Open Source BDM Interface Users Manual

1.0 Introduction to Open Source BDM

This document describes an Open Source programming and debugging development tool designed to work with Freescale HCS08 microcontrollers. Called Open Source BDM, it can be obtained from the 8-bit message board at http://forums.freescale.com. While there is no support for Open Source BDM from Freescale, the Open Source BDM is provided with all required source code for both hardware and software components. Because it is open source, the source code can be used and/or modified from its original design free of charge. Figure 1 provides a pictorial overview of the typical connections required for programming and debugging using the Open Source BDM. A PC connects to the Open Source BDM PCB, in turn the PCB is connected to a Programming/Debug target. In this example, the GB60 demonstration boards are being programmed and debugged.

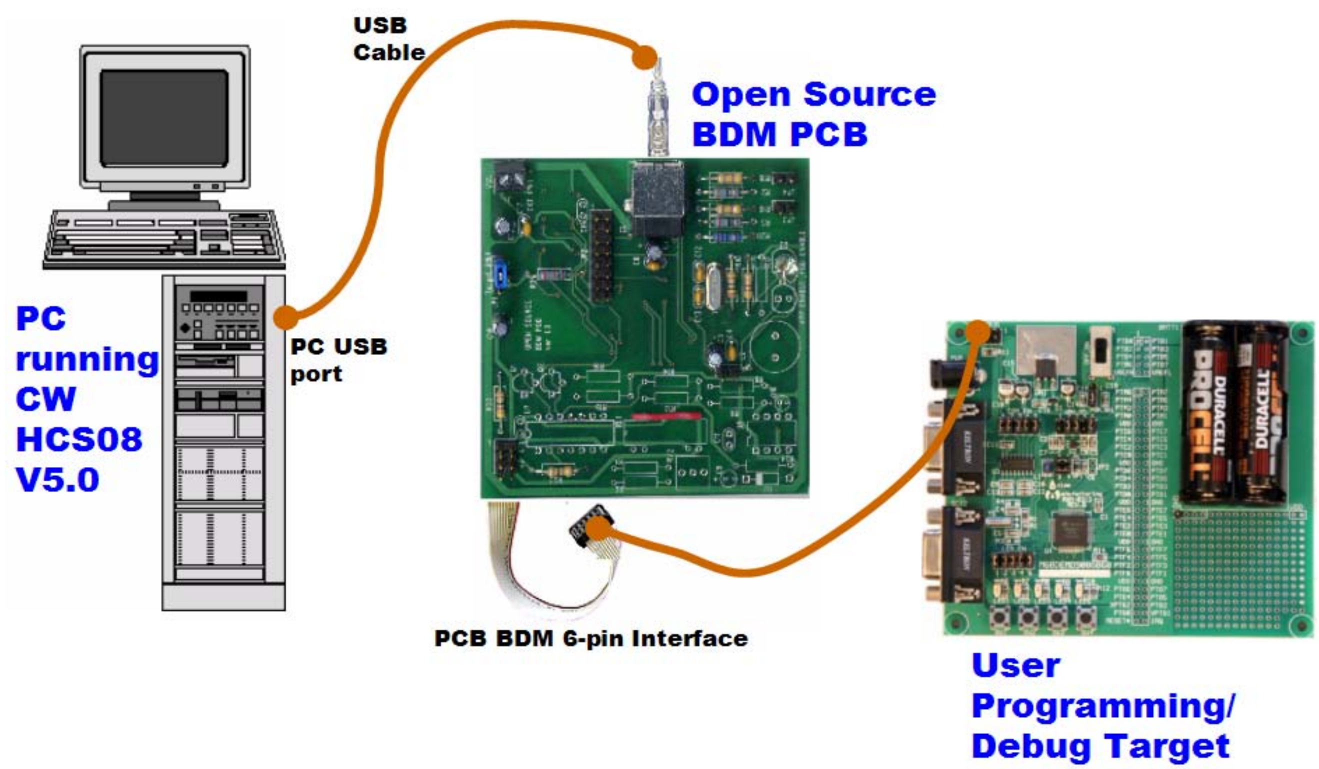


Figure 1. Debugging with Open Source BDM

Open Source BDM, with its hardware and software components, provides a transparent connection between a computer running CodeWarrior Development Studio for HCS08 version 5.0 to a Freescale HCS08 microcontroller via the microcontrollers BKGD pin. With a connection to the BKGD pin, the Open Source BDM enables debuggers and other software tools to communicate with the microcontroller including downloading of user code into the microcontroller's on-chip flash. Programming and debugger functionality is made possible by the HCS08 microcontroller's Background Debug Controller (BDC) and In-Circuit Emulator (ICE) Debug (DBG) modules.

1.1 About the HCS08 BDC/ICE Debug Module

HCS08 microcontrollers contain a single-wire background debug interface, supporting in-circuit programming of on-chip nonvolatile memory and sophisticated non-intrusive debug capabilities. The BKGD pin on HCS08 devices provides this single-wire background debug interface to the on-chip BDC and ICE Debug modules. See the Development Tools chapter of any HCS08 data sheet for more information about both the BDC and ICE Debug modules. While the interface is single wire, typically a 6-pin connector, a BDM port is used to interface with the target. Figure 2 depicts the 6-pin BDM port.

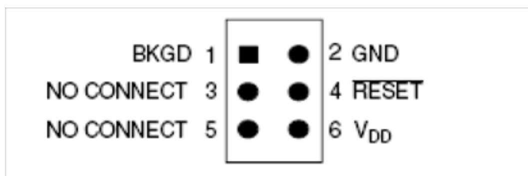


Figure 2 . Target 6-Pin Connector for BKGD Pin

The primary function of this pin is for bidirectional serial communication of active background mode commands and data. During reset, this pin is used to select between starting in active background mode or starting the user's application program. Additionally, this pin requests a timed sync response pulse, allowing a host development tool to determine the correct clock frequency for background debug serial communications.

BDC commands are sent serially from a host computer to the BKGD pin of the target HCS08 MCU. All commands and data are sent MSB-first using a custom BDC communications protocol. Two groups of BDC commands are listed below. A complete list of these commands is provided in the Development Tools chapter.

1. Active Background Mode Commands: These commands allow the CPU registers to be read or written. Users can also trace one user instruction at a time, or begin the user program in this mode.

2. Non-intrusive Commands: These commands permit read or write of MCU memory locations, or access status and control registers within the background debug controller. Non-intrusive commands can be executed at any time.

With a single-wire background debug interface, a relatively simple interface pod is used to translate commands from a host computer into commands for the BDC. In the case of the Open Source BDM, a Low-speed (LS) universal serial bus (USB) interface is used to communicate between the host PC and the pod. Functionality provided by the BDC and ICE DBG modules include:

- Single pin for mode selection and background communications
- BDC registers not located in the memory map
- SYNC command to determine target communications rate
- Non-intrusive commands for memory access
- Active background mode commands for CPU register access
- GO and TRACE1 commands
- BACKGROUND command can wake CPU from Stop or Wait modes
- One hardware address breakpoint built into BDC
- Oscillator runs in Stop mode when BDC is enabled
- COP watchdog disabled while in Active Background mode
- Features of the debug module (DBG) include:
  - Two trigger comparators: Two address + read/write (R/W) or One full address + data + R/W
  - Flexible 8-word by 16-bit first-in, first-out (FIFO) buffer for capture information: change-of-flow addresses or event-only data
  - Two types of breakpoints: Tag breakpoints for instruction opcodes and force breakpoints for any address access
  - Nine trigger modes

1.2 Scope of the User Manual

This documentation describes the Open Source BDM solution. The description provides sufficient detail, enabling the Open Source community to update, change, and maintain the Open Source BDM. This user manual describes the the organization and operation of the following:

- Open Source BDM Generic Debug Instrument (GDI) DLL plug-in for the CodeWarrior hiwave debugger
- Open Source BDM interface DLL and USB driver (libusb.lib)
- HC908JB16 USB/BDM firmware
- Open Source BDM PCB hardware

1.3 Open Source BDM Overview

While using the Open Source BDM, supplemental understanding of a debugger pod may be required with possibly more user maintenance to provide a low-cost alternative for development tools. The Open Source BDM software and hardware were developed to support existing and future HCS08 devices. It is designed to provide maximum accuracy and performance for HCS08 devices. Open Source BDM is compatible with CodeWarrior Studio HCS08 version 5.0, and currently supports the following HCS08 families:

- GB60
- AW6
- QG8
- RCx

As other HCS08 families are developed and released, the open source community may have to modify the Open Source BDM along with installation of CodeWarrior Studio HCS08 version 5.0 service packs. Other features of the Open Source BDM are:

- Open source distribution
- Low-cost development tools
- Designed for the modern and widely available USB interface
- Firmware developed with the HCS08 CodeWarrior Special Edition version
- Supports targets with operating voltages from 1.8 to 5.0V
- Supports target bus speeds from 1.0 to 20MHz
- Double-side PCB uses mostly though-hole design for ease of assembly
- PCB can optionally supply 5.0V power to the MCU target board
- PCB has an optional 16-pin MONO8 header to program the JB16
- PC USB DLL drivers source code is provided in ANSI C
- JB16 firmware source is mostly C with some assembly for time critical operations
- Firmware can be flash programmed using USB and Freescale interface. See AN2399 - these procedures are documented within this document.
- Windows USB drivers included using Open Source LIBUSB USB drivers
- Uses a JB16 MCU with 12MHz crystal clock source
- Documented API for easy integration into debuggers

As indicated, all the Open Source BDM source code is provided without charge. In addition, the Open Source BDM hardware uses low-cost components and is very simple to assemble. Unassembled PCB cost approximately under five U.S. dollars and the components can also be obtained for less than U.S. five dollars, depending on volume. Subsequent sections provide a detailed description of both the Open Source BDM hardware and software.

1.4 Open Source BDM Block Diagram

To better understand the implementation of the Open Source BDM, Figure 3 delineates the Open Source BDM solution into its most basic components. The diagram illustrates part of the Open Source BDM IP residing on the PC host for the debugging software and some resides on the Open Source BDM PCB.

At the time of release, the Open Source BDM is supported by the version 5.0 release of CodeWarrior Development Studio for Freescale HC(S)08 Microcontrollers. The Studio provides both a software development IDE and a debugger.

