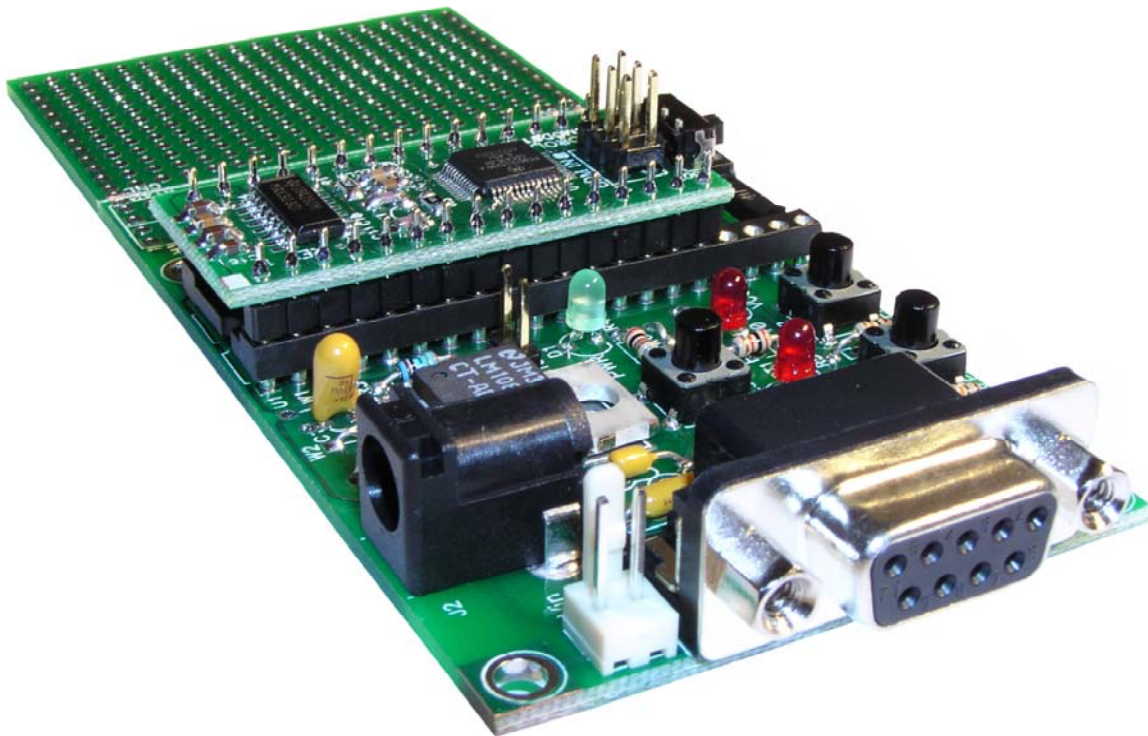


Using Your M68DKIT912C32 Microcontroller Kit



Freescale Semiconductor, Inc.



www.technologicalarts.com

**For More Information On This Product,
Go to: www.freescale.com**

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PRECAUTIONS

- 1) Electro-Static Discharge (ESD) prevention measures should be followed when handling this product. ESD damage is not covered by the warranty.
- 2) Electro-magnetic Compatibility:
 - a) This product, as shipped from the factory with associated power supply and cables, has been tested to meet the requirements of CE and the FCC as a "Class A" product.
 - b) This product is designed and intended for use as a platform for the development of hardware or software in an educational or professional laboratory.
 - c) In a domestic environment this product may cause radio interference in which case the user may be required to take adequate prevention measures.
 - d) Attaching additional wiring to this product or modifying the product's configuration from the factory default may affect its performance. Such alteration may cause interference with other apparatus in the immediate vicinity. If such interference is detected, suitable preventive measures should be taken.

1 Introduction

1.1 Congratulations!

With M68DKIT912C32, you are now ready to explore the power and versatility of the latest member of Motorola's most advanced 16-bit microcontroller family! Whether you're new to Motorola microcontrollers or you've used some of the earlier ones, such as 68HC05, 68HC11, or 68HC12, you'll be impressed with the well thought-out design and implementation of the 9S12C family. And the 'DKIT912C32 gives you the opportunity to explore the 9S12C family's potential at a very affordable price! Add to that the proven advantages of its popular design approach, and you'll see why you picked a real winner!

1.2 Support

To help you get the most out of this product, and to make the experience as enjoyable and productive as possible, we've put together a comprehensive website, loaded with resources, support, and applications information. If you experience any difficulties, or need help with your application, the World Wide Web is arguably the most valuable resource available to you. There you'll find the latest information, software, and troubleshooting help, as well as discussion groups where you can network with people around the globe to get the answers you need. So if you still need help, or have questions after reading this manual and perusing the contents of the included CD, visit our website: www.technologicalarts.com and tap into the collective! Pay particular attention to our Support, Applications, and Resources webpages. While on our Support page, be sure to join our techart-micros discussion group and Motorola's HC12 discussion group.

1.3 Product Configuration

M68DKIT912C32 was designed as a versatile evaluation and application tool for the Motorola MCS12 "C" family of microcontrollers. While it is based on the 9S12C32, it is also suitable for developing applications for any of the forthcoming derivatives (9S12C64, 9S12C96, 9S12C128, etc.). All of the subsystems are identical, with the differentiating factor among the chips being the amounts of Flash and RAM offered.

In addition to the MCU module (M68MOD912C32), the M68DKIT912C32 includes a Docking Module, which provides convenient support circuitry for working with the microcontroller. This includes a power regulator, a socket for the MCU module, a couple of user LEDs and pushbuttons, and a snap-off prototyping area. A power supply and serial cable are included with the kit to help you get plugged in. A resource CD containing this manual, example programs, and all the MCU documentation, along with a CodeWarrior C compiler on CD complete the package.

