TWR–MC–MVHB1EVB Tower System Platform

Figure 1. TWR–MC–MVHB1EVB
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1 Important Notice

Freescale provides the enclosed product(s) under the following conditions:

This evaluation kit is intended for use of ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY. It is provided as a sample IC pre-soldered to a printed circuit board to make it easier to access inputs, outputs, and supply terminals. This evaluation board may be used with any development system or other source of I/O signals by simply connecting it to the host MCU or computer board via off-the-shelf cables. This evaluation board is not a Reference Design and is not intended to represent a final design recommendation for any particular application. Final device in an application will be heavily dependent on proper printed circuit board layout and heat sinking design as well as attention to supply filtering, transient suppression, and I/O signal quality.

The goods provided may not be complete in terms of required design, marketing, and or manufacturing related protective considerations, including product safety measures typically found in the end product incorporating the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge. In order to minimize risks associated with the customers applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards. For any safety concerns, contact Freescale sales and technical support services.

Should this evaluation kit not meet the specifications indicated in the kit, it may be returned within 30 days from the date of delivery and will be replaced by a new kit.

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2 Getting Started

2.1 Kit Contents/Packing List
The TWR-MC-MVHB1EVB contents include:
• Assembled and tested evaluation board/module in anti-static bag
• Quick Start Guide, Analog Tools
• Warranty card

2.2 Jump Start
Freescale’s analog product development boards help to easily evaluate Freescale products. These tools support analog mixed signal and power solutions including monolithic ICs using proven high-volume SMARTMOS mixed signal technology, and system-in-package devices utilizing power, SMARTMOS and MCU dies. Freescale products enable longer battery life, smaller form factor, component count reduction, ease of design, lower system cost and improved performance in powering state of the art systems.
• Click here: www.freescale.com/TWR-MC-MVHB1EVB
• Review your Tool Summary Page
• Look for

Jump Start Your Design

• Download documents, software and other information

Once the files are downloaded, review the user guide in the bundle. The user guide includes setup instructions, BOM and schematics. Jump start bundles are available on each tool summary page with the most relevant and current information. The information includes everything needed for design.

2.3 Required Equipment and Software
To use this kit, you need:
• Power supply 8.0 V—36 V with current limit set initially to max 5.0 A.
• Typical loads: DC brushed motor, stepper motor,
• Wire cables for power supply and load connection.
• Other Tower modules (MCU, ELEV etc): www.freescale.com/tower
• (Optional) MVHBRIDGE-PEXPERT: (See www.freescale.com/MVHBRIDGE-PEXPERT)

2.4 System Requirements
The kit requires the following to function properly with the software:
• Windows® XP, Windows 7, or Vista in 32- and 64-bit versions
3 Understanding the Freescale Tower System Platform

Freescale's Tower System peripheral module is designed to be used in conjunction with other Tower System modules.

The Freescale Tower System platform is a modular development environment for 8-, 16- and 32-bit MCUs and MPUs that enables advanced development through rapid prototyping. Featuring more than fifty development boards or modules, the Tower System platform provides designers with building blocks for entry-level to advanced MCU development.

![Figure 2. Tower System Overview](image)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWR-MC-MVHB1EVB</td>
<td>TWR-MC-MVHB1EVB Evaluation Board</td>
</tr>
<tr>
<td>Tower MCU Board</td>
<td>Additional Freescale Tower boards (Optional)</td>
</tr>
<tr>
<td>TWR-ELEV-PRI</td>
<td>Tower System Elevator Primary Module</td>
</tr>
<tr>
<td>TWR-ELEV-SEC</td>
<td>Tower System Elevator Secondary Module</td>
</tr>
</tbody>
</table>

Table 1. Description
3.1 Block Diagram

Figure 3. TWR-MC-MVHB1EVB Block Diagram

Table 2. Device Features

<table>
<thead>
<tr>
<th>Device</th>
<th>Description</th>
<th>Features</th>
</tr>
</thead>
</table>
| MC33932    | MC33932 is a monolithic H-bridge Power IC in a robust thermally enhanced package with two independent H-bridges. | • 5.0 V to 28 V continuous operation (transient operation from 5.0 V to 40 V)  
  • 235 mΩ maximum $R_{DS(on)}$ at 150 °C (each H-bridge MOSFET)  
  • 3.0 V and 5.0 V TTL / CMOS logic compatible inputs  
  • Output short-circuit protection (short to VPWR or GND)  
  • Overcurrent limiting (regulation) via internal constant-off-time PWM  
  • Temperature dependant current limit threshold reduction to allow for continuous operation without shutdown  
  • Sleep mode with current draw < 50 μA (each half with inputs floating or set to match default logic states) |
| MC33926    | MC33926 is a monolithic H-bridge Power IC in a robust thermally enhanced package with single H-bridge | • 5.0 V to 28 V continuous operation (transient operation from 5.0 V to 40 V)  
  • 235 mΩ maximum $R_{DS(on)}$ at 150 °C (each H-bridge MOSFET)  
  • 3.0 V and 5.0 V TTL / CMOS logic compatible inputs  
  • Output short-circuit protection (short to VPWR or GND)  
  • Overcurrent limiting (regulation) via internal constant-off-time PWM  
  • Temperature dependant current limit threshold reduction to allow for continuous operation without shutdown  
  • Sleep mode with current draw < 50 μA (each half with inputs floating or set to match default logic states)  
  • Fast or slow slew rate adjustment |

Note
1. For MC33931, MC34931, and MC34931S software development, use one half of the MC33932. For MC34932, use MC33932.
4 Getting to Know the Hardware

4.1 Board Overview
The TWR-MC-MVHB1EVB is a Tower System peripheral module circuit board allowing the user to exercise all the functions of two H-bridge motor driver ICs (MC33932 and MC33926.)