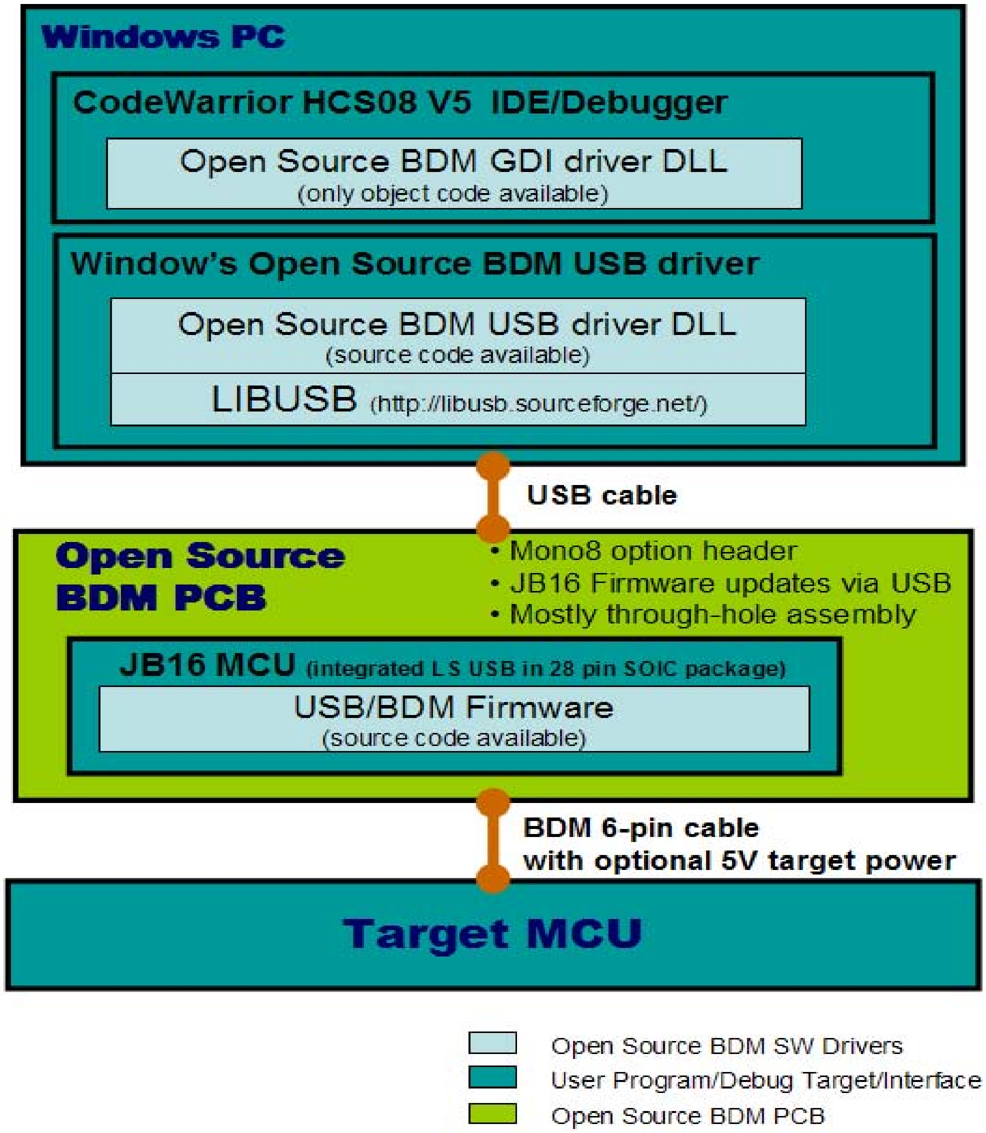


Figure 3. Block Diagram

Figure 3 illustrates five primary components, four software in nature and one hardware; these are itemized below. All of the software components are intended to be used as binaries by majority of users. For those who would like to look deeper, the source code of the JB16 firmware and the Open Source BDM interface DLL is provided in Table 1.

Table 1 Open Source BDM IP Components

Component	Description/Interfaces	Available/Comments
Open Source BDM GDI driver	File - OpenSourceBDM_gdi.dll Software interfacing with the CW V5.0 debugger GDI interface, providing function call to the Open Source BDM USB driver.	This software is available only as object code in the form of a DLL.
Open Source BDM USB driver	File - OpenSourceBDM.dll Software interfacing with the Open Source BDM GDI driver, providing function calls to the Windows USB drivers. This file is also required for the PC when it detects the Open Source BDM PCB as a new USB device on the PC USB port.	This software is available as both object (DLL) and source code. The DLL is provided in an Open Source BDM USB install package. Point the PC Hardware Wizard to the USB install package when the PC detected the Open Source BDM PCB.
Windows USB drivers	File - libusb.lib Software used by the Open Source BDM USB driver it interfaces to PC USB ports.	This USB library is compiled with the Open Source BDM USB driver and is also part of the Open Source BDM USB install package. The source code for libusb can be found at (http://libusb.sourceforge.net/)
JB16 USB/BDM firmware	File - OpenSourceBDM.s19 Software running on the JB16 that receives commands via USB from the PC and converts them into commands as defined by the BDC. These command are serial outputted - “bit - banged” - by the JB16 using port pins to drive the BKGD pin on the user’s target.	This file is provide as a S-recorded and need to be programmed the the JB16 on-chip flash
Open Source BDM PCB hardware	PCB: OpenSourceBDM Pod ver. 1.0 This hardware contains the JB16 and circuitry, clock, and power to provide the interface to the program/debug target.	All schematics and gerber files for the Open Source BDM PCB is provided along with a Bill of Materials (BOM). Also included is a complete HW description which enables you to build the interface

1.5 Open Source BDM Package

This section describes the contents of the Open Source BDM package. The package is distributed in zip file and includes both release and development folders. The development files folder contains source files while the release files folder contains only binary release files. A detailed discussion is provided for each of these items in the next sections. An illustration of the unzipped Open Source BDM package directory structure is provided in Figure 4.

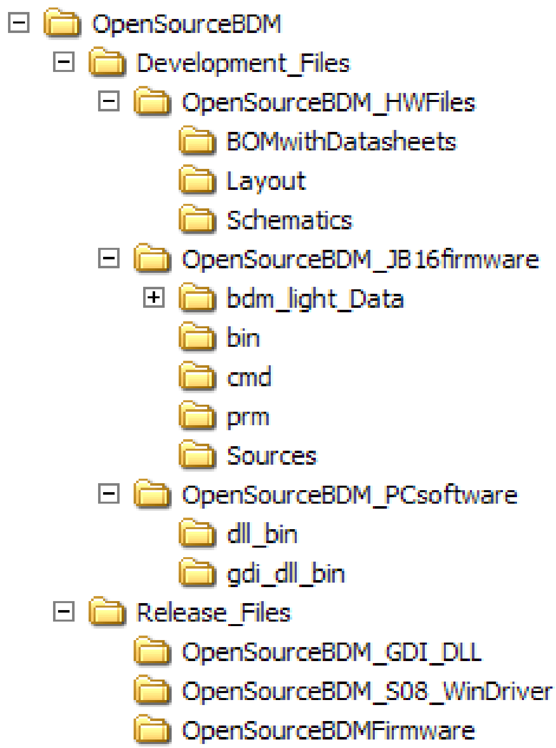


Figure 4. Unzipped Open Source BDM Package

1.6 Support and Licensing

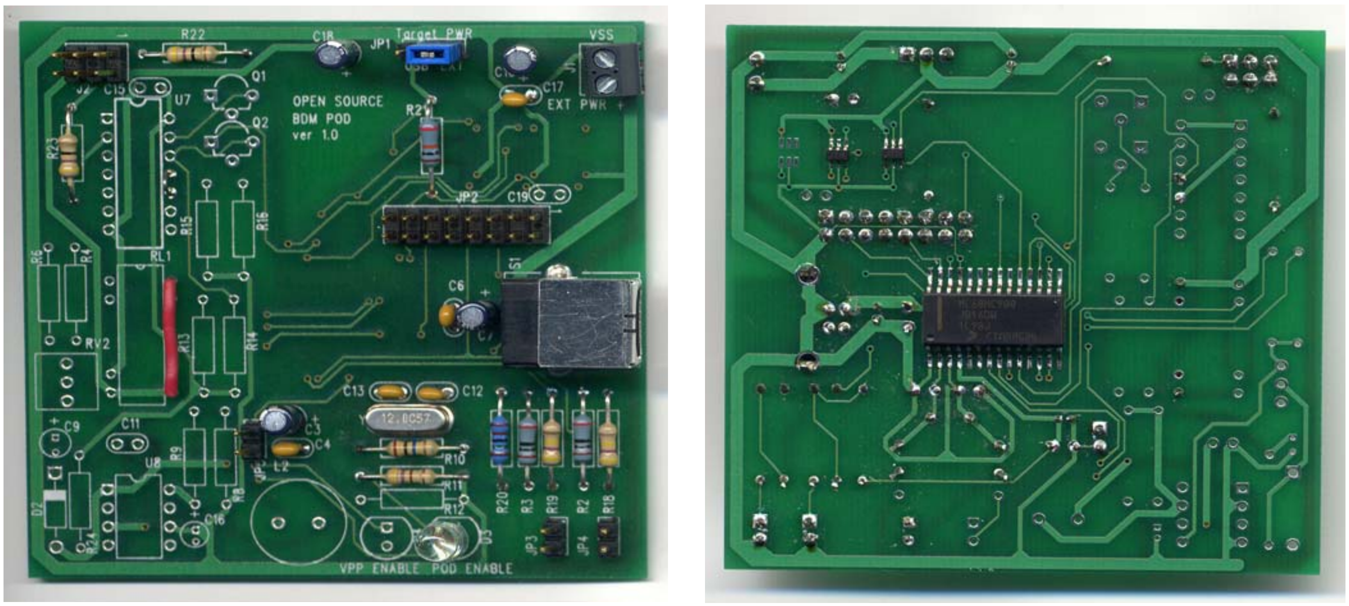
Open Source BDM is not supported by Freescale; it is open source. Any bugs, enhancements, or support questions should be addressed through the Open Source BDM forum. Open Source BDM has been thoroughly tested, but there are no guarantees about error-free operation. All of the work, with exception of the GDI DLL, is available to anyone under the GNU general public license. The Open Source BDM is a deriviative project of the TBMDL project.

2.0 Open Source BDM PCB Hardware and MC68HC908JB16

Photos of the Open Source BDM PCB top and bottom sides are provided in Figure 5. The bottom side shows the MC68HC908JB16 used to decode incoming USB messages into BDC commands and then bit-bang the BDC commands to a target. The Open Source BDM PCB is designed with many desirable features, making it a robust development tool. The following list is a summary of those features:

- Based on MC68HC908JB16 MCU from Freescale with a 12MHz crystal
- Provides circuitry to facilitate Firmware upgrades of the MC68HC908JB16
- USB interface with a type B USB connector

- PCB provides optional circuitry used to update the Open Source BDM PCB to support other targets besides HCS08 devices
- Double-side PCB uses mostely through-hole design for ease of assembly
- PCB can optionally supply 5.0V power to the MCU target board
- PCB has an optional 16-pin MONO8 header to program the JB16



Top Side **Bottom Side**

Figure 5. Open Source BDM PCB

2.1 MC68HC908JB16 Overview

The Open Source BDM is based on MC68HC908JB16 MCU from Freescale. The MC68HC908JB16 provides:

- Relatively low-cost HC08
- A low speed USB 2.0 compatible interface
- Surface mount 28-pin SOIC package

Figure 6 provides quick reference of the MC68HC908JB16 pinout.

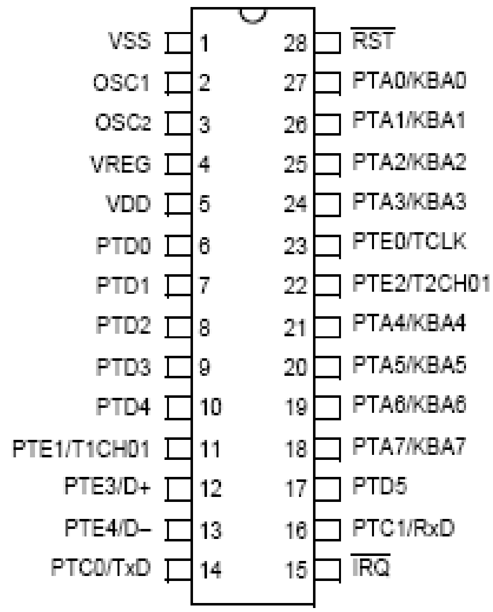


Figure 6. MC68HC908JB16 Pin-Out

2.1.1 Other MC68HC908JB16 Features

- High-performance M68HC08 architecture
- Low-power design; fully static with Stop and Wait modes
- 6MHz internal bus frequency
- 16,384 bytes of on-chip FLASH memory with Security1 feature
- 384 bytes of on-chip random access memory (RAM)
- Up to 21 general-purpose input/output (I/O) pins
- Two 16-bit, 2-channel timer interface modules (TIM1 and TIM2)
- Universal Serial Bus specification 2.0 low-speed functions
  — In-circuit programming capability using USB communication
- Serial communications interface (SCI) module
- System protection features:
  — Optional computer operating properly (COP) reset
  — Optional Low-voltage detection with reset
- IRQ interrupt pin with internal pull-up and Schmidt-trigger input

2.1.2 MC68HC908JB16 USB

Open Source BDM is designed to use USB as the means of talking to the computer because:

- USB provide plug and play functionality
- USB can provide power to the Open Source BDM PCB and the target, avoiding the requirement of an additional power supplies
  — By routing the USB power to the BDM connector, the Open Source BDM PCB can also provide 5.0V power to the target board

The LS USB peripheral of the MC68HC908JB16 provides sufficient USB functionality to facilitate the Open Source BDM operations. The MC68HC908JB16 USB features include:

- 1.5Mbps data rate
- On-chip 3.3V regulator
- Three Endpoints
  — Endpoint 0 with 8-byte transmit buffer and 8-byte receive buffer
  — Endpoint 1 with 8-byte transmit buffer
  — Endpoint 2 with 8-byte transmit buffer and 8-byte receive buffer

2.1.3 MC68HC908JB16 Development

- The development environment and the hiwave debugger looks the same for both HC08 and HC(S)08
- The development environment is available free of charge for the size of project

2.2 Open Source BDM PCB

The schematics are provided for the Open Source BDM PCB in Figure 7. The schematics provide details of the power and clocking connections for the Open Source BDM PCB. These schematics also show various jumpers settings. The optional circuity is not discussed in this document.