The M68MOD912C32 MCU module is supplied in a 32-pin DIP footprint that plugs into the 40-pin DIP socket on the Docking Module. The Docking Module is designed to support other MCU modules to be introduced later in 24-pin and 40-pin DIP packages.

A BDM connector is provided on the MCU Module for development tool application and is compatible with standard HCS12 BDM interface cables and software.

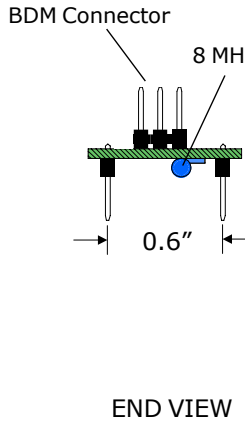
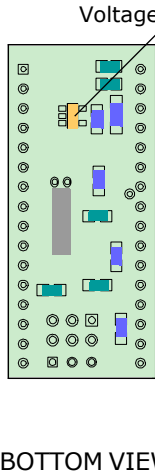
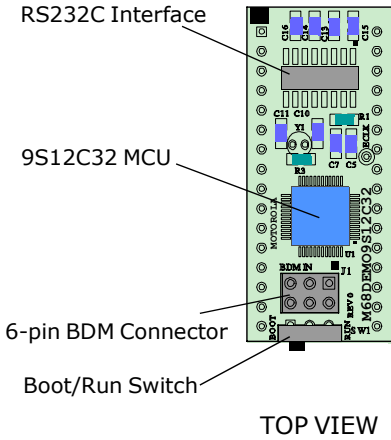
1.4 Features and Specifications

The design consists of two parts: a 'C32 MCU Module in 32-pin wide DIP form-factor, and a Docking module which provides a programming interface with a personal computer. The MCU module, once programmed, can be used independent of the Docking Module, and is compatible with standard 0.6" wide DIP sockets and solderless breadboards.

Figure 1 - Identification of Hardware Features

Freescale Semiconductor, Inc.

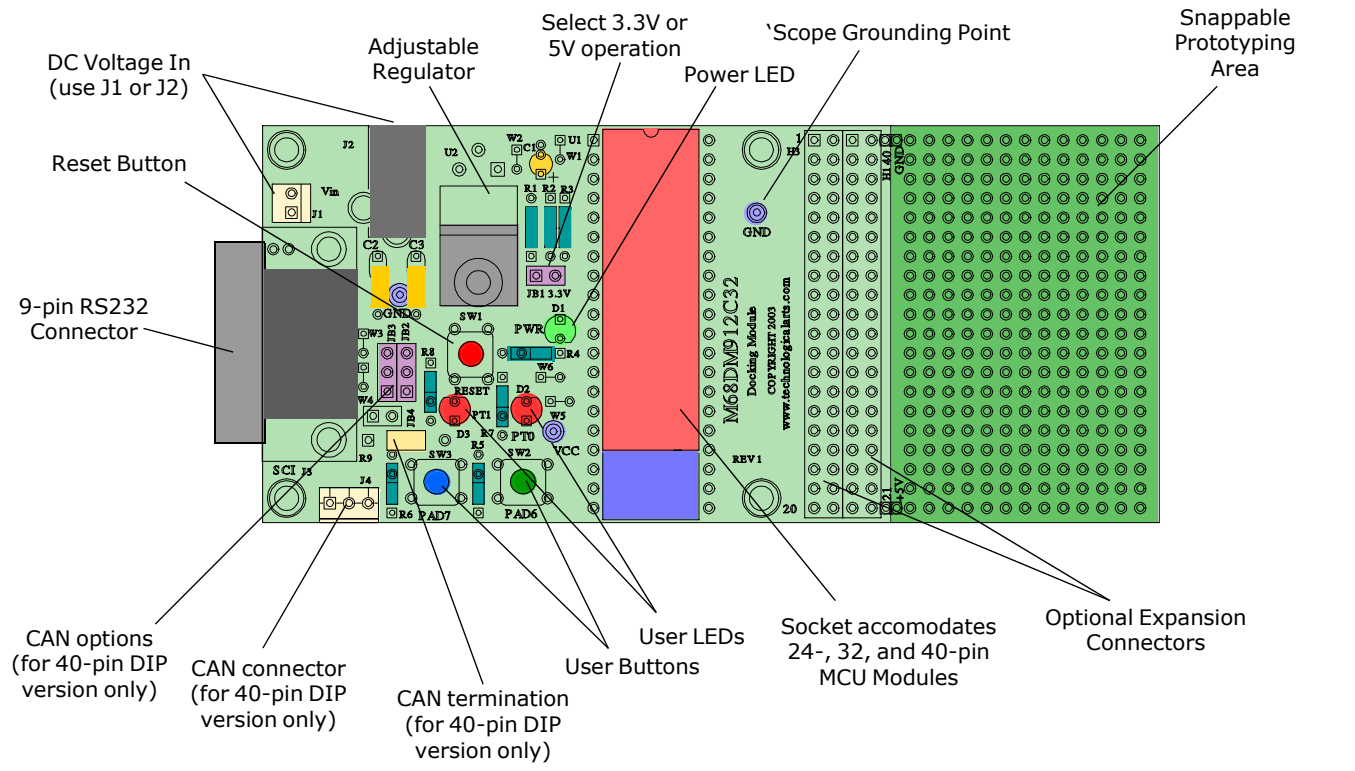
9S12C32 MCU Module



1	○ TX	VIN	○ 32
2	○ RX	VSS	○ 31
3	○ DTR	RES	○ 30
4	○ VSS	VCC	○ 29
5	○ AN0	PE0	○ 28
6	○ AN1	PE1	○ 27
7	○ AN2	PT7	○ 26
8	○ AN3	PT6	○ 25
9	○ AN4	PT5	○ 24
10	○ AN5	PT4	○ 23
11	○ AN6	PT3	○ 22
12	○ AN7	PT2	○ 21
13	○ PM5	PT1	○ 20
14	○ PM4	PT0	○ 19
15	○ PM3	PM0	○ 18
16	○ PM2	PM1	○ 17

