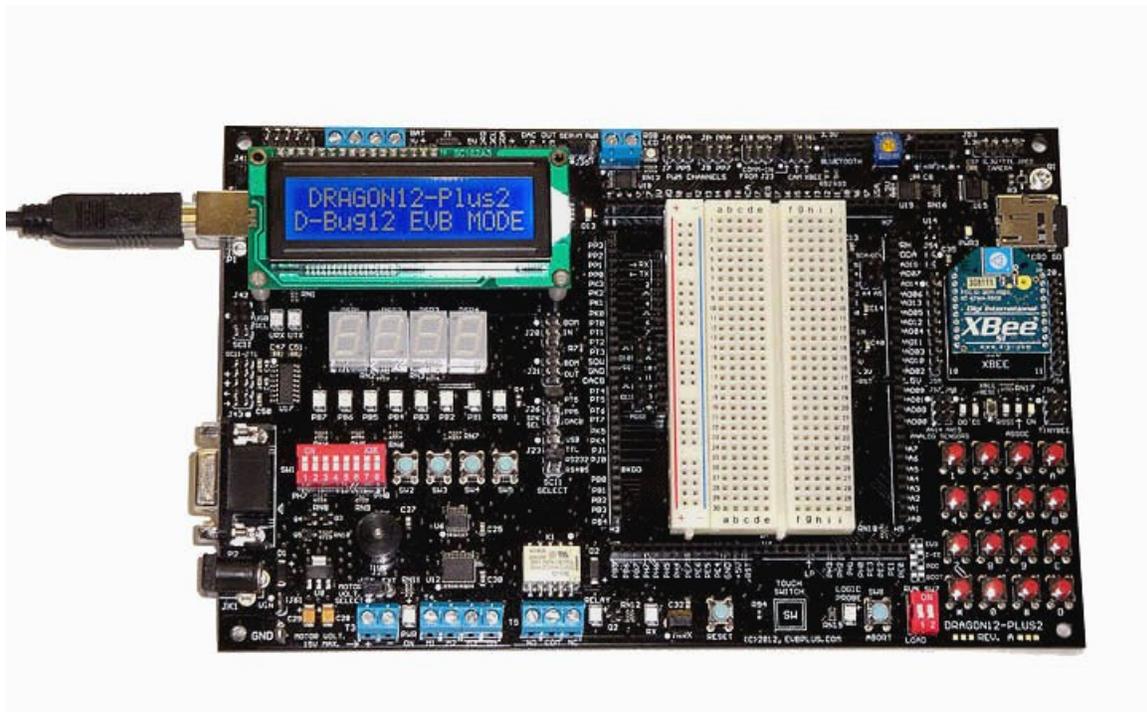


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# Dragon12-Plus2 Trainer

For Freescale HCS12 microcontroller family

User's Manual for Rev.A board  
Version 1.01



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**Note: For users who will use CodeWarrior IDE with serial monitor:**

This manual is written for the board that is pre-installed with bootloader and D-Bug12 monitor. If you ordered the board with Freescale serial monitor for CodeWarrior, the board would be pre-installed with the serial monitor and a factory test program. The software installation on the page 12 is not needed. Once the serial monitor is installed, the board will not work with AsmIDE or other terminal emulation programs.

The state of the left switch of the 2-position DIP switch (SW7) is tested by the serial monitor for selecting RUN or LOAD mode during power up or reset, and the 8 port B LED indicators will light up from right to left and the speaker will chirp once to indicate that the serial monitor is functioning. If the left switch is placed in the "LOAD" mode (the "lower" position) the monitor will wait for a command from a PC. If the left switch is placed in the "RUN" mode (the "upper" position) the port B LED indicators will light up again from left to right to indicate that the program execution is diverted to the user code (the factory test program).

The left DIP switch of SW7 has been set in the "up" position as a factory default setting for running the test program.

The CodeWarrior communicates with Freescale serial monitor only in LOAD mode and so in order to interface with the CodeWarrior you have to place the left switch in the "low " position. The port B LED indicators will light up from right to left and the speaker will chirp once when the board is powered up.

If your board does not communicate with CodeWarrior, the first thing you should check is that if the left DIP switch of the SW7 is in the LOAD mode ( in the "low" position).

# Chapter 1. Introduction

## 1.1 Welcome

Thank you very much for purchasing our Dragon12-Plus2 trainer. The Dragon12-Plus2 trainer is a low-cost, feature-packed training board for the new Freescale HCS12 microcontroller family. It is compatible with the Freescale 9S12DP256EVB board and other similar development boards on the market today, but it also incorporates many on-board peripherals that make this board a popular trainer in universities around the world.

For engineers, it is a convenient prototype system suitable for designers who want to rapidly develop and prototype new HCS12 applications. For students, it can not only be used as a general trainer for freshman and sophomore students, but also as a versatile platform for senior projects as well. The new features of the Dragon12-Plus2 board create a new potential for students at every level.

The Dragon12-Plus2 trainer kit comes with the following items:

1. Dragon12-Plus2 board
2. Software downloadable from our web site:
  - a. AsmIDE with HCS12 assembler
  - b. Sample programs with source code
  - c. User's manualFreescale application no
3. 6 foot USB type B cable
4. 9V, 500mA switching power supply AC adapter for North America customers only.

If you miss any part of the kit, please contact [sales@EVBplus.com](mailto:sales@EVBplus.com) or call 630 894-1440 for help.

The new Dragon12-Plus2 board is fully backward compatible to the Dragon12-Plus-USB board. All software written for the Dragon12-Plus-USB board will run on the new Dragon12-Plus2 board without modifications.

Please carefully examine the default jumper settings before turning on the board:

1. The J1 should have a jumper for LCD backlight.
2. The J26 should have a jumper installed on the two top pins labeled with "PT5", so the speaker will be driven by PT5. The speaker can be driven by timer (PT5) or PWM (PP5) or DAC. It defaults for PT5. Without a jumper installed on J26 the speaker won't sound.
3. The J41 should have a jumper installed on the two lower pins, so the SCI0 receives signal from USB port.
4. The J42 should have two jumpers installed **vertically** on the four upper pins, so the USB interface is connected to SCI0. The AsmIDE or CodeWarrior IDE only works with SCI0.

If these two jumpers are installed on the four lower pins and the jumper on J23 in the two top pins labeled with "USB" then the USB interface is connected to SCI1.

The specification of the switching power supply AC adapter is:

- DC input: 110V-240V
  - DC output: 9V
  - Current rating: 500mA
  - Type of plug: 2.1mm female barrier plug, center positive
-

## 1.2 MC9S12DG256 features and memory map:

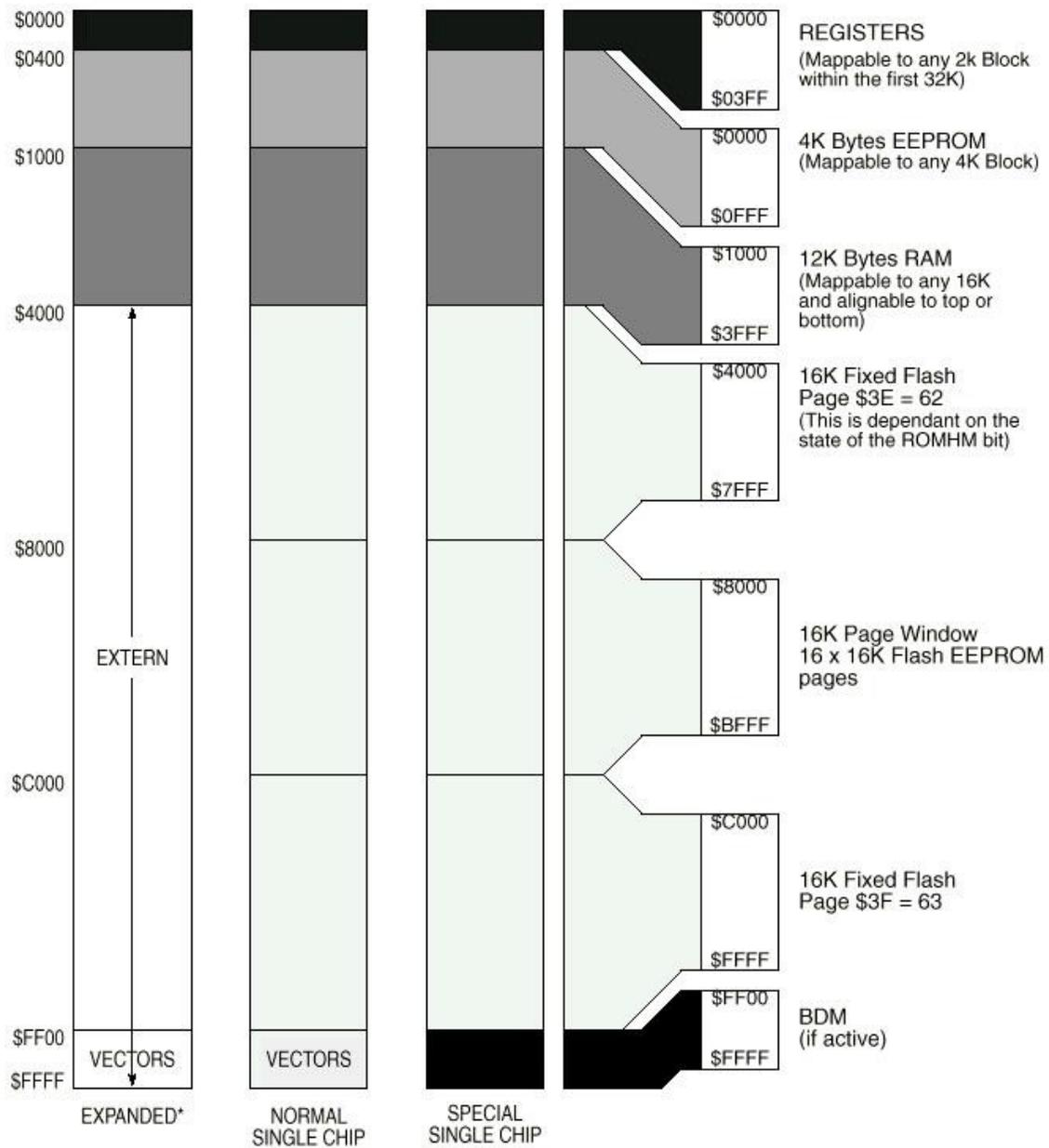
The Dragon12-Plus2 board comes with the MC9S12DP256CCPV or the MC9S12DG256CVPE installed. The MC9S12DG256 is a replacement for the MC9S12DP256 since the latter has been discontinued by Freescale. The only difference between DG256 and DP256 is the number of CAN ports. The DG256 has 2 CAN ports, but the DP256 has 5 CAN ports. Other than the different number of CAN port these two microcontrollers have the same features. If you don't use more than 2 CAN ports these two chips are identical and **all datasheets and manuals** for the DP256 can be used for the DG256.

If your application that needs more than two CAN ports please contact us at [sales@evbplus.com](mailto:sales@evbplus.com) and we may be able to ship the board installed with the DP256.

The MC9S12DG256 microcontroller consists of a powerful 16-bit CPU (central processing unit), 256K bytes of flash memory, 12K bytes of RAM, 4K bytes of EEPROM and many on-chip peripherals.