4.2 Board Features
The board features are as follows:

- Compatibility with Freescale's Tower Platform. (A zero \( \Omega \) resistor is placed between the tower connector and each control pin of the device for maximum flexibility.)
- LEDs to indicate power supply and error status
- Transient voltage suppressor to handle system level transients
- Test points to allow probing of signals
4.3 Board Description

The TWR–MC–MVHB1EVB consists of the following components:

**Table 3. Board Description**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jumper</td>
<td>VDD power selection. Select 3.3 V / 5.0 V power from tower elevator (based on what MCU tower board is connected)</td>
</tr>
<tr>
<td>LEDs</td>
<td>Indicate power supply and fault detection status</td>
</tr>
<tr>
<td>Test Points</td>
<td>Allow signal probing</td>
</tr>
<tr>
<td>Tower Connectors</td>
<td>Primary and secondary connectors that plug into corresponding Tower Elevator modules</td>
</tr>
<tr>
<td>MC33932 Connectors</td>
<td>H-bridge Power IC with two independent H-bridges</td>
</tr>
<tr>
<td>MC33926 Connectors</td>
<td>H-bridge Power IC with single H-bridge</td>
</tr>
<tr>
<td>MC33932 Connectors</td>
<td>MC33932 outputs and power/ground inputs</td>
</tr>
<tr>
<td>MC33926 Connectors</td>
<td>MC33926 outputs and power/ground inputs</td>
</tr>
</tbody>
</table>
4.4 LED Display

The following LEDs are provided as visual output devices for the TWR-MC-MVHB1EVB evaluation board:

Table 4. LEDs

<table>
<thead>
<tr>
<th>Schematic Label</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Green LED</td>
<td>Indicates when power supply is connected to MC33932</td>
</tr>
<tr>
<td>D2</td>
<td>Red LED</td>
<td>Illuminates when a fault is detected in H-bridge Channel B of MC33932</td>
</tr>
<tr>
<td>D5</td>
<td>Green LED</td>
<td>Indicates when power supply is connected to MC33932</td>
</tr>
<tr>
<td>D8</td>
<td>Green LED</td>
<td>Indicates when power supply is connected to MC33926</td>
</tr>
<tr>
<td>D10</td>
<td>Green LED</td>
<td>Indicates when power supply is connected to VDD (Digital power from primary connector)</td>
</tr>
<tr>
<td>D11</td>
<td>Red LED</td>
<td>Illuminates when a fault is detected for H-bridge of MC33926</td>
</tr>
</tbody>
</table>
4.5 Connectors

Input/output connectors provide the following signals:

Table 5. Connectors

<table>
<thead>
<tr>
<th>Schematic Label</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1</td>
<td>Motor - A</td>
<td>Motor connector for H-bridge Channel A of MC33932</td>
</tr>
<tr>
<td>J2</td>
<td>Motor - B</td>
<td>Motor connector for H-bridge Channel B of MC33932</td>
</tr>
<tr>
<td>J3</td>
<td>33932 PWR - IN 8 - 28V</td>
<td>Power supply for MC33932 MCU</td>
</tr>
<tr>
<td>J4</td>
<td>Motor</td>
<td>Motor connector for H-bridge Channel A of MC33926</td>
</tr>
<tr>
<td>J5</td>
<td>33926 PWR - IN 8 - 28V</td>
<td>Power supply for MC33926 MCU</td>
</tr>
<tr>
<td>J7 Primary</td>
<td>Primary Tower Platform Connector</td>
<td>Plugs into primary Tower Elevator connector TWR-ELEV-PRI</td>
</tr>
<tr>
<td>J7 Secondary</td>
<td>Secondary Tower Platform Connector</td>
<td>Plugs into secondary Tower Elevator connector TWR-ELEV-SEC</td>
</tr>
<tr>
<td>J8</td>
<td>Reserved Connector</td>
<td>Reserved for MCU ADC/PWM interface</td>
</tr>
</tbody>
</table>
4.6 Test Point Definitions

The following test-point jumpers provide access to signals on the TWR-MC-MVHB1EVB IC:

![Figure 7. Test Points]

<table>
<thead>
<tr>
<th>Schematic Label</th>
<th>Signal Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP2</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>TP3</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>TP4</td>
<td>IN1</td>
<td>Logic input control for OUT1 - MC33932</td>
</tr>
<tr>
<td>TP5</td>
<td>IN2</td>
<td>Logic input control for OUT2 - MC33932</td>
</tr>
<tr>
<td>TP6</td>
<td>EN/D2_bar</td>
<td>Enable input 1 - MC33932</td>
</tr>
<tr>
<td>TP7</td>
<td>D1</td>
<td>Disable input 1 - MC33932</td>
</tr>
<tr>
<td>TP8</td>
<td>SFA_bar</td>
<td>Status flag A - MC33932</td>
</tr>
<tr>
<td>TP9</td>
<td>FBA</td>
<td>Feedback A - MC33932</td>
</tr>
<tr>
<td>TP10</td>
<td>IN3</td>
<td>Logic input control for OUT3 - MC33932</td>
</tr>
<tr>
<td>TP11</td>
<td>IN4</td>
<td>Logic input control for OUT4 - MC33932</td>
</tr>
</tbody>
</table>
Table 6. Test Points (continued)

<table>
<thead>
<tr>
<th>Schematic Label</th>
<th>Signal Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP12</td>
<td>EN/D4_bar</td>
<td>Enable input 2 - MC33932</td>
</tr>
<tr>
<td>TP13</td>
<td>D3</td>
<td>Disable input 2 - MC33932</td>
</tr>
<tr>
<td>TP14</td>
<td>SF_bar</td>
<td>Status flag B - MC33932</td>
</tr>
<tr>
<td>TP15</td>
<td>FBB</td>
<td>Feedback B - MC33932</td>
</tr>
<tr>
<td>TP16</td>
<td>IN1</td>
<td>Logic input control for OUT1 - MC33926</td>
</tr>
<tr>
<td>TP17</td>
<td>IN2</td>
<td>Logic input control for OUT2 - MC33926</td>
</tr>
<tr>
<td>TP18</td>
<td>EN</td>
<td>Enable input - MC33926</td>
</tr>
<tr>
<td>TP19</td>
<td>D1</td>
<td>Disable input 1 - MC33926</td>
</tr>
<tr>
<td>TP20</td>
<td>D2_bar</td>
<td>Disable input 2 - MC33926</td>
</tr>
<tr>
<td>TP21</td>
<td>INV</td>
<td>Inverter input - MC33926</td>
</tr>
<tr>
<td>TP22</td>
<td>SLEW</td>
<td>Slew rate control - MC33926</td>
</tr>
<tr>
<td>TP23</td>
<td>SF_bar</td>
<td>Status flag - MC33926</td>
</tr>
<tr>
<td>TP24</td>
<td>FB</td>
<td>Feedback - MC33926</td>
</tr>
<tr>
<td>TP27</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>TP28</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>TP29</td>
<td>GND</td>
<td>Ground</td>
</tr>
</tbody>
</table>
4.7 Jumper Definitions