PINOUT

9S12C Docking Module



The MCU module includes the following features:

- 9S12C32 MCU in 48-pin LQFP
- 8 Mhz crystal
- PLL circuit
- local 5 Volt low-dropout 100 mA regulator
- RS232 transceiver circuit
- standard 6-pin BDM connector
- on-chip Serial Monitor
- BOOT/RUN switch to support Serial Monitor
- 32K Bytes Flash
- 2K Bytes Ram
- user access to 16 digital port lines, including Port M, Port T, and PORTE
- user access to eight 10-bit analog input or digital I/O port lines (Port AD)
- five PWM timer channels (PT0 - PT4)
- eight Input Capture/Output Compare (Port T)
- serial peripheral interface (SPI)
- serial communications interface (SCI)
- controller area network (CAN 2.0)
- key wake-up inputs
- user access to MCU reset signal
- background debug mode (BDM) connector
- pinout is super-set of competing 24-pin modules on the market

The Docking Module implements the following features:

- 9-pin D-sub socket for serial interface to user personal computer
- dual-voltage regulator configuration to permit user-selectable 3.3V and 5V operation
- low-dropout, low-power regulator, with thermal shutdown and reverse-polarity protection
- polarized power connector to prevent reverse polarity application by user
- oscilloscope grounding point
- high-efficiency green LED power indicator
- reset button
- 40-pin DIP socket to accomodate a range of modules from 24 to 40 pins
- rubber feet
- user application support features:
 - dual high-efficiency red user LEDs (PT0, PT1)
 - dual user pushbuttons (PAD0, PAD1)
 - snappable prototyping area (sea of plated-through holes on 0.1" grid)
 - accomodation for dual 40-pin I/O bus expansion connectors (user-installed option)
 - expansion connectors supports available accessories (eg. standard ribbon cable, prototyping card, motor driver, etc.)

Specifications:

- MCU Module:
 - size: 1.7" x 0.75"
 - pin-spacing: 0.1" x 0.6"
 - pin 1 location: 0.75" x 0.05" (with respect to corner of circuit board)
 - pins: 0.03" round, machined, gold-plated
 - input voltage range (Vin): 5 to 15VDC
 - current draw: 25 mA, nominal (@24 MHz bus speed)
- Docking Module:
 - Power Input: +6 to +20VDC, 9VDC typical
 - Current Draw: 5 mA, nominal, with 9VDC input

Documentation:

- Quick Start Guide (2-page hardcopy)
- schematics and pinout/component placement drawings (on CD)
- manual with details of design features, suggested uses, and examples (on CD)
- datasheets on all semiconductors used in the design

Software:

- Code Warrior CD from Metrowerks
- Resource CD (Serial Monitor GUI for Windows, code examples, schematic, manual, data sheets, etc.)

1.5 M68DKIT912C32 vs. Traditional Evaluation Boards

Most available evaluation and development systems tend to be too expensive and bulky for embedding into a real application, so they lie on a shelf gathering dust once you've reached a certain point in the learning curve. Or maybe you think up some clever way to hack it apart and make it fit inside your robot or product prototype. Even then, the prototyping area provided is often limited, and does not lend itself to re-usability. And what if you burn out a chip the night before the contest or product demo? What a mess to repair or re-design!

The M68DKIT912C32 solves all of these problems and more! Since the MCU module is packaged in a standard 32-pin DIP footprint, it is modular and re-usable. It can simply be plugged into your application, or moved from one application board to another, allowing your whole system to be re-configured at the last minute. The prototyping area on the Docking Module offers you a platform for your initial application, which can be snapped off and discarded when you no longer need it. Two 40-pin connector footprints remain, and can be used with various types of connectors, ribbon cables, backplanes, prototyping cards, etc. that are available now or are under development. Make a point to visit our website from time to time, just to see what's new.

The detachable nature of the prototyping card means that you can easily replace it with other cards, including some application cards available from Technological Arts. You can build up a collection of different application circuits, and use them all with the same microcontroller board. Of course, if the prototyping card approach doesn't suit you, the standard 32-pin DIP format of the MCU Module makes it easy for you to incorporate it into your own designs. In fact, it's pinout is a superset of the popular 24-pin DIP MCU modules available from other vendors. You can plug it into a DIP socket in your application, or directly into a solderless breadboard.

The modular nature of this product is especially advantageous in an educational environment, where the student can progress from simple to more complex applications throughout a semester, or from one course to the next-- even incorporating the board into a final project. In fact, where budgets are tight, different students can share the same microcontroller module, and plug in their own interface cards when it's their turn to use it.

1.6 Resident Debug/Monitor

Residing in a 2K protected block of on-chip flash memory is Motorola's versatile Serial Monitor program. When used with the included (on CD) free uBug12 Windows application running on a personal computer, you can display and edit memory and registers, erase and program flash, set breakpoints, and do instruction tracing. In Run Mode, your program runs automatically from Flash, following reset. See Chapter 2 and Appendix A for details on uBug12 and the resident monitor.

