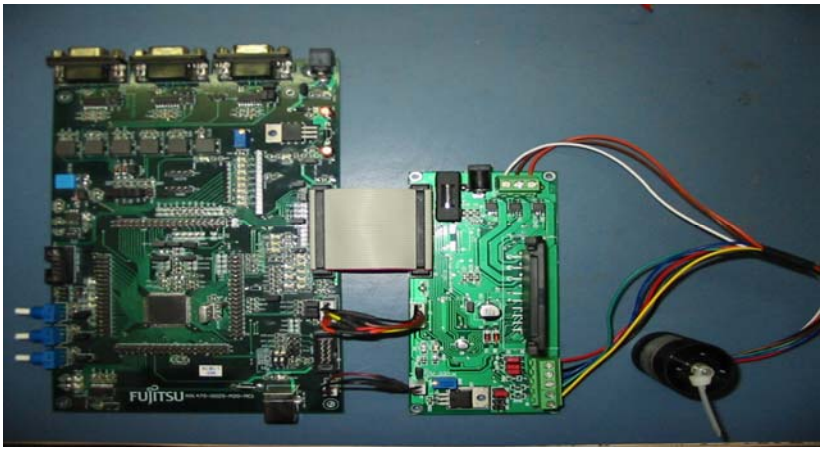
MB91470 Family Motor Control Kit
User Manual

P/N: A91470-MOTOR-Kit



Revision History

Revision #	Date	Comment
1.0	1.25.09	New Document

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Date: 22.01.99, V1.0

Contents

1. Introduction

1.1 Overview

The BLDC/PMSM Motor control kit is an evaluation kit to provide the user a platform to evaluate the Fujitsu motor control microcontroller and develop the own solution with no external component. The starter kit is built around the Fujitsu 32 bit MB91F479 microcontroller, which has the integrated peripheral for motor control application. The motor peripherals can control three phase motor such as Brushless DC motors, PMSM motor, and Induction motor. The motor control kit shows how effectively the Fujitsu family of microcontrollers can be used in advanced motor control application. The motor control kit supports both Hall sensor and a sensorless control for BLDC motor and sensorless FOC control for PMSM motor.

This document contains detail information for system specification, board physical components, board connection, installation, demo operation, signal measurement, precaution and trouble shooting guide for the motor control kit.

1.2 Evaluation Kit Features

- Self contained, No additional components required for evaluation.
- Start/Stop and forward/reverse direction switches.
- Hall sensor inputs for sensor brushless dc motor control
- Socket for Emulator
- Fault indication LEDs
- Headers for MCU pins
- Support for BLDC and PMSM motor

