FM3, MB9AF110K

32-bit ARM® Cortex® - M3 Washing Machine Evaluation Board

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1. Introduction

Scope of This Document

This application note describes the below products:

Series	Product Number(Not Including Package Suffix)
MB9AF110K Series	All products

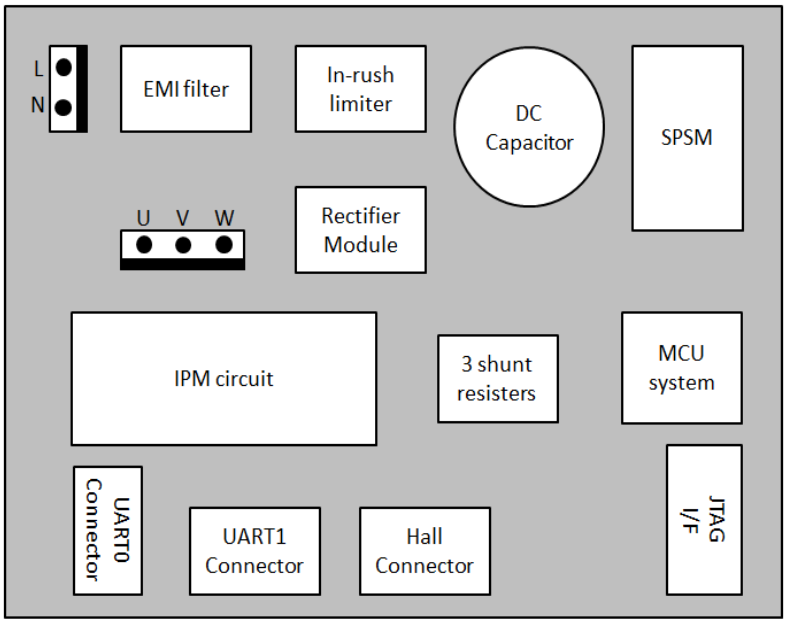
1.1 Overview

The FM3 washing machine board is intended to aid the user in the rapid evaluation and development of washing machine motor control applications using FM3 Series MCUs which are embedded with ARM Cotex-M3 core. This Board is targeted to control Permanent Magnet Synchronous Motors or BLDC that are widely employed in washing machine.

Hardware version: schematic v0.3.1, board v0.3.1

Figure 1 provides the block diagram of the board.

Figure 1. Block Diagram



1.2 Features

This board is composed of many elements. The key features of the solution board are listed as below:

AC power stage:

220VAC ± 15% input compatible

On-board EMI filter and in-rush limiter

15A/800V rectifier module

Inverter stage:

Three-phase Intelligent Power Module (IPM) with a power rating of 600V/15A

Phase current sense resistor for dual shunt vector control

Over-current protection

Input / Output:

One hall sensor input connector (J5)

Two UART connectors (J2 and J9), share the same UART module

Programming and debug interface:

JTAG via 6- pin connector (J8)

2. Getting Started

2.1 Board Elements

The Washing Machine Board comprises four main parts:

- EMI filter and In-rush Limiter

  In order to suppress the common mode noise and in-rush current, the board employs EMI filter and in-rush limiter before rectifier module.

- Rectifier Module and Power Module Stage

  The rectifier module converts the AC voltage to full wave voltage. Then, it goes through the DC capacitor and provides DC power to the inverter power module.

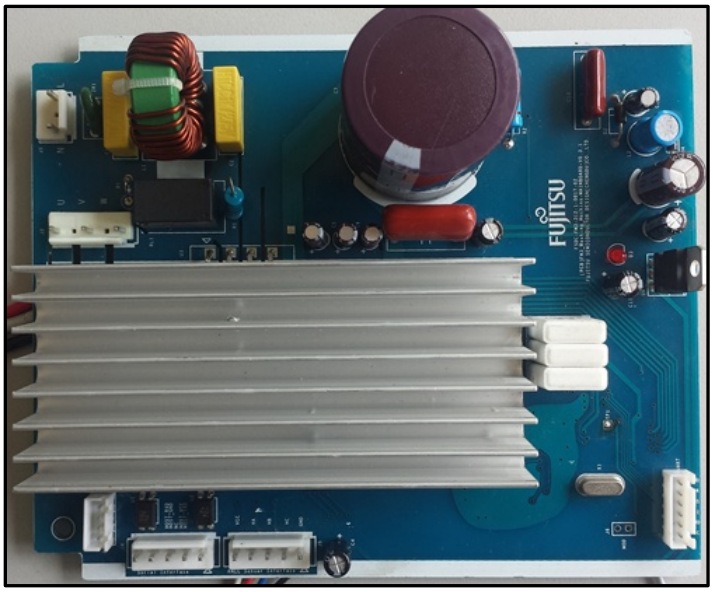
- SMPS

  This board adopts the transformer-less SMPS to provide 5Vpower to the control unit and 15Vpower to the driver unit of power module.