Besides the HC908JB16, the schematic of the Open Source BDM interface shows several main parts:

- A USB interface with jumper options
  — Options to program the HC908JB16
  — Options for standard Open Source BDM operation
- BDM interface driver based on 74LVC1T45 buffer with tri-state outputs

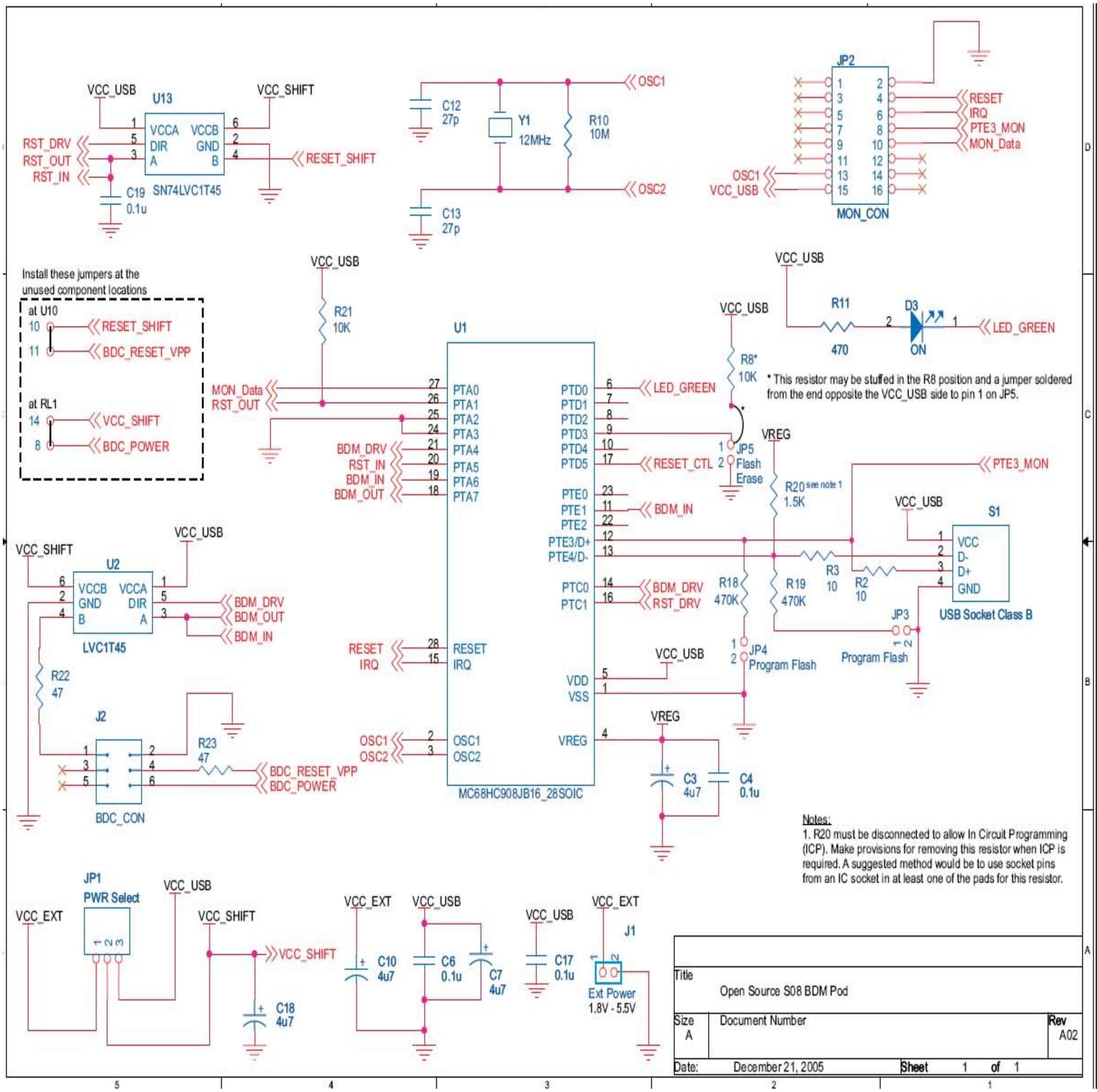


Figure 7 . Open Source BDM Schematic

2.2.1 USB interface Details

A 1.5 KΩ (±1%) pull-up resistor is provided on D-USB signal. A jumper is added to the pull-up resistor in order to assist in the ICP programming of the JB16, using techniques from AN2399.

Note: PCB is provided with footprint for the USB B connector. This is actually in violation of the USB specification as low-speed devices should have the cable hard-wired to them, but a detachable cable is very useful. If violation of the specification is not desired, solder the cable straight into the PCB.

2.2.2 Response Time and Transfer Rate

By the nature of the USB protocol the response time for low and full speed devices cannot be below 1ms. Optimization of the communication protocol on the USB to achieve maximum throughput was tested. However, practical limitations, caused by the Windows operating system, cause additional delays. Average execution times for different kinds of commands are detailed in Table 2.

Table 2 Average Execution Command Times

Command Type	Description	Average Execution Speed
Short	Commands which transfer up to 5 bytes of data into Open Source BDM and require no return values.	3ms
Normal	Commands which transfer up to 5 bytes of data into Open Source BDM and request up to 8 bytes of return values.	4ms
Data transfer	Commands which transfer large blocks of data.	6.7 kB/s

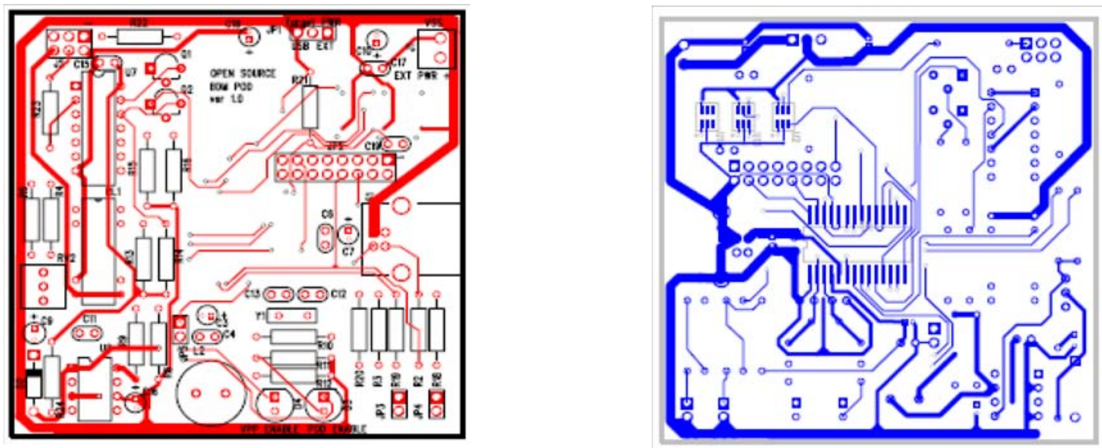
When programming the flash of the target MCU, there is additional overhead created by the flash programming routines. The speed is also dependant on crystal frequency; the higher, the better. The Metrowerks hiwave debugger with Open Source BDM interface connected to HCS08 target with 4.0MHz crystal typically programs the flash at 2.7kB/s rate.

2.2.3 AN2399 ICP Programming Jumpers

The ICP programming setup, procedures, and operation details are provided in the *JB16 USB/ BDM firmware* section.

2.3 Open Source BDM Layout and Guidelines

The Open Source BDM is a two-sided PCB, roughly 3 in x 3 in larger, illustrated in Figure 8. The gerber files are provided with the Open Source BDM in a later release. The gerber files can be used to develop the design into another form factor if desired.



Top View **Bottom View**

Figure 8. Open Source PCB Layout

2.4 Getting Open Source BDM Components

A complete BOM is provided in Table 3, including all parts required for the Open Source BDM. Each part is provided with order numbers from Digi-Key. Some of these components are available as free samples. Free samples of Freescale's HC908JB16 are available from www.freescale.com.

Table 3 BOM

Generic Part	Description	Package	Component No.	Digi-Key Part No.	Qty
MC68HC908JB16DW	MCU	28-Pin SOIC	U1	MC68HC908JB16DW-ND	1
SN74LVC1T45DBVR	Level Shifter	6-Pin SOT-23	U2, U13	296-16843-1-ND	2
Crystal, 12 MHz	Citizen HC49US12.000MABJB-UB	HC-49US	Y1	300-8492-ND	1
Capcitator, Electronic, 4.7µF	Panasonic ECE-A1VKG4R7	Radial Lead	C3, C7, C10, C18	P920-ND	4
Capcitator, Ceramic, 27pF	EPCOS B37979N1270J054	Radial Lead	C12, C13	495-1005-1-ND	2
Capcitator, 0.1µF	Kemet C320C104K5R5CA	Radial Lead	C4, C6, C17, C19	399-2054-ND	4
Resistor, 10 1/4W 5%		Axial Lead	R2, R3	10QBK-ND	2
Resistor, 470K 1/4W, 5%		Axial Lead	R18, R19	470KQBK-ND	2
Resistor, 10M 1/4W 5%		Axial Lead	R10	10MQBK-ND	1
Resistor, 470 1/4W 5%		Axial Lead	R11	470QBK-ND	1
Resistor, 47 1/4W 5%		Axial Lead	R22, R23	47QBK-ND	2
Resistor, 1.5K 1/4W 1%		Axial Lead	R20	1.5KXBK-ND	1
Resistor, 10K 1/4W 5%		Axial Lead	R21, R8*	10KQBK-ND	2
LED, Green, Round, 5mm, T13/4	Fairchild HLMP3950A	Radial Lead	D3	HLMP3950AFS-ND	1
USB Connector, Type B, PCB	Tyco 292304-1	Through Hole PCB	S1	A31725-ND	1
Power Connector, 2-Pin Terminal Blk	On-Shore Tech ED555/2	Through Hole PCB	J1	ED1514-ND	1
Dual Row Header, 22-Pin	Molex/Waldom Electronics Corp.	Through Hole PCB	JP2, J2	WM6822-ND	1
Single Row Header, 9-Pin	Molex/Waldom Electronics Corp.	Through Hole PCB	JP1, JP3, JP4, JP5	WM6509-ND	1

3.0 JB16 USB/BDM Firmware

The HC908JB16 firmware was developed with the 3.1 special edition version of the CodeWarrior Development Studio for HCS08. The project also works with the 5.0 special edition version. The special edition provides a free solution for developing and debugging the Open Source BDM project.