The main features of the MC9S12DG256 are listed below:

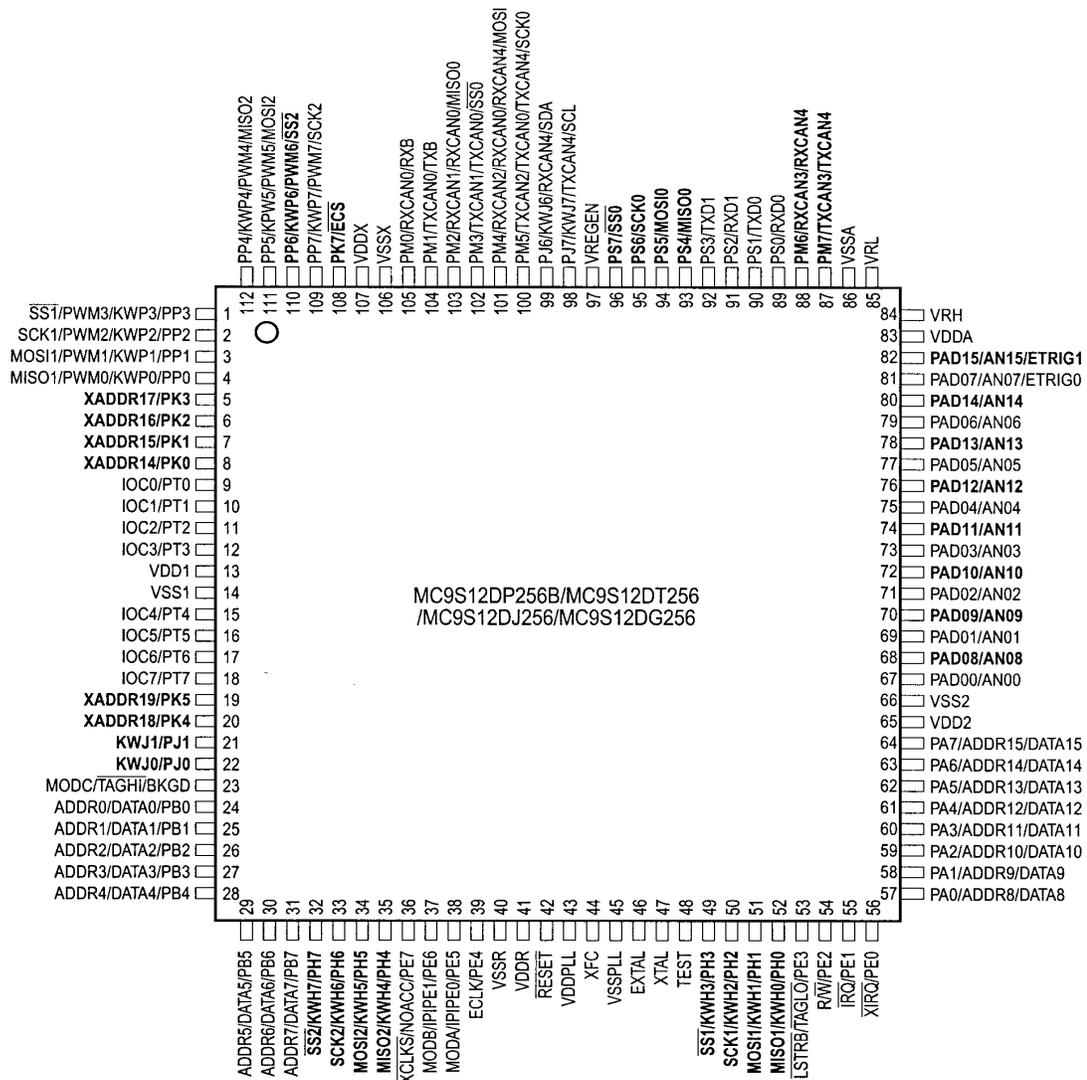
- Powerful 16-bit CPU
  - 256K bytes of flash memory
  - 12K bytes of RAM
  - 4K bytes of EEPROM
  - SCI ports
  - SPI ports
  - CAN 2.0 ports
  - I<sup>2</sup>C interface
  - 8-ch 16-bit timers
  - 8-ch 8-bit or 4-ch 16 bit PWM
  - 16-channel 10-bit A/D converter
  - Fast 25 MHz bus speed via on-chip Phase Lock Loop
  - BDM for in-circuit programming and debugging
  - 112-pin LQFP package offers up to 91 I/O in a small footprint
-



\* Assuming that a '0' was driven onto port K bit 7 during MCU is reset into normal expanded wide or narrow mode.

**Fig 1-1: MC9S12DG256 Memory map**





Signals shown in **Bold** are not available on the 80 Pin Package

**Fig 1-3: MC9S12DG256 MCU pin assignments**

### 1.3 On-board hardware features:

The Dragon12-Plus2 board includes the following features compatible to the previous versions:

1. On-board USB interface selectable for SCI0 or SCI1
2. RGB color LED
3. RS485 communication port
4. DS1307 RTC with capacitor backup included for testing I<sup>2</sup>C interface
5. I<sup>2</sup>C expansion port for interfacing external I<sup>2</sup>C devices
6. CAN port
7. SPI expansion port for interfacing external SPI devices
8. Dual 10-bit DAC for testing SPI interface and generating analog waveforms
9. Four robot servo controllers with terminal block for external 5V

10. Four digit 7-segment LED display for learning multiplexing technique
11. Eight LEDs
12. Eight-position DIP switch
13. Four push button switches
14. 3.3V and 5V regulators
15. Speaker to be driven by timer, or DAC or PWM signal for alarm or music applications.
16. Dual H-Bridge motor driver controls two DC motors or one Stepper motor
17. 3.3V and 5V Power-On LED indicators
18. IR detector
19. BDM-in connector to be connected with a BDM from multiple vendors for debugging
20. BDM POD mode for programming other HCS12 boards. No extra hardware needed
21. Logic probe with LED indicator
22. Abort switch for stopping program when program is hung in a dead loop
23. Mode switch for selecting 4 operating modes: EVB, Jump-to-EEPROM, BDM POD and Bootloader
24. 4 X 4 keypad
25. Form C relay output rated at 3A/30V or 1A/125V
26. Relay-On LED indicator
27. X-Y-Z accelerometer interface or GP2-D12 distance measuring sensor interface for distance measurement
28. Potentiometer trimmer pot for analog input
29. Temperature sensor
30. Communication port for VGA camera (Camera is optional)
31. Light sensor
32. Female headers provide shortest distance (great for high speed applications!) from bread board to every I/O pin of the MC9S12DG256
33. PC board size is 8.4" X 5.3"

The Dragon12-Plus2 board also includes the following new features:

34. Xbee sockets.
35. a 4X2 female header for Nordic nRF24L01+ transceiver
36. a 4x1 female header for Bluetooth transceiver
37. SD memory card slot and VGA camera interface
38. Arduino Shield Compatible headers
39. A capacitive touch switch

The Dragon12-Plus2 board has the following features as options:

40. Xbee wireless transceiver module
41. Nordic nRF24L01+ wireless transceiver
42. Bluetooth transceiver
43. VGA camera
44. 3-axis accelerometer

#### 1.4 I/O Pin Usage

Many I/O pins of the MC9S12DG256 on the Dragon12-Plus2 board are used by on-board peripherals and it seems that there are only a few of unused pins left for your circuits on the breadboard. Fortunately, it's unlikely that all on-board peripherals will be used by one application program. So the I/O pins on unused peripheral devices can still be used by your circuits on the breadboard. For instance, if you don't touch the 4x4 on-board keypad, the entire port A will be available to your circuits. If you don't use the LCD or just unplug the LCD, the port K will be available as well. Port B drives LEDs, but if you ignore the status of the LED, the port B can drive any other I/O devices on the breadboard. Each pin in port H reads a switch, but it still can be used as an input for reading a TTL or CMOS output from your circuits.

---

Pin Name	Pin #	I/O Usage
PA0 (output)	Pin 57	Col_0 of keypad
PA1 (output)	Pin 58	Col_1 of keypad
PA2 (output)	Pin 59	Col_2 of keypad
PA3 (output)	Pin 60	Col_3 of keypad
PA4 (input)	Pin 61	Row_0 of keypad
PA5 (input)	Pin 62	Row_1 of keypad
PA6 (input)	Pin 63	Row_2 of keypad
PA7 (input)	Pin 64	Row_3 of keypad
PB0 (output)	Pin 24	LED0 or H-bridge
PB1 (output)	Pin 25	LED1 or H-bridge
PB2 (output)	Pin 26	LED2 or H-bridge
PB3 (output)	Pin 27	LED3 or H-bridge
PB4 (output)	Pin 28	LED4
PB5 (output)	Pin 29	LED5
PB6 (output)	Pin 30	LED6
PB7 (output)	Pin 31	LED7
PE0 (input)	Pin 56	Abort switch SW8
PE1	Pin 55	not used
PE2 (output)	Pin 54	Relay
PE3 (output)	Pin 53	not used
PE4	Pin 39	not used
PE5	Pin 38	not used
PE6	Pin 37	not used
PE7	Pin 36	not used
PH0 (input)	Pin 52	DIP switch 1 or pushbutton switch SW5
PH1 (input)	Pin 51	DIP switch 2 or pushbutton switch SW4 (input)
PH2 (input)	Pin 50	DIP switch 3 or pushbutton switch SW3 (input)
PH3 (input)	Pin 49	DIP switch 4 or pushbutton switch SW2 (input)
PH4 (input)	Pin 35	DIP switch 5 (input)
PH5 (input)	Pin 34	DIP switch 6 (input)
PH6 (input)	Pin 33	DIP switch 7 (input)
PH7 (input)	Pin 32	DIP switch 8 (input)
PJ0 (output)	Pin 22	DIR of RS485
PJ1 (output)	Pin 21	LED enable
PJ6	Pin 99	SDA for DS1307(U11) or external I2C (J2)
PJ7	Pin 98	SCL for DS1307(U11) or external I2C (J2)
PK0 (output)	Pin 8	RS of LCD module
PK1 (output)	Pin 7	EN of LCD module
PK2	Pin 6	DB4 of LCD module (bi-directional)
PK3	Pin 5	DB5 of LCD module (bi-directional)
PK4	Pin 20	DB6 of LCD module (bi-directional)
PK5	Pin 19	DB7 of LCD module (bi-directional)
PK7 (output)	Pin 108	R/W of LCD module