- MCU and User Interface

  This solution supports MB9AF110K series MCUs. The board provides some dedicated interfaces for washing machine application, for example: UART for data communication between drive board and top board, and hall sensor input interface. The board can be used to drive the washing machine directly.

Figure 2. Top View of the Board



2.2 User Interface

This board uses the following components to interact with user. Figure 3 shows the position of the related components.

- LED

  One LED(DT3) is used to indicate 5V.

- Isolated UART port

  There are two isolated UART connectors, sharing only one UART port.

- Debugging port

  The 6-pin connector(J8) is for JTAG connecting.

- Hall sensor input port

  The board provides a hall sensor input connector(J5). This board supports three-phase hall sensor.

- Motor Connectors

Figure 3. User Interfaces

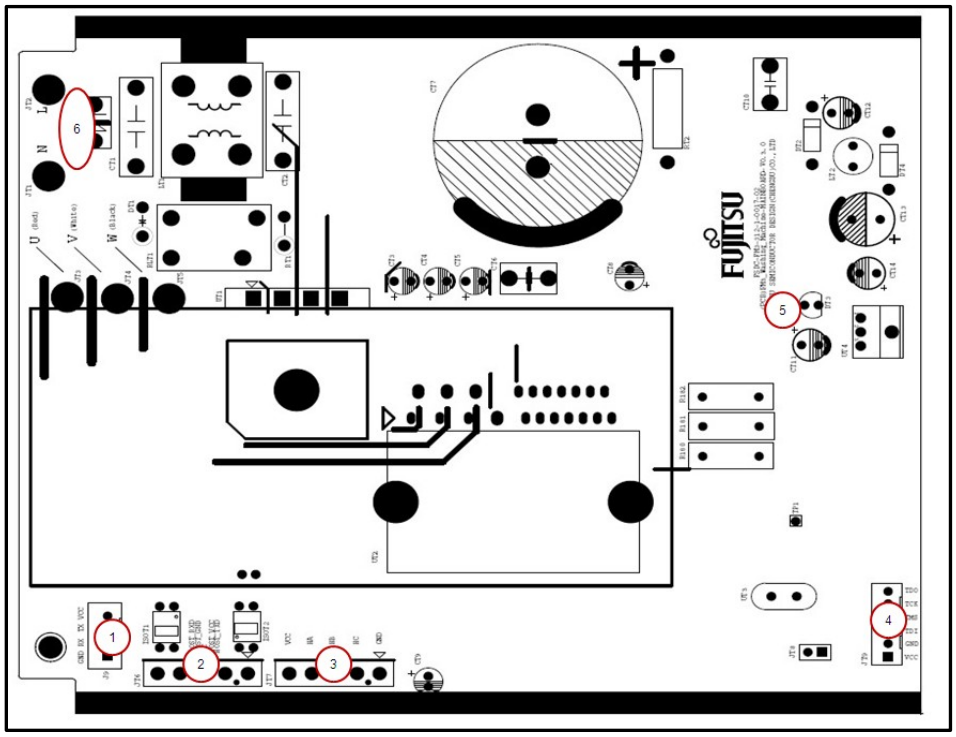


Table 1 collects the connectors.

Table 1. Definition of Connectors

Number	Component Designator	Description
1	J9	UART connector
2	J2	Isolated UART connector
3	J5	Hall sensor connector
4	J8	JTAG connector
5	D3	Power supply indicator
6	J1	AC mains connector

2.3 Connection Sequence

The recommended connection sequence is listed below. The user should ensure that the following sequence is met before connecting the system to the AC mains and a motor.

1. ConnectJ1 to the AC mains with a 10A cable.
2. Connect J5 to the hall sensor connector of the motor.
3. Connect J2 to the motor phases respectively.
4. Connect the J-Link to the JTAG port(J8) on board and connect J-Link to host computer via USB cable.