The following table defines the evaluation board jumper position and explains its function:

Table 7. Jumpers

<table>
<thead>
<tr>
<th>Jumper</th>
<th>Description</th>
<th>Setting</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>J6</td>
<td>VDD power supply selection</td>
<td>1-2</td>
<td>VDD connected to 3.3 V (from Tower Elevator)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2-3</td>
<td>VDD connected to 5.0 V (from Tower Elevator)</td>
</tr>
</tbody>
</table>

Figure 8. Jumpers
## 4.8 Tower Elevator Connections

TWR-MC-MVHB1EVB features two expansion card edge connectors that interface to elevator boards in a Tower System: the Primary and Secondary Elevator Connectors. Table 8 provides the pinouts for the Primary Elevator Connector (TWR-ELEV-PRI). There are no electrical connections to the Secondary Elevator Connector (TWR-ELEV-SEC.)

### Table 8. Primary Elevator Connector Pinouts

<table>
<thead>
<tr>
<th>Side B</th>
<th>Side A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pin #</strong></td>
<td><strong>Name</strong></td>
</tr>
<tr>
<td>-----------</td>
<td>----------</td>
</tr>
<tr>
<td>B1</td>
<td>5V</td>
</tr>
<tr>
<td>B2</td>
<td>GND</td>
</tr>
<tr>
<td>B3</td>
<td>3.3V</td>
</tr>
<tr>
<td>B4</td>
<td>ELE_PS_SENSE</td>
</tr>
<tr>
<td>B5</td>
<td>GND</td>
</tr>
<tr>
<td>B6</td>
<td>GND</td>
</tr>
<tr>
<td>B7</td>
<td>SDHC_CLK / SPI1_CLK</td>
</tr>
<tr>
<td>B8</td>
<td>SDHC_CS1_D3 / SPI1_CS1</td>
</tr>
<tr>
<td>B9</td>
<td>SDHC_CS0_D3 / SPI1_CS0</td>
</tr>
<tr>
<td>B10</td>
<td>SDHC_CMD / SPI1_MOSI</td>
</tr>
<tr>
<td>B11</td>
<td>SDHC_D0 / SPI1_MISO</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>B12</td>
<td>ETH_COL</td>
</tr>
<tr>
<td>B13</td>
<td>ETH_RXER</td>
</tr>
<tr>
<td>B14</td>
<td>ETH_TXCLK</td>
</tr>
<tr>
<td>B15</td>
<td>ETH_TXEN</td>
</tr>
<tr>
<td>B16</td>
<td>ETH_TXER</td>
</tr>
<tr>
<td>B17</td>
<td>ETH_TXD3</td>
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<tr>
<td>B18</td>
<td>ETH_TXD2</td>
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<td>B19</td>
<td>ETH_TXD1</td>
</tr>
<tr>
<td>B20</td>
<td>ETH_TXD0</td>
</tr>
<tr>
<td>B21</td>
<td>GPIO1 / RTS1</td>
</tr>
<tr>
<td>B22</td>
<td>GPIO2 / SDHC_D1</td>
</tr>
<tr>
<td>B23</td>
<td>GPIO3</td>
</tr>
<tr>
<td>B24</td>
<td>CLKIN0</td>
</tr>
<tr>
<td>B25</td>
<td>CLKOUT1</td>
</tr>
<tr>
<td>B26</td>
<td>GND</td>
</tr>
<tr>
<td>B27</td>
<td>AN7</td>
</tr>
<tr>
<td>B28</td>
<td>AN6</td>
</tr>
<tr>
<td>B29</td>
<td>AN5</td>
</tr>
<tr>
<td>B30</td>
<td>AN4</td>
</tr>
<tr>
<td>B31</td>
<td>GND</td>
</tr>
<tr>
<td>B32</td>
<td>DAC1</td>
</tr>
<tr>
<td>B33</td>
<td>TMR3</td>
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<tr>
<td>B34</td>
<td>TMR2</td>
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<tr>
<td>B35</td>
<td>GPIO4</td>
</tr>
<tr>
<td>B36</td>
<td>3.3V</td>
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<tr>
<td>B37</td>
<td>PWM7</td>
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<tr>
<td>B38</td>
<td>PWM6</td>
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<tr>
<td>B39</td>
<td>PWM5</td>
</tr>
</tbody>
</table>
### Table 8. Primary Elevator Connector Pinouts

<table>
<thead>
<tr>
<th>Side B</th>
<th>Side A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin #</td>
<td>Name</td>
</tr>
<tr>
<td>B40</td>
<td>PWM4</td>
</tr>
<tr>
<td>B41</td>
<td>CANRX</td>
</tr>
<tr>
<td>B42</td>
<td>CANTX</td>
</tr>
<tr>
<td>B43</td>
<td>1WIRE</td>
</tr>
<tr>
<td>B44</td>
<td>SPI0_MISO</td>
</tr>
<tr>
<td>B45</td>
<td>SPI0_MOSI</td>
</tr>
<tr>
<td>B46</td>
<td>SPI0_CS0</td>
</tr>
<tr>
<td>B47</td>
<td>SPI0_CS1</td>
</tr>
<tr>
<td>B48</td>
<td>SPI0_CLK</td>
</tr>
<tr>
<td>B49</td>
<td><strong>GND</strong></td>
</tr>
<tr>
<td>B50</td>
<td>SCL1</td>
</tr>
<tr>
<td>B51</td>
<td>SDA1</td>
</tr>
<tr>
<td>B52</td>
<td>GPIO5/ SD_CARD_DET</td>
</tr>
<tr>
<td>B53</td>
<td>USB0_DP_PDOWN</td>
</tr>
<tr>
<td>B54</td>
<td>USB0_DM_PDOWN</td>
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<tr>
<td>B55</td>
<td>IRQ_H</td>
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<td>B56</td>
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<td>EBI_ALE/EBI_CST b</td>
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<td>B64</td>
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<td>EBI_D5</td>
</tr>
<tr>
<td>B76</td>
<td>EBI_D4</td>
</tr>
<tr>
<td>B77</td>
<td>EBI_D3</td>
</tr>
<tr>
<td>B78</td>
<td>EBI_D2</td>
</tr>
<tr>
<td>B79</td>
<td>FB_D1</td>
</tr>
<tr>
<td>B80</td>
<td>FB_D0</td>
</tr>
<tr>
<td>B81</td>
<td><strong>GND</strong></td>
</tr>
<tr>
<td>B82</td>
<td>3.3V</td>
</tr>
</tbody>
</table>

Notes:
2. 0 Ω resistor is connected between the pin and the connector to create a flexible connection.
5 Setting up the Hardware

When configured as a Freedom Tower platform module, the TWR-MC-MVHB1EVB must be used in conjunction with another Tower MCU evaluation board (available at www.freescale.com/tower.)

