. The 2060 CPU uses EEPROM to store Setup information of up to 1024 user available words. Access to this memory is with the help of special routines that come together with the controller. [4]

IV. WATCHDOG TIMER FOR SAFETY

This hardware feature monitors the program work and resets the system in a case of unexpected software stops. It is enabled, disabled and strobed under software control. The time period for activation is programmable from 2 ms to 120 s with a variability of ±50%. To avoid an undesired reset of the system, the timer should be strobed at least twice faster than the programmed activation period. Such an approach will guarantee that no control period will be lost, which will consequently reset the system.

A. PC/104 interface

This is a standard interface feature accepting 8- and 16-bit PC/104 expansion boards. Up to four such PCBs may be stacked on the 2060 CPU Card.

B. Power and Environmental Ratings

The Card is single voltage operated – +5V – and typically consumes between one and 2 A in different modes of operation. Operating temperature is -40^{o} to 85^{o}C at both operating frequencies (-55^{o} to 95^{o}C no operating). Guaranteed shock steadiness is 40g in three axes and vibration stability is 5g in three axes. Partly these features are due to the extremely compact dimensions of the board – 9 x 9.5 x 2 cm.

The major software features correspond to the main use of the controller as an industrial one, and consists of: a start-up diagnostics operating automatically at power start-up or reset conditions; Phoenix Software BIOS with special Octagon defined extensions (access to watchdog functions, serial EEPROM, digital I/O, etc.); multiple boot sequence ability from CompactFlash, floppy disk, hard disk, or a CD-ROM.

The 2060 CPU Card does not come with an installed operating system. Users may install an operating system onto a hard drive or CompactFlash card. All common OS can be installed on the Octagon Systems – Windows CE.net, Linux, QNX and ROMDOS 7.1. The manufacturer offers a number of development kits for these OS, but there is no problem to install the software without them. Such an installation of a Linux OS was tried during tests with the 2060 CPU Card at the Technical University of Varna. No loss of functionality was noticed by the developers including special features of the board like watchdog timer and digital I/O. The CompactFlash storage option was selected as most convenient.

The 2060 CPU Card BIOS has a comprehensive Setup configuration program, available during BIOS POST sequence by pressing “F2” key. An option for reverting to factory-programmed defaults allows reconfiguring the Setup by forcing all adjustable features to predetermined values. Basic system configurations are available through main and submenus, similar to common PCs. [1, 2, 3, 4]

V. Application Issues - 2060

For test and evaluation purposes a basic configuration with Octagon 2060 was produced (see Fig.1)

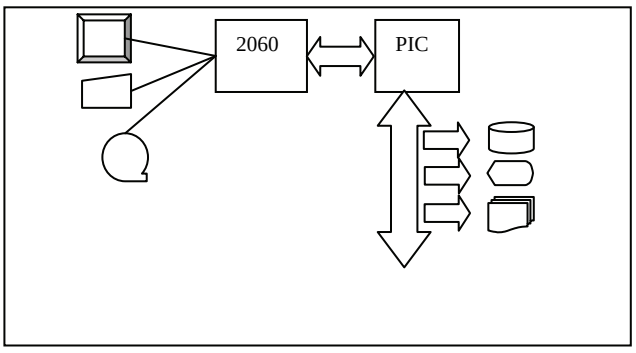

Fig. 1

In this configuration, the main embedded PC is based on the use of 2060 Octagon CPU Card, which provides basic communication with standard I/O devices – display, keyboard, storage media. The link to the primary sources for information and execution units is through a special PIC microcomputer. The 2060 and the PIC microcomputer communicate through the built-in USB port of the 2060. Similarly, the two devices can be connected through the ISA bus. In this case, however, the latter must be simulated on the on-board 80-pin connector with appropriate drivers from both sides. The final solution depends on the overall information flow between basic I/Os and the Octagon CPU Card as well as on the speed of information exchange through the channel.

As mentioned earlier a CompactFlash option for storing OS and application was selected in the test configuration described in this paper. The built-in CompactFlash socket of 2060 supports 3.3 V devices. The storage media attached to this port appears to the system as an IDE device. It is automatically detected and configured as a hard drive during bootup. The CompactFlash socket is connected to the Primary IDE channel. The channel itself is configured for a Master device only. Therefore if a CompactFlash device is installed, it will show up as a Master on the Primary IDE channel. Any additional IDE devices will show up as Secondary IDE devices. The design in test used 512 MB flash card to store OS and application. This was possible because of the compact size of the OS (limited Linux version). An advantage of the implemented BIOS is its ability to support any floppy drive, and any standard IDE hard drive that has 16-bit IDE interface. Practically no additional software is necessary to attach all kinds of IDE devices. There is a quantitative limitation in the BOIS used with the 2060 CPU Card – this refers to three IDE devices (including CompactFlash) and two floppy drives, however the LPT connector will only support one floppy drive.

The industrial use of the test design required special role for the digital I/Os. 2060 offers 24 lines of the kind, grouped in 3 ports of 8 bits. All of the bits are with equal weight and priority. They can be independently programmed as either 5 V inputs or 5 V outputs. Any one of them can sink or source 15 mA, which in most cases is sufficient. In the practical application discussed here these I/O lines were used to control several (5) LEDs to signal different states of the device, to sense few switches (4) for control of special modes of operation and another 12 lines to read from a keypad to enter control data to the device. The latter were organized as 4 x 3 matrix outputs. The input from the keypad was organized by scanning the rows and the columns of the matrix.

The main communication between the PIC microcomputer and the 2060 was made via one of the USB ports of the 2060. As the exchange speed from the side of the 2060 exceeded the speed of the PIC, an interrupted flag-controlled mode was used to synchronize the two blocks. The equivalent speed of exchange was limited to 1 MB/s, which was sufficient for the purposes of the controller. The USB driver for the PIC was written in assembler language, while the 2060 OS used a standard Linux driver available from Internet. The second USB port of the 2060 was dedicated for wireless module connection for communication with any standard portable PC

with Windows OS. [4]

As the uninterrupted work of the device is critical for the safety of the equipment controlled by it, the watchdog timer function is not used in this application of the 2060 CPU Card.

VI. Conclusion

1. The Octagon 2060 CPU Card performs with an excellent stability in a wide range of operating temperatures (-30^o to +80^{o}C from test results).

2. High flexibility of the software possible for use allows for wide range of industrial control applications with provision for all common interfaces.

3. Low power requirements contribute essentially for the overall reliability of the devices using the 2060 controller by reduction of the thermal load to other modules when mounted in a common box with the 2060.

4. The compact dimensions and possibility to use CompactFlash devices as major storage media for the 2060, make the controller extremely suitable for remote standalone applications with a very high level of self sustainability.

5. The possibility for operation without any mechanically moving parts (hard drives or floppy disk drives) increases significantly the overall reliability of the devices based on the 2060 CPU Card.

References

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