3.1 Firmware Description

The CodeWarrior Project Manger window for the HC908JB16 firmware project is illustrated in Figure 9. The source files are organized so the firmware is delineated into logical blocks including:

- USB Block
- Command Processing Block
- BDM Block

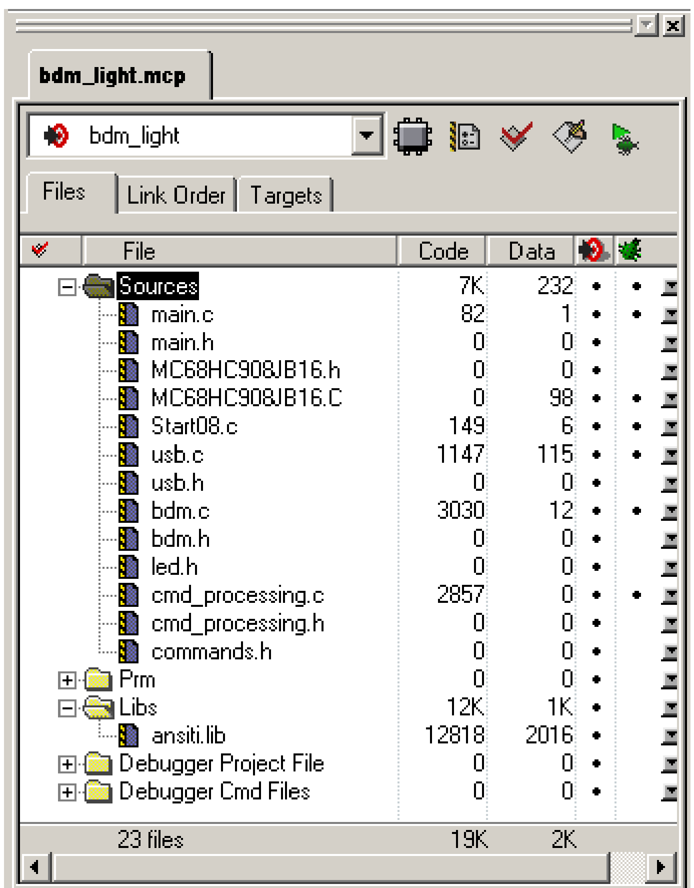


Figure 9. Open Source BDM CodeWarrior Project Manager

main.c/.h	Main program
Command.h	Provides command code use within the USB messages
cmd_processing.c/.h	Decodes USB messages and commands into BDM commands conform to the BDC. This source code calls functions from bdm.c/.h.
bdm.c/.h	Provides tx/rx function to driver JB16 ports controlling the targets BKGD pin. Time critical code uses assembly code.
usb.c/.h	Provides function for USB communication using endpoint 0 and endpoint 2

3.2 Programming Firmware into HC908JB16

Before a computer can recognize the Open Source BDM interface as a valid USB peripheral, the Open Source BDM firmware requires downloading into the HC908JB16 microprocessor. The following text describes programming of a blank HC908JB16 using the USB interface. Programming the HC908JB16 using the USB interface uses the techniques described in AN2399. A step-by-step guide is provided below.

1. Unzip the USB_ICP_demo.zip onto your computer. Included in these files are the USB ICP drivers.

3.2.1 Configuring the Open Source BDM PCB

2. Close Jumpers JP3 and JP4. Also make sure R20 is not placed. This configures the JB16 for USB In Circuit Programming.
3. Connect the Open Source BDM board to your computer through the USB cable.

3.2.2 Installing USB ICP Drivers

4. Once the Open Source BDM board to the computer, you should be prompted that a new device has been detected and the Hardware Wizard should appear. Select *Install from a list or specific location*, illustrated in Figure 10.

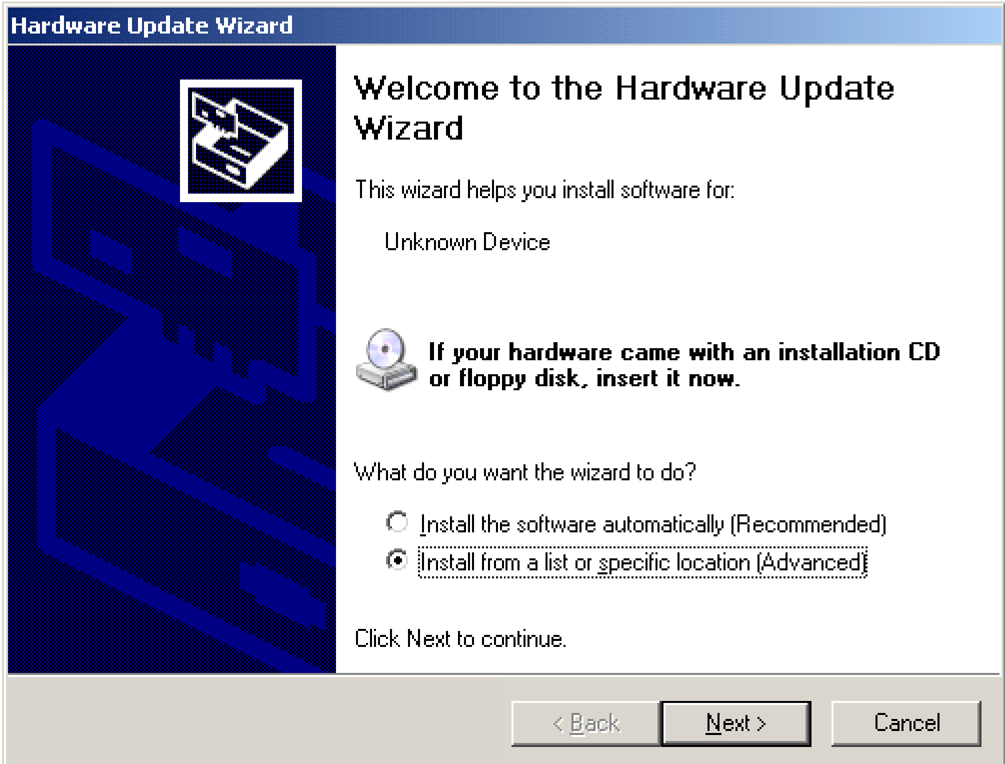


Figure 10. Installation Wizard Screen

5. Direct the install to the folder where the USBICP files reside. Your computer should now recognize a USBICP device is connected.

Note: It may be necessary to attempt this install many times, sometimes the computer will not recognize the board. If this occurs try connecting reset to GND before plugging in the USB cable, then releasie reset. Reset and GND are accessible at the MON08 header.

3.2.3 Operation of AN2399 Flash Programming Application

6. Open USBICP.exe, see Figure 11, when prompted for an IMP file select jb16_icp_me.imp.

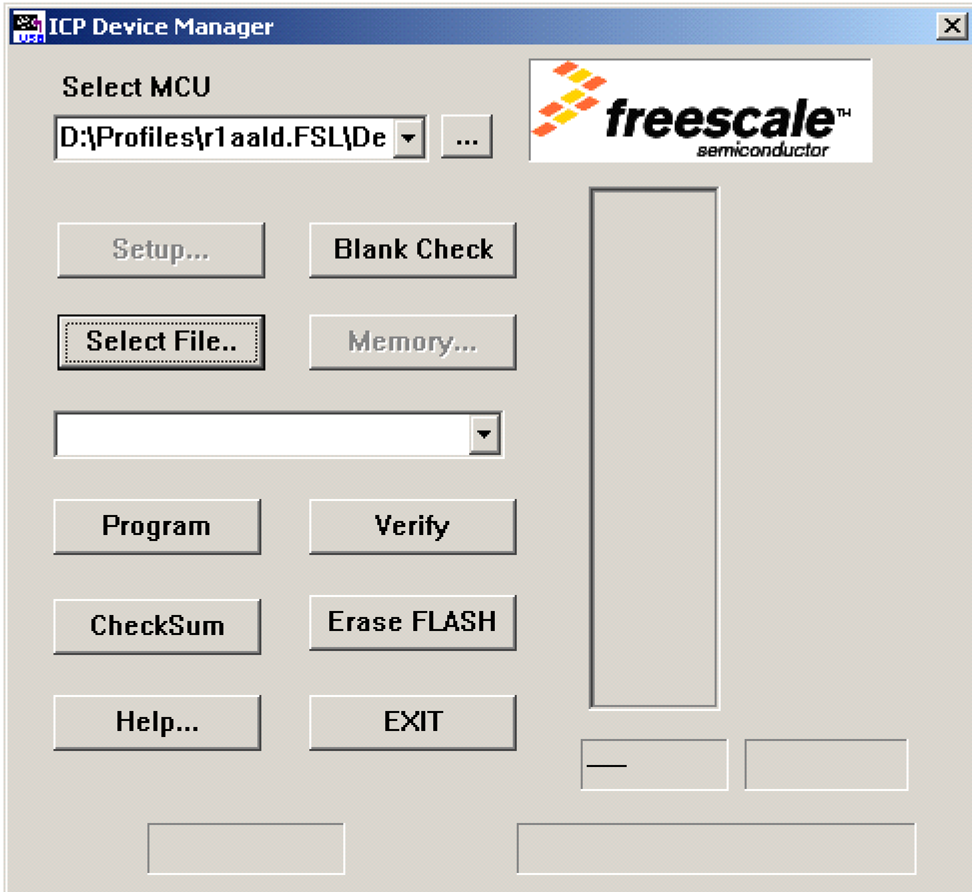


Figure 11. Flash Operation Screen

Selection of the Flash operation in the above screen results in the following screen in Figure 12.

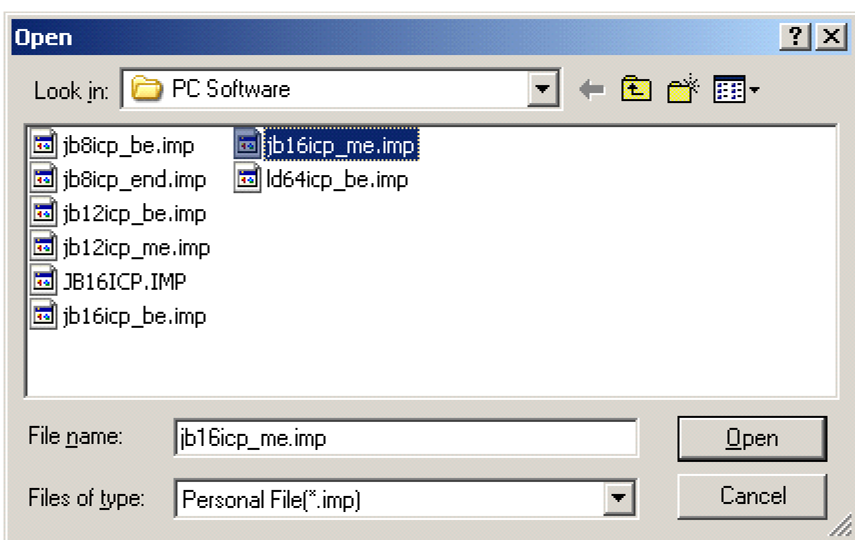


Figure 12. PC Software Section Screen

7. Select File. Navigate to the desired s19 file.

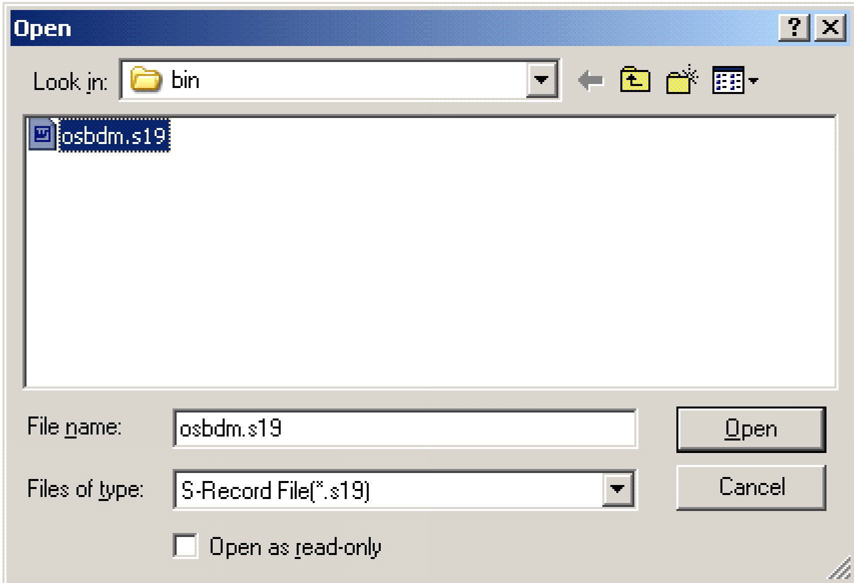


Figure 13. Open Screen

8. Select Program. The firmware is now installed.

3.2.4 Updating the USB Firmware

To update the firmware:

1. Power down the board by removing the USB connection.
2. Close jumper JP5. This tells the USB firmware to jump to the ICP routines upon power-up.
3. Connect the Open Source BDM board to your computer through the USB cable. The computer should recognize the board as a USB ICP device.
4. Open USBICP.exe. when prompted for an IMP file select jb16_icp_me.imp
5. Select *Erase Flash*.
6. If Problems persist with In Circuit Programming to update the firmware the best solution is to replace the JB16 unit with a blank part. This will ensure that an update to the firmware can be completed.

The Firmware is now removed. The steps outlined in *programming the firmware into the JB16* can be used to update the firmware.

Note: Remember to remove R20.

Note: Firmware installed on Alpha Units (Boards Pre-Programmed with the firmware) does not contain the ability to do this.