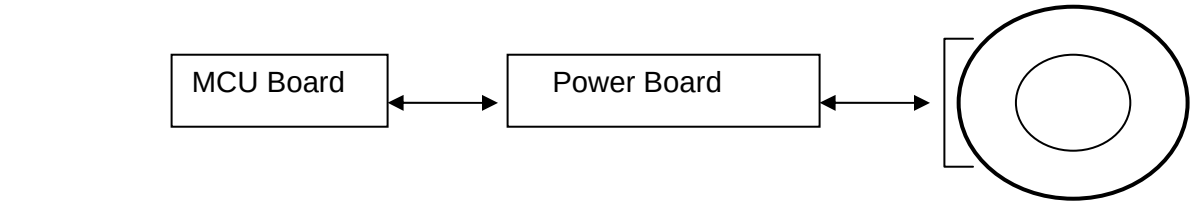
1.3 Supported Microcontroller series

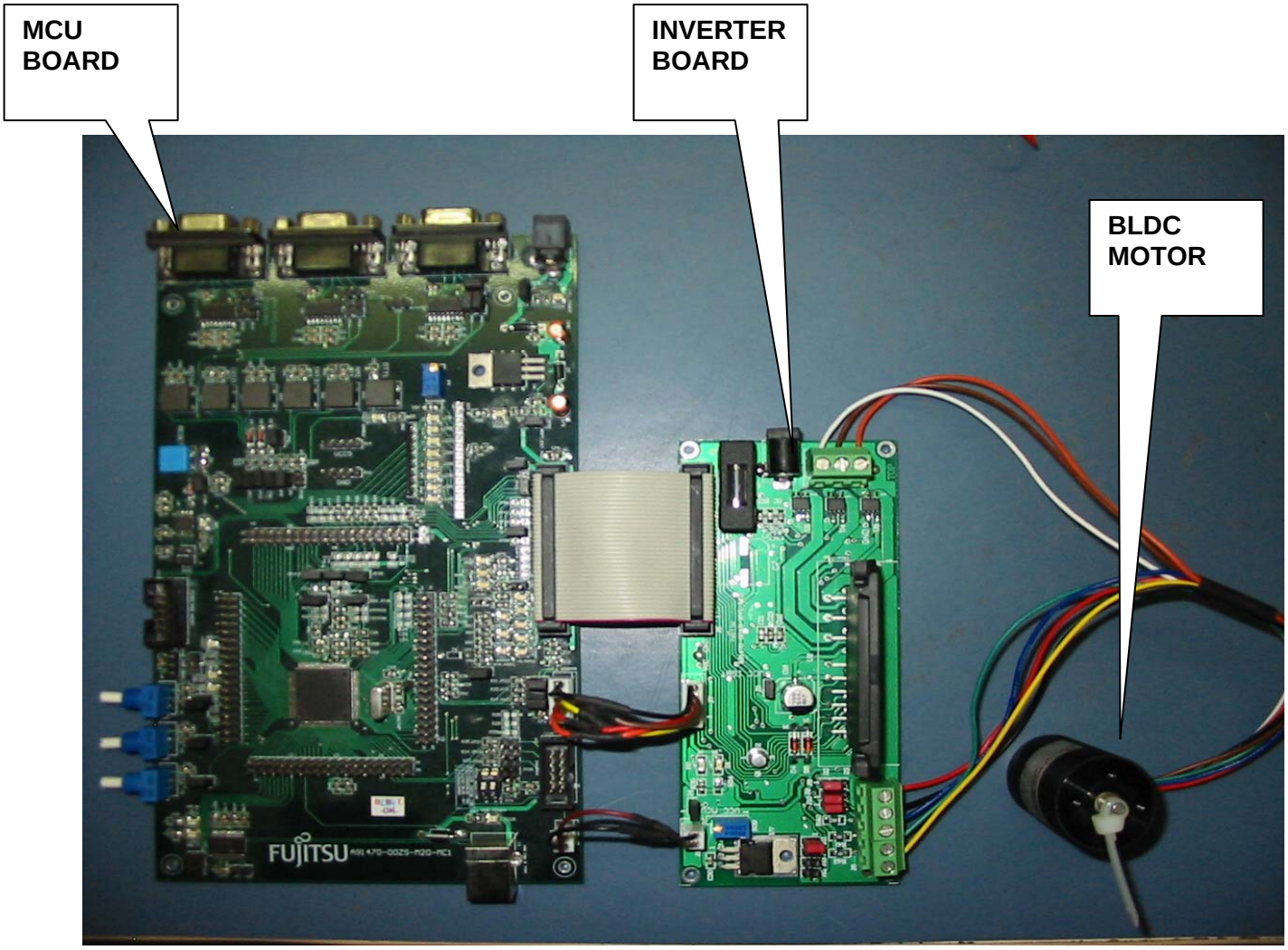
The kit is designed to work only with MB91475 series. The following MCU parts can be used with the Kit:

- MB91V470
- MB91F479

2. Fujitsu Motor Control Starter Kit Components

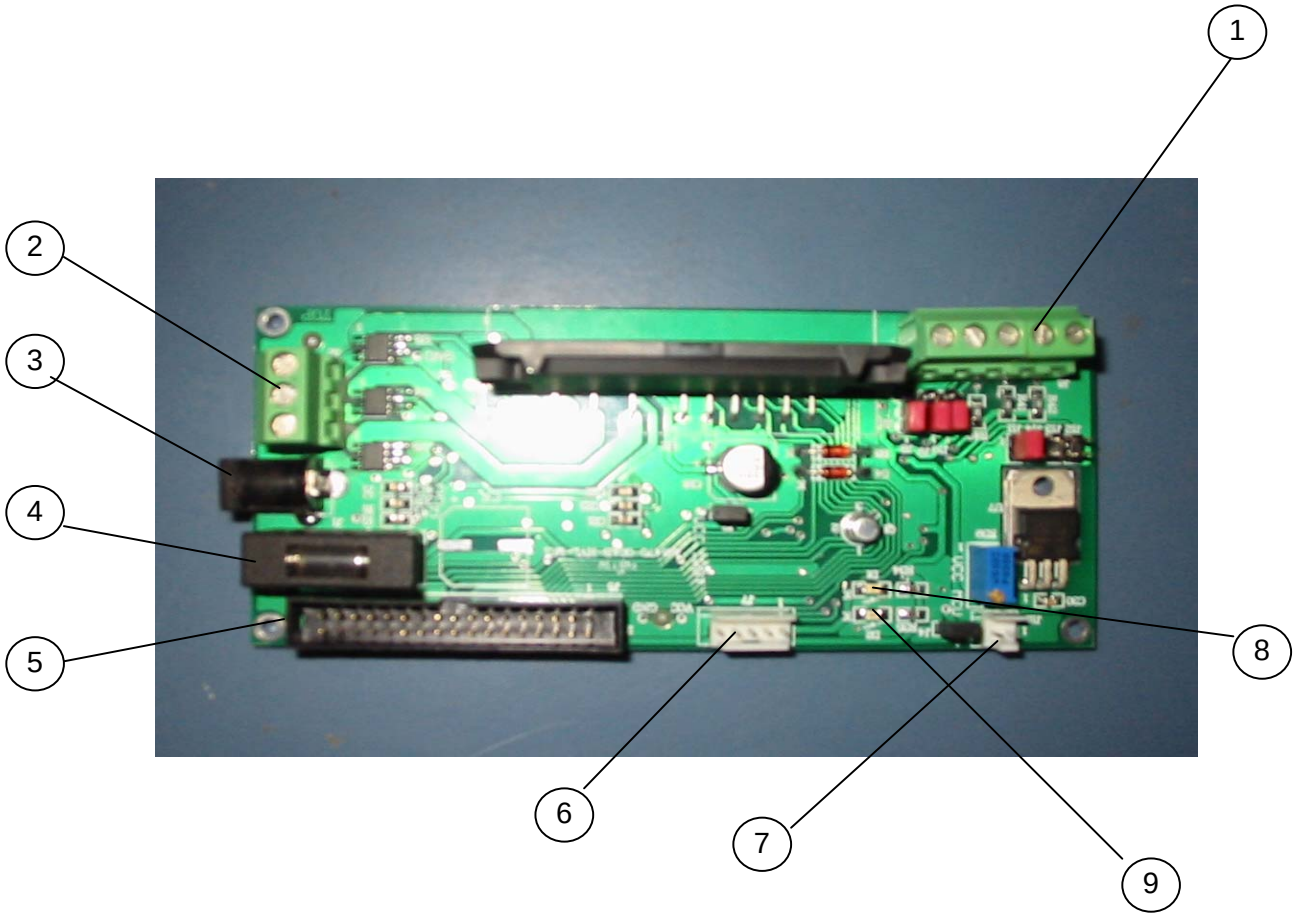
The kit consists of the following major units:
1. Inverter Board
2. MCU Board
3. BLDC/PMSM Motor





