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SOFTWARE COMPABILITY FREESCALE MICROCONTROLLERS HC08, HC11 AND HC12

PROGRAMOVÁ KOMPABILITA MIKROŘADIČŮ HC08, HC11 A HC12 FIRMY FREESCALE

Abstract

68HC11 represents the older generation of the Motorola microcomputers and its using is on the end. The microcomputers new generation step by step supply this very successful product and embody more high qualitative properties for the users and their applications. During the many years using HC11 there were built many software products and this contribution shows the one possible way to transfer finished software product for the HC08 and HC12 families using. There are described some products from the area of technological processes monitoring and discrete control as well as the necessary real time operating system for this applications.

Abstrakt

Jednočipový mikropočítač 68HC11 reprezentuje starší generaci mikropočítačů firmy Motorola. Jejich využití je již utlumováno a u nových aplikací se přechází na mikropočítače nové generace, které jsou výkonnější a z hlediska využití mají širší možnosti. Pro mikropočítač 68HC11, jehož aplikacemi se naše pracoviště zabývalo přibližně 15let, vznikla celá řada programů a knihoven programů pro aplikace v oblasti monitorování a řízení technologických procesů. Pokusili jsme se vloženou práci do vývoje programového vybavení zúročit ve smyslu hledání cest, jak programy přenést na novou řadu mikropočítačů. Volili jsme dva representanty této techniky – mikropočítače řady HC08 a HC12. V příspěvku jsou popsány realizované postupy, jak programy převést na tyto nové procesory.

1 INTRODUCTION

*Due to the compatibility of the instruction file of the families of single-chip microcomputers FreeScale HC11 and HC12, we were looking for a reduction of the software portability from HC11 to HC12. In the case of HC08 family using is the principle of the transformation program described. For solution HC11/HC12 compatibility we chose a specific representative of the HC12 family – MC9S12E128CPV for hardware and as for software, we chose a user library of modules for monitoring and control of technological processes developed for the HC11 microcomputers [1]. A part of this library is also the standard library for working in floating point and a real-time operation system, which is necessary for the above-mentioned kind of applications.

2 BASIC ARCHITECTURE OF 68HC12

Central processor unit (CPU12)

The core of the microprocessor 68HC12 is the CPU12, a high-speed 16-bit version of the 68HC11 architecture, which is projected to keep the compatibility with the 68HC11 at the level of the

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source code. 68HC12 fully supports all the internal registers, instructions, addressing modes and operating modes of the 68HC11. Additional features and advantages of the 68HC12:

- An up to 8MHz concentrator at the feed of 5V voltage, or a 5MHz concentrator at 3V
- 64 new instructions, a 20-bit arithmetical-logical unit (ALU), instruction queue and 7 new indexed addressing modes
- The CALL and RTC instructions for an efficient page addressing
- Instructions of the Fuzzy logic for simplifying of programming, reduced core and a faster code performance
- Quick mathematical instructions
- Low-powered WAIT and STOP regimes
- Background Debug Mode (BDM) – a possibility to debug the program right in the circuit

Flexible modular design

A standard concentrator Lite Module Bus (LMB) projected for a low input is used to connect the CPU12 to specialized peripheral modules. The LMB is similar to the Intermodule Bus (IMB) in the processor families 68HC16, 68300 and MPC500 that enables Motorola to convert the existing peripheral modules to the development of new 68HC12 derived types.

Low power, low supply voltage, low noise

The 68HC12 run at the frequency up to 8MHz and it was projected for an extended voltage range as well as for a low consumption. The device works with the supply voltage from 3,0V to 5,5V.

Background Debug Mode (BDM)

The 68HC12 offers the Background Debug Mode (BDM), i.e. tuning during the program running, which enables to reduce the time of application development. This extended, patented BDM version in 68HC16 and 68300 microcontrollers substitutes the usual tuning mode.

It enables an undisturbed access of reading and writing within the real time to the memory and registers for a faster program tuning. It also provides a FLASH reprogramming within the diagnostics and upgrade of final products.

FLASH EEPROM memory

Some kinds of the 68HC12 contain on their chip a permanent memory, which is repeatedly erasable and which supports operations with 8-bit or 16-bit data. Further more, a quick interruption is provided by a single-cycle access speed and optionally there are 1 up to 2 kB of a protected booting block. This innovative 16-bit memory sub-system offers many advantages.

EEPROM memory erasable by bytes

The 68HC12 family also contains a byte-erasable EEPROM on their chip to extend the programming possibilities no further infeed.