1.7 Communications

An RS-232C serial interface port (RX & TX only) is included on the Docking Module, allowing communication with a PC com port, or any other device which has an RS-232 serial port. The RS-232 channel (implemented via the SCI of the MCU) is available via a 9-pin D-sub connector on the Docking Module. When the MCU Module is reset in Load mode, the resident serial monitor uses this port to communicate with an appropriate program running on your PC.. In RUN mode, the port is available for your application.

While the MCU does support Controller Area Network (CAN), no physical layer circuit is provided. If you would like to use CAN, you'll need to add the appropriate transceiver cir-

cuit externally to PM0 and PM1 (pins 18 and 17 of the MCU module).

In passing, it should be mentioned that the MCU also supports SPI. Since this is a logic-level protocols, meant for local communications among peripheral chips, no transceivers are required nor are they provided. Commonly used SPI chips and modules include serial memory, temperature controllers, clock/calendar chips, DACs, MP3 decoders, etc. See the MCU datasheets for details on these subsystems.

2 Getting Started

2.1 Introduction

Support software for the M68DKIT912C32 is designed to be used with any computing platform running one of the Windows 98/NT/2000/XP operating systems. Users should also familiarize themselves with the hardware and software operation of the target HCS12 device. Refer to the Motorola 9S12C Family Device User Guide and the CPU12 Reference Manual for details. The `DKIT912C32 serves to promote the features of the 9S12C32 device and to assist the user in quickly developing an application within a known working environment. Users who are familiar with memory mapping techniques, various memory types, and embedded software design are likely to experience the most successful and rapid application development.

Development may be performed through the resident Serial Debug Monitor, or by attaching a compatible HCS12 BDM cable and employing supporting host software. The Serial Monitor utilizes the SCI port as its connection to the host PC, and does not use the traditional background debug mode, thus eliminating the need for a BDM pod or cable.

The Serial Monitor interfaces with a program running on a host personal computer (PC) to provide an effective, low-cost debug approach. The Serial Monitor provides the user with the ability to erase and program the MCU's Flash memory, and also to load and debug application programs. Windows-based host software (uBug12) is included to provide an interface to the monitor. Host support is also built into the CodeWarrior C Development environment .

Serial Monitor firmware resides in a 2K protected block of the MCU's internal flash memory, and reserves some of the MCU resources for its operation. Refer to Appendix A and Motorola's Serial Monitor application note for details.

Once a user program has been loaded into Flash via monitor control, the BOOT/RUN switch (SW1) on the MCU Module determines whether control is passed to the user program (RUN) or to the Serial Monitor. The Monitor will remain in protected flash memory for future use if needed. It is possible to erase and re-load the Serial Monitor via a BDM pod.

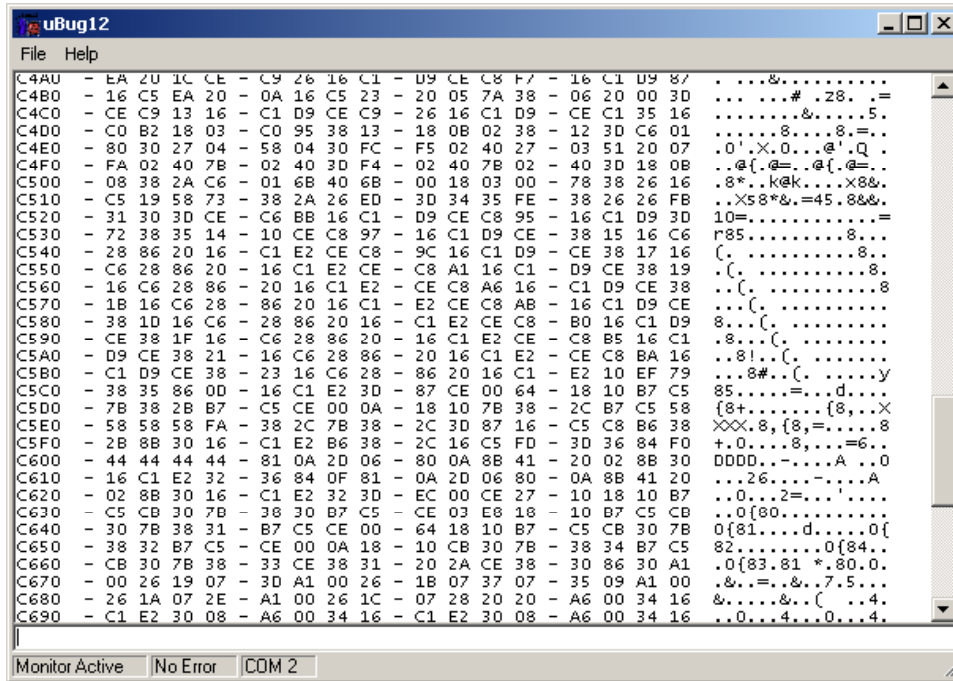
2.2 Getting Started with uBug12

- Perform a quick visual check of the MCU Module and Docking Module for any damage during transit
- Ensure that the MCU Module is properly oriented and seated in the Docking Module's 40-pin socket (square white dot indicates pin 1)
- Connect the Docking Module's RS232 port (J3) to a COM port of a personal computer, using the cable supplied
- Locate and install the Windows application called uBug12, included on the CD (also on webpage). You will also need to install the Microsoft .NET framework (included on CD) if it is not already on your computer.
- Launch uBug12
- Activate the serial port connection by entering **CON x** (where x is the COM port you are using; usually 1 or 2)
- Set switch SW2 to the BOOT position
- Connect the supplied power source to barrel jack J2
- uBug12 will display a short message, followed by its command prompt
- The Monitor is now ready for your commands (see Appendix B for full list of uBug12 commands)