4.0 Open Source BDM PC Software

4.1 Overview

This section describes the Open Source BDM solution PC software components. These components include:

- Open Source BDM Generic Debug Instrument (GDI) DLL plug-in for the CodeWarrior hiwave debugger
- Open Source BDM interface DLL
- USB driver (libusb.lib)

Figure 14 illustrates these software components and a simplification of their interfaces.

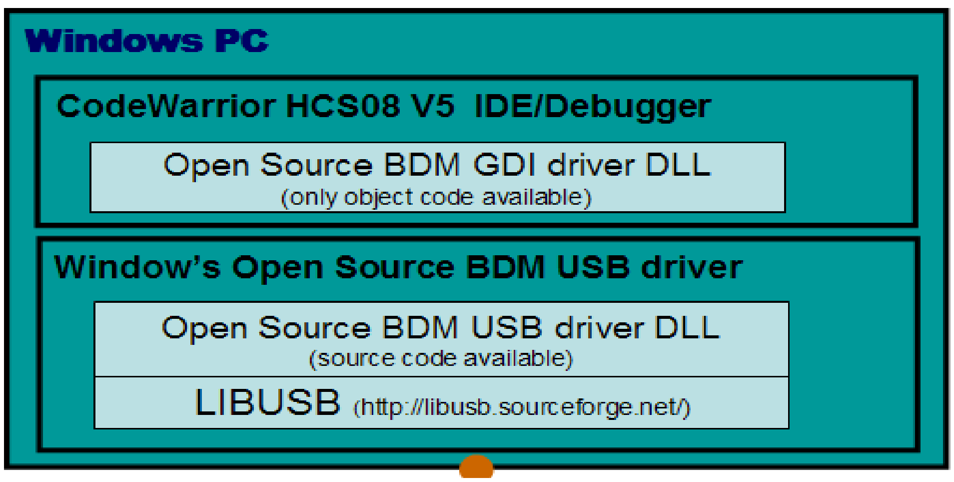


Figure 14. Open Source BDM Windows PC Software and Interfaces

4.2 Open Source BDM GDI DLL

The Open Source BDM GDI DLL plug-in for the CodeWarrior hiwave debugger is only available as a binary file. No source code is provided. The GDI DLL for the CodeWarrior hiwave debugger is created partially based on information not available in the public domain. The license attached to these files does not allow disclosure of the file's source code.

The Open Source BDM takes advantage of the CodeWarrior version 5.0 Degugger's Generic Debug Instrument (GDI) protocol interface. Tasking Incoporated provides more detailed information about the GDI Open Interface Specification (see http://www.tasking.com/resources/technologies/debuggers/gdikdi/); the Tasking specification is publicly available.

4.3 Open Source BDM DLL and LIBUSB

The Open Source BDM DLL provides an interface between the Open Source BDM GDI DLL and the Open Source BDM firmware. This section describes the API of the Open Source BDM DLL including a Windows Open Source USB drivers library, LIBUSB. The source code for the Open Source BDM DLL is available.

4.3.1 Command.h

Command.h provides command code use within the USB messages. This file matches the command.h file in the Open Source BDM firmware.

4.3.2 OpenSourceBDM.h/.c

OpenSourceBDM.c/.h provides the API functions for the Open Source BDM DLL. These functions are called by the Open Source BDM GDI DLL. The functions in turn call functions of LIBUSB. These functions are encapsulated into the OpenSourceBDM.dll. OpenSourceBDM.dll is a part of the Windows USB install package for the Open Source BDM. The Open Source BDM DLL functions are listed and briefly described below.

unsigned char OpenSourceBDM_OpenSourceBDM_dll_version(void)

Returns version of the DLL in BCD format (major in upper nibble and minor in lower nibble).

unsigned char OpenSourceBDM_init(void)

Initializes the USB interface, returning the number of Open Source BDM devices found attached to the computer. This function should be called before a device can be opened.

unsigned char OpenSourceBDM_open(unsigned char device_no)

Opens communication with device number *device_no*. First device has number 0. Returns 0 on success and non-zero on failure. A device must be open before any communication with the device can take place.

void OpenSourceBDM_close(void)

Closes communication with currently opened device.

unsigned int OpenSourceBDM_get_version(void)

Returns version of HW (MSB) and SW (LSB) of the Open Source BDM interface in BCD format.

unsigned char OpenSourceBDM_get_last_sts(void)

Returns status of the last executed command: 0 on success and non-zero on failure.

unsigned char OpenSourceBDM_set_target_type(target_type_e target_type)

This function sets target MCU type. *target_type* can be either *HC12* or *HCS08*. Returns 0 on success and non-zero on failure.

unsigned char OpenSourceBDM_target_sync(void)

Measures BDM frequency of the target using the SYNC BDM feature and connects to the target. Returns 0 on success and non-zero on failure (no device connected or the SYNC feature not supported). If this function succeeds, there is no need to set the BDM communication speed as it is measured automatically.

unsigned char OpenSourceBDM_target_reset(target_mode_e target_mode)

Resets the target MCU to normal or special mode. *target_mode* can be either *SPECIAL_MODE* or *NORMAL_MODE*. Returns 0 on success and non-zero on failure (reset pin stuck to ground, etc.).

unsigned char OpenSourceBDM_bdm_sts(bdm_status_t *bdm_status)

bdm_status is a pointer to allocated structure the function fills with current state of BDM communication. Returns 0 on success and non-zero on failure.

The structure has the following format:

typedef struct {

ackn_state_e ackn_state;

reset_state_e reset_state;

connection_state_e connection_state; } bdm_status_t;

ackn_state can be either *ACKN* (target supports ACKN BDM feature) or *WAIT* (target does not support ACKN BDM feature).

reset_state can be either *RESET_INACTIVE* (no reset activity detected) or *RESET_DETECTED* (target was reset since the last call). *reset_state* defaults to *RESET_INACTIVE* after each call.

connection_state can be *NO_CONNECTION* (no target MCU detected), *SYNC* (target supports the SYNC BDM feature) or *MANUAL_SETUP* (BDM speed was set-up by calling OpenSourceBDM_set_speed - see below).

unsigned char OpenSourceBDM_target_go(void)

Starts target code execution from current PC address. Returns 0 on success and non-zero on failure.

unsigned char OpenSourceBDM_target_step(void)

Steps over a single target instruction. Returns 0 on success and non-zero on failure.

unsigned char OpenSourceBDM_target_halt(void)

Brings the target into active background mode, i.e., debug mode with user code execution halted. Returns 0 on success and non-zero on failure.

unsigned char OpenSourceBDM_set_speed(float crystal_frequency)

Sets the BDM communication speed. *crystal_frequency* is crystal, or external source, frequency in MHz. Returns 0 on success and non-zero on failure. It is essential to provide frequency accurate at least to two decimal places in MHz.

float OpenSourceBDM_get_speed(void)

Returns crystal (or external source) frequency of the target in MHz.

unsigned char OpenSourceBDM_read_byte(unsigned int address)

Reads one byte from memory at the supplied address.

void OpenSourceBDM_write_byte(unsigned int address, unsigned char data)

Writes one byte to memory at the supplied address.

void OpenSourceBDM_read_block(unsigned int address, unsigned int count, unsigned char *data)

Reads *count* bytes from address *address*. The data is written to a user supplied buffer.

void OpenSourceBDM_write_block(unsigned int address, unsigned int count, unsigned char *data)

Writes *count* bytes to address *address*. The data is take from a user supplied buffer.

unsigned char OpenSourceBDM_read_regs(registers_t *registers)

Reads contents of target registers. Returns 0 on success and non-zero on failure. The register values are filed into user-allocated structure of the following format:

```
typedef union {
struct {
unsigned int pc;
unsigned int sp;
unsigned int ix;
unsigned int iy;
unsigned int d;
unsigned int ccr;
} hc12;
struct {

unsigned int pc;
unsigned int sp;
unsigned int hx;
unsigned int a;
unsigned int ccr;
} hcs08; } registers_t;
```

void OpenSourceBDM_write_reg_pc(unsigned int value)

Writes a new value into the PC target register.

void OpenSourceBDM_write_reg_sp(unsigned int value)

Writes a new value into the SP target register.

void OpenSourceBDM_write_reg_x(unsigned int value)

Writes a new value into the H:X (S08) target register.

void OpenSourceBDM_write_reg_d(unsigned int value)

Writes a new value into the A (S08) target register.

void OpenSourceBDM_write_reg_ccr(unsigned int value)

Writes a new value into the CCR target register.

LIBUSB

The LIBUSB is Open Source software available under combination of GNU general and lesser general public licenses. The Open Source BDM DLL functions utilize the following LIBUSB API functions:

- usb_find_buses
- usb_find_devices
- usb_close
- usb_open
- usb_get_version
- usb_init
- usb_control_msg
- usb_bulk_write
- usb_bulk_read

5.0 Erasing and Programming Algorithms

Other aspects of the development tool system are the erasing and programming algorithms. Before a new program can be uploaded into the target system, the target must be erased before it can be programmed. In order to both erase and program the target, a program must be loaded into RAM first. Both are separate erase and program algorithms. These programs provide a means to write to, and erase flash.

Every part family and every derivative has a distinct erasing and programming algorithm file. These files are not included in this version of the Open Source BDM, but some erasing and programming algorithm file from within the CodeWarrior installation can be used. Erasing and programming algorithm are not directly supported by CodeWarrior, consquently they are not guaranteed. Figure 15 illustrates the location of these files within the CodeWarrior installation in the fpp directory. It is not necessary to access the files directly, the Open Source BDM is configured to access the files during target erase and programming operations.

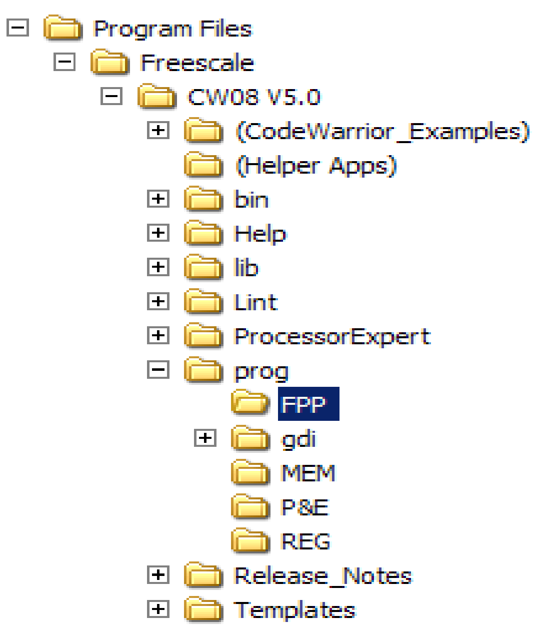


Figure 15. Path to FPP

6.0 Installation and Operation of the Open Source BDM

6.1 Configuration of the Open Source BDM PCB

This section assumes the Open Source BDM firmware is programmed on to the JB16.

6.1.1 Open Source BDM PCB HCS08 Configuration

Table 4 details the Open Source BDM PCB jumper configuration settings for Programming and debugging targets for the HCS08. Other types of target may required other settings.

Table 4 Open Source BDM PCB HCS08 Configuration

Jumper	Description	Setting
JP1	Target Power Selection	• Short 1-2: Power target externally via J1 or target is self-powered • Short 2-3: Power target using 5V USB power
JP3	Flash Program	Off
JP4	Flash Program	Off
JP5	Flash Erase	Off

6.2 Installing Windows Open Source BDM DLL and USB Drivers

The following procedure specifies the installing of the Open Source BDM USB hardware drivers under the Windows operating system. This procedure assumes Open Source BDM windows USB driver package is unpacked onto the development PC, running the CodeWarrior Studio.

With the Open Source BDM PCB configured, the Open Source BDM PCB can be connected to the development PC USB port. When the configured Open Source BDM PCB is connected to the PC for the first time, the Windows operating system recognizes a new USB device, the Open Source BDM PCB. This initial connection starts the Windows driver installation procedure. Figure 16 illustrates the Windows New Hardware Wizard dialog box that opens.

Figure 16. Found New Hardware Dialog Box

For this installation, select the option to *Install from a Specific Location,* then click *Next*. When the *Next* button is selected, the *Specify Location of the Drivers* dialog box opens, illustrated in Figure 17.