The following procedure describes how to set up the hardware when the TWR-MC-MVHB1EVB is configured to drive two DC brushed motors. (The MC33932 can only support a single stepper motor, attached to either the Channel A or the Channel B connector.)

1. Assemble the Freescale Tower platform by sliding the TWR-MC-MVHB1EVB elevator connectors into the top slots on the Tower Elevator modules. Insert the Tower MCU evaluation board in the Tower Elevator modules in a set of slots below the TWR-MC-MVHB1EVB.

2. Connect the USB cable between the PC and the USB port on the Tower MCU evaluation board.

3. Connect the MC33932 Channel A load to connector J1 (OUT2 & OUT1) and the MC33932 Channel B load to connector J2 (OUT4 and OUT3) on the TWR-MC-MVHB1EVB evaluation board.

4. Connect the MC33932 8.0 V—28 V DC power supply to connector J3 (PWR-IN) on the evaluation board.

5. Connect the MC33926 load to connector J4 (OUT2 & OUT1) on the TWR-MC-MVHB1EVB evaluation board.

6. Connect the MC33926 8.0 V—28 V DC power supply to connector J5 (PWR-IN) on the evaluation board.

7. Launch the software application used to communicate with the board.

Figure 9 illustrates the procedure.
6 Installing Processor Expert Software

6.1 Installing CodeWarrior on your Computer

This procedure explains how to obtain and install the latest version of CodeWarrior (version 10.6 in this guide).

**NOTE**
The sample software in this kit requires CodeWarrior 10.6 or newer. The component and some examples in the component package are intended for Kinetis Design Studio 3.0.0. If you have CodeWarrior 10.6 and Kinetis Design Studio 3.0.0 already installed on your system, skip this section.

2. Run the executable file and follow the instructions.
3. In the **Choose Components** window, select the Kinetis component and click on **Next** to complete the installation.

![Figure 10. Choose CodeWarrior Components Screen](image)
6.2 Downloading the MVHBridge Component and Example Projects

The examples used in this section are based on a pre-configured CodeWarrior project. You must first download the project and its associated components:

2. Download example projects and H-Bridge component zip file.
3. Unzip the downloaded file and check that the folder contains the files listed in Table 9.

<table>
<thead>
<tr>
<th>Table 9. MVHBridge Example Project and Components</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Folder Name</strong></td>
</tr>
<tr>
<td>CodeWarrior_Examples</td>
</tr>
<tr>
<td>MVH_K20D72M_brushed</td>
</tr>
<tr>
<td>MVH_K20D72M_brushed_FreeMaster</td>
</tr>
<tr>
<td>MVH_K20D72M_step_FreeMaster</td>
</tr>
<tr>
<td>MVH_K20D72M_stepper</td>
</tr>
<tr>
<td>MVH_K20D72M_stepper_fullstep</td>
</tr>
<tr>
<td>MVH_K20D72M_stepper_ramp</td>
</tr>
<tr>
<td>MVH_K64F120M_brushed_2component</td>
</tr>
<tr>
<td>MVH_K70F120M_brushed</td>
</tr>
<tr>
<td>MVH_K70F120M_stepper</td>
</tr>
<tr>
<td>MVH_KL25Z48M_brushed_2component</td>
</tr>
<tr>
<td>MVH_KL25Z48M_fullstep_ramp</td>
</tr>
<tr>
<td>Component</td>
</tr>
<tr>
<td>DriverSuite_Examples</td>
</tr>
<tr>
<td>MVH_K20D72M_stepper</td>
</tr>
<tr>
<td>KDS_Examples</td>
</tr>
<tr>
<td>MVH_K20D72M_stepper</td>
</tr>
<tr>
<td>MVH_K20D72M_stepper_ramp</td>
</tr>
<tr>
<td>FRDM34931SEVB_Examples</td>
</tr>
<tr>
<td>MVH_KL25Z_brushed</td>
</tr>
</tbody>
</table>

6.2.1 Importing the MVHBridge Component into the Processor Expert Library

1. Launch CodeWarrior by clicking on the CodeWarrior icon (located on your desktop or in Program Files -> Freescale Codewarrior folder.)
2. When the CodeWarrior IDE opens, go to the menu bar and click Processor Expert -> Import Component(s).
3. In the pop-up window, locate the component file (.PEupd) in the example project folder MVHBridge_PEx_SWComponent. Select MVHBridge_bxxx.PEupd and ChannelAllocator_bxxx.PEupd files then click Open (see Figure 11).
4. If the import is successful, the MVHBridge component appears in Components Library -> SW -> User Component (see Figure 12). The MVHBridge component is ready to use.

Figure 11. Importing the MVHBridge Component

Figure 12. MVHBridge Component Location After Importing to CodeWarrior
6.2.2 Importing an Example Project into the Processor Expert Library

The following steps show how to import an example from the downloaded zip file into CodeWarrior.

1. In the CodeWarrior menu bar, click **File -> Import**... In the pop-up window, select **General -> Existing Projects into Workspace** and click **Next**.

![Figure 13. Importing an Example File (a)](image)
2. Click **Browse** and locate the folder where you unzipped the downloaded example files. Find the folder MVHBridge_PEx_SW\CodeWarrior_Examples and select a project to import. (see Figure 14, which shows MVH_K20D72M_step_FreeMaster as the imported project). Then click **OK**.