2.3 Loading a Program via uBug12

To download one of the supplied example programs into flash and execute it, follow these steps:

- Type **fbulk** <enter> at the uBug12 prompt to erase any existing program
- Type **fload ;b** <enter>
- From the displayed file browser, select one of the example program's output files (they will have a filename extension of .s19, .s2 or .sx)
- After loading has finished, move SW2 to the RUN position, and press the Reset button (SW1)
- If you wish to debug the program, move SW2 back to the BOOT position and press Reset
- The uBug12 prompt will appear
- Use Monitor commands to debug your code, if desired



2.4 Getting Started with CodeWarrior 3.0

- 1) Attach included serial cable between Docking Module serial port and an available COM port on the host PC.
- 2) Install uBug12 Serial Monitor user interface software on the host PC
- 3) Ensure that the MCU Module is properly oriented and seated in the Docking Module 40-pin socket (square white dot indicates pin 1)
- 4) Plug in the included power supply, and attach it to J2 of the Docking Module
- 5) Verify that Power LED D1 is illuminated.
- 6) Move MCU Module BOOT/RUN switch SW1 to BOOT position
- 7) Press Docking Module RESET button SW1 to enable the Serial Monitor.
- 8) Install CodeWarrior and launch it
- 9) Create a new project:
 - Click **File**
 - Click **New**
 - Click **HC(S)12 Project Wizard**
 - In the dialog box for *Project Name*, type **Example1**, select OK
 - Click on **MC9S12C32**, select Next
 - Click **C Programming**, select Next
 - Click **No** to *Processor Expert*, select Next
 - Click **No** to *PC Lint*, select Next
 - Click **None** for *Floating Point*, select Next
 - Click **Small** for *Memory Model*, select Next
 - Click **Motorola Serial Monitor Hardware Debugging**, select Next
- 10) Copy and paste the following code into the *main.c* file. (under Sources in the project window)

```

-----CODE-----
#pragma CODE_SEG DEFAULT

void main(void) {
    DDRT = 0x03;
    ATDCTL23 = 0x0;
    ATDCTL45 = 0x0;
    ATDDIEN = 0xFF;
    while(1){
        PTT = ~(PTAD/64);
    }
}
-----CODE-----

```

- 11) Click on **Project** -> **Make** (F7)
- 12) Launch uBug12
- 13) Type **con 1** or **con 2** (to connect to the comport you are using)
- 14) Type **fbulk** to ensure flash is erased
- 15) Type **fload ;b**
- 16) Navigate to "My Documents\Example1\Bin\ " and select the .s19 file (it should have the name *Monitor.abs.s19*)
- 17) Type **go**
- 18) Now when you press either of the user buttons on the Docking Module, the corresponding user LED will glow.

2.5 Serial Monitor Operation

Refer to the Serial Monitor application note (AN2548) for complete details of operation. The following paragraphs present the basics. The Monitor resides in a 2K byte protected block of Flash memory, and uses about 50 bytes of stack space. It implements a binary command set via the HC12 SCI port. Serial communication is enabled at 115.2Kbps, using the MCU's SCI Interrupt features. The Monitor enables the PLL to boost the MCU bus speed to 24Mhz.

2.6 Commands

Unlike previous HC12 resident debuggers (eg. D-Bug12), the Serial Monitor does not implement a text-based (ASCII) command set. Instead, the command set is binary, which means a user interface is required on the host pc. This approach allows the Monitor to occupy a very small footprint, yet retain a high level of functionality. As a result, however, it is not possible to enter commands directly via a terminal program (eg. HyperTerminal).

2.7 Interrupt Service Support

The Monitor implements vector relocation in the 9S12C32 Flash (also known as pseudo-vectors). The user interrupt vectors are implemented in a block of non-protected Flash from 0xF780 to 0xF7FF. SCI, SWI, and RESET vectors are inaccessible to the user while the monitor is operating. Programming the user Reset vector will cause the monitor to execute the user program upon Reset.

2.8 Monitor Memory Map

0x0000 - 0x03FF	9S12C32 Register Space. See the 9S12C32 User Manual for details
0x0400 - 0x37FF	Not used
0x3800 - 0x3FFF	9S12C32 Ram space, user application ram Initial Monitor stack = 0x3FFF (reserve 50 bytes)
0x4000 - 0x7FFF	User Application Flash Memory
0x8000 - 0xBFFF	Do not use
0xC000 - 0xF77F	User Application Flash Memory
0xF780 - 0xF7FF	User Interrupt Vectors
0xF800 - 0xFFFF	Monitor Flash Memory Space (Protected)

3 M68DKIT912C32 Operation

The M68DKIT912C32 provides input and output features to assist in application development. These features may be isolated from the applied HCS12 I/O ports by the option jumpers. This allows alternate use of the HCS12 I/O ports for other application and connection on the I/O port connectors. Caution should be observed so that the HCS12 I/O port pin applied to an on board feature is not also applied to external components by the user.

3.1 Power Supply

Input power is applied by external connection to the J1 or J2 power jack of the Docking Module. J1 is an optional power input, compatible with a 2-pin Molex connector (pin 1 is positive). J2 is the the default external power input to the board. It accepts a standard 2.1mm center barrel plug connector (center positive) to provide the VIN supply of +6 to +20VDC (+9VDC typical). A 9VDC power supply is included with M68DKIT912C32 for this purpose. VIN is fed to voltage regulator U2, which provides the regulated +5V supply (VDD) for the MCU Module. By placing a shunt on JB1, 3.3V operation is enabled.