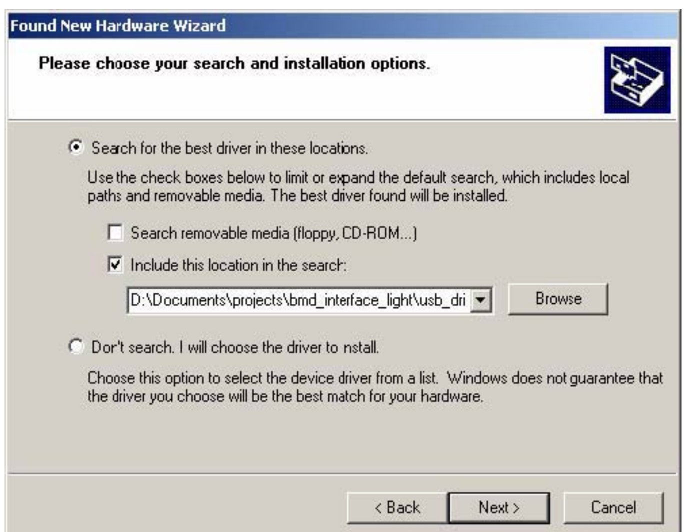


Figure 17. Specifying Location of Drivers Dialog Box

In the *Specify Location of the Drivers* dialog box, point the Hardware Wizard to the unzipped Open Source BDM windows driver package, using the *Browse* button. Once the Windows *Specify Location of the Drivers* dialog box is configured with the correct path to the Open Source

BDM windows driver package, select the *Next* button. This will initiate the installation of the Open Source BDM USB required driver and DLL file, ilustrated in Figure 18.

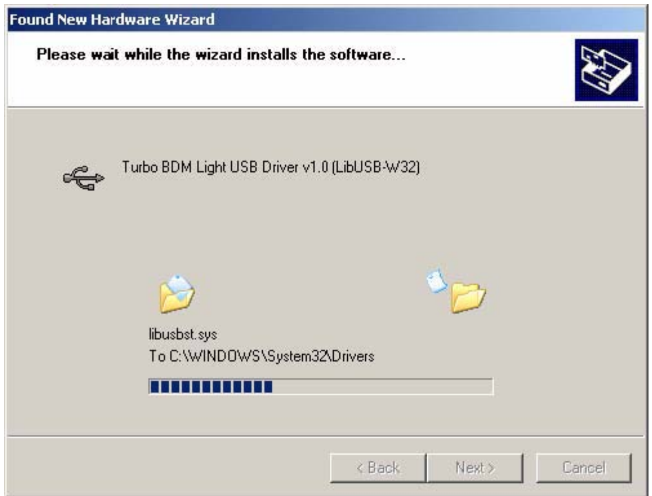


Figure 18. Driver Installation in Progress

Once the installation procedure is completed, the device will be ready to use, illustrated in Figure 19. Select the *Finish* button at this point. Because of the *plug and play* nature of USB, a reboot of Windows is not required.

Figure 19. Finishing Installation Open Source BDM Windows USB Driver

6.3 Configuring the Hiwave Debugger for the Open Source BDM GDI DLL Plug-in

Once the Open Source BDM device is recognized by Windows, the CodeWarrior version 5.0 hiwave debugger is one step closer to programming and debugging targets with the Open Source BDM development tool. The initial release of the CodeWarrior version 5.0 and the hiwave debugger does not have obvious support for the Open Source BDM. A patch is planned for the CodeWarrior version 5.0 Studio, adding more visible Open Source BDM support. This section describes configuration of the hiwave for the Open Source BDM with and without the patch to add Open Source BDM support.

The procedure detailed in this section explains how to configure the hiwave debugger to work with the Open Source BDM interface. Please be certain to download the latest version of the tools from Metrowerks. The debugger interface of older versions do not support the required features. The Open Source BDM was tested with the minimum required debugger version 6.1.

6.3.1 Operation Without the CW Service Patch

Even without the Open Source BDM patch for the CodeWarrior HCS08 Studio, the hiwave debugger can be configured to select the OpenSourceBDM GDI DLL using the *set gdi* command in the Debugger command window, illustrated in Figure 20.

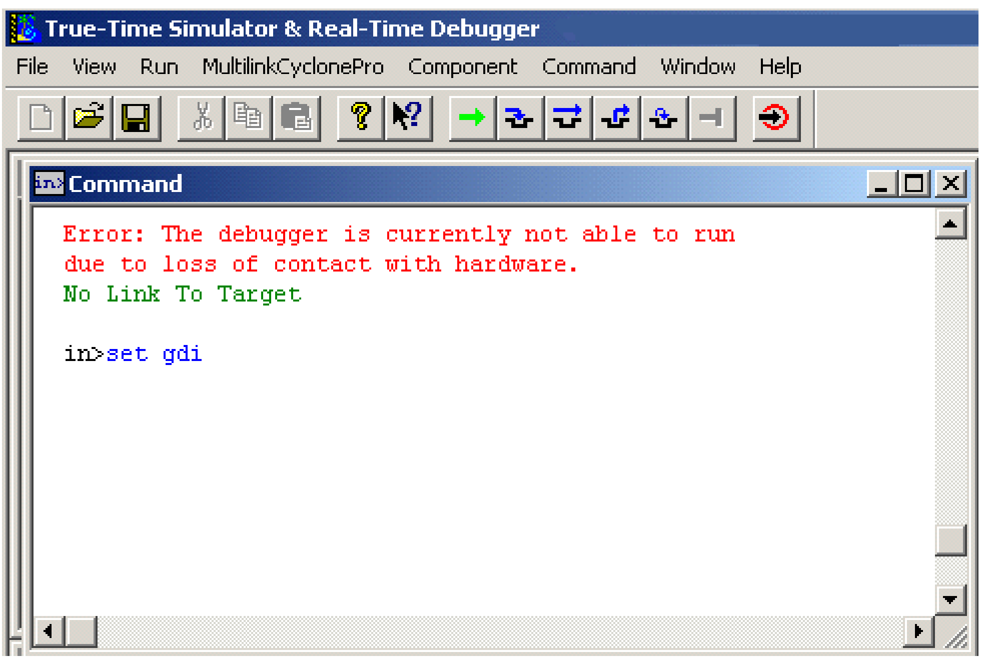


Figure 20. *set gdi* Command

When the *set gdi* command is executed, the *GDI Setup DLL* dialog box opens. To use the Open Source BDM, select the *Browse* button to choose the required OpenSourceBDM_gdi.dll file. The *GDI Setup DLL* dialog box is illustrated in Figure 21.

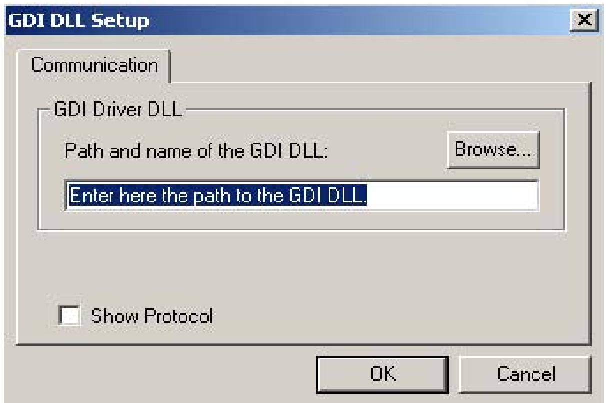


Figure 21. GDI Setup DLL Dialog Box

Sometimes the "set gdi" command does not force a change of the GDI DLL setup (note the active GDI setup is shown in the debugger menu, i.e. Open Source BDM menu option vs. MultilinkCyclonePro vs. MONITOR-HCS08 vs. Softec-HCS08). This issue occurs when the Softec-HCS08 debugger target is selected in the Code Warrior IDE. The solutions is to NOT to select the Softec-HCS08 debugger target (select P&E instead). When a service patch for Code Warrior to add support for the Open Source BDM is avaiable, the set gdi command is not necessary since the Open Source BDM target will be selectable from the Code Warrior IDE.

6.3.2 Operation With the CW Service Patch

In this case, when a project is created, it can be created based on the Open Source BDM connection. Figure 22 illustrates the *Connection Option* dialog box. CodeWarrior provides a Open Source BDM option in this dialog box.

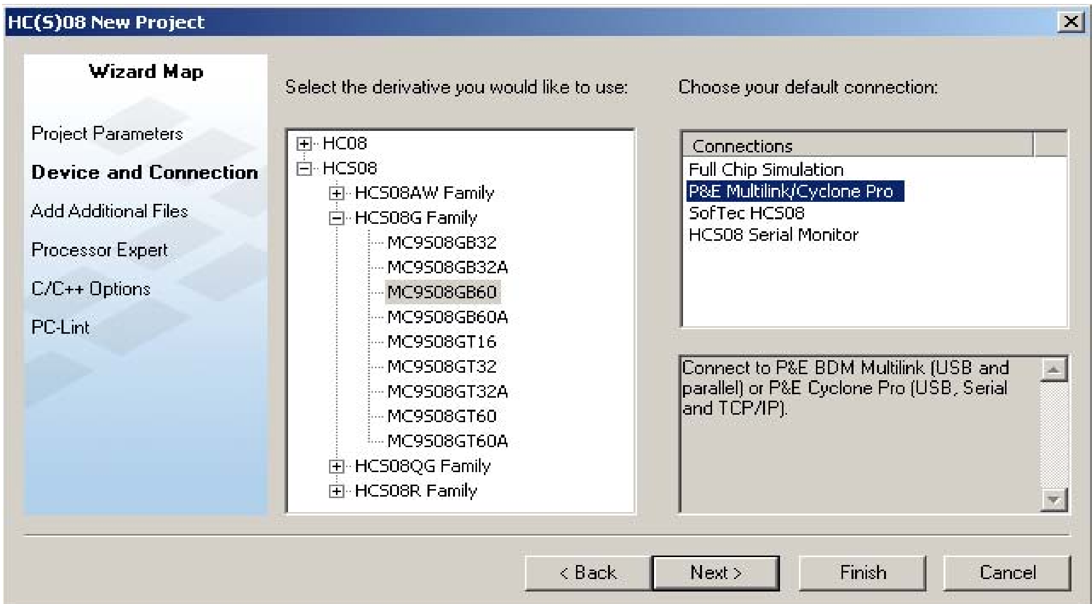


Figure 22. New Project Debugger Interface Connections Dialog Box

Alternatively, if the project was built with other connection using the *New Project Debugger Interface Connections* dialog box, it can be easily changed in the CodeWarrior IDE project manager, illustrated Figure 23. Also, the *set gdi* command can still be used in the hiwave debugger.

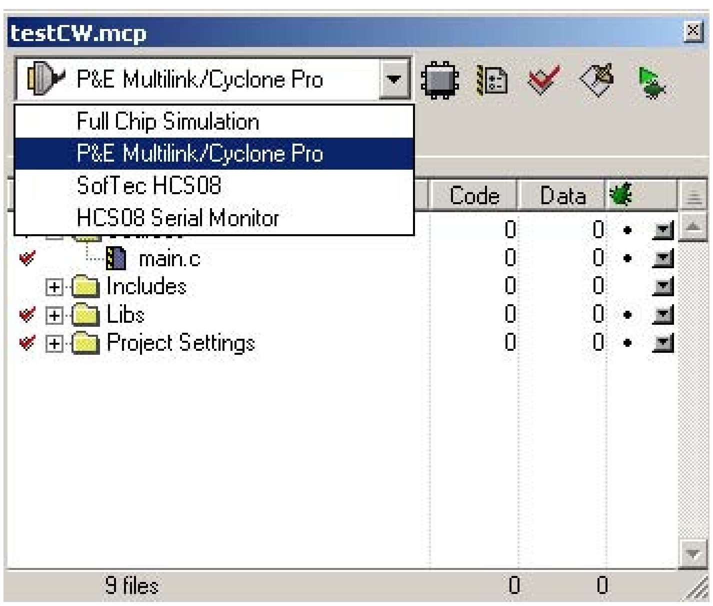


Figure 23. Project Manager Connection Options

6.3.3 Hiwave Debugger Options with Open Source BDM

Once the OpenSourceBDM GDI DLL is configured and the debugger is open, the hiwave debugger and OpenSourceBDM GDI DLL provide full featured functionality provided below. The folowing options are found in the OpenSourceBDM menu:

- Show status dialog box
- Reset to normal command option
- Select derivative option
- Detection and indication of target frequency changes
- Auto derivative selection

Otherwise, operation for the hiwave debugger remains unchanged from other debugger interfaces. Figure 24 illustrates the hiwave program opened and configured for the Open Source BDM debugger interface, shown by the hiwave menu bar with menu entry call Open Source BDM.