![Figure 14. Importing an Example File (b)](image)
3. With your project now loaded in the Select root directory box, click on the Copy projects into workspace checkbox. Then click Finish. Figure 15 shows the CodeWarrior Projects panel and the Components panel after the project has been successfully imported.

The project is now in the CodeWarrior workspace where you can build and run it.

- Select **Copy projects into workspace**
- Click **Finish**

**Figure 15. Importing an Example File** (c)
6.3 Creating a New Project with Processor Expert and the MVHBridge Component

If you choose not to use the example project, the following instructions describe how to create and setup a new project that uses the MVHBridge component. If you do not have the MVHBridge component in the Processor Expert Library, please follow steps in Importing the MVHBridge Component into the Processor Expert Library on page 18.

To create a new project do the following:

1. In the CodeWarrior menu bar, select File -> New -> Bareboard Project. When the New Bareboard Project dialog box opens, enter a project name into the text box and then click Next. (see Figure 16).

![Figure 16. Creating an MCU Bare-board Project](image)
2. In the **Devices** dialog box, select the MCU class your project is using in the MCU board (In **Figure 17**, MK20DX256 has been selected). Then click **Next**.

3. In the **Connections** dialog box, select the type of connection your project uses. (In **Figure 17** P&E USB Multilink Universal (FX)/USB MultiLink has been selected). Then click **Next**.

---

#### Figure 17. Selecting a Device and a Connection

4. Select the device you are using

5. Select the connection you are using

6. Click **Next**
4. In the **Language and Build Tools Options** dialog box, select the options that apply to your project. (In **Figure 18**, the default options are selected.) Then click **Next**.

5. In the **Rapid Application Development** dialog box, make sure that the **Processor Expert** button is selected. Then click **Finish**.

---

**Figure 18. Selecting the Language, Build Tools, and the Rapid Application Development Options**
6. **Figure 19** shows the CodeWarrior Projects panel and the Components panel after the project has been successfully created. Before you can build and run your project, you must add the MVHBridge component (imported in Importing the MVHBridge Component into the Processor Expert Library on page 18) into your project. Adding the MVHBridge Component into the Project on page 27 outlines this procedure.

![CodeWarrior Projects panel and Components panel upon completion](image)

**Figure 19. CodeWarrior Projects and Components Panels with Project Created**
6.3.1 Adding the MVHBridge Component into the Project

1. Find MVHBridge in the Components Library and add it into your project (see Figure 20).

2. Figure 21 shows the Components panel after the component has been added. To view the Component Inspector options, double-click on the MVHBridge component in the Components panel.

Figure 20. Add the MVHBridge Component to the Project

Figure 21. Select the component
6.3.2 General Settings of MVHBridge Component

The Component Inspector view provides a means of accessing and modifying component properties. When CodeWarrior is set to the Classic view, properties in the Component Inspector are arranged in a collapsible tree-structure. Property names appear in the Name column. The Values column lists the current value assigned to the property. Values that are not greyed-out in this column may be modified. The Details column contains additional information (including error conditions) about the selected property. (If you have CodeWarrior preferences set to the Tab view, properties will be arranged differently in the Component Inspector; However, the same definitions apply.)

Figure 22 shows typical Component Inspector properties for a project using a DC brushed motor and an MC33926 device with a single H-Bridge. Different components and settings may apply when other types of motors and MCU’s are used.

For the project in Figure 22 the H-Bridge Model is the top node in the tree structure. A drop-down menu in the Value column allows you to select the H-Bridge model your project uses.

The Motor Control group is directly below the H-Bridge Model node. The group contains two child nodes: Timer Setting and H-Bridge A MCU Interface. An MCU with dual H-Bridges would have an H-Bridge B MCU Interface group with settings similar to H-Bridge A. The settings in each of these groups are detailed below:

- **Timer Setting** when enabled, defines timer settings for the project. (For the MC33926 used in this example, the timer is enabled by default.) The group contains the following settings:
  - Timer Component defines the name of the linked TimerUnit_LDD Component.
  - Timer Device defines the name of the hardware timer being used.

- **H-Bridge A MCU Interface** defines H-Bridge interface setting. The group contains three child nodes:
  - DC Brush allows you to select the motor control mode and the motor direction:
    - **Control Mode** allows you to select whether your settings control the motor speed (Speed Control) or whether the motor is controlled by GPIO pin signals (State Control).
    - **PWM Frequency** sets the Pulse Width Modulation frequency.
  - **Direction Control** determines in which direction the motor is allowed to rotate. **Forward** means the motor can rotate only in the clockwise direction. **Reverse** allows movement in the counterclockwise direction only. **Bidirectional** allows the motor to rotate in either direction.
  - **Init Direction** determines which direction (forward or reverse) the motor moves at startup.
Device Mode defines the H-Bridge operational mode for the selected device. The mode specifics depend on the device, but Normal, Sleep, and Stand-by are typical. For more information, see the data sheet for your device. Device Mode is controlled by enabling and disabling pins. The mode can be changed in your C code using the SetMode method.

Device Settings A associates each of the output pins with a corresponding input pin name.

Enable and Disable Pins settings control the Device Mode. The number and the names of pins in this group depends on the H-Bridge model you have selected. In all cases, you must assign the appropriate value to each pin name in the group.

Slew Rate enables the selection of fast or slow slew rate.

- Pin for Slew defines the component setting associated with the device’s SLEW pin.

Input Invert allows you to set the device’s INV pin, subsequently causing IN1 and IN2 to be set to LOW = TRUE (see the device’s data sheet for additional information on the Input Invert (INV) pin).

- Pin for INV defines the component setting associated with the device’s INV pin.

Input Control Pins settings define H-Bridge outputs. These pins are controlled by timer channels or by GPIO pins according to other settings in the component.

Feedback Pin settings define current measurements on the feedback pin. H-Bridge feedback provides ground-referenced 0.24% of the high side output current.

- ADC Component sets the name of the linked ADC_LDD component.
- ADC Device defines the device used for current measurement.
- ADC Pin defines the pin used for ADC current sensing.

ADC Conversion Time specifies the time interval in micro-seconds allowed for a single analog to digital conversion.

Status Flag Pin allows tracking of the H-Bridge status flag. Method GetStatusFlag provides current device status. Method ClearStatusFlag clears the status flag. Use Event OnStatusFlagA or OnStatusFlagB (depending on the H-Bridge interface) to handle errors indicated by the status flag.