3.2 MCU Module Power

If the MCU Module is to be operated independent of the Docking Module, a supply of +6 to +15VDC can be applied across VIN (pin 32) and VSS (pin 31). The onboard regulator is capable of supplying a total of 100 mA. Since the MCU Module uses about 25 mA, an additional 75 mA or less of regulated 5V is available for user applications via the VCC pin (29). If a BDM pod is connected to the BDM connector (J1), it will probably require all or most of the available 5V power. If a BDM pod with external power supply is used, this is not an issue. Check the specifications of the BDM pod to be used to ensure compatibility. If the current draw is too large, the on-board regulator will enter thermal shutdown, and the module will stop working until the overcurrent condition is resolved.

Optionally, a regulated 5V or 3.3V supply may be fed directly into the VCC pin (pin 29) of the MCU Module. In this configuration, VIN should be left open, and the on-board regulator is unused.

3.3 Reset Switch

Reset Switch operation will place the MCU in the Reset state. *Caution: the RESET switch should not be pressed while a BDM cable is connected to the MCU Module. Instead, the BDM should control Reset generation via the connection on the BDM connector.*

3.4 MODA and MODB Options

The 48-pin version of 9S12C32 used on the MCU Module supports Single-chip mode by default. MODA, MODB, and address/databus signals are not pinned out, so it is not possible to operate the MCU in expanded modes.

3.5 MODC Option

MODC selects Special Background Mode when in the GND or logic low state. MODC is in the default Normal mode position at all times unless a BDM cable is attached to the BDM connector.

3.6 J3 RS232 Port

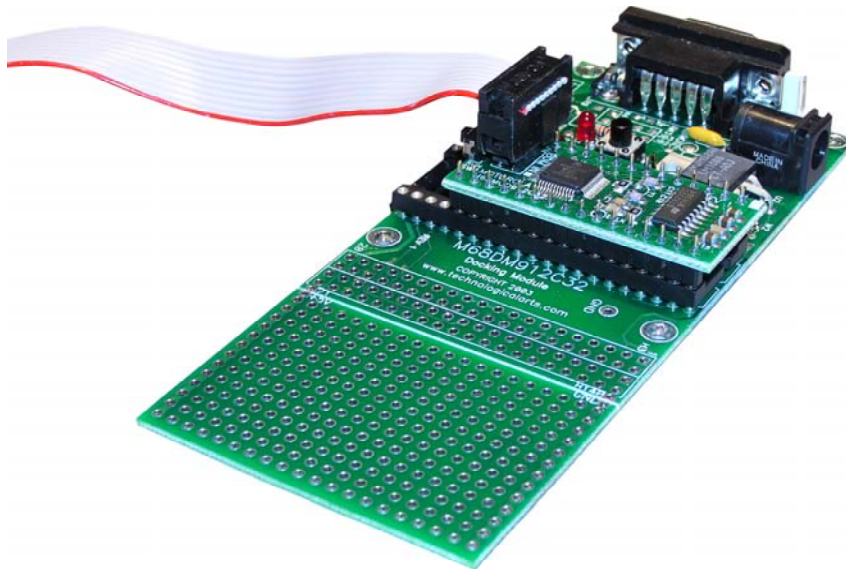
Connector J3 on the Docking Module provides the connection point for a standard RS-232C compatible serial port controlled by the MCU's SCI port. The physical interface transceiver circuit is implemented on the MCU Module itself, and the signals TX (pin1) and RX

(pin2) of the MCU Module socket are routed to the 9-pin D-sub connector J3 on the Docking Module. PB4 of the MCU is used for an optional DTR signal, which may be implemented by the user. Note that the Monitor communication does not implement the DTR signal.

3.7 BDM Connector

For proper functioning of a BDM pod, pin 1 on the BDM cable must mate with pin 1 of the BDM connector on the MCU Module. The location of pin 1 is marked with a square white dot. The cable usually has a colored stripe on one edge, and/or an index mark on the connector.

If the BDM pod you are using has a 10-pin plug, only the first six pins are used-- let the other four pins overhang the connector, as shown in the photo below.



4 Software Considerations

4.1 Using the Serial Monitor

When you are working without a BDM pod, the Serial Monitor program is the only method available to load and erase flash. It is in a protected block of flash, so there's virtually no way to accidentally erase it. There are two modes, controlled by switch SW2: Run and Load. The monitor mode is determined immediately following reset by checking the position of switch SW2. When working with the monitor program in place, there are a few points to be noted:

- 1) while the user vectors are implemented by the monitor at 0xF780 to 0xF7FF, you don't really have to worry about it, because the monitor program will automatically adjust them when your s-record is loaded. It's good to know, however, so you don't get alarmed when you are snooping around in the vector area and don't see what you expected.
- 2) the monitor relocates RAM to the address range 0x3800 to 0x4000 from the default location after MCU reset of 0x0000 to 0x07FF.
- 3) the monitor program enables the phase-locked loop (PLL), so the target is running at a bus speed of 24MHz (when in LOAD mode) and not at the startup bus speed of 4Mhz. If you intend to use the PLL, you'll need to enable it in your code, though.
- 4) the user code must clear the CCR I-Bit (eg. via CLI instruction in assembler).
- 5) SCI0 cannot be used by the user program when in BOOT mode, since it is dedicated to the monitor program; however, it is available to the user in RUN mode.
- 6) COP cannot be disabled in BOOT mode.

4.2 Using a BDM Pod

You can ignore the on-chip serial monitor altogether if you have an appropriate BDM pod (such as the MicorBDM12SX, from Technological Arts). When using a BDM pod, you'll find that the memory resources are mapped as per the Motorola documents, following a reset event. So your program will need to take care of any desired initializations to relocate resources or enable PLL, as relevant to your application.