**Table 1-1: I/O pin usage list 1**

Pin Name	Pin #	I/O Usage
PM0	Pin 105	CAN0
PM1	Pin 104	CAN0
PM2	Pin 103	Write Enable for MicroSD memory
PM3	Pin 102	Card detect for MicroSD memory
PM4	Pin 101	CS of MicroSD memory
PM5	Pin 100	CS of nRF24L01+
PM6	Pin 88	CS of LTC1661 (DAC)
PM7	Pin 87	Not used
PP0 (output)	Pin 4	Digit 3 of 7-segment display or EN12 of H-bridge
PP1 (output)	Pin 3	Digit 2 of 7-segment display or EN34 of H-bridge
PP2 (output)	Pin 2	Digit 1 of 7-segment display
PP3 (output)	Pin 1	Digit 0 of 7-segment display
PP4 (output)	Pin 112	Servo motor 1 or RGB LED
PP5 (output)	Pin 111	Servo motor 2 or RGB LED
PP6 (output)	Pin 110	Servo motor 3 or RGB LED
PP7 (output)	Pin 109	Servo motor 4
PS0	Pin 89	SCI0 for PC communication, RECV (DB9 connector P1)
PS1	Pin 90	SCI0 for PC communication, XMIT (DB9 connector P1)
PS2	Pin 91	SCI1 for user applications, RECV, selected by J23
PS3	Pin 92	SCI1 for user applications, XMIT
PS4	Pin 93	MISO for LTC1661, MicroSD memory and external SPI (J10)
PS5	Pin 94	MOSI for LTC1661, MicroSD memory and external SPI (J10)
PS6	Pin 95	SCLK for LTC1661, MicroSD memory and external SPI (J10)
PS7	Pin 96	/SS for external SPI (J10), or nRF24L01+ or Arduino header
PT0	Pin 9	not used
PT1	Pin 10	not used
PT2	Pin 11	not used
PT3 (input)	Pin 12	IR detector
PT4 (output)	Pin 15	Capacitive touch switch
PT5 (output)	Pin 16	Speaker (output)
PT6 (output)	Pin 17	BDMout reset (used in POD mode only)
PT7	Pin 18	BDMout data line (bi-directional, used in POD mode only)
PAD0	Pin 67	D-bug12 mode select, SW7
PAD1	Pin 69	D-bug12 mode select, SW7
PAD2	Pin 71	not used
PAD3	Pin 73	not used
PAD4	Pin 75	Light sensor (phototransistor Q1)
PAD5	Pin 77	Temperature sensor (U14, LM45)
PAD6	Pin 79	not used
PAD7	Pin 81	Trimmer pot VR2
PAD8	Pin 68	X axis input for Wytec accelerometer or ADC input for GP12D2
PAD9	Pin 70	Y axis input for Wytec accelerometer or ADC input for GP12D2
PAD10	Pin 72	Z axis input for Wytec accelerometer or ADC input for GP12D2
PAD11	Pin 74	not used
PAD12	Pin 76	not used
PAD13	Pin 78	not used
PAD14	Pin 80	not used
PAD15	Pin 82	not used

**Table 1-2: I/O pin usage list 2**

## Chapter 2. Quick Start

By default the Dragon12-Plus2 board is pre-installed with the bootloader (Freescale AN2153.pdf) and the D-Bug12 monitor (Freescale DB12RG4.pdf). In chapters 2 and 3 the AsmIDE is used as the main software tool to develop and debug assembly programs. If you prefer to use CodeWarrior IDE for program development and your board is pre-installed, per your request, with the serial monitor (Freescale AN2548.pdf), **skip the chapters 2 and 3 after installing software from CD.**

People often use different terminologies. In our product manuals, **Download** means to transfer a file from PC to a development board, while **Upload** means to transfer a file from a development board to PC. Through out the manual, **left click** means that you click the left button of the mouse and **right click** means that you click the right button of the mouse.

### 2.1 Install software:

After downloading software from our web site, the installation is automated by double clicking on the **SETUP.BAT**. It will create a folder named c:\Dragon12Plus2\examples and copy all example program files from the CD to c:\Dragon12Plus2\examples

If the filename is only shown as **SETUP**, not **SETUP.BAT**, you should change a folder option of the Explorer to show file extension. When a file's extension is hiding, it is hard to know what it is.

To have your files to be shown with extensions, click on the TOOL tab in Explorer menu, then click on folder options, then click on view tab, finally un-check the item named 'Hide extensions for knowing file types'.

After the software is successfully installed, you can make a shortcut to AsmIDE.exe on the desktop. It's important to make a shortcut so that its target location is C:\Dragon12Plus2, not c:\Windows\desktop or other locations. First, right click the Start button, then left click "Explorer", left click on C:\Dragon12Plus2, right click on AsmIDE.exe (an application program), left click "Send to" and finally left click "Desktop" (do not click "COPY"). It will create an icon named "shortcut to AsmIDE" on the desktop and you can rename it to Dragon12-Plus2. You can double check the target location by right clicking on the icon, then left click on "properties". You should see that the target location is C:\Dragon12Plus2. If you want to make a shortcut for AsmIDE on the Desktop, this is the correct way to do it. If you don't follow this method, your may have a problem running your program. Never drag the AsmIDE.exe to the desktop folder.

The default setting of AsmIDE for the Dragon12-Plus2 board is created in a text file named c:\Dragon12Plus2\AsmIDE.ini. In the future if you get lost with all the changes, you always can copy this file into the folder named c:\Dragon12Plus2.

### 2.2 Getting Started (for the AsmIDE and D-Bug12 monitor firmware only)

To operate the Dragon12-Plus2 board, follow steps1 through 5 below:

1. Make sure that the both DIP switches of SW7 must be set in the "LOW" positions for EVB mode, then Plug the USB cable to the USB jack P1 on the **upper left** corner of the Dragon12-Plus2 board. Plug the other end of the USB cable into a USB port of your PC. Make sure that the jumpers on the J41 and J42 are set correctly for USB interface for the SCI0. The header J43 is the MC9S12DG256's SCI1 port in TTL interface that can be used by a user's application program. After power up, the PB7-PB0 LEDs should light up from left to right one at a time, the speaker should chirp once (If the chirp is too soft you can remove the sticker on the speaker to increase the volume) and the LCD should display the following message:
-

“ DRAGON12-plus2 ” ; you can display your name on LCD and see details  
“D-Bug12 EVB MODE” ; at C:\CDROM\examples\name\_display\readme.txt

If it does not occur, make sure that the Power-On LED indicator is on. The PWR LED is on when VCC (5V) is present.

2. To invoke the AsmIDE, you can right click the Start button, then left click “Explorer”, left click on C:\Dragon12Plus2 and finally, double left click on AsmIDE.exe. If you have created a shortcut icon on the desktop, just double click the AsmIDE icon on the desktop.

**Warning note: In order to establish a reliable USB communication, always connect the Plus2 board to your PC's USB port first before invoking the IDE (CodeWarrior or AsmIDE), otherwise the IDE will not be able to communicate with the Plus2. During a debugging session, if you accidentally unplug the USB cable from the Plus2, you need to re-establish the USB communication. The IDE will not recognize the Plus2 again if you just simply plug the USB cable back in.**

**To re-establish the USB communication you need to exit the IDE and disconnect the USB cable from the Plus2 board, wait for a few seconds before re-plugging in the USB cable, then wait for a few more seconds and allow the USB communication to be re-established with the Plus2. After re-establishing the USB communication you can invoke the IDE again and the IDE will start to communicate with the Plus2 board. If this does not work, you need to restart your PC.**

**If restarting the PC does not solve the problem, you may need to re-install the USB driver.**

The AsmIDE is simple and very easy to use. You only need to use three commands from the AsmIDE for your HCS12 development work. Use the File command to edit your source code, the Build->Assemble command to assemble your source code, and the Build->Download command to download an s19 file to the Dragon12-Plus2 board.

In the View->Option->Terminal Window Options menu, set the COM port as 1 or 2 to match the COM port number that is assigned to the USB port by Device Manager in control panel. Also, set the COM port options at 9600, N,8,1, and check the “enable the terminal window”.

3. After reset, the D-Bug12 monitor defaults baud rate at 9600 and and Hyperbaud function is disabled. If Hyperbaud function is enabled, the Hyperbaud toolbar button sends the BAUD 57600 command to the D-Bug12 monitor, and then it also changes the serial port to the 57600 baud rate. **IMPORTANT:** When you reset your board it will go back to 9600 baud and you will see characters ‘aaaaaaaa’ on the screen. You will need to press the Hyperbaud button once to return AsmIDE to 9600 baud, and press it again to get 57600 baud. To stay at the 57600 baud all the time, you need to press the Hyperbaud button twice after every reset. The Hyperbaud function is disabled by default and it should only be used by an experienced user, not a beginner.
4. You can program text values for function keys to be sent from the terminal window. Some function keys are pre-programmed, but you can change it any time in configuration options (View->Options->Terminal Func Keys).

In the View->Option->Assembler menu, make sure that the chip family is **68HC12**, not 68HC11. If you would like to use your own assembler, you can replace the as12.exe with the name of your own assembler.

---

5. The screen is divided into two windows. The top window is for editing your source code and the bottom window is shared by the **message window** and the **terminal window**.

If the terminal options are set correctly, you should see the following prompt every time the reset button on the Dragon12-Plus2 board is pressed. If you do not see this, the bottom window may be set for message window. Sometime it's a little confusing when terminal window is disabled and the message window does not display what you have typed. In order to enable terminal window you have to click the terminal button in the bottom window to enable the terminal window display, then move the cursor to any location in the terminal window and click the left button on the mouse. After seeing a solid block cursor flashes, press the <Enter> key and it will enable the terminal window.

```
D-Bug12 v4.0.0b32
Copyright 1996 - 2005 Freescale Semiconductor
For Commands type "Help"
>
```

**Warning note:** If you see the above message, but you cannot type in any character on keyboard then the jumper on J41 is probably installed on the two upper pins. In order to use USB interface, the jumper on J41 must be installed on the two lower pins.

### 2.3 Test Hardware:

To help users get up and running, the Dragon12-Plus2 board comes with many fully debugged and ready-to-run sample programs including source code. The hardware test program, test.asm, simultaneously scans the keypad, plays a song, multiplexes the 4 LED seven segment display, changes display brightness by adjusting the trimmer pot and detects an IR signal.

All sample programs must be run from RAM in EVB mode. In order to run the test program in EVB mode, the both DIP switches of SW7 must be set in the "low" positions (the picture above the SW7 shows the switch settings for 4 different modes).

The steps to run your first sample program are as follows:

1. Click the File button to open the test.asm from c:\Dragon12Plus2\examples. After the test.asm is loaded into the AsmIDE window, you can view instructions of how to test all hardware on the Dragon12-Plus2 board.
  2. Click the Build button to assemble code and generate the test.s19 file. This is how you normally generate an s19 file. You can omit this step, because the test.s19 is already on your hard disk.
  3. Press the reset button on the board, you will see:

```
D-Bug12 v4.0.0b32
Copyright 1996 - 2005 Freescale Semiconductor
For Commands type "Help"
>
```
  4. Type "LOAD", then hit <Enter> key.
  5. Click the Build button. Select Download option and locate the file 'test.s19' for downloading. If it prompts you with the "save changes?" message, you can ignore that message and click the "No" answer.
  6. After download is done, type "G 2000" and hit <Enter> key to run the test program.
-

All sample programs on the CD are developed in RAM. You can try to run a different example program later after you have finished reading this manual. You should always press the reset button before downloading a new program, because the new program may not work if an interrupt was enabled by a previous program.

All example programs are fully debugged, so the assembler won't generate an error. If you have an error, even a warning error, in your program, you must correct it before it can generate an s19 file.