Auto Initialization when set, causes Processor Expert to automatically make an initialization call. If this option is not set, your code must make the Init call.
6.3.3 Setting up a Project to Control a DC Brushed Motor

1. Select the H-Bridge model you want to configure and set the Motor Control property to Brushed.

2. Set the Control Mode property. There are two ways to control the DC brushed motor:
   - **Speed Control** - motor speed is controlled by your settings. The TimerUnit_LDD component is used to generate the PWM signal. The PWM Frequency property is visible in this mode only. If you set the Speed Control mode on both interfaces (i.e. Interface A and Interface B), the PWM Frequency property on Interface B will be set automatically to the same value as Interface A (because Interface B uses the same timer.)
   - **State Control** - motor is controlled by GPIO pins (BitIO_LDD components). This means you can switch the motor on or off without speed adjustments. The advantage of this mode is that you do not need timer channels. If you set State Control on both interfaces or you have only a single H-Bridge model (one interface) with State Control, the TimerUnit_LDD component is not required by the MVHBridge component and you can remove it from the project.

3. Set the PWM Frequency.

4. Set the Direction Control property. The Direction Control property determines what direction the motor is allowed to move in. Setting the property to Forward restricts the motor's movement to the forward direction only. Setting the property to Reverse restricts movement to the reverse direction only. A Bidirectional setting allows the motor to move in either direction. The Bidirectional mode requires two timer channels. Forward or Reverse requires only one timer channel and one GPIO port. This setting is available only when Speed Control mode is set in the Control Mode property.
6.3.4  Setting up a Project to Control a Stepper Motor

1. Select the dual H-Bridge model you want to configure and set Stepper in the Motor Control property. Notice that you must use a dual H-Bridge model because a two phase bipolar stepper motor has four inputs.

![Component Inspector - MVHBL Components Library](image)

**Figure 24. Stepper Motor Control Setup**

2. In the Stepper Motor group, set the properties that apply to your environment.

   **Output Control** property defines the control method for the H-Bridge outputs.

   With PWM selected the component utilizes four channels of a timer to control the stepper motor. Signals are generated in hardware and micro-step mode is available.

   With GPIO selected, GPIO pins instead of timer channels control the motor and only full-step mode is available. Micro-step mode is not available. This mode consumes more MCU clock cycles because all signals are generated in interrupts using four GPIO pins.

   **Manual Timer Setting** (only visible when Advanced is selected) is designed to change the Counter frequency property of the linked TimerUnit_LDD component. By default Counter frequency is set automatically by the MVHBridge component. In some cases the frequency value does not have to be set appropriately (for example, when you want to set a different value or when an error has occurred). For more information see Stepper Motor Speed on page 32.

   **Motor Control Mode** allows you to select the step mode. The allowable values are Full-step, Micro-step and Full-step and Micro-step. Selecting Full-step and Micro-step allows you to switch between full-stepping and micro-stepping in C code.

   The Full-step Configuration group contains speed and acceleration settings. Code for the acceleration and deceleration ramp is generated when the Acceleration property is set to a value greater than zero. Note that acceleration is always the same as deceleration. An example of an acceleration ramp is depicted in Figure 25. The acceleration setting is 400, as shown in Figure 24.
Initial Speed is set to 100 full-steps per second. This value can be changed in C code.

Acceleration Ramp defines the ramp speed for both acceleration and deceleration. In this example the value is set to 400 full-steps per second². Note that the motor reaches the speed in 0.25 second (desired_speed / acceleration = 100 / 400 = 0.25).

![Figure 25. Acceleration and Deceleration Ramp](image)

Micro-step Configuration group settings are similar to those of the Full-step Configuration. PWM Frequency is the frequency of the micro-step PWM signal. Micro-step per Step is the number of micro-steps per one full-step.

### 6.3.5 Stepper Motor Speed

This defines the stepper motor’s minimum and maximum speed. These limit values are used by various component methods. Minimum and maximum speeds depend on the MVHBridge component settings. Counter input frequency does not influence micro-stepping speed, but could affect full-stepping speed.

Table 10: Minimum and maximum stepper motor speed

<table>
<thead>
<tr>
<th>Mode Description</th>
<th>MVHBridge component properties</th>
<th>Stepper motor speed [steps per second]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Timer Device</td>
<td>Output Control</td>
</tr>
<tr>
<td>Full-step mode</td>
<td>FTM</td>
<td>PWM</td>
</tr>
<tr>
<td>Micro-step mode</td>
<td>FTM or TPM</td>
<td>PWM</td>
</tr>
<tr>
<td>Full-step mode</td>
<td>TPM</td>
<td>PWM</td>
</tr>
<tr>
<td>(using TPM timer)</td>
<td>FTM or TPM</td>
<td>GPIO</td>
</tr>
</tbody>
</table>

Possible values for the timer input frequency (Counter frequency property in TimerUnit_LDD) are in Table 11. Input frequency values depend on MVHBridge component settings. Note that, in one case, two frequency values are needed in Full-step and Micro-step mode when FTM timer is used (the MVHBridge component switches in runtime between these two values).
### 6.3.5.1 Computation of Minimum Full-stepping Speed

The minimum full-stepping speed depends on the timer input frequency only when the Timer Device is set to FTM (FTM0_CNT, or FTM1_CNT, etc.), and **Output Control** is set to PWM. The Full-step signal is generated by a timer while channels toggle on compare (See Figure 26).

![Generating the Full-step Control Signal](image_url)

---

**Table 11. Minimum and maximum timer input frequency per stepper control mode**

<table>
<thead>
<tr>
<th>Mode Description</th>
<th>MVHBridge component properties</th>
<th>Stepper motor speed [steps per second]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Timer Device</td>
<td>Output Control</td>
</tr>
<tr>
<td>Full-step mode</td>
<td>FTM or TPM</td>
<td>PWM</td>
</tr>
<tr>
<td>Micro-step mode</td>
<td>FTM or TPM</td>
<td>PWM</td>
</tr>
<tr>
<td>Full-step and Micro-step mode</td>
<td>FTM</td>
<td>PWM</td>
</tr>
<tr>
<td>Full-step and Micro-step mode (using TPM timer)</td>
<td>TPM</td>
<td>PWM</td>
</tr>
<tr>
<td>Full-step mode (SW control)</td>
<td>FTM or TPM</td>
<td>GPIO</td>
</tr>
</tbody>
</table>

---

---
The Full-step minimum speed is derived from the input frequency of the timer device (the Counter frequency property of the TimerUnit_LDD component being used). You can find minimum values for speed in the MVHBridge header file (see constant <component_name>_MIN_FULLSTEP_SPEED). The formula for calculation of this value is as follows:

\[
\text{Speed}_{\text{min}} = \frac{2 \times \text{Counter frequency}}{65536} + 1
\]

where:
- Counter frequency = input frequency of the timer device
- 65536 = maximum value of TimerUnit_LDD counter (16-bit counter).