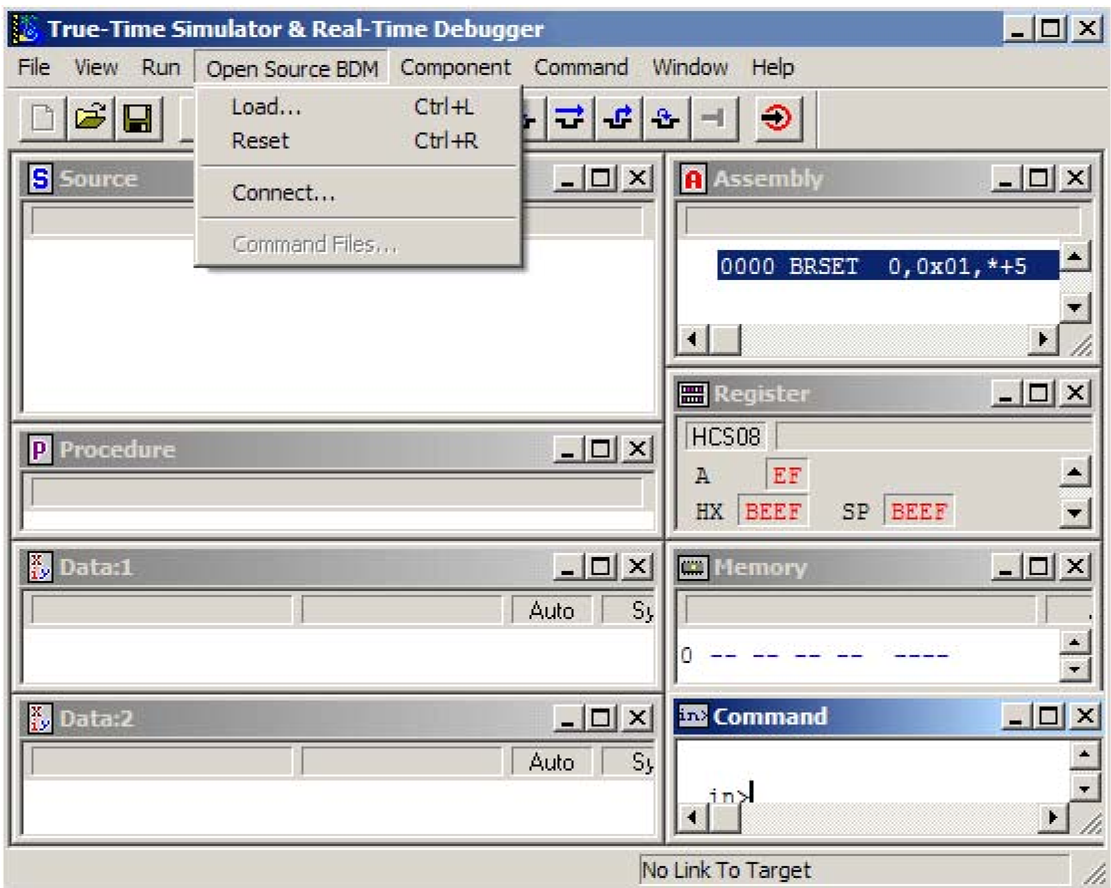


Figure 24. Hiwave Program Opened and Configured

6.4 Programming and Erasing Flash with Open Source BDM

Using the Open Source BDM is no different than using other debugger development tools. The basics steps for configuration and operation of the Open Source BDM for programming and debugging a target system are:

1. Build or otherwise obtain the Open Source BDM PCB
2. Configure the debugger hardware for the Open Source BDM PCB. See "Open Source BDM PCB HCS08 Configuration," Section 6.1.1
3. Connect the debugger hardware as shown in Figure1
4. If necessary, install the debugger hardware windows drivers. See "Installing Windows Open Source BDM DDL and USB Drivers," Section 6.1
5. Develop a user application and select the desired debugger interface in the CodeWarrior IDE. See "Configuring the Hiwave Debugger for the Open Source BDM GDI DLL Plug-in" Section 6.3
6. Execute the command to open the hiwave debugger, making certain the correct debugger interface is selected. Open Source BDM. See step five above.
7. The hiwave debugger opens and erases, then programs the target system. A manually selected file can also be used to upload into the target system. See "Step-by-step Instructions: Flash Programming with the Hiwave Debugger," Section 6.4.2
8. Debug the code using the hiwave debugger. Users have access to all debugger functions including breakpoints, trace, program halt/go, program step/step-over/step-into, and many other debugger command options.

Figure 25 illustrates the cable connections between the PC, the Open Source BDM, and the user target. Detailed information is provided below about using the CodeWarrior IDE.

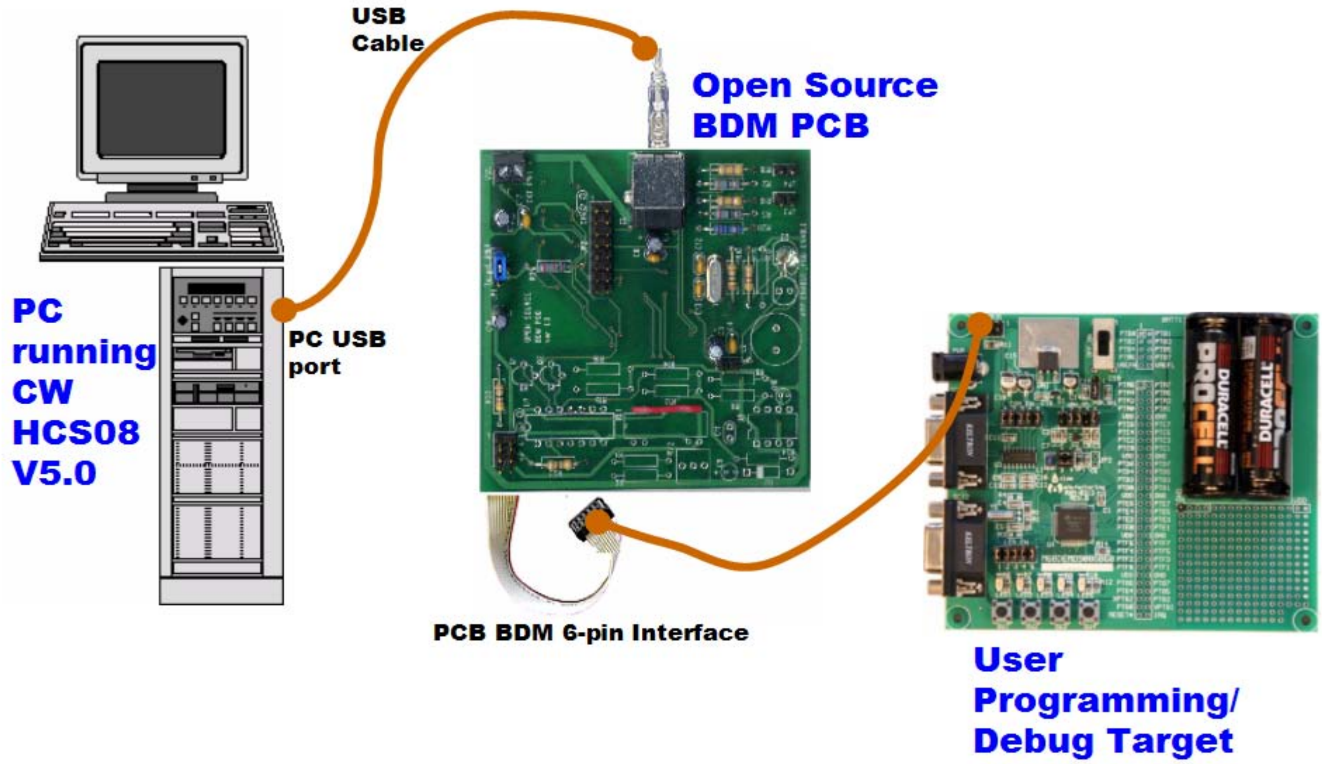


Figure 25. Cable Connections Between the PC and the Open Source BDM

6.4.1 Opening the Hiwave Debugger

Once the main code is added, the project code can be downloaded into the target MCU flash memory. Figure 26 shows pressing the debug icon in the CodeWarrior IDE's program manger window will initiate the programming of the target MCU flash memory. This icon executes a command to open the hiwave program.

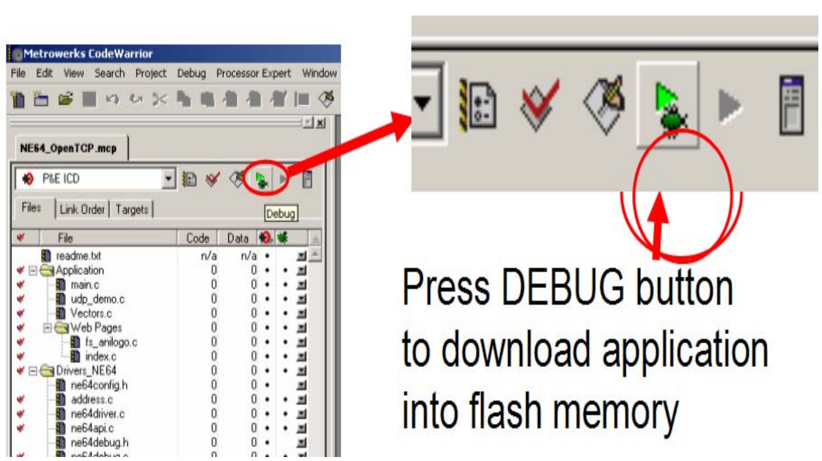


Figure 26. Code Warrior IDE Debug Icon

Figure 27 illustrates the hiwave program again. Selecting the *Load...* or *Flash* command in the Open Source BDM menu initiates flash programming algorithms to erase and reprogram the target MCU. The *Load...* menu command will first allow a selected file to upload during the flash programming operation.

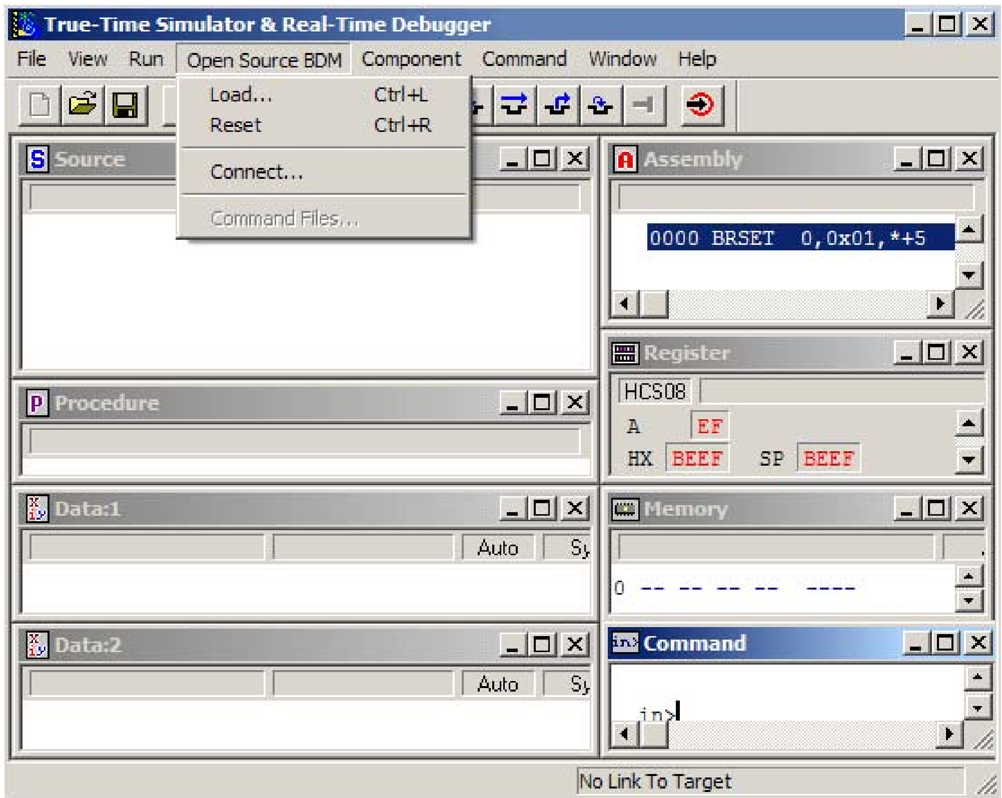


Figure 27. Code Warrior Programmer/Debugger Interface

6.4.2 Step-by-Step Instructions: Flash Programming with the Hiwave Debugger

This sections provides detailed step-by-step instructions for flash programming with the Hiware debugger. From the Open Source BDM menu, both the "Flash" and "Load" command can be used to flash program the target.