2.1 Inverter Board

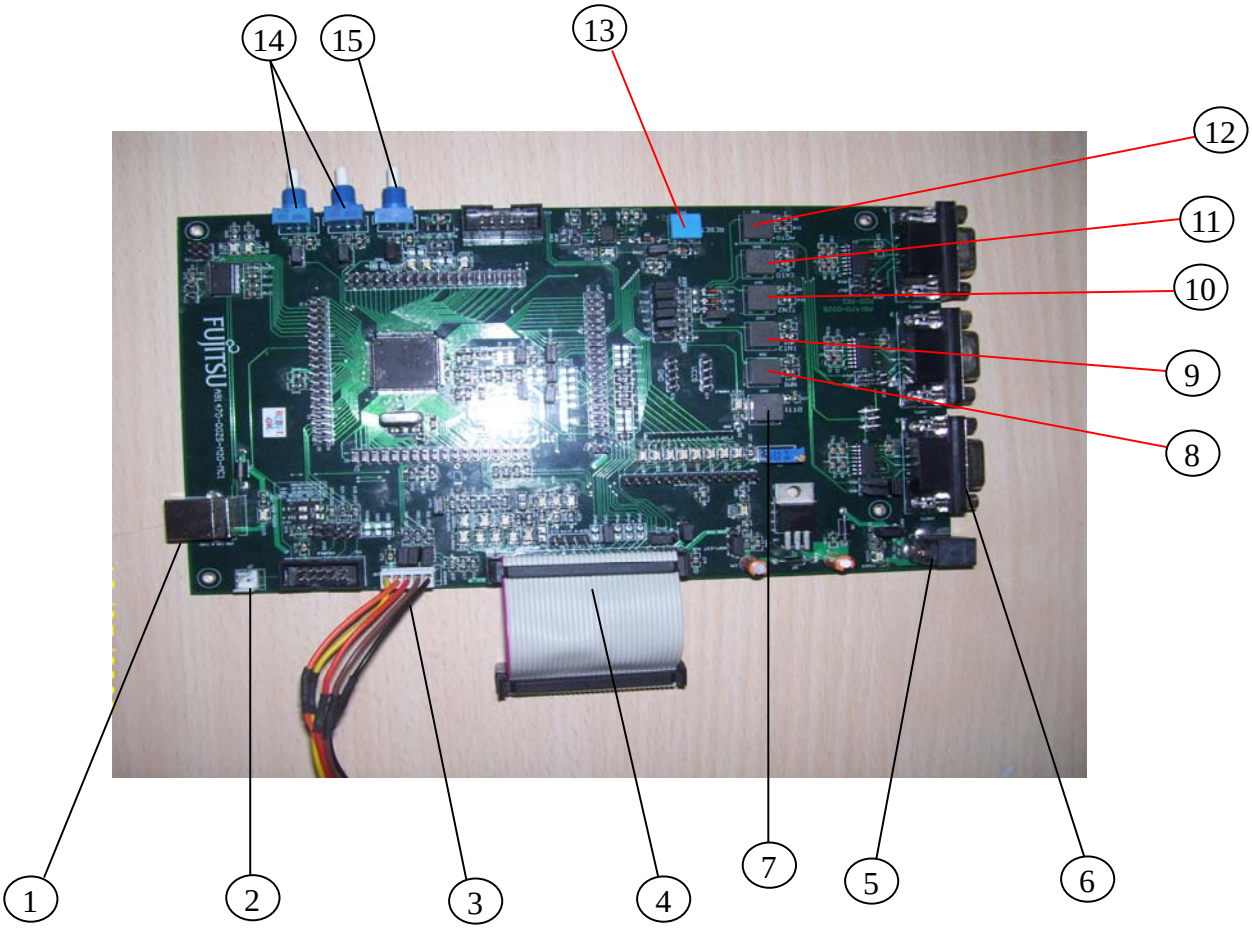
Following picture shows the Inverter board connector details