Adding 1 ensures that the 16-bit counter does not overflow (which is the point of the formula).

For example if the Counter frequency is set to 187,500 Hz, the minimum speed is:

\[
\text{Speed}_{\text{min}} = \frac{2 \times 187500}{65536} + 1 = 2 \times 2.872089888 + 1 = 6.744279776
\]

The MCU rounds the value down, so the result is 6 full-steps per second.

### 6.3.5.2 Setting the Minimum Full-stepping Speed

This section describes how to change the input frequency of the TimerUnit_LDD component.

1. Launch Processor Expert and select the MVHBridge component.
2. In the Processor Expert menu bar, set component visibility to Advanced.
3. In the Properties tab, find the Manual Timer setting property and set the value to Enabled. If you do not see this property, make sure that component visibility is set to Advanced (see Figure 27).

4. In the Components panel, expand the Referenced_Components folder and double-click on the component TU1:TimerUnit_LDD.
5. Click the Counter frequency value field. An ellipsis button appears at the right edge of the cell.
6. Click on the ellipsis button.
7. Set the frequency value (163.84 kHz in illustration). The list of available frequencies depends on the CPU component settings (with an external crystal as the clock source and a core clock of 48 MHz).

8. Set the **Allowed Error** value at 10% (see Figure 29).

9. Click **OK** to complete the process.

---

**Figure 28. Component TimerUnit_LDD Timing Dialog**

**Figure 29. Component TimerUnit_LDD Timing Dialog—Select Input Frequency**
6.3.6 Generating Driver Source Code

After you have completed configuring the components, you are ready to generate the driver code that will be incorporated into your application. The process is as follows:

1. Click on the Generate Processor Expert Code icon in the upper right corner of the Components panel.

![Generate Processor Expert Code icon](image)

**Figure 30. Generating the Source Code**

2. The driver code for the H-Bridge device is generated into the Generated_Code folder in the Project panel. The component only generates the driver code. It does not generate application code. Figure 31 shows the locations of the generated driver source and the application code.

![Generated Code and Application Code Locations](image)

**Figure 31. Source Code Locations**
### 6.3.7 Developing Application Code in Processor Expert

Processor Expert allows you to write application code, add component methods, and build your application without leaving the CodeWarrior environment.

#### 6.3.7.1 Writing your Application Code

All of your application code must reside in the **Sources** folder in your project directory. You may modify the code in **main.c** and **Events.c**, but retain the original comments related to usage directions.

#### 6.3.7.2 Adding Component Methods

To add a component method into your application source code:

1. In the **Components** panel for your project, click on **Components**. Find the method you wish to add to your code.
2. Drag and drop the method directly into the source code panel
3. Add the appropriate parameters to the method. (Hovering your mouse over the method displays a list of the required parameters.)

For example, you can open the MVHBridge component method list, drag and drop **RotateProportional** to **main.c** and add the necessary parameters (see Figure 32).
6.3.7.3 Finding Descriptions of the MVHBridge Methods

Hovering your mouse over any of the methods displays a description of the method, including a list of required parameter. See Figure 33.

6.3.7.4 Jumping into Function Source Code

CodeWarrior is based on the Eclipse IDE which allows you to jump directly into the source code of a function from within the main routine while you are editing. To do so, move your mouse cursor over the function name and click. The source code appears in the edit window.

Figure 33. MVHBridge Method Descriptions

Figure 34. Jumping into a Function’s Source Code
6.3.7.5 Compiling, Downloading and Debugging

To compile, download and debug on board, click compile, then click the debug icon in the toolbar. CodeWarrior will download and launch the program on board (see Figure 35).

To compile, click here  To download and debug, click here

Figure 35. Compiling and Downloading the Application

6.4 Stepper Motor Control Application Notes

The MVHBridge component is designed to control a two phase bipolar stepper motor. Because a stepper motor uses electrical commutation to rotate, it requires a dual H-Bridge device. The basic control method is full-stepping which fully powers each coil in sequence. Increased precision can be achieved by using PWM to control coil current (open loop control). This method is called micro-stepping (available in the MVHBridge component.)

In both micro-step and full-step mode you can control motor speed, direction, acceleration and deceleration and the position of the stepper motor.

The following application notes apply to stepper motor control:

• The MVHBridge component was tested with a core clock frequency ranging from 20 MHz (minimal value) to 120 MHz.
• Do not change the settings of the timer device (TimerUnit_LDD) linked by the MVHBridge component. The component sets the timer device automatically.
• The acceleration and deceleration ramp of the stepper motor is computed in real-time using integer arithmetic. This solution is based on the article "Generate stepper-motor speed profiles in real time" (Austin, David, 2005.)
• The stepper motor holds its position (coils are powered) after motor movement is completed. Use method DisableMotor to set H-Bridge outputs to LOW (coils are not powered).
• Forward motor direction indicates that steps are executed in the order depicted in Figure 36. IN1 through IN4 are the input pins of the H-Bridge device which control H-Bridge outputs. These pins input to the stepper motor. You must connect the stepper motor to output pins OUT1-OUT4 and select control input pins on your MCU in the component settings.
• The FTM or TPM timer device is needed by stepper control logic.
• The AlignRotor method affects the position of the motor. This method executes four full-steps. It is available only when full-step mode is enabled.
6.4.1  Full-step Control Mode

The component uses normal drive mode where two coils are powered at the same time.