6.4.2.1 Using the Load Command:

1. Select Open Source BDM > Load... from the menu
2. When the load command is executed, the "Load Executable File" dialog box opens.

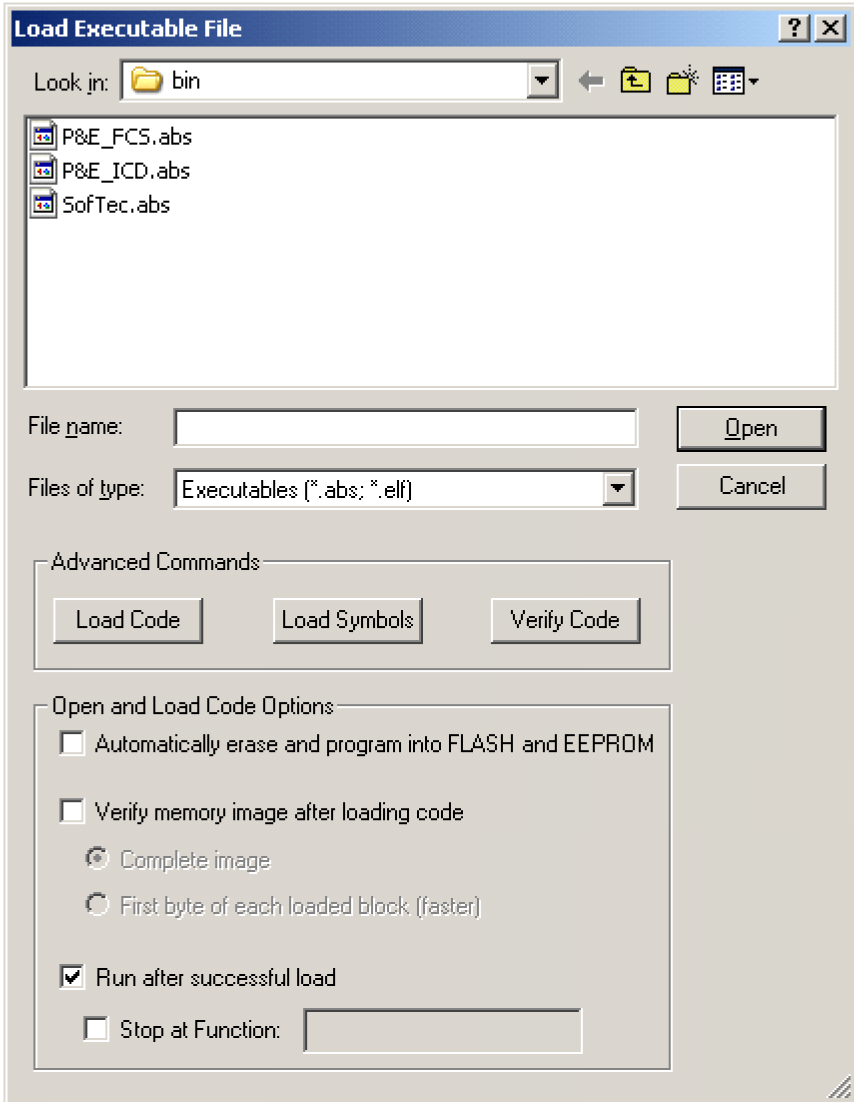


Figure 28. Load Executable File Dialog Box

3. The user must navigate to the file that will be used to program the part and select it
4. Before pressing the "Open Button," the "Automatically erase and program into FLASH and EEPROM" checkbox must be checked

To make the "Automatically erase and program into FLASH and EEPROM" option the default setting for a project, the user must configure the debugger accordingly. These steps are provide below:

1. Select File > Configuration from the menu
2. The "Preference" dialog box opens
3. Select the "Load" Tab

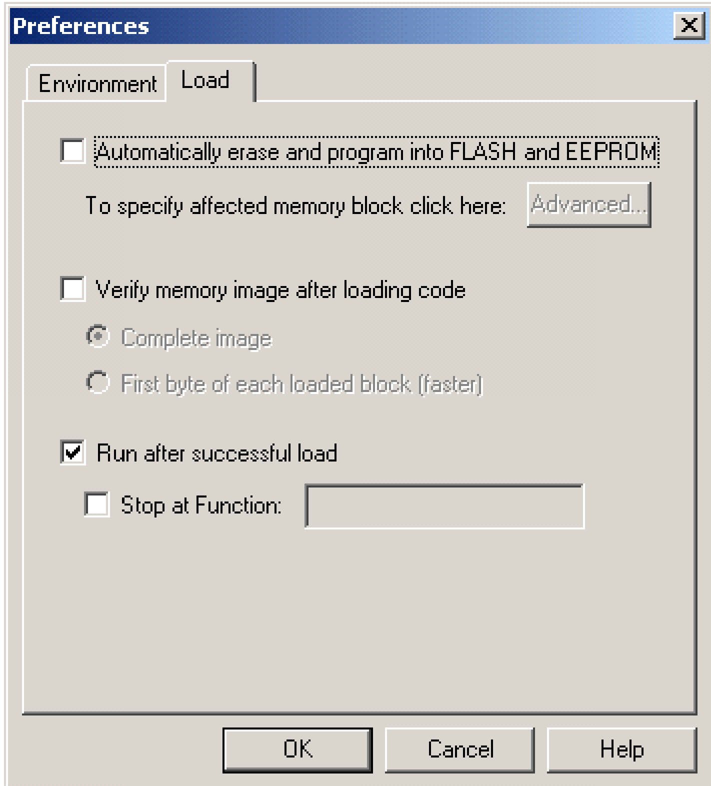


Figure 29. Preferences Dialog Box

4. Check the "Automatically erase and program into FLASH and EEPROM" checkbox
5. Close "Preference" dialog box by pressing the "OK" button
6. Select File > Save Configuration from the menu
7. Next time, auto erase and flash functions will be performed by default

6.4.2.2 Using the Flash Command:

1. Select Open Source BDM > Flash... from the menu
2. The "Non Volatile Memory Control" dialog box opens

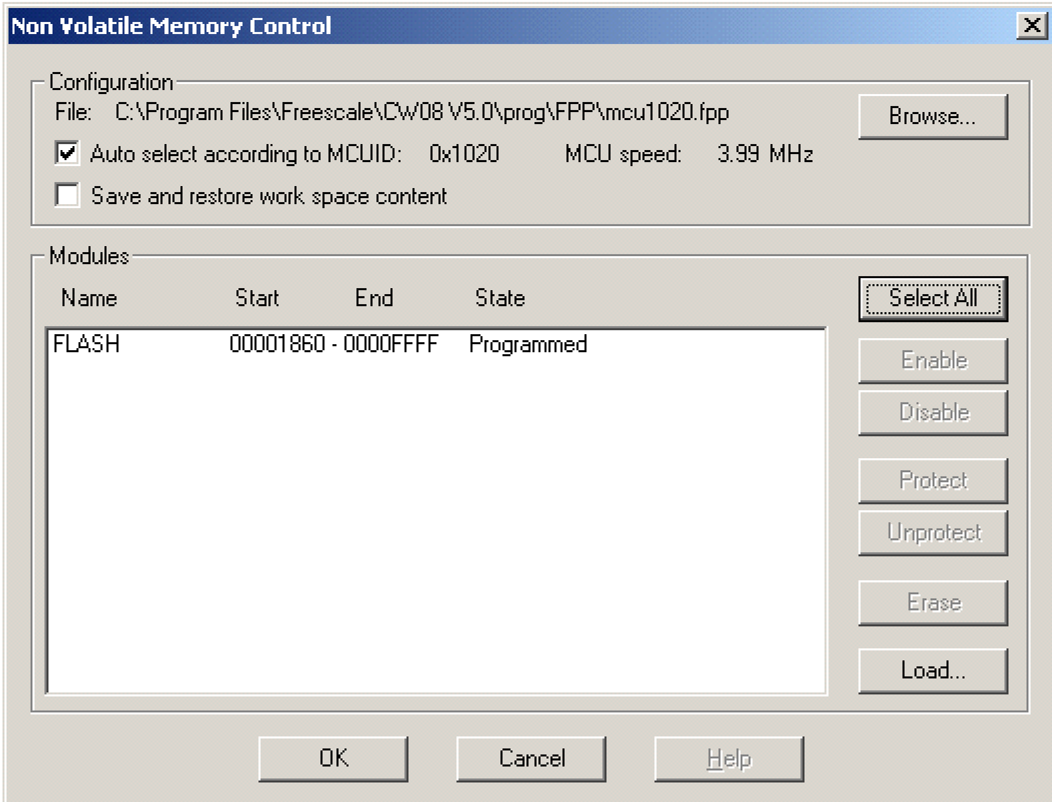


Figure 30. Non Volatile Memory Control Dialog Box

3. Press the "Select All" button
4. Press the "Erase" button
5. Press the "Load..." button
6. When the load button is pressed, the "Load Executable File" dialog box opens.
7. The user must navigate to the file that will be used to program the part and select it
8. Pressing the "Open" button programs the part

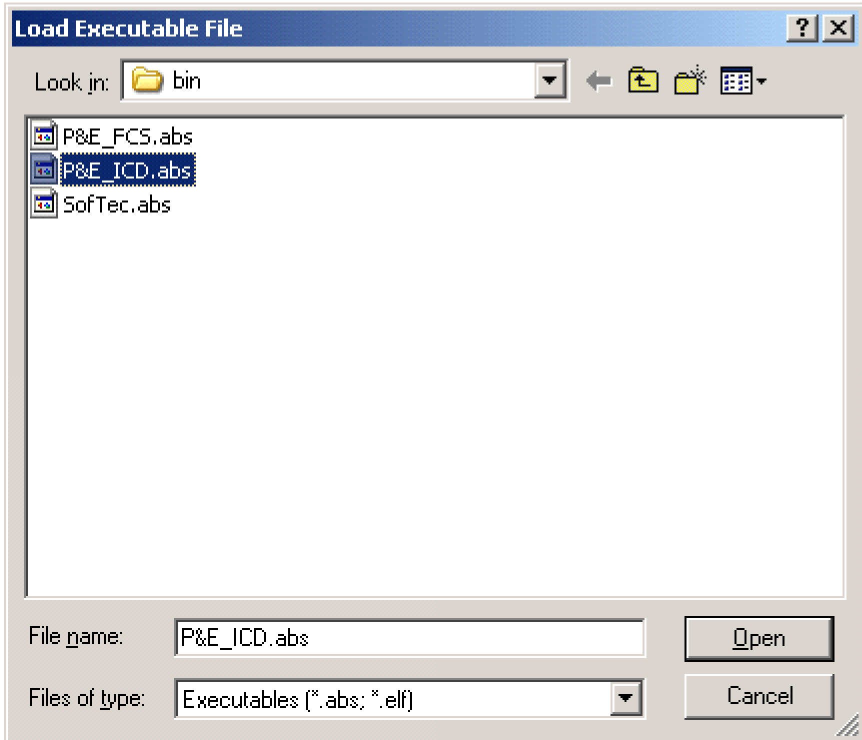


Figure 31. Load Executable Dialog Box

9. To close the "Non Volatile Memory Control" dialog box, press the "Unselect All"
10. Then press the "OK" button"

7.0 References

1. LIBUSB documentation, http://libusb.sourceforge.net/
2. Data sheet to HC908JB16, MC68HC908JB16.PDF available from Freescale
3. Documentation to Generic Debugging Interface, available from Tasking, www.tasking.com
4. TBDML HCS12 project, see either http://forums.freescale.com or www.freegeeks.net