1.Hall sensor interface connector (Motor)
2.Motor interface connector
3.Power supply input jack
4.Fuse
5.MCU signal interface connector (FRC)
6.Hall sensor interface connector (MCU)
7.EXOR signal interface connector
8.Fault indication LED
9.Power indication LED

2.2 MCU Board

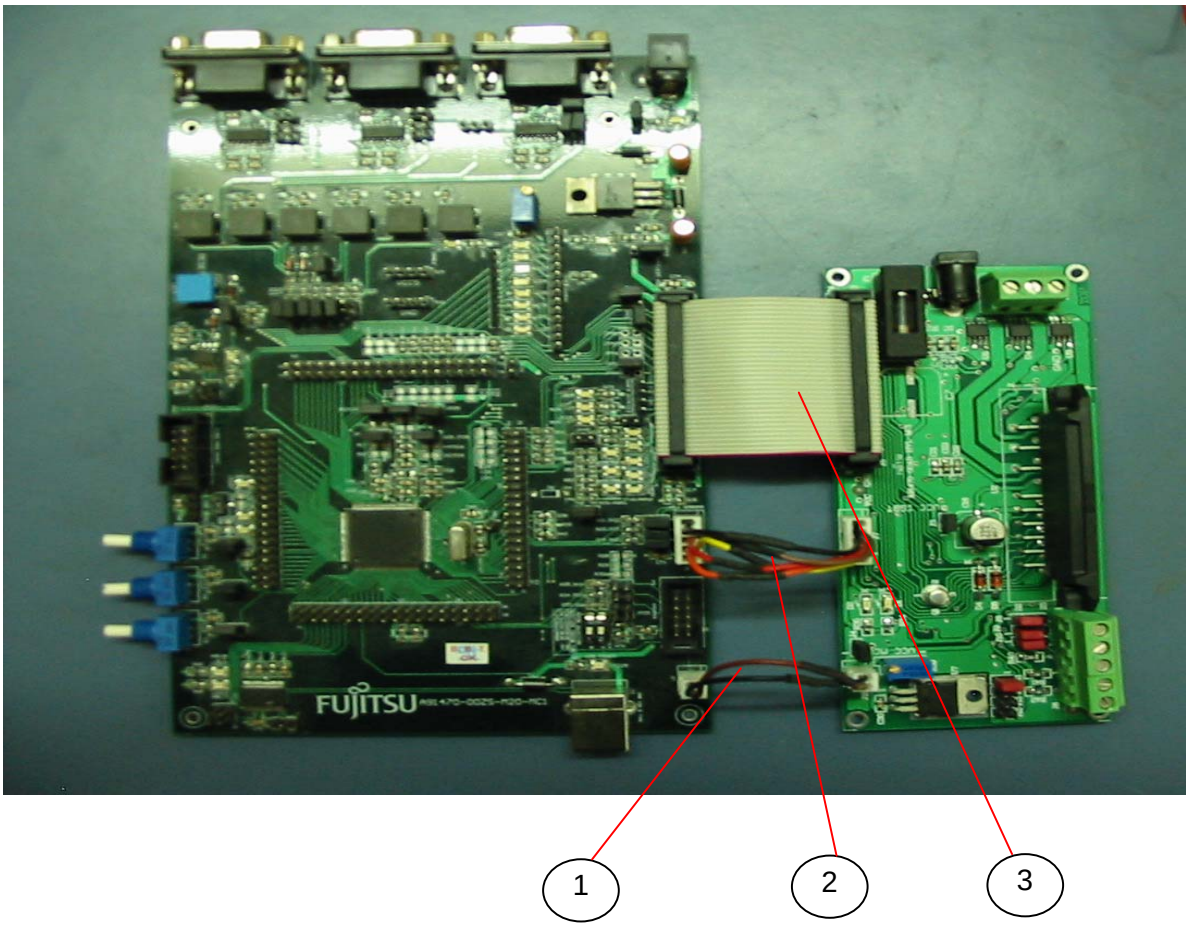
Following picture shows the MCU board connector details



1.USB type B connector
2.EXOR signal interface connector
3.Hall / Zero crossing signal interface connector
4.Inverter board signal interface connector
5.Power jack
6.Serial programming connector
7.Special function switch
8.Start/Stop Switch SW1.
9.Reverse (Anti clockwise) direction rotation switch SW3
10.Speed Increase switch SW4
11.Speed Decrease switch SW5
12.Forward (clock wise) direction rotation switch SW6
13.Reset switch
14.Potentiometers P2,P3
15. Potentiometer P1, for closed loop speed control.