If you use an assembler or compiler other than CodeWarrior, you'll probably need to use the SRecCvt utility to properly format the s-records generated by the compiler/assembler before attempting to load them into the target chip's flash. Use the following command line:

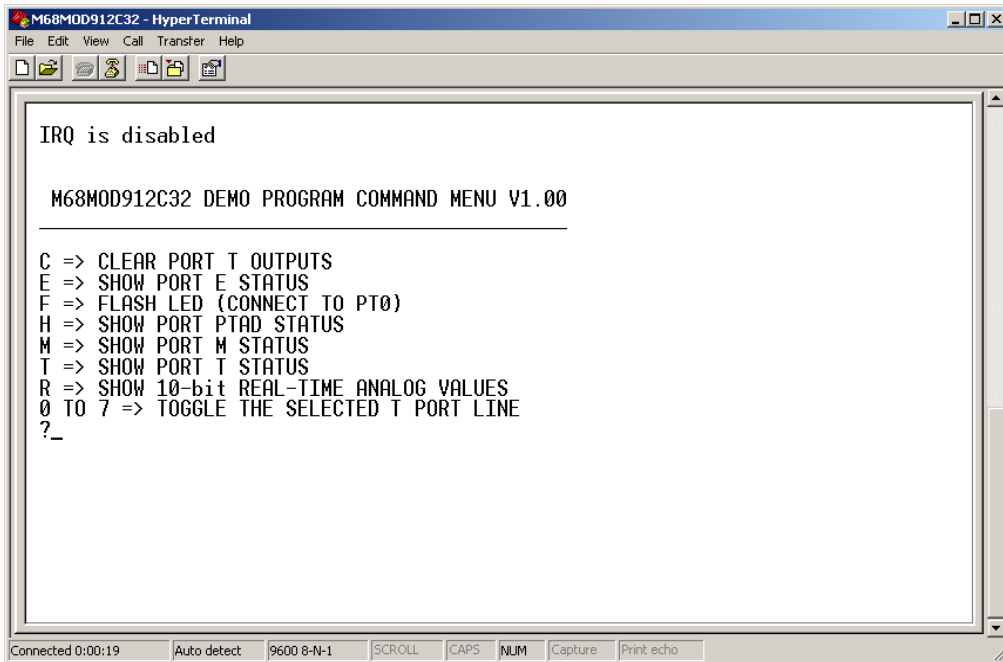
```
srecvvt.exe -m C0000 FFFFF 32 -lp -o outfile.s2 infile.s19
```

where *infile* refers to the file you are converting and *outfile* is the result

5 Tutorial

As mentioned in the Quick Start Guide included with the M68DKIT912C32, the MCU Module is shipped from the factory with a Demo program loaded into its memory. This program is useful for familiarizing yourself with the hardware features of the MCU. It was written in assembler, using Motorola's MCUEz Windows integrated development environment (http://e-www.motorola.com/files/soft_dev_tools/software_tools/ide_integrated_development_environment_/MCUEZIDE.html). The sourcecode can be found on the included Resource CD, if you would like to examine or modify it.

If you've already erased the demo program, you may use uBug12 to re-load it. Then follow the relevant steps in the QuickStart Guide to open HyperTerminal and achieve the display shown below.



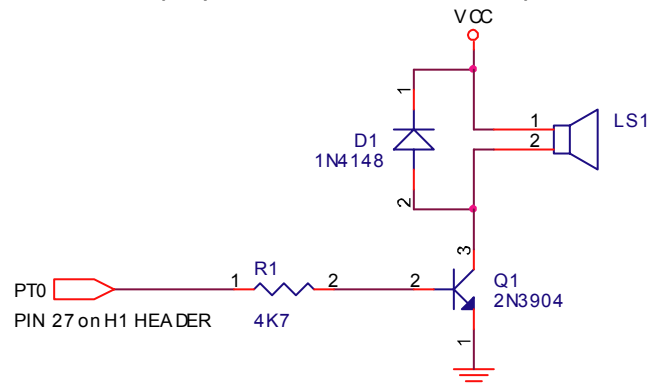
5.1 Executing Demo Commands

- Type the digit 0 repeatedly and observe that LED D2 toggles on and off.
- Type the digit 1 repeatedly and observe that LED D3 toggles on and off.
- Type the letter F to cause LED D2 to flash twice.

Typing E, H, M, or T will cause a hex number to be displayed, whose bit values represent the logic levels of the respective pins. If the pins are unconnected to external circuitry, they will assume a logic 1 level, due to internal pullup resistors.

5.2 A Simple Audio Circuit

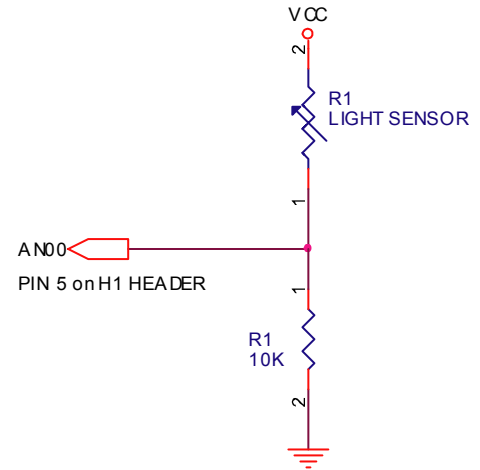
Connect a simple audio transducer circuit, as shown, and type the letter F. LED D2 will flash twice, and two audible "beep" tones will be emitted from the transducer. If you press and release the



Reset button on the Docking module, LED D2 will flash four times, and you'll hear four "beep" sounds from the transducer.