As mentioned in Setting up a Project to Control a Stepper Motor on page 31, you can generate a full-stepping signal either by using four channels of a timer or by using four GPIO pins. The signal generated by the MCU (inputs of H-Bridge device) using four timer channels is shown in Figure 36. The voltage levels applied to the coils of the stepper motor are depicted in Figure 37. Note that the voltage is applied to both coils at the same time.

![Figure 36. Signals of Logic Input Pins Generated by the MCU in Full-step Mode](image)

![Figure 37. Output of the H-Bridge Device in Full-step Mode](image)
6.4.2 Micro-step Control Mode

Micro-stepping allows for smoother motor movement and increased precision. The current varies in motor windings A and B depending on the micro-step position. A PWM signal is used to reach the desired current value (see the following equations). This method is called sine cosine micro-stepping.

\[ I_A = I_{MAX} \times \sin(\theta) \]
\[ I_B = I_{MAX} \times \cos(\theta) \]

where:
- \( I_A \) = the current in winding A
- \( I_B \) = the current in winding B,
- \( I_{MAX} \) = the maximum allowable current
- \( \theta \) = the electrical angle

In micro-step mode, a full-step is divided into smaller steps (micro-steps). The MVHBridge component offers 2, 4, 8, 16 and 32 micro-steps per full-step. The micro-step size is defined by the property Micro-steps per Step and can be changed later in C code.

![Figure 38. Micro-stepping Phase Diagram](image)

The micro-stepping signal is generated using four timer channels (see Figure 39). Output from logic analyzer in Figure 40 shows the change of PWM duty with respect to the micro-step position. Current values applied to the stepper motor coils are depicted in Figure 41.
Figure 39. Logic Input Pin Signals Generated by the MCU in Micro-step Mode

Figure 40. Logic Analyzer output

Figure 41. H-Bridge device output in Micro-step mode
6.5 Frequently Asked Questions

Q: Why do I occasionally unexpected behavior in my stepper or DC brushed motor?

A: Check the value of the signals on the enable and disable pins (D1, EN/D2, D3, EN/D4). These signals affect the H-Bridge device mode. To provide a wider range of MCU compatibility, some pins are wired to more than one MCU board pin using $0 \, \Omega$ resistors. Check your schematic and remove resistors as needed to disconnect unused pins.

Q: How do I set up the MVHBridge component when two or more components with conflicting values are configured to control brushed motors? (See Figure 42)

![Figure 42. Conflict in the Required Values for Components in the Project](image)

A: You can use more than one MVHBridge components in same project. These components can share the same timer device in brushed motor control mode, but the PWM Frequency and Timer Device properties must conform in all of the components.

Q: Can I use both a stepper motor and a brushed DC motor on a single timer?

A: The stepper motor control needs a dedicated timer because the timer period can be dynamically changed. Using a stepper motor and a brushed DC motor on the same timer pins is possible only when the Control Mode property of the brushed DC motor is set to State Control.

Q: The TimerUnit_LDD component used by MVHBridge is not set properly and shows some errors.

A: The reason may be that the TimerUnit_LDD component channels are not allocated correctly. Change some MVHBridge component properties to force channel allocations. If you are configuring a stepper motor (Motor Control property set to Stepper), change the Output Control property to GPIO then back to PWM. For brushed DC motors (Motor Control property set to Brushed), change the Control Mode property to State Control and back to Speed Control on interface A or interface B.

Q: I sometimes get the following unexpected error while generating Processor Expert code: "Generator: FAILURE: Unexpected status of script: Drivers\Kinetis\TimerUnit_LDD.drv, please contact Freescale support". What causes this?

A: Occasionally, when you enable the MVHBridge component in your project, the TimerUnit_LDD component channels have not been allocated. If this occurs, changing certain MVHBridge properties will force allocation of the channels. If you are configuring a stepper motor (Motor Control property set to Stepper), try changing the Output Control property to GPIO and then back to PWM. If you are configuring a brushed motor (Motor Control property set to Brushed), change the Control Mode property to State Control and then back to Speed Control on interface 1 or interface 2.

![Figure 43. Unexpected error related to the MVHBridge TimerUnit_LDD component](image)

Q: I have set up several CPU clock configurations (via the Clock configurations property of the CPU component). Sometimes during runtime, when I switch between these configuration (using the CPU SetClockConfiguration method), the speed of the stepper motor appears to be inaccurate. Why does this occur?

A: Switching to a different configuration results in the use of a different input frequency by a timer device. The MVHBridge component may not pick up the new value and continues to use the previous value in its calculations.
Figure 44. Evaluation Board Schematic, Part 1
Figure 45. Evaluation Board Schematic, Part 2
Figure 46. Evaluation Board Schematic, Part 3
8 Board Layout

8.1 Silkscreen
# 9 Board Bill of Materials

Table 12. Bill of Materials (3)

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<tr>
<th>Item</th>
<th>Qty</th>
<th>Schematic Label</th>
<th>Value</th>
<th>Description</th>
<th>Part Number</th>
<th>Assy Opt</th>
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<tr>
<td>3</td>
<td>3</td>
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<td>LED RED CLEAR SGL 30MA 0805</td>
<td>LTST-C170EKT</td>
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<td>DIODE TVS UNIDIR 600 W 24 V AEC-Q101 SMB</td>
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<td>24</td>
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Notes

3. Freescale does not assume liability, endorse, or warrant components from external manufacturers are referenced in circuit drawings or tables. While Freescale offers component recommendations in this configuration, it is the customer's responsibility to validate their application.
4. Do not populate
10 References

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<th>Freescale.com Support Pages</th>
<th>Description</th>
<th>URL</th>
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Visit [www.freescale.com/support](http://www.freescale.com/support) for a list of phone numbers within your region.

10.2 Warranty

Visit [www.freescale.com/warranty](http://www.freescale.com/warranty) to submit a request for tool warranty.
## 11 Revision History

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<tr>
<th>Revision</th>
<th>Date</th>
<th>Description of Changes</th>
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<td>7/2015</td>
<td>• Initial Release</td>
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<tr>
<td>2.0</td>
<td>9/2015</td>
<td>• Added Processor Expert section</td>
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<tr>
<td></td>
<td>9/2015</td>
<td>• Fixed invalid Section reference</td>
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<tr>
<td></td>
<td></td>
<td>• Added Processor Expert, CodeWarrior, Kinetis to trademark citations in last page</td>
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