2.3 Interface Between MCU and Inverter board

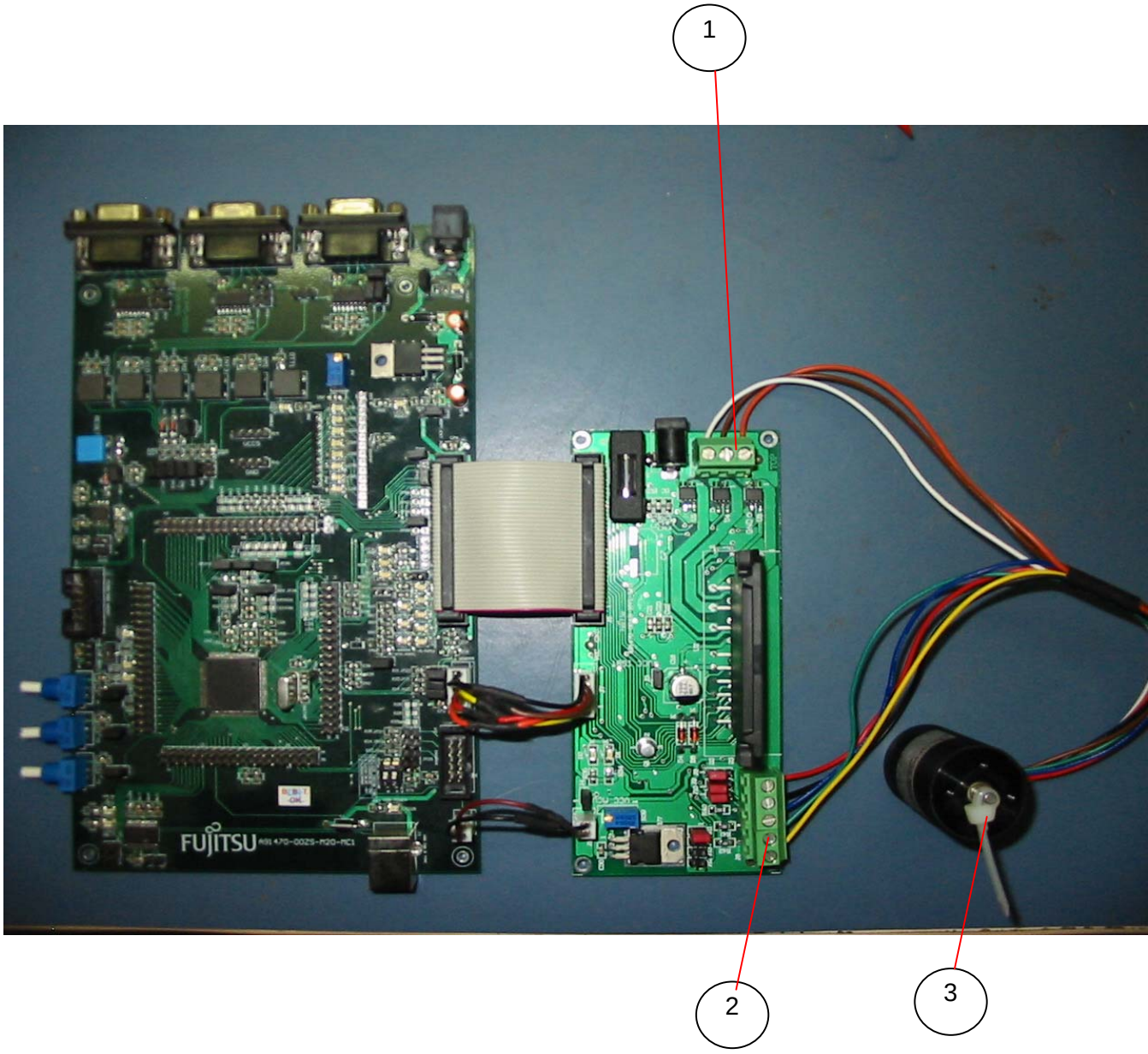
Following picture shows the interface between MCU and Inverter board



1. EXOR signal interfacing connections . J15 of inverter board and J7 of MCU board.
2. Hall sensor / Zero crossing and Power supply interfacing connection. J7 of Inverter board and x8 of MCU board.
3. PWM and other signal interfacing connector. J5 of inverter board and X12 of MCU board.