## Chapter 3. Software descriptions

### 3.1 Bootloader and D-Bug12 Monitor

The MC9S12DG256 on the Dragon12-Plus2 board is pre-loaded with bootloader and D-Bug12 monitor firmware and it will operate in 4 different modes depending on the setting of the 2-position DIPswitch, SW7. After power up or reset, the MC9S12DG256 will read the PAD0 and PAD1 to decide which mode to boot up.

The bootloader (**AN2153.PDF**), the D-Bug12 reference guide (**DB12RG4.PDF**) and the MC9S12DG256 data book (**MC9SDG256.PDF**) are the most important documentations. They can be found on the folder named C:\Dragon12Plus2\document after software installation. The HCS12 instruction set, register map and memory map can be found on page 26, 65 and 120 of the data book, respectively.

The new D-Bug12 V4.x is much different and much larger (about 60K) than old D-Bug12 V2.x. The \$C000-\$EFFF are just a part of the monitor, In 16-bit S1 record they are \$C000-\$EFFF. In 24-bit S2 record, they are \$FC00-\$EFFF (ppage=\$3F). Since the ppage register deals with the 16K window \$8000-\$BFFF the addresses \$C000-\$FFFF are not affected by the ppage. The other part of the monitor is at C000-C87FF (16K window \$8000-\$BFFF when ppage=\$30,\$31 and \$32). See details on page 20 of the app note AN2153 or page 71 of the D-Bug12 v4 reference guide on the CD.

#### 3.1.1 EVB mode: PAD1=0, PAD0=0.

This is the standard debug environment running on the MC9S12DG256 for on-chip RAM or EEPROM based code development. Using an IDE program to view and modify registers and memory locations, you may set breakpoints, single step through programs, and assemble and disassemble code as you would in a BUFFALO monitor based Freescale 68HC11 EVB. It gives you 12K RAM and 3K EEPROM to develop and debug your code. You must place your interrupt vectors at \$3E00-\$3E7F, because real interrupt vector addresses are taken by bootloader, bootloader and D-Bug12 monitor will redirect interrupts to the RAM interrupt vector table at \$3E00-\$3E7F.

After booting up in this mode, the LCD should display the following message:

```
" DRAGON12-plus2 "  
"D-Bug12 EVB MODE"
```

and you should see the following message on PC screen:

```
D-Bug12 v4.0.0b32  
Copyright 1996 - 2005 Freescale Semiconductor  
For Commands type "Help"
```

>

Typing “help” then <Enter> will display a list of available commands.

In this mode, you **cannot** erase or program on-chip flash memory.

If the D-Bug12 monitor is erased, the LCD will display the following message after reset:

“ **DRAGON12-plus2** ”  
“ **D-Bug12 ERASED** ”

You can use bootloader to re-program D-Bug12 monitor into flash memory.

**Note:** Some user may accidentally erase D-Bug12 monitor in bootloader mode, so it is important to know how to re-program D-Bug12 monitor in bootloader mode.

### 3.1.2 **Jump-to-EEPROM mode:** PAD1=0, PAD0=1

This mode enables the MC9S12DG256 to jump directly to the internal EEPROM at location \$0400 upon reset.

This mode makes the MC9S12DG256 a replacement for the old 68HC811E2 microcontroller, but it also gives you 3K EEPROM instead of 2K EEPROM with the 68HC811E2. The bus speed is 4MHz, one half of the crystal frequency by default, the PLL function must be initialized by user’s code for a higher bus speed, because the D-Bug12 monitor firmware that boosts bus speed to 24 MHz is bypassed. If you need to auto start your code upon reset, the procedure is available in the folder named eeprom\_programming.

After booting up in this mode, the LCD should display the following message:

“ **DRAGON12-plus2** ”  
“ **JUMP TO EEPROM** ”

### 3.1.3 **BDM POD mode:** PAD1=1, PAD0=0

In this BDM POD mode, the D-Bug12 firmware acts as a master to access all target MCU resources on the target board (another Dragon12-Plus2 board) via the BDM port in a non-intrusive manner. It becomes a BDM that will have all the features that a standard BDM has in debugging the target MCU. Also, it gains all the features a programmer has for programming the flash memory of the MCU on the target board (another Dragon12-Plus2 board).

To use the master board as a programmer, you need a 6-pin ribbon cable to connect from the BDM OUT of the master board to the BDM IN of the target board (make sure that the orientation of the cable is correct). You don’t have to provide the power to both boards, but only to one board. The master board communicates to a PC COM port while the target board does not need to be connected to a PC COM port.

After booting up in this mode, the LCD should display one of the following two messages:

If the D-Bug12 monitor is erased, the LCD will display the following message after reset:

“ **DRAGON12-plus** ”

---

**“POD-Bug12 ERASED”**

Otherwise it will display:

**“ DRAGON12-plus2 ”**  
**“ BDM POD MODE ”**

and you should see the following message on PC screen:

Can't Communicate With Target CPU

- 1.) Set Target Speed (48000 KHz)
- 2.) Reset Target
- 3.) Reattempt Communication
- 4.) Erase & Unsecure
- ?

You first must set the target speed with the choice 1). After entering the first choice, you will be prompted to enter the target speed. It's the crystal frequency, not the bus speed that is boosted up by the on-chip PLL. After a reset, before the PLL is enabled, the target MC9S12DG256 is running from the crystal frequency, not the PLL frequency. Enter 8000 for the target speed. After the correct speed is entered, the master will try to communicate with the target board. If it's not successful, enter choice 2) to reset the target board.

**Note:** The newer D-Bug12 monitor in POD mode may auto-detect the crystal frequency of a target board, so most likely the step 1 may not be needed.

Can't Communicate With Target CPU

- 1.) Set Target Speed (8000 KHz)
- 2.) Reset Target
- 3.) Reattempt Communication
- 4.) Erase & Unsecure
- ? 1

Enter Target Crystal Frequency (kHz): 8000

Can't Communicate With Target CPU

- 1.) Set Target Speed (8000 KHz)
- 2.) Reset Target
- 3.) Reattempt Communication
- 4.) Erase & Unsecure
- ? 2

When the communication is established, you will see the following:

D-Bug12 v4.0.0b32  
Copyright 1996 - 2005 Freescale Semiconductor  
For Commands type "Help"

S>

You will notice that the debug prompt is “S>” in the POD mode, not just a “>” in the EVB mode. The S> tells that this is the POD mode and the MC9S12DG256 on target (slave board) is stopped. Sometimes the prompt could be a “R>” that means the target MCU is

---

running. If you see the "R>", just type "reset" then <Enter> to reset the target and it will come back to the "S>" prompt.

```
R>Reset <Enter>
S>
```

**Note:** The initial communication in POD mode does not always work smoothly and sometimes the PC screen would only display an incomplete sign-on message. You need to re-start it all over again by pressing reset buttons on both master board and target board, then press the Enter key on PC keyboard. You cannot go to the next step until PC screen shows the prompt 's>'.

In order to program the flash memory, you have to erase it by using the FBULK command.

```
S>fbulk <Enter>
S>
```

When the prompt "s>" returns, the FBULK command has already erased all of the flash memory contents of the target MC9S12DG256 including the bootloader. If it returns with a message "Flash or EEPROM Failed To Erase" the MC9S12DG256 is defective.

Now we are going to program the bootloader and the D-Bug12 into the flash memory of the target MC9S12DG256.

Before we actually program the flash memory, we must understand there are two different types of s-record file that can be generated by compilers and assemblers.

An s1-record uses a 16-bit starting address field while an s2-record uses a 24-bit starting address field.

An s1-record file looks like this:

```
S123FFA0F64CF650F654F658F65CF660F664F668F66CF670F674F678F67CF680F684F6883D
S123FFC0F68CF690F694F698F69CF6A0F6A4F6A8F6ACF6B0F6B4F6B8F6BCF6C0F6C4F6C81D
S123FFE0F6CCF6D0F6D4F6D8F6DCF6E0F6E4F6E8F6ECF6F0F6F4F6F8F6FCF700F704F00009
S9030000FC
```

An s2-record file looks like this:

```
S2240FEFA0DB70DB66DB5CDB52DB48DB3EDB34DB2ADB20DB16DB0CDB02DAF8DAEEDAE4DADA41
S2240FEFC0DAD0DAC6DABCDAB2DAA8DA9EDA94DA8ADA80DA76DA6CDDD0DA62DA58DA4EDA4494
S2240FEFE0DA02DA0ADA12DA1ADA22DA2ADA32DA3AD9FAD9F2D9AFD98AD9D5EF00EF00EF0039
S9030000FC
```

We are not going to explain the s-record format here. If you would like to know more on the subject, you can review the D-Bug12 reference guide on the CDROM (**BD12RG4.PDF**). It explains the subject in great details. Right now, all you need to know is that an s1-record file must be converted to an s2-record file before using the FLOAD command. The "FLOAD" command in the D-Bug12 is for downloading an s2-record file.

Our Dragon12-Plus2 bootloader is modified from the Motorola's BootDP256.asm. We added our modification to the original source code and the s record file is generated by the AsmlIDE. It's an s1-record file and we converted it into an s2-record file by using the following commands:

```
Sreccvt -m c0000 ffff 32 -of f0000 -o Boot_DR12_8MHz.s29 Boot_DR12_8MHz.s19
```

Now we type “FLOAD” <Enter> at the prompt. Click the Build button, select the Download option, and select the file named **Boot\_DR12P\_8MHz.s29** located in the folder named “D-Bug12\_Monitor”. You should see the following on the terminal window when programming is done (when the prompt “s>” appears):

```
S>fload <Enter>
```

```
*****
```

```
S>
```

Now we are going to program the D-Bug12 monitor into the flash memory. We need to type “FLOAD” <Enter> at the prompt. Click the Build button, select the Download option, and select the file named **DBug12v32\_DR12P\_8MHz** located in the folder named “D-Bug12\_Monitor”. You should see the following on the terminal window when programming is done (when the prompt “s>” appears):

```
S>fload <Enter>
```

```
*****
```

```
*****
```

```
*****
```

```
*****
```

```
*****
```

```
*****
```

```
*****
```

```
*****
```

```
*****
```

```
*****
```

```
*****
```

```
S>
```

With the bootloader and the D-Bug12 programmed in the flash memory, the target board now becomes a true development board. That’s how we program the board before we ship it. Your Dragon12-Plus2 board actually becomes a programmer. You can then repeat above steps as many times as you want. Just unplug the 6-pin BDM cable from the target board, and then plug it into a new target board to program its flash memory with these two files. You even don’t have to turn off the power while doing this.

For your convenience, we combined both the bootloader and the D-Bug12 monitor into a single s2 file named **Boot\_DBug12v32\_DR12P\_8MHz .s29**. In case you need to update both of them, you can download this combined file.

The D-Bug12 monitor is an application program runs from the bootloader. If you program the D-Bug12 portion of flash memory with your application program, your program will run automatically in EVB mode after power up or reset. When running your code instead of the D-Bug12 monitor, the bus speed is 4MHz, one half of the crystal frequency by default. The PLL function must be initialized by your code for a higher bus speed, because the D-Bug12 monitor firmware was not in flash memory anymore. For your convenience, we include a PLL code template in chapter 7.

If you need to auto start your code upon reset, the procedure is available in the folder named flash\_programming.