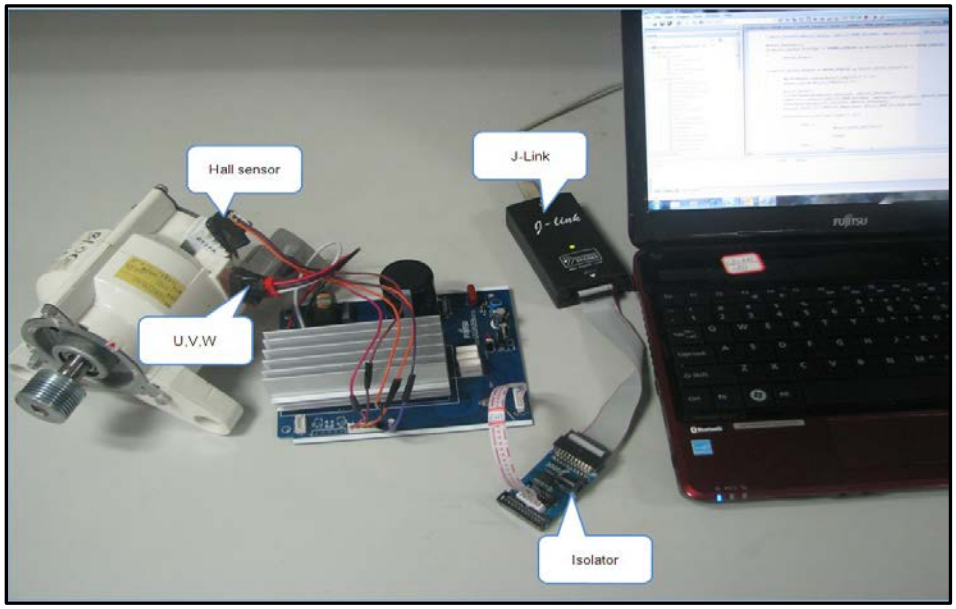
Note:

Please make sure the AC mains power is isolated power if trying to debug with computer!

2.4 System Connection

Figure 4 shows the system connection for debugging.

Figure 4. System Connection



2.5 Pin Assignment of Connector

2.5.1 UART0 ConnectorJ9

Table 2 lists pins of J9.

Table 2. Pin Assignment of J9

Pin Number	Pin Name	Description
1	GND	Ground
2	RX	Data input
3	TX	Data output
4	5V	Power supply

2.5.2 UART1 connectorJ2

Table 3 lists pins of J2

Table 3. Pins of J2

Pin Number	Pin Name	Description
1	HOST_TXD	Isolated data output
2	HOST_VCC	Isolated VCC
3	NC	Not connected
4	HOST_GND	Isolated Ground
5	HOST_RXD	Isolated data input

2.5.3 Hall Sensor Connector J5

Table 4 lists pins of J5

Table 4. Pins of J5

Pin Number	Pin Name	Description
1	VCC	5V
2	HA	Phase A of Hall sensor
3	HB	Phase B of Hall sensor
4	HC	Phase C of Hall sensor
5	GND	Ground

2.5.4 JTAG Connector J8

Table 5 lists pins of J8

Table 5. Pins of J8

Pin Number	Pin Name	Description
1	VCC	5V
2	GND	Ground
3	TDI	JTAG data input of target CPU
4	TMS	JTAG mode set input of target CPU
5	TCK	JTAG clock to target CPU
6	TDO	JTAG data from target MCU