2.4 Interface Between MCU, Inverter board and Motor

Following picture shows Motor connection to Inverter board



1.3 phase power supply for the motor
2.Hall sensor interface.
3.BLDC/PMSM Motor

3. Board Configuration

This chapter describes all jumpers and switches that can be modified on the evaluation board. The default setting (for MB91F479) is shown with a grey shaded area.

3.1 MCU Board

3.1.1 Jumper and Switches

3.1.1.1 Power Supply (JP: 26, 41)

The onboard voltage regulator provides stabilized 5V supply to the MCU and peripherals. Even though it is thermally protected against overload, care must be taken when supplying current for additional circuitry, like sensors.

JP41 Selects on-board (X15) or ext. (X12) DC input
JP26 Connects the MCU supply to VCC5; can be used for MCU current measurement

Jumper	Setting	Description
JP26 (MCU/VCC)	Closed	MCUVCC connected to VCC5
	OPEN	for current measurement
JP41((DCIN EXT/INT)	**1-2**	DC input by X15
	2-3	DC input by INVERTER board (J16)
JP49	**1-2**	DC input by inverter Power board or by X15
	2-3	USB POWER

3.1.1.2 Programming Jumper (JP32)

This jumper is used for the purpose of executing the existing code in MCU or programming the MCU.

Jumper	Setting	Description
JP41((DCIN EXT/INT)	**1-2**	RUN Mode
	2-3	Programming mode

Note: Switch **SW8** is to be set in RUN mode to execute the program in the MCU.

3.1.1.3 Analog Power Supply Voltage (JP: 24, 27, 28, 35, 36)

The power supply as well as the positive reference voltages for the A/D-converters can be

provided internally or externally.

JP24, JP35 connects analog power supply voltages (AVcc and AVss)
JP27 connects the analog reference voltage AVRH2 to AVcc
JP28 connects the analog reference voltage AVRH3 to AVcc
JP36 connects the analog reference voltage AVRH4 to AVcc

Jumper	Setting	Description
JP24 (AVcc)	Closed	AVcc is connected to Vcc
	OPEN	AVcc is disconnected from Vcc
JP27 (AVRH2	Closed	AVRH2 is connected to AVcc
	OPEN	AVRH2 defined by resistor network*1
JP28 (AVRH3)	Closed	AVRH3 is connected to AVcc
	OPEN	AVRH3 defined by resistor network*1
JP36 (AVRH4)	Closed	AVRH4 is connected to AVcc
	OPEN	AVRH4 defined by resistor network*1
JP35 (AVss)	Closed	AVss is connected to GND
	OPEN	AVss is disconnected from GND

*1By default the resistor networks are not mounted on the board

By default, the A/D-converter supply and reference voltages are the same as the microcontroller supply voltage.

Note:

If JP24 and JP35 are open, the user has to supply an adequate analog voltage supply (AVcc and AVss) to the A/D-converter.
If JP27 is open, the resistors R27 and R37 define AVRH2.
If JP28 is open, the resistors R26 and R36 define AVRH3.
If JP36 is open, the resistors R43 and R47 define AVRH4.
By default the resistor networks are not mounted on the board. Standard SMD0805 chip resistors can be used.

3.1.1.4 UART0 (JP: 2, 3, 4)

One RS232-transceiver (U2, X5) can be connected to the microcontrollers UART interface 0.
JP2, JP3 connect UART 0 to the RS232 transceiver (U2, X5)
JP4 Some programs (e.g. Terminals) need a connection between CTS and RTS

Jumper	Setting	Description
JP2 (SIN0)	Closed	SIN0 of MCU is connected to UART0
	OPEN	SIN0 not connected to UART0
JP3 (SOT0)	Closed	SOT0 of MCU is connected to UART0
	OPEN	SOT0 not connected to UART0
JP4 (RTS-CTS)	Closed	RTS and CTS of X5 are connected
	OPEN	RTS and CTS of X5 are not connected

By default, UART0 (SIN0/SOT0) is connected to X5.
UART0 is also used for asynchronous in-circuit Flash programming and also to view the motor control result.

3.1.1.5 UART1 (JP: 12, 14, 15)

One RS232-transceiver (U3, X6) can be connected to the microcontrollers UART interface 1.

JP12, JP14 connect UART 1 to the RS232 transceiver (U3, X6)
JP15 Some programs (e.g. Terminals) need a connection between CTS and RTS

Jumper	Setting	Description
JP12 (SIN1)	Closed	SIN1 of MCU is connected to UART1
	OPEN	SIN1 not connected to UART1
JP14 (SOT1)	Closed	SOT1 of MCU is connected to UART1
	OPEN	SOT1 not connected to UART1
JP15 (RTS-CTS)	Closed	RTS and CTS of X6 are connected
	OPEN	RTS and CTS of X6 are not connected

By default, UART1 (SIN1/SOT1) is connected to X6.