### 3.1.4 BOOTLOADER mode: PAD1=1, PAD0=1

This bootloader allows you to erase/program flash memory and erase EEPROM. It is mainly used to program the D-Bug12 monitor into flash memory or download a user's fully debugged code into the D-Bug12 portion of flash memory. The latter allows the board to be operated in EVB mode and start your code every time the board is turned on or reset.

When you program your code into the D-Bug12 portion of flash memory, it wipes out the D-Bug12 monitor. You can restore it any time, just as if you were downloading another application program since the bootloader is not erased. You can erase and program the D-Bug12 monitor portion of the flash memory of the MC9S12DG256 on its own board in bootloader mode, but you cannot erase and program bootloader by itself. **The bootloader can only be erased by an external BDM via BDM-in port.**

After booting up in this mode, the LCD should display the following message:

```
" DRAGON12-plus2 "  
"  BOOT LOADER  "
```

and you should see the following bootloader menu on PC screen:

MC9S12DG256 bootloader menu:

- a) Erase Flash
- b) Program Flash
- c) Set Baud Rate
- d) Erase EEPROM
- ?

The option a) will erase the D-Bug12 portion of flash memory, not the bootloader itself.

The option b) will program the D-Bug12 portion of flash memory, not the bootloader itself.

The file to be programmed into flash memory must be an s2-record file. If your assembler and compiler generate s1-record files only, you must convert an s1-record file to an s2-record file before programming flash memory with the bootloader.

The option c) will set a new baud rate.

The option d) will erase all on-chip EEPROM.

**Note:** Some users may accidentally erase the D-Bug12 monitor when entering this mode, so it is important to know how to re-program the D-Bug12 monitor.

To program flash memory with the D-Bug12 monitor:

1. Enter the option a) to erase D-Bug12 portion of flash memory. Wait until the bootloader menu re-appears after flash memory is erased.
2. Enter the option b), the bootloader will wait for your file. **Do not type** any thing on keyboard.
3. Click the Build button, select the Download option, and select the file named **DBug12v32\_DR12P\_8MHz .s29** located in the folder named "D-Bug12\_Monitor" for downloading. You should see the following on the screen:

```
*****  
*****  
*****  
*****  
*****
```

4. It will take 3 minutes to program the D-Bug12 at 9600 baud rate and the bootloader menu will reappear after the D-Bug12 monitor is successfully programmed into flash memory.

### 3.2 Making a simple assembly program in RAM:

We are using AsmIDE as a terminal program and the following instructions to create your first assembly program. If you are using a different terminal program, the instructions may vary.

The steps to create your first program are as follows:

1. Click the **File** button to open a new file.

In assembly language, you specify the starting address of your CODE by an ORG statement.

You can start the data RAM at address \$1000 with the statement org \$1000 followed by RAM variables, as shown by:

```
org    $1000

count: rmb    1           ; reserve one byte of RAM for temp storage
temp:  rmb    2           ; reserve two bytes of RAM for temp storage
```

If your program is small, say less than 4K, you can start your program at address \$2000 with the statement org \$2000 followed by your program, as shown by:

```
org    $2000
```

It will assemble your source program and generate hex code within 4K locations from \$2000 to \$2FFF.

Here is a very simple program, but it's complete. It will flash the PBO LED at 2Hz when it's running. The RAM byte named 'counter' is added for demonstrating how a RAM data byte is used in a user program. In this simple program it's not really necessary, because the accumulator A can be used as the RAM byte 'counter'.

For a good programming practice, you should always place the lds instruction in the first line of your code.

```
#include    reg9s12.h
REGBLK:    equ    $0000
STACK:    equ    $2000           ; do not use $4000
;
org    $1000
counter:  rmb    1

org    $2000           ; program code
start:   lds    #STACK
        idx    #REGBLK

        ldaa   #$ff
        staa  ddrr,x       ; make port J an output port
        staa  ddrb,x       ; make port B an output port
```

---

```

        staa  ddrp,x      ; make port P an output port
        staa  ptp,x      ; turn off 7-segment LED display

back:   clr    ptj,x      ; make PJ1 low to enable LEDs
        clr    portb,x   ; turn off PB0
        jsr   d250ms     ; delay 250ms
        inc   portb,x   ; turn on PB0
        jsr   d250ms     ; delay 250ms
        jmp   back

*
d250ms: ldaa  #250       ; delay 250 ms
        staa  counter

delay1: ldy   #6000     ; 6000 x 4 = 24,000 cycles = 1ms
delay:  dey                     ; this instruction takes 1 cycle
        bne   delay      ; this instruction takes 3 cycles
        dec   counter
        bne   delay1     ; not 250ms yet, delay again
        rts

        end

```

2. Click File button, select Save option to save your assembly source file. Save your file frequently while editing. If you are creating a new file and giving the file a name to save, enter the file name including file extension, such as "Flash\_PB0.asm", not just "Flash\_PB0".
3. Click Build button, select Assemble option, or click the assembler button on the toolbar to assemble your code and generate an s19 file. If the assembler detects an error, the error message will show the line numbers of your source code that caused the error. You have to correct all errors in your program.
4. Go to the line and correct the errors and go back to step 3 until there are no errors.
5. Press the reset button on the board, you will see:
 

```

D-Bug12 v4.0.0b32
Copyright 1996 - 2005 Freescale Semiconductor
For Commands type "Help"
>

```
6. Type "LOAD" and then hit <Enter> key
7. Click Build button, select Download option and locate the file named 'Flash\_PB0.s19' for downloading. After download is done, type "G 2000" and hit <Enter> key to run the program.

For your convenience, we have included this sample program in the folder named "example".

---

### 3.3 Software development

#### 3.3.1 Use on-chip 12K RAM for software development in EVB mode.

You can download your s19 file into the RAM and debug it with the D-Bug12 monitor in EVB mode. You must place your interrupt vectors at \$3E00-\$3E7F, because real interrupt vector addresses are taken by the bootloader. The bootloader and the D-Bug12 monitor will redirect interrupts to the RAM interrupt vector addresses at \$3E00-\$3E7F

Because RAM will lose its contents after power off, you have to load your program every time after power-up. In the beginning of your program, you must initialize the interrupt vectors at \$3E00-\$3E7F.

In all sample programs, the user program code locations are at \$2000-\$3FFF. The user data RAM locations are at \$1000-\$1FFF. The 64 RAM interrupt vector addresses are at \$3E00-\$3E7F.

The 64 RAM interrupt vector addresses (128 bytes of RAM) are assigned by the D-Bug12 monitor to different interrupt sources. The listing of interrupt sources is show on chapter 7.

#### 3.3.2 Use on-chip 3K EEPROM for testing your code in EVB mode.

If your program is small enough to fit into a 3K range, then you can download your code into the EEPROM. In this way, your program can be auto started from \$0400 upon reset. You cannot set software breakpoints and single step in the EEPROM in EVB mode, so it makes sense to do development work in the RAM first. When your code is completely debugged, then re-assemble or re-compile it at \$0400 and download the final s19 file into the EEPROM for the auto start feature. With the early versions of D-Bug12 monitor, an s19 file must be converted to an s29 file to program the EEPROM, but it's not required in the current version.

Like the RAM-based development, your interrupt vectors are at \$3E00-\$3E7F. In the beginning of your program, you must initialize the interrupt vectors at \$3E00-\$3E7F.

#### 3.3.3 Program on-chip flash memory in BOOTLOADER mode.

In this mode, you download your program code directly into on-chip flash memory. You first erase the D-Bug12 monitor portion of flash memory, and then program that portion of the flash memory by downloading your application program code in an s29 file. Your program code will replace the D-Bug12 monitor in the flash memory. The bootloader portion of the flash memory remains intact. To run your code, set the mode switch SW 7 to EVB mode, then press the reset button. It usually runs the D-Bug12 monitor, but now it runs your program. The flash memory is non-volatile like the EEPROM. Your code will run every time the board is turned on or reset.

The bootloader redirects interrupts to the secondary interrupt vectors at \$EF80-\$EFFF. The D-BUG12 is not present and the interrupt vectors of your program are at \$EF80-\$EFFF. The addresses \$EFFE and \$EFFF contains the starting address of your program.

---

In order to program the MC9S12DG256 flash memory, you must program an even number of bytes and begin on an even address boundary for each s-record. If any one s-record in the file contains an odd number of bytes or begins with an odd address, the flash memory cannot be programmed. If your assembler or compiler cannot generate the even format, you must use the Freescale s-record conversion utility **sreccvt.exe** to convert your odd format to the even format by using the following command line:

```
Sreccvt -m c0000 ffff 32 -of f0000 -o test.s29 test.s19
```

It will create a new file named test.s29 that has the even format and can be programmed into flash memory. For your convenience, the sreccvt.exe is included in the folder named CDRom\document\Sreccvt-GUI.

## Chapter 4: Hardware Descriptions

The crystal frequency is 8 MHz and usually it will result in a 4 MHz bus speed, but on this board the MC9S12DG256's internal PLL boosts the bus speed up to 24 MHz.

The circuit is designed in such way that the value of all resistors and capacitors are not critical.

### 4.1 LEDs:

Each port B line is monitored by a LED. In order to turn on port B LEDs, the PJ1 (pin 21 of MC9S12DG256) must be programmed as output and set for logic zero.

### 4.2 DIP switch and pushbuttons:

Port H is connected to an 8-position DIP switch. The DIP switch is connected to VCC via the RN4 (four 2.7K resistors) and RN5 (four 2.7K resistors). Via RN8 (four 47K resistors) and RN9 (four 47K resistors), so it's not dead short to VCC or GND. When port H is programmed as an output port, the DIP switch setting is ignored, but for the best result all 8 DIP switches should be open (at the low positions).

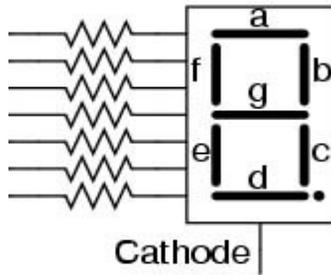
### 4.3 7-Segment LED multiplexing

There are 4 digits of 7-segment LEDs on the Dragon12-Plus2 board. The type of the 7-segment LED on board is called common cathode. In an individual digit, all anodes are driven individually by an output port and all cathodes are internally connected together.

Before sending a number to a 7-segment LED, the number must be converted to its corresponding 7-segment code depending how the 7-segment display is connected to an output port.

The Dragon12-Plus2 board uses port B to drive 7-segment anodes and uses PP0-PP3 to drive common cathodes. We will explain how to multiplex 7-segment by displaying the number 1234 on the display.