High performance timer

The 68HC12 timer offers flexibility, performance and an easy application. The system is based on a free-running 16-bit counter with a programmable pre-divider, an interruption when overflowed and with other functions of interruption.

Digital-analogue converter

The A/D converter periodically samples analogue signals and produces the corresponding numeric values.

- A linear approximation
- 8- or 10-bit recognition of the conversion

Pulse-width modulation

The 68HC12 family offers a choice of up to six canals of the pulse-width modulation (PWM) for the support of various applications.

Serial communication interface

Likewise HC11, the HC 12 also allows serial communications SPI and SCI.

Motorola Scalable CAN module (MSCAN)

The protocol of the local network of controllers (Controller Area Network – CAN) was originally developed by the Robert Bosch GmbH company to be used within the communication network in cars. Nowadays, the CAN is becoming a very popular device for application within industrial automation networks. The Motorola Scalable CAN module (MSCAN) is an advanced communication controller, performing the CAN protocol with the following features:

- Implementation of the CAN version 2 parts A and B
- Standard 11-bit and extended 29-bit data frames
- Data length from 0 to 8 bytes
- Programmable transmission speed up to 1Mb/s
- Support of distant frames
- Interception with a double buffer
- Emission with a triple buffer with an inner priorization applying the concept of "local priority"
- A flexible maskable filter of the identifier supporting alternatively two filters of the identifier of the full size of 32 bits, four 16-bit filters or eight 8-bit ones
- Programmable wakeup functions with an integrated bottom-permeable filter
- A programmable feed-back mode supporting the self-testing
- The ability of separated signalization and the interruption for the error states of all the CAN receivers and transmitters (warnings, interruption of the concentrator ...)

SAE J1850 Byte Data Link Control module (BDLC-D)

The BDLC-D is a circuit of an advanced serial communication multiplex concentrator working in compliance with the SAE J1850 Class B protocol. A typical application of the BDLC is in cars, where more BDLC microcontrollers can communicate through one- or two-wire concentrator; that reduces the weight and amount of wiring and adds more diagnostic possibilities.

The microprocessor applied

For the testing of the converted program modules, a derived model of the 68HC12 microprocessor has been used, namely the MC9S12E128CPV. This microprocessor is equipped with 8kB of the data memory RAM and with 128kB of the program memory RWM. This microprocessor further contains:

- Three independently adjustable communication canals SCI, one of which is connected to an IR interface IrDA
- One communication canal SPI
- A communication concentrator IIC
- A 16-bit A/D converter with an adjustable recognition of 8 or 10 bits
- 11 input-output ports (A, B, E, K, AD, M, P, Q, S, T, U)
- Two single-canal D/A converters
- Three 4-canal 16-bit timers
- 6 PWM canals
- COP Watchdog

• A real-time interruption

3 HC11/HC12 CONVERSION

For the tests, the following items were chosen from the existing library of user program modules:

- An operating system module
- Module of a library for working with the floating point
- Inputs
- Outputs
- Modules of controllers

To transfer the programs to the HC12 microcomputer, it is necessary to formally adapt the source texts due to different notation syntax in HC11-as11 translator and the translator for HC12 integrated within the development environment CodeWarior. For this adaptation, the “HC11toHC12” program has been compiled with the use of the Visual Basic language.

Generally there is a principle that the adaptation of source modules via this converting program runs trouble-free in cases when the programs do not turn right on the hardware components of the microcomputer. If so, it is necessary to distil the applied hardware components into the program equipment; in some cases only to modify their addressing.

Adaptations of individual modules

Real Time operating system

To generate the time base, the real-time operating system RTMON, modified for a school microcomputer HC11, uses the external real-time circuit 68HC68T1. The 68HC12 microprocessor is not equipped with this circuit; that is why the internal real-time circuit and the real-time interruption RTI have been used to generate to interruption.

MATH11

The mathematical library MATH11 is hardware independent. It does not approach any circuits of the microprocessor and after the conversion through the “HC11toHC12” program it is fully operating.

The “Inputs” module

The module Inputs serves for loading the binary and analogue inputs of the microprocessor. It approaches right the microprocessor hardware, so it was necessary to carry out adaptations related to the adjustment of the A/D converter, the addresses of the control and data registers and the operation of loading the converted values.

The “Outputs” module

This module also approaches the microprocessor hardware, but unlike the Input modules it is necessary to make almost no adaptations in this case. The user only adjusts the address of the output port to the required address.

Modules of the controllers

All the controller modules are only the matter of software, independent on the hardware used, and after the conversion through the “HC11toHC12” program they are fully operating without any modifications.