3.1.1.6 UART2 (JP: 17, 18, 19)

One RS232-transceiver (U4, X7) can be connected to the microcontrollers UART interface 2.

JP17, JP18 connect UART 2 to the RS232 transceiver (U4, X7)
JP19 Some programs (e.g. Terminals) need a connection between CTS and RTS

Jumper	Setting	Description
JP17 (SIN1)	Closed	SIN2 of MCU is connected to UART2
	OPEN	SIN2 not connected to UART2
JP18 (SOT1)	Closed	SOT2 of MCU is connected to UART2
	OPEN	SOT2 not connected to UART2
JP19 (RTS-CTS)	Closed	RTS and CTS of X7 are connected
	OPEN	RTS and CTS of X7 are not connected

By default, UART2 (SIN2/SOT2) is connected to X7.

3.1.1.7 Reset-Generation (JP: 9, 23, 25, 30)

In addition to the internal Power-On reset, the microcontroller can be reset by an external reset circuit (Voltage Monitor) and also by a RS232 interface.

JP9 This jumper selects whether the DTR line from UART0 or UART1 will generate a system reset.
JP23 This jumper connects the MCU Pin 17 (Base timer output TOUT3) to the external watchdog IC's trigger input
JP25 Open this jumper if no external Reset shall be generated, e.g. to avoid accidental reset during long-term testing or demonstration.
JP30 This jumper enables the watchdog function of the reset IC U5. If this is closed, U5 U5 issues a reset if it is not periodically re-triggered by the MCU (PJ7/TOUT3)

Jumper	Setting	Description
JP9	1 - 2	DTR of UART0 is selected for reset generation
	2-3	DTR of UART1 is selected for reset generation

JP23 (WD_TOUT3)	Closed	MCU Pin 17 (PJ7/TOUT3) connected to U5
	OPEN	MCU Pin 17 (PJ7/TOUT3) not connected to U5
JP25 (Ext. Reset)	Closed	INITX connected to reset circuit / supply monitor U5
	OPEN	No connections to INITX
JP30 Closed U5 watchdog function enabled (Watchdog)	Closed	U5 watchdog function enabled
	OPEN	U5 watchdog function disabled

Note:
While a reset signal is asserted the red Reset-LED (LED16) is lit. During normal operation, this LED should be off.

If the reset LED is steadily on or blinks periodically, check the power supply input voltage and the settings for the reset generation by UART as well as the jumpers JP23 and JP30.

3.1.1.8 Buttons SW1-SW7 (JP: 1, 5, 6, 8, 10, 11, 25, 38)

JP1, JP5, JP8, JP10, JP11, JP38
Six user push buttons SW1-SW6 can be connected to the microcontroller.
SW2 also serves as test button for the MCU DTTI function, which stops the PWM output e.g. in case of an inverter fault.

JP6 Common interrupt for SW3-SW6: Eases up button event handling when the buttons are used to control an application
JP25 External reset circuit and button SW7 can be connected to the microcontroller.

Jumper	Setting	Description
JP1 (SW1)	Closed	NMIX of the MCU is connected to SW1
	OPEN	No connection to the microcontroller
JP38 (SW2)	Closed	DTTI button + LED15 connected to MCU Pin 57 (DTTI)
	OPEN	No connection to the microcontroller

JP5 (SW3)	Closed	Pin 23 (INT3) of MCU is connected to SW3 and JP6
	OPEN	No connection to the microcontroller
JP8 (SW4)	Closed	Pin 14 (TIN2) is connected to SW4
	OPEN	No connection to the microcontroller
JP10 (SW5)	Closed	Pin 56 (CKI0) of the MCU is connected to SW5
	OPEN	No connection to the microcontroller
JP11 (SW6)	Closed	Pin 67 (ADTG4) of the MCU is connected to SW6
	OPEN	No connection to the microcontroller
JP6	Closed	SW3 - SW6 connected to INT3 (wired-OR) (COMM. INT)
	OPEN	Only SW3 is connected to INT3
JP25 (Reset)	Closed	INITX is connected to the reset IC and SW7
	OPEN	No connection to INITX

By default, all push-buttons as well as the reset circuit are connected to the microcontroller.

For Motor control operation the switches are used for the following functionality:

- **Start/Stop Switch. (**SW1)
  It is used to start or stop the motor. Default condition will be stop.
- **Reverse (Anti clockwise) direction rotation switch**.(SW3)
  It is used to rotate the motor in reverse direction.
- **Speed Increase switch. (SW4)**
  This is used to increase the speed of motor while in open loop control.
- **Speed Decrease switch**.(SW5)
  It is used to decrease the speed of motor while in open loop control.
- **Forward (clock wise) direction rotation switch. (**SW6)
  It is used to rotate the motor in forward direction.
- **Reset switch (SW7)**
  This switch will reset the controller.