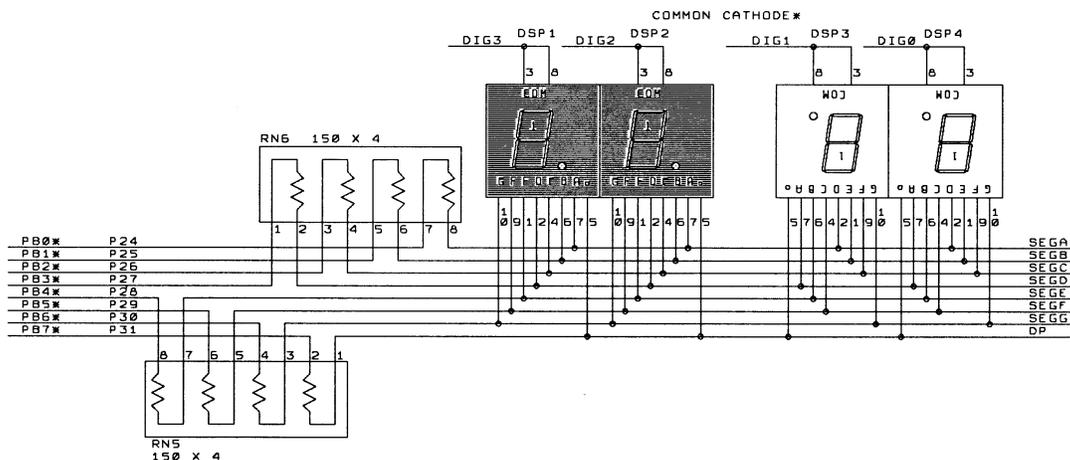
By convention, the 7 segments are called segment A, B, C, D, E, F and G. Their locations in the display are shown below:



The segment A, B, C, D, E, F, G and Decimal Point are driven by PB0, PB1, PB2, PB3, PB4, PB5, PB5 and PB7, respectively. The hex value of the segment code is shown in the following table:

Number	DP	G	F	E	D	C	B	A	Hex Value
1	0	0	0	0	0	1	1	0	\$06
2	0	1	0	1	1	0	1	1	\$5B
3	0	1	0	0	1	1	1	1	\$4F
4	0	1	1	0	0	1	1	0	\$66

The schematic for multiplexing 4 digits is shown below. The two of the digits at the right are deliberately placed upside down and the hardware connections compensate for this configuration. The reason for the upside down digits is to place two decimal pointers on the middle as a colon for a clock display.



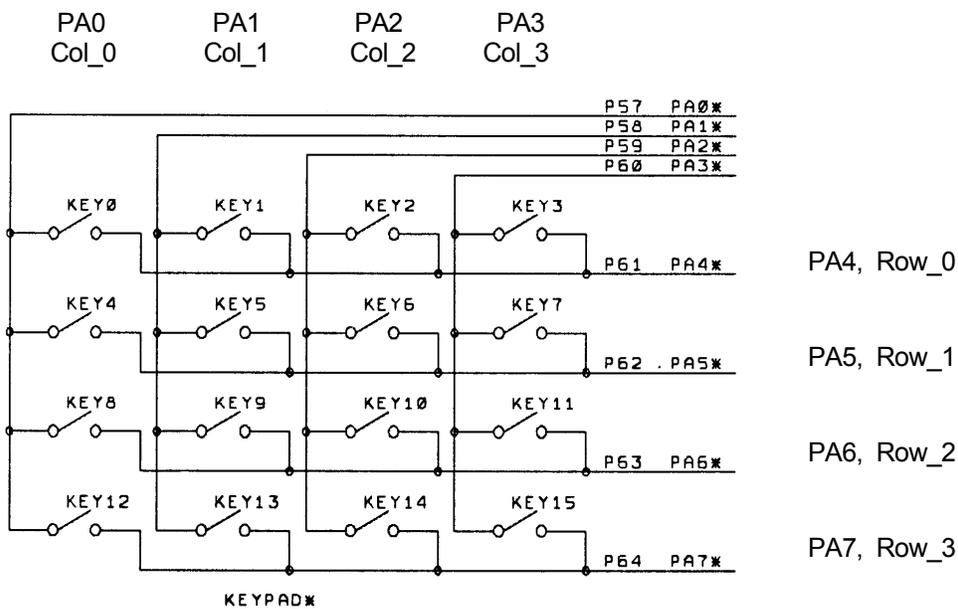
The digit 3, 2, 1, and 0 are driven by PP0, PP1, PP2 and PP3, respectively. The 7-segment LED is turned on one at a time at 250 Hz refresh rate. It's so fast that our eyes will perceive that all 4 digits are turned on at the same time. To display the number 1234 on the 7-segment display, the following steps should be taken:

1. Output \$06 to port B, set PP0 low and PP1, PP2, and PP3 high. The number 1 is shown on the digit 3 (the leftmost digit), but other 3 digits are turned off.
2. Delay 1ms.
3. Output \$5B to port B, set PP1 low and PP0, PP2, and PP3 high. The number 2 is shown on the digit 2, but other 3 digits are turned off.
4. Delay 1ms.
5. Output \$4F to port B, set PP2 low and PP0, PP1, and PP3 high. The number 3 is shown on the digit 1, but other 3 digits are turned off.
6. Delay 1ms.
7. Output \$66 to port B, set PP3 low and PP0, PP1, and PP2 high. The number 4 is shown on the digit 0 (the rightmost digit), but other 3 digits are turned off.
8. Delay 1ms.
9. Go back to step 1.

#### 4.4 Keypad:

Port A is an 8-bit bi-directional port. Its primary usage is for a 4X4 keypad. If the port is not used for the keypad, it can be used as a general-purpose I/O.

The schematic for the keypad connections is shown below:



Keypad connections:

- PA0 connects COL0 of the keypad
- PA1 connects COL1 of the keypad
- PA2 connects COL2 of the keypad
- PA3 connects COL3 of the keypad

PA4 connects ROW0 of the keypad  
PA5 connects ROW1 of the keypad  
PA6 connects ROW2 of the keypad  
PA7 connects ROW3 of the keypad

Keypad scan routine sets PA3 low and PA0, PA1, PA2 high, then tests PA4-PA7.

If no key is down, PA4-PA7 remain high.  
If PA7 = low, the key 15 is down.  
If PA6 = low, the key 14 is down.  
If PA5 = low, the key 13 is down.  
If PA4 = low, the key 12 is down.

Keypad scan routine sets PA2 low and PA0, PA1, PA3 high, then tests PA4-PA7.

If no key is down, PA4-PA7 remain high.  
If PA7 = low, the key 11 is down.  
If PA6 = low, the key 10 is down.  
If PA5 = low, the key 9 is down.  
If PA4 = low, the key 8 is down.

Keypad scan routine sets PA1 low and PA0, PA2, PA3 high, then tests PA4-PA7.

If no key is down, PA4-PA7 remain high.  
If PA7 = low, the key 7 is down.  
If PA6 = low, the key 6 is down.  
If PA5 = low, the key 5 is down.  
If PA4 = low, the key 4 is down.

Keypad scan routine sets PA0 low and PA1, PA2, PA3 high, then tests PA4-PA7.

If no key is down, PA4-PA7 remain high.  
If PA7 = low, the key 3 is down.  
If PA6 = low, the key 2 is down.  
If PA5 = low, the key 1 is down.  
If PA4 = low, the key 0 is down.

#### 4.5 LCD display

Port K is an 8-bit bi-directional port. It's used for the LCD display module. If the port is not used for the LCD display, it can be used as a general-purpose I/O port.

The pinouts of J11 and J12 are as follows:

Pin 1	GND	
Pin 2	VCC (5V)	
Pin 3	Via a 220 Ohm resistor to GND	
Pin 4	PK0	RS pin for LCD module
Pin 5	PK7	R/W pin for LCD module
Pin 6	PK1	EN pin for LCD module
Pin 7	Not used	
Pin 8	Not used	
Pin 9	Not used	
Pin 10	Not used	
Pin 11	PK2	DB4 pin for LCD module
Pin 12	PK3	DB5 pin for LCD module
Pin 13	PK4	DB6 pin for LCD module
Pin 14	PK5	DB7 pin for LCD module
Pin 15	Via a 22 Ohm resistor to VCC	LED backlight for LCD module
Pin 16	GND	

---

Please notice that PK2-PK5 (not PK4-PK7) are used to drive DB4-DB7 of the LCD module.

The LCD module is hardwired for write-only operation. Experienced user can cut the trace between two pads of the J5 on solder side, then solder a wire from the pin 5 of the LCD header J11 to the PK7 of the female header H8 to make it for both read and write operations.

#### **4.6 Logic probe**

An on-board logic probe LED is connected to pin 47 of the header H4 and can be used to monitor high or low states of a circuit as a logic probe. The pin 47 of the U10 (MC9S12DG256) is not connected to the header H4.

#### **4.7 Trimmer pot**

The trimmer pot VR2 is connected to the AN07 input of the ADC port.

#### **4.8 Dual Digital-to-Analog Converters (DACs)**

The on-board 2-ch, 10-bit DAC is installed for learning SPI communication. It converts a digital binary code to an analog signal so a program can generate different waveforms from the DAC.

The DAC installed on the board is LTC1661. Its analog output, OUTA, is provided on the pin between the headers H7 and H8. The other analog output, OUTB, is provided on the pin between the headers H1 and H2. A good application is to connect a DAC output to an ADC input, so a user can send a binary code to the DAC and read the code back from the ADC.

#### **4.9 Speaker**

The speaker is a 5V audio transducer and it can be driven by PT5, Output Comparator 3, or PP5 (PWM 5), or the output B of the DAC LTC1661. The jumper on J26 is preset for the PT5 at factory and all sample programs on the CD will drive the speaker via PT5.

During reset, the bootloader or the serial monitor will generate a chirp via the speaker. If the jumper is not installed for the PT5, the chirp won't happen.

#### **4.10 IR detector**

The IR detector can be used for IR remote control applications. If a 38 KHz signal from an IR transmitter is detected by the IR detector, the output of the detector goes low.

The output of the IR detector is connected to the PT3.

---

#### 4.11 Dual SCI communication ports

The SCI0 is used by D-Bug12 or serial monitor for developing and debugging user programs.

The SCI1 can be used by user's application programs. The receiver of the SCI1 can receive signals from many different devices, but only from one device at a time, or it will cause a signal collision. The main header J51 and auxiliary header J23 are used to select which device the SCI1 will receive. The J51 selects a source from J23, VGA camera module and XBee module. The J23 selects a source from USB interface via P1 (USB jack), Async serial communication in TTL logic level via J43, RS232 via P2 (DB9 connector) and RS485 via T2 (2-postion terminal block).

1. When a jumper is installed vertically on the two leftmost pins of the J51, the SCI1 will receive signal from one of four sources decided by the jumper on the J23.
2. When a jumper is installed vertically on the two middle pins of the J51, the SCI1 will receive signal from VGA camera module and the jumper on the J23 has no effect.
3. When a jumper is installed vertically on the two rightmost pins of the J51, the SCI1 will receive signal from XBee module and the jumper on the J23 has no effect.

#### 4.12 RS485 communication port

U5, SN75176, converts the TTL signal from SCI1 to RS485 differential signals and vice versa.

PJ0 (pin 22) of the MC9S12DG256 is used to control the direction of RS485 communication. If PJ0=0, the RS485 port, U5 DS75176, is set as a receiver port. If PJ0=1, the RS485 port, U5 DS75176, is set as a transmitter port.