Further adaptations

With respect to the fact that the HC12 microprocessor has the memory divided into the data memory RAM and the program memory RWM it is necessary that all the memory space for the program data reserved by the directive RMB is situated within the area of the data memory RAM. If this memory space was reserved within the program memory RWM, the record to this place from the running program would fail. The used microprocessor 9S12E128 has a total of 8kB of the data memory RAM, which is situated at the address $2000 to $3FFF.

4 HC11/HC08 CONVERSION

The aim of the software tool for program conversion is to transform assembly language source files of M68HC11 in the format of compiler AS11 to the source files, which can be assembled using the compiler CASM08Z and subsequently executed on M68HC08 microcontrollers with the same results.

Principle of operation

Regarding to smaller number of M68HC08 central processing unit internal registers, all have been replaced by variables located in the first page of internal RAM at address space $40-$FF. These memory locations are called “virtual registers”, because they are supplying all registers from M68HC11 microcontroller. Nonexistent instructions, especially arithmetic and logic with 16-bit operands, are emulated with more basic instructions of M68HC08 microcontroller resulting in slower execution speed in some cases. Next compatibility problem is hidden in condition code registers because positions of the each flag are not identical (only C flag is on the same position). This issue with swapped flags in CCR affects instructions TAP and TPA that transfers content from accumulator A to CCR and vice versa. It is solved by swapping flags in CCR register when these instructions are called. Branch operations with relative addressing mode, such as conditional branches, are extended to absolute addressing mode, because converted source file is always longer, so jumps would be out of range. Individual instructions of M68HC11 are converted to the macros or subroutines (used method depends on optimization type setting), which completely substitute their function on M68HC08. Instruction replacements are stored in two separate files - the first one contains macros substituting all M68HC11 instructions. The second file contains subroutines, which can be used only on subset of whole instruction set.

Program conversion tool description

On the basis of instruction set analysis of both microcontrollers software tool WinHC11 was created. In the Fig. 1 is main window of the software converter program, which appears after startup. During initialization process default configuration is automatically loaded and program is ready for operation. Conversion process can be initiated, after selection of source (supported are files in the form of AS11 compiler) and target file, by pressing of “Convert Now “button. Actual processed line, status and error messages during software conversion process are displayed in the status window. Source and converted file can be viewed by pressing buttons “View Source” and “View converted file”.

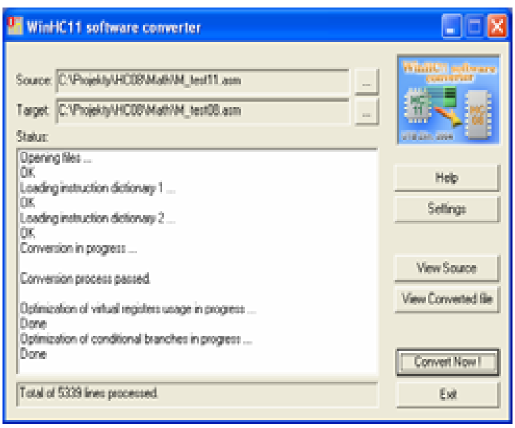

Figure 1: Main window of the conversion utility

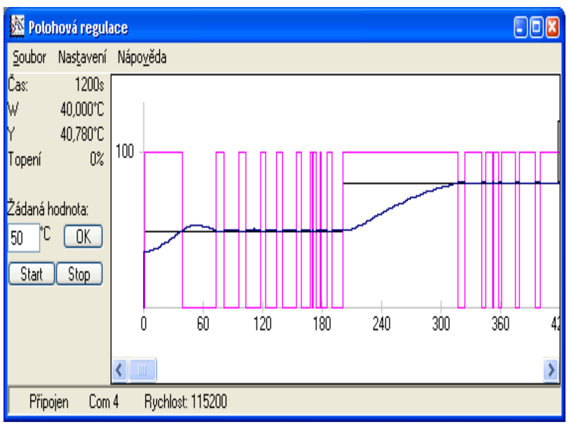

Figure 2: Temperature control

5 VERIFICATION OF THE CONVERTED PROGRAM MODULES

The conversion of the above-mentioned program equipment was proved on a real thermal system and the results were compared with the results obtained by the HC11 microcomputer. The thermal system was connected to the HC12 microcomputer via a special “Measuring circuit” representing a technological transformation unit. The results of the measurements of the temperature control by a two positional controller with penalization are shown on the Fig. 2.

6 CONCLUSION

A methodology has been developed to convert functioning program modules made for the HC11 microcomputers to a new hardware platform represented by the modern families of HC08 and HC12 microcomputers. A conversion programs has been compiled and proved for formal adaptations of the source texts.

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