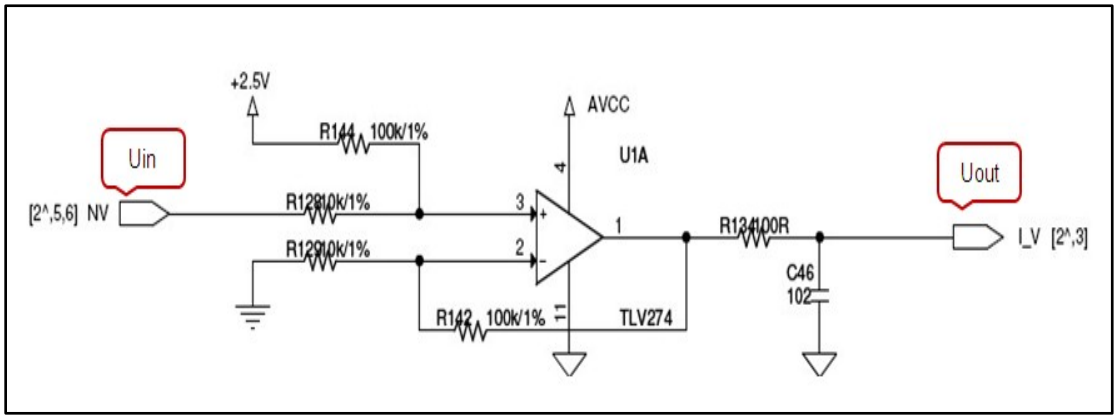
3. Hardware

3.1 Amplifier Circuit for Phase Current

This solution employs two shunt resistors to measure the phase current of a motor. Accordingly, two channel of amplifier are needed to extend the range of current waveform and lift the middle point of current waveform from ground to 2.5V.

Figure 5 shows the detail of amplifier circuit.

Figure 5. Amplifier Circuit



Compute the voltage of current waveform as follow:

$$Uout = 2.5 + \left(\frac{R142}{R129}\right) * Uin$$

Where:

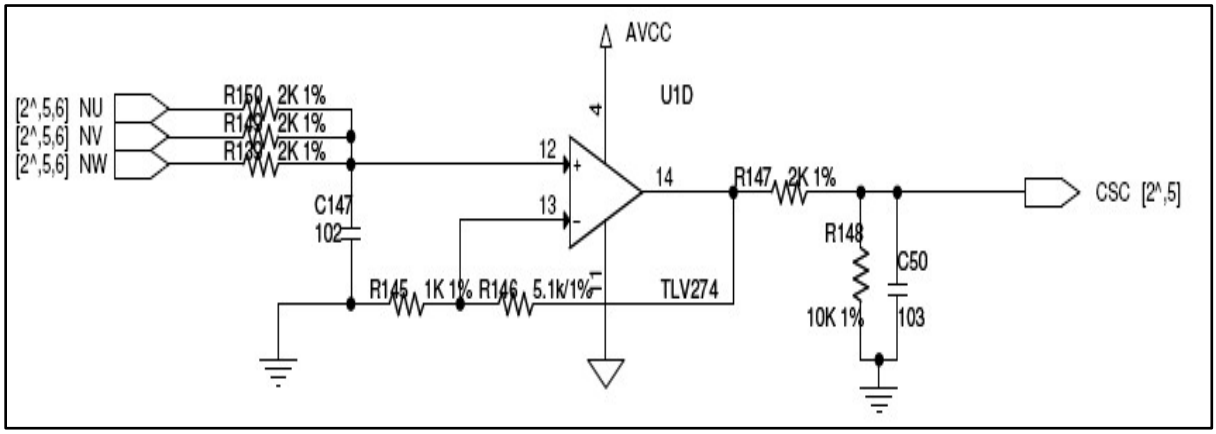
$Uout$ = amplified voltage

Uin = voltage between shunt resistor

3.2 Over-current Protection Circuit

To prevent the damage to the IPM caused by the unexpected huge current. The system needs over-current protection circuit Figure 6 to detect the current surge.

Figure 6. Over-Current Projection Circuit



Compute the output as follow:

$$Uout = \frac{1}{3} * \left(\frac{R148}{R147 + R148}\right) * \left(\frac{R146}{R145} + 1\right) * Unu\ (Unv\ or\ Unw)$$

Where:

$Uout$ = voltage to fault pin of IPM

Unu, Unv, Unw = voltage between shunt resisters

As mentioned in the specification of IPM, the self-protection function will be trigged if the voltage on the fault pin is higher than 0.5V. Then, it is easy to calculate and adjust the threshold value that trigs the over-current protection.

4. Additional Information

For more Information on Cypress semiconductor products, visit the following websites:

English version address:

http://www.cypress.com/cypress-microcontrollers

Chinese version address:

http://www.cypress.com/cypress-microcontrollers-cn

Please contact your local support team for any technical question

America: http://www.cypress.com/cypress-solutionsnetwork

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5. Revision History

Document Revision History

Document Title: FM3, MB9AF110K, 32-Bit ARM® Cortex® - M3 Washing Machine Evaluation Board Document Number:002-04443			
Revision	Issue Date	Origin of Change	Description of Change
**	02/01/2015	BOZH	Initial Release
*A	06/14/2016	BOZH	Migrated Spansion guide “MB9AF111K_AN706-00097-E “ to Cypress format