#### 4.13 External SPI interface

SPI port (J10) pinouts are as follows:

SPI port (J10) pinouts are as follows:

Pin 1	MISO (PS4)	Pin 2	VCC (5V)
Pin 3	SPSLK (PS6)	Pin 4	MOSI (PS5)
Pin 5	/SS (PS7)	Pin 6	VSS (GND)

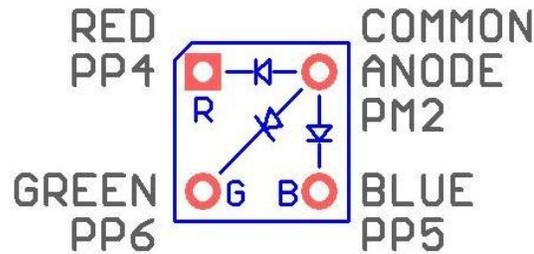
#### 4.14 External I<sup>2</sup>C interface

I2C port (J2) pinouts are as follows:

Pin 1	VCC (5V)	Pin 2	/IRQ
Pin 3	PJ7 (SCL)	Pin 4	PJ6 (SDA )
Pin 5	VSS (GND)		

#### 4.15 RGB LED ( Common Anode)

The anode is enabled by PM2.



The PP4, PP5 and PP6 control Red, Blue and Green LEDs, respectively.

#### 4.16 All jumper settings

All on-board jumpers:

- J1 Enables LCD backlight
- J2 I<sup>2</sup>C interface
  
- J4 Two channel 10-bit DAC outputs. The output A is also available between PJ6 of H8 and PJ7 of H7. The output B is also available between GND of H1 and PT4 of H2
- J5 R/W of LCD module. It's hardwired for write-only. (Located on solder side)
- J6 PP4 PWM output for a servo, the servo connector must be installed horizontally
- J7 PP5 PWM output for a servo, the servo connector must be installed horizontally
- J8 PP6 PWM output for a servo, the servo connector must be installed horizontally
- J9 PP7 PWM output for a servo, the servo connector must be installed horizontally
- J10 SPI connector, 6-pin
- J11 On-board LCD connector for a 16x2 LCD
  
- J13 RS of CAN0 (U2), is hard-wired to VSS. (Located on solder side)
  
- J16 Connects SQW of the DS1307 to /IRQ. It's not connected. (Located on solder side)
  
- J20 BDM input
- J21 BDM output, when the board is booted in POD mode
  
- J23 SCI1 receiver source select (numbering from top to bottom)  
It's only functioning if a jumper is installed vertically on the two leftmost pins of J51
  - 1= SCI1's PS2 receives signal from USB interface chip FT232RL
  - 2= SCI1's PS2 receives signal from J43 in TTL logic level
  - 3= SCI1's PS2 receives signal from P2 (DB9 connector) in RS232 logic level
  - 4= SCI1's PS2 receives signal from the terminal block T2 of RS485 port
  
- J25 DC motor power select. The jumper is installed on the two left pins if motors are powered by the on-board unregulated 9V (VIN). The jumper is installed on the two right pins if motors are powered by external voltage source that is less than 15V at the terminal block T3

- J26 Selects speaker driving source. The speaker can be driven by PT5 (OC3), PP5 (PWM) and DAC B
- J34 Connects PE2 to relay circuit. It's hard-wired. (Located on solder side)
- J35 Servo motor power select. The jumper is installed on the two left pins if servos are powered by the on-board VCC (5V). The jumper is installed on the two right pins if servos are powered by an external 5V power supply at the terminal block T7
- J36 X-Y-X Accelerometer module interface
- J39 Connects PM0 to RXD of CAN interface U2, It's hard-wired. (Located on solder side)
- J40 TTL logic level of the SCI0. In order to use this header, a jumper must be installed on the two upper pins of the J41.
- J41 Selects SCI0 interface. A jumper is installed on the two lower pins for USB interface, or on the two upper pins for TTL interface
- J42 Both jumpers are installed vertically on the four upper pins for connecting SCI0 to USB port. Both jumpers are installed vertically on the four lower pins for connecting SCI1 to USB port. When connecting SCI1 to USB port, the jumper on J23 must be installed horizontally on the "TOP" position labeled with "USB"
- J43 TTL logic level of the SCI1 for user application. In order to use this header, the jumper on the J23 must be horizontally installed on the second position from the top labeled with 'TTL'
- J49 Connects VRH to VDDA, it's hard-wired. (Located on solder side)  
If a different voltage level is needed for the VRH, cut this jumper and solder a wire from VRH pin to whatever voltage, such as 2.5V from the VDD2
- J50 External 3V battery backup volatage for the Real Time Clock, U11(DS1307). The RTC is backed up by a large capacitor without a battery. If the capacitor is fully charged ( after the board being turned on for 12 hours) it will normally keep the RTC running at least two weeks when the power is turned off. If that's not long enough an external 3V battery backup is recommended
- J51 Main SCI1 select header
- When a jumper is installed vertically on the two leftmost pins of the J51, the SCI1 will receive signal from one of four sources decided by the jumper on the J23
- When a jumper is installed vertically on the two middle pins of the J51, the SCI1 will receive signal from VGA camera module and the jumper on the J23 has no effect
- When a jumper is installed vertically on the two rightmost pins of the J51, the SCI1 will receive signal from XBee module and the jumper on the J23 has no effect
- J52 Nordic nRF24L01+ interface
- J53 VGA camera interface
- J54 Wi-Fi enable of a Wi-Fi module on XBEE footprint
- J55 XBEE pin 1 to pin 10 breakout
- J56 XBEE pin 11 to pin 20 breakout
- J57 Analog sensor input 1 and can be used for an IR distance sensor, such as GP2D12 or other ananlog or digital sensors
-

- J58 Analog sensor input 2 and can be used for an IR distance sensor, such as GP2D12 or other analog or digital sensors
  - J60 Connects capacitor backup to the RTC. It's hard-wired (Located on solder side). If an external battery backup is connected to the J50, cutting off this jumper will disconnect the capacitor from the RTC and prevent any leakage current caused by the capacitor.
  - J61 Provides VCC to the H-Bridge motor control IC, U12 (TB6612FNG). It's hard-wired (Located on solder side). In case the U12 is damaged, VCC and VSS may be internally shorted, by cutting this jumper the board may be able to work again without the H-Bridge.
  - J62 External 9V DC input
-

## Chapter 5: CodeWarrior and Serial monitor

CodeWarrior is a very powerful and professional IDE. The main feature of CodeWarrior IDE is the source level debugger in assembler and C. CodeWarrior Special Edition is a wonderful gift from Freescale to all of us and it's free for educational use. What's more, by CodeWarrior supporting serial monitor, they have made it very affordable to support CodeWarrior for the OEM.

Freescale has invested millions of dollar into CodeWarrior and the current versions work very well. What's more, Freescale knows they will never sell enough copies of CodeWarrior to make back what they have invested. They did it to drive chip sales.

As a software developer, the first thing you look at is available tools and what it will cost. There are many companies making MCU chips these days and for the most part they all have about the same features at a similar price. Special Edition CodeWarrior sets Freescale apart from others.

CodeWarrior IDE does not work with D-Bug12, but it works with serial monitor. Before Freescale created the serial monitor a BDM is needed as an interface between the PC and HCS12. Freescale created the serial monitor for working with CodeWarrior to eliminate the cost of a BDM.

Now a student can use the serial monitor with CodeWarrior to debug his program and in fact, many universities have been using the serial monitor with CodeWarrior without a BDM in their classrooms.

Without spending money on a BDM, a student will be able to spend his savings on purchasing a more advanced trainer, like the Dragon12-Plus2 board with many on-board peripherals. Purchasing an EVB board that comes with a BDM at a reasonable price, most likely leaves the student with an EVB of only limited functionality.

Some universities use D-Bug12 monitor first, then replace the D-Bug12 monitor with serial monitor to be used with CodeWarrior IDE later. In this case, a school laboratory only needs to have one BDM or use one Dragon12-Plus2 board as a BDM POD, to program all students' boards with serial monitor.

To replace bootloader and D-Bug12 monitor with serial monitor, you need a BDM or a BDM POD to perform the task. The procedure to program the on-chip flash memory is shown at:

[http://www.evbplus.com/freescale\\_usbdm\\_osbdm/usbdm\\_osbdm\\_bdm\\_multilink.html](http://www.evbplus.com/freescale_usbdm_osbdm/usbdm_osbdm_bdm_multilink.html)

Some universities use CodeWarrior IDE only. In this case, we pre-load the on-chip flash memory with serial monitor.

For more information on CodeWarrior please visit:

[http://www.evbplus.com/Code\\_Warrior\\_hcs12.html](http://www.evbplus.com/Code_Warrior_hcs12.html)

---

## Chapter 6: PLL code

```
; The crystal frequency on the Dragon12-Plus2 board is 8 MHz so the default bus speed is  
; 4 MHz. In order to set the bus speed high than 4 MHz the PLL must be initialized.
```

```
; You can cut and paste the following code to the beginning of your program.
```

```
; The math used to set the PLL frequency is:  
;  
; PLLCLK = CrystalFreq * 2 * (initSYNR+1) / (initREFDV+1)
```

```
; CrystalFreq = 8 MHz on Dragon12-Plus2 board  
; initSYNR = 5, PLL multiplier will be 6  
; initREFDV = 1, PLL divisor will be 2  
; PLLCLK =  $8 * 2 * 6 / 2 = 48$  MHz  
; The bus speed =  $PLLCLK / 2 = 24$  MHz
```

```
;Assembly code
```

```
;start:
```

```
; PLL code for 24MHz bus speed from a 4/8/16 crystal
```

```
sei  
ldx #0  
bclr clkssel,x,%10000000 ; clear bit 7, clock derived from oscclk  
bset pllctl,x,%01000000 ; Turn PLL on, bit 6 =1 PLL on, bit 6=0 PLL off  
ldaa #$05 ; 5+1=6 multiplier  
staa synr,x  
; ldaa #$03 ; divisor=3+1=4,  $16 * 2 * 6 / 4 = 48$  MHz PLL freq, for 16 MHz crystal  
; ldaa #$01 ; divisor=1+1=2,  $8 * 2 * 6 / 2 = 48$  MHz PLL freq, for 8 MHz crystal  
; ldaa #$00 ; divisor=0+1=1,  $4 * 2 * 6 / 1 = 48$  MHz PLL freq, for 4 MHz crystal  
  
staa refdv,x  
wait_b3: brclr crgflg,x,%00001000 wait_b3 ; Wait until bit 3 = 1  
bset clkssel,x,%10000000
```

```
/* C code */
```

```
void Set_Clock(void)  
{  
    CLKSEL &= 0x7F;  
    PLLCTL |= 0x40;  
    SYNRR = 0x05;  
    REFDV = 0x01;  
  
    /* REDDV=0x00 for 4 MHz */  
    REDDV=0x01 for 8 MHz  
    /* REDDV=0x03 for 16 MHz */  
  
    while(!(0x08 & CRGFLG));  
    CLKSEL |= 0x80;  
}
```

## Chapter 7: Appendix

### 7.1 D-Bug12 utility routines

The AN1280 was written for OLD 68HC12 family. If you happen to use printf routine with your old 68HC12 board you should be aware that I/O utility routines are moved to different addresses in D-Bug12 V4.x.