5.3 A Simple Analog Circuit

Connect a CdS light sensitive resistor (photo cell) in the configuration shown. Then type the letter R to see the value of AN00 change as you vary the amount of light reaching the photocell. The value displayed is a 10-bit representation of the voltage level on the AN00 pin, with fullscale being approximately 5V (represented by the hexadecimal number 3FF).





Appendix A - Serial Monitor

Introduction

This appendix describes the Motorola 2 Kbyte monitor program for the HC9S12 series MCU. This program supports 23 primitive debug commands to allow FLASH / EEPROM programming and debug through an RS232 serial interface to a personal computer. These include commands to reset the target MCU, read or modify memory (including FLASH /EEPROM memory), read or modify CPU registers, go, halt, or trace single instructions. In order to allow a user to specify the address of each interrupt service routine, this monitor redirects interrupt vectors to an unprotected portion of FLASH just below the protected monitor program. This monitor is intended to be device unspecific, this single application with very slight modification should execute on any HC9S12 derivative. A user on a tight budget can evaluate the MCU by writing programs, programming them into the MCU, then debug using only a serial I/O cable and free software (uBug12) for their personal computer.

This monitor does not use any RAM other than the stack itself. The COP watchdog is utilized for a cold reset function; user code should not disable the COP (ie. by writing 0x00 to COPCTL). This development environment assumes you reset to the monitor when you are going to perform debug operations. If your code takes control directly from reset, and then an SCI0 interrupt or a SWI attempts to enter the monitor, the monitor may not function because SCI0, the phase locked loop (PLL), and memory initialization registers may not be initialized as they would be for a cold reset into the monitor. There is no error handling for the PLL. If the frequency source is missing or broken, the monitor will not function. The monitor sets the operating speed of the MCU to 24 MHz. Modification of the MCU speed by the user with out considerations for the monitor program will render the monitor nonfunctional. If the PLL loses lock during operation, the monitor will fail.

Block Protection

In order to prevent accidental changes to the monitor program itself, the 2 Kbyte block of FLASH memory where it resides (\$F800-\$FFFF), is block protected. Additionally all write commands are restricted from modifying the monitor memory space. The only way to change the contents of this protected block is to use a BDM-based development. In the lowest cost applications where the monitor is used with an SCI serial interface to the RS232 serial port on a personal computer, there is no way to accidentally erase or modify the monitor software.

COP Configuration

The monitor as written creates hard reset function by using the COP watchdog timer. It does so by enabling the COP and waiting for a COP timeout reset to occur. If the user application uses the COP two issues must be considered.

- If the COP is disabled in the user application, the monitor will be unable to perform a hard reset and will soft reset to the start of the monitor instead.
- The monitor does not service the COP timer. If the user application implements COP timer servicing, upon re-entry into the monitor a hard reset is likely to occur.

Memory Configuration

- 1) Register space is \$0000-\$03FF.
- 2) Flash memory is any address greater than \$4000. All paged addresses are assumed to be Flash memory.
- 3) RAM ends at \$3FFF and builds down to the limit of the device's available RAM.
- 4) External devices attached to the multiplexed external bus interface are not supported.

Serial Port Usage

In order for this monitor to function the SCI0 serial interface is used. It is assumed that the monitor has exclusive use of this interface. User application code should not implement communications on this serial channel. This monitor accommodates RS232 serial communications through SCI0 at 115.2 kbaud. For applications requiring the use of SCI0, you should purchase a BDM pod which allows for more advanced debugging.

Vector Redirection and Interrupt Use

Access to the user vectors is accomplished via a jump table located within the monitor memory space. This table points all interrupt sources to a duplicate vector table located just below the monitor. (\$F780-\$F7FE). The monitor will automatically redirect vector programming operations to these user vectors. The user's code should therefore continue to implement the normal (non-monitor) vector locations (\$FF80-\$FFFE). If execution of an interrupt with an un-programmed vector is attempted, behavior is undefined. For this reason, the user is strongly encouraged to implement a software trace for all vectors, as is good programming practice. The monitor depends on interrupts being available for monitor re-entry after GO or TRACE commands. Therefore, it is important that the user application executes with interrupts enabled.

APPENDIX B - uBUG12 Command LIST

----- **REGISTERS** -----

RD - Register Display
 RM <RegisterName> <Data8/16> - Register Modify
 CCR <Data8> - Set CCR register
 D <Data16> - Set D register
 PC <Data16> - Set PC register
 PP <Data8> - Set PP register
 SP <Data16> - Set SP register
 X <Data16> - Set X register
 Y <Data16> - Set Y register

----- **MEMORY MODIFY** -----

BF <StartAdd> <EndAdd> <Data8> - Block fill
 BFW <StartAdd> <EndAdd> <Data16> - Block fill word
 MD <StartAdd> [<EndAdd>] - Memory display
 MDW <StartAdd> [<EndAdd>] - Memory display word
 MM <Address> <Data8> - Memory modify byte
 MMW <Address> <Data16> - Memory modify word

----- **FLASH** -----

FBULK - Flash bulk erase
 FLOAD []<M> - Flash load

----- **DEVICE INFO** -----

DEVICE - Get device name

----- **GO/HALT** -----

GO [<StartAddress>] - Start execution
 HALT - Halt execution
 RESET - Reset target

----- **GUI** -----

CON <Comport> - Connect to target
 DISCON - Disconnect from target
 EXIT - Terminate GUI
 HELP - Display help
 OP <Opacity%> - Set main GUI opacity

APPENDIX C - M68MOD912C32 Pinout