The address for the printf is \$EE88 and addresses of other I/O routines are listed below:

Function	Description	Pointer Address
far main()	Start of D-Bug12	\$EE80
getchar()	Get a character from SCI0 or SCI1	\$EE84
putchar()	Send a character out SCI0 or SCI1	\$EE86
printf()	Formatted Output - Translates binary values to characters	\$EE88
far GetCmdLine()	Obtain a line of input from the user	\$EE8A
far sscanf()	Convert an ASCII hexadecimal string to a binary integer	\$EE8E
isxdigit()	Checks for membership in the set [0..9, a..f, A..F]	\$EE92
toupper()	Converts lower case characters to upper case	\$EE94
isalpha()	Checks for membership in the set [a..z, A..Z]	\$EE96
strlen()	Returns the length of a null terminated string	\$EE98
strcpy()	Copies a null terminated string	\$EE9A
far out2hex()	Displays 8-bit number as 2 ASCII hex characters	\$EE9C
far out4hex()	Displays 16-bit number as 4 ASCII hex characters	\$EEA0
SetUserVector()	Setup user interrupt service routine	\$EEA4
far WriteEEByte()	Write a data byte to on-chip EEPROM	\$EEA6
far EraseEE()	Bulk erase on-chip EEPROM	\$EEAA
far ReadMem()	Read data from the M68HC12 memory map	\$EEAE
far WriteMem()	Write data to the M68HC12 memory map	\$EEB2

Fig 8-1: D-Bug12 utility routines

## 7.2 Interrupt vector table

**Table 5-1 Interrupt Vector Locations**

Vector Address	Interrupt Source	CCR Mask	Local Enable	HPRIO Value to Elevate
\$FFFE, \$FFFF	Reset	None	None	–
\$FFFC, \$FFFD	Clock Monitor fail reset	None	PLLCTL (CME, SCME)	–
\$FFFA, \$FFFB	COP failure reset	None	COP rate select	–
\$FFF8, \$FFF9	Unimplemented instruction trap	None	None	–
\$FFF6, \$FFF7	SWI	None	None	–
\$FFF4, \$FFF5	XIRQ	X-Bit	None	–
\$FFF2, \$FFF3	IRQ	I-Bit	IRQCR (IRQEN)	\$F2
\$FFF0, \$FFF1	Real Time Interrupt	I-Bit	CRGINT (RTIE)	\$F0
\$FFEE, \$FFEF	Enhanced Capture Timer channel 0	I-Bit	TIE (C0I)	\$EE
\$FFEC, \$FFED	Enhanced Capture Timer channel 1	I-Bit	TIE (C1I)	\$EC
\$FFEA, \$FFEB	Enhanced Capture Timer channel 2	I-Bit	TIE (C2I)	\$EA
\$FFE8, \$FFE9	Enhanced Capture Timer channel 3	I-Bit	TIE (C3I)	\$E8
\$FFE6, \$FFE7	Enhanced Capture Timer channel 4	I-Bit	TIE (C4I)	\$E6
\$FFE4, \$FFE5	Enhanced Capture Timer channel 5	I-Bit	TIE (C5I)	\$E4
\$FFE2, \$FFE3	Enhanced Capture Timer channel 6	I-Bit	TIE (C6I)	\$E2
\$FFE0, \$FFE1	Enhanced Capture Timer channel 7	I-Bit	TIE (C7I)	\$E0
\$FFDE, \$FFDF	Enhanced Capture Timer overflow	I-Bit	TSRC2 (TOF)	\$DE
\$FFDC, \$FFDD	Pulse accumulator A overflow	I-Bit	PACTL (PAOVI)	\$DC
\$FFDA, \$FFDB	Pulse accumulator input edge	I-Bit	PACTL (PAI)	\$DA
\$FFD8, \$FFD9	SPI0	I-Bit	SP0CR1 (SPIE, SPTIE)	\$D8
\$FFD6, \$FFD7	SCI0	I-Bit	SC0CR2 (TIE, TCIE, RIE, ILIE)	\$D6
\$FFD4, \$FFD5	SCI1	I-Bit	SC1CR2 (TIE, TCIE, RIE, ILIE)	\$D4
\$FFD2, \$FFD3	ATD0	I-Bit	ATD0CTL2 (ASCIE)	\$D2
\$FFD0, \$FFD1	ATD1	I-Bit	ATD1CTL2 (ASCIE)	\$D0
\$FFCE, \$FFCF	Port J	I-Bit	.PTJIF (PTJIE)	\$CE
\$FFCC, \$FFCD	Port H	I-Bit	PTHIF(PTHIE)	\$CC
\$FFCA, \$FFCB	Modulus Down Counter underflow	I-Bit	MCCTL(MCZI)	\$CA

**Fig 8-2: MC9S12DG256 Interrupt vector table 1**

\$FFC8, \$FFC9	Pulse Accumulator B Overflow	I-Bit	PBCTL(PBOVI)	\$C8
\$FFC6, \$FFC7	CRG PLL lock	I-Bit	CRGINT(LOCKIE)	\$C6
\$FFC4, \$FFC5	CRG Self Clock Mode	I-Bit	CRGINT(SCMIE)	\$C4
\$FFC2, \$FFC3	BDLC	I-Bit	DLBCR1(IE)	\$C2
\$FFC0, \$FFC1	IIC Bus	I-Bit	IBCR (IBIE)	\$C0
\$FFBE, \$FFBF	SPI1	I-Bit	SP1CR1 (SPIE, SPTIE)	\$BE
\$FFBC, \$FFBD	SPI2	I-Bit	SP2CR1 (SPIE, SPTIE)	\$BC
\$FFBA, \$FFBB	EEPROM	I-Bit	EECTL(CCIE, CBEIE)	\$BA
\$FFB8, \$FFB9	FLASH	I-Bit	FCTL(CCIE, CBEIE)	\$B8
\$FFB6, \$FFB7	CAN0 wake-up	I-Bit	CAN0RIER (WUPIE)	\$B6
\$FFB4, \$FFB5	CAN0 errors	I-Bit	CAN0RIER (CSCIE, OVRIE)	\$B4
\$FFB2, \$FFB3	CAN0 receive	I-Bit	CAN0RIER (RXFIE)	\$B2
\$FFB0, \$FFB1	CAN0 transmit	I-Bit	CAN0TIER (TXEIE2-TXEIE0)	\$B0
\$FFAE, \$FFAF	CAN1 wake-up	I-Bit	CAN1RIER (WUPIE)	\$AE
\$FFAC, \$FFAD	CAN1 errors	I-Bit	CAN1RIER (CSCIE, OVRIE)	\$AC
\$FFAA, \$FFAB	CAN1 receive	I-Bit	CAN1RIER (RXFIE)	\$AA
\$FFA8, \$FFA9	CAN1 transmit	I-Bit	CAN1TIER (TXEIE2-TXEIE0)	\$A8
\$FFA6, \$FFA7	CAN2 wake-up	I-Bit	CAN2RIER (WUPIE)	\$A6
\$FFA4, \$FFA5	CAN2 errors	I-Bit	CAN2RIER (CSCIE, OVRIE)	\$A4
\$FFA2, \$FFA3	CAN2 receive	I-Bit	CAN2RIER (RXFIE)	\$A2
\$FFA0, \$FFA1	CAN2 transmit	I-Bit	CAN2TIER (TXEIE2-TXEIE0)	\$A0
\$FF9E, \$FF9F	CAN3 wake-up	I-Bit	CAN3RIER (WUPIE)	\$9E
\$FF9C, \$FF9D	CAN3 errors	I-Bit	CAN3RIER (TXEIE2-TXEIE0)	\$9C
\$FF9A, \$FF9B	CAN3 receive	I-Bit	CAN3RIER (RXFIE)	\$9A
\$FF98, \$FF99	CAN3 transmit	I-Bit	CAN3TIER (TXEIE2-TXEIE0)	\$98
\$FF96, \$FF97	CAN4 wake-up	I-Bit	CAN4RIER (WUPIE)	\$96
\$FF94, \$FF95	CAN4 errors	I-Bit	CAN4RIER (CSCIE, OVRIE)	\$94
\$FF92, \$FF93	CAN4 receive	I-Bit	CAN4RIER (RXFIE)	\$92
\$FF90, \$FF91	CAN4 transmit	I-Bit	CAN4TIER (TXEIE2-TXEIE0)	\$90
\$FF8E, \$FF8F	Port P Interrupt	I-Bit	PTPIF (PTPIE)	\$8E
\$FF8C, \$FF8D	PWM Emergency Shutdown	I-Bit	PWMSDN (PWMIE)	\$8C
\$FF80 to \$FF8B	Reserved			

**Fig 8-3: MC9S12DG256 Interrupt vector table 2**

Interrupt Source	Secondary Vector Address	Interrupt Source	Secondary Vector Address
Reserved \$FF80	\$EF80	I <sup>2</sup> C bus	\$EFC0
Reserved \$FF82	\$EF82	DLC	\$EFC2
Reserved \$FF84	\$EF84	SCME	\$EFC4
Reserved \$FF86	\$EF86	CRG lock	\$EFC6
Reserved \$FF88	\$EF88	Pulse accumulator B overflow	\$EFC8
Reserved \$FF8A	\$EF8A	Modulus down counter underflow	\$EFCA
PWM emergency shutdown	\$EF8C	Port H interrupt	\$EFC C
Port P interrupt	\$EF8E	Port J interrupt	\$EFC E
MSCAN 4 transmit	\$EF90	ATD1	\$EFD0
MSCAN 4 receive	\$EF92	ATD0	\$EFD2
MSCAN 4 errors	\$EF94	SC11	\$EFD4
MSCAN 4 wakeup	\$EF96	SC10	\$EFD6
MSCAN 3 transmit	\$EF98	SPI0	\$EFD8
MSCAN 3 receive	\$EF9A	Pulse accumulator A input edge	\$EFDA
MSCAN 3 errors	\$EF9C	Pulse accumulator A overflow	\$EFD C
MSCAN 3 wakeup	\$EF9E	Timer overflow	\$EFD E
MSCAN 2 transmit	\$EFA0	Timer channel 7	\$EFE0
MSCAN 2 receive	\$EFA2	Timer channel 6	\$EFE2
MSCAN 2 errors	\$EFA4	Timer channel 5	\$EFE4
MSCAN 2 wakeup	\$EFA6	Timer channel 4	\$EFE6
MSCAN 1 transmit	\$EFA8	Timer channel 3	\$EFE8
MSCAN 1 receive	\$EFAA	Timer channel 2	\$EFEA
MSCAN 1 errors	\$EFAC	Timer channel 1	\$EFEC
MSCAN 1 wakeup	\$EFAE	Timer channel 0	\$EFEE
MSCAN 0 transmit	\$EFB0	Real-time interrupt	\$EFF0
MSCAN 0 receive	\$EFB2	IRQ	\$EFF2
MSCAN 0 errors	\$EFB4	XIRQ	\$EFF4
MSCAN 0 wakeup	\$EFB6	SWI	\$EFF6
FLASH	\$EFB8	Unimplemented instruction trap	\$EFF8
EEPROM	\$EFBA	COP failure reset	\$EFFA
SPI2	\$EFBC	Clock monitor fail reset	\$EFFC
SPI1	\$EFBE	Reset	\$EFFE

**Fig 8-4: MC9S12DG256 secondary interrupt vector table**