- **Potentiometer (P1)**
  It is used for closed loop speed control. Anti clockwise rotation will result in decrease of speed while clockwise rotation will result in increase of speed.
- **Switch (SW14)**
  Decide for sensored/sensorless BLDC Motor Control. If on SW14, A=0, B=0, then the code will execute for sensorless control. If A=1, B=0, then the code will execute for Hall sensored control.

SW1	SW4	SW5	SW6	SW3	POT P1
Start/Stop	Speed Increase	Speed Decrease	Forward rotation	Reverse rotation	Closed Loop

3.2 Inverter Board sections

1. Power supply jack, 12V. This is the power to be supplied to run the motor.
2. Connector for BLDC/PMSM Motor Phases.
3. Connector for BLDC Motor Hall sensors and power.
4. IGBT module. It supplies the 3 phase PWM to Motor.

Inverter Board Connectors	jumper setting
J1	12V power supply
J2	Motor Phase
J15	To J7 on MCU board
J7	To X8 on MCU board
J5	To X12 on MCU board
Fuse F1	connect 1.5A fuse
Jumper J3, J4, J11	Closed

3.2.1 BLDC Motor Control - Hall Sensor

- Connector **J6** should be populated with Hall connector.
- Jumpers **J8, J9, J10** should be in position 2-3 (near to hall connector).
- In switch SW14 on MCU board, A=1, B=0

J6 on Inverter board	Should be populated with Hall Connector
Jumper J8, J9, J10 on Inverter board	Should be in position 2-3
Switch SW14 on MCU	A=1(ON); B=0 (OFF)

3.2.2 BLDC Motor Control - Sensorless

- Jumpers **J8, J9, J10** should be in position 1-2 (away from hall connector).
- In switch SW14 on MCU board, A=0, B=0.

3.2.3 PMSM Motor Control - Sensorless

Motor Connected to the inverter board should be PMSM motor. No extra conditions required

4. Motor Specification

4.1 BLDC Motor

The kit comes with the following motor

Manufacture:	BLDC motor from BPMC
P/N:	BL2644 -12-004 is a
Specification:	3 phase, 12V

4.2 PMSM Motor

The motor control kit can also be used with PMSM motor. The PMSM motor tested with the hardware:

Manufacture:	Faulhaber
P/N:	1628T 012B
Specification:	3 phase, 12V BLDC

5 Motor control Kit Operation

5.1 Motor Control Mode configuration

Motor can operate in two Modes: Open, Closed.

- Default mode is Closed loop mode.
- Motor operates in **closed loop** by varying the Potentiometer **P1** on MCU board.
- Motor can switch to **open loop** mode by pressing UP/DWN button on MCU board.
- Once the control is switched from closed loop mode to open loop mode, the control stays in open loop mode. It cannot be switched back to closed mode.
- Open and closed loop modes are followed both in sensored and sensorless control.

5.2 Starter Kit Default Mode

- Motor control will be in Closed loop mode.
- Motor will RUN in forward (clock wise) direction.
- Required speed and control will depend on Pot P1 position.

5.3 Motor operation (Open/closed loop)

- When the power is given to the starterkit, it will not start until user presses the Start/Stop Button. When the Start/Stop button is pressed again the Motor will Stop.
- When the start button is pressed the Motor will attain the required speed and it will run in closed loop mode. Error will be corrected through the software and in a short period required and actual speed will be same. The required speed can be varied by P1 Potentiometer (on MCU board).
- The Actual and Required Speed can be observed on the Hyper Terminal (UART 0 of MCU board with 2400,8,N,1 baud setting).
- Whenever Up or Down Button is pressed the motor will come out of the Closed loop and it will run in Open Loop Mode. The Motor will always remain in Open Loop if the Up or Down Button is Pressed.
- In Running condition the direction of the motor can be changed by Pressing the FWD or REV Button.

5.4.1 LED's Indication

5.4.1.1 LEDs on Power ON

- LED D2 : ON.
- LED17 : ON.
- LED26 : ON
- LED1 :ON
- LED10, LED12, LED14 :ON

5.4.1.2 LEDs when Start button (SW2) Pressed

- LED9, LED11, LED13 : ON

5.4.1.3 LEDs when Reset button (SW7) Pressed

- LED16 : ON (RED)

6. Monitor Motor Control Parameters by UART0

The UART0 can be used for monitoring the Actual and Required Speed of the motor using Hyper Terminal software on PC. The required settings are as follows:

Baud rate: 2400,8, N,1

In case of closed loop control, both Actual and Required speed will change.

- Required speed can be changed through Pot P1 on MCU board.
- Actual speed will be controlled through sensored/sensorless algorithm through software.
- In case of open loop control, only Actual speed can be changed through switches SW4 & SW5.

7. Error Condition on Starter kit

- LED **D1** on Inverter power board will be RED.
- If this LED is RED for more than **5 seconds**, press the RESET switch on the MCU board.
- When the Start button is pressed (or during run state), and if the motor is not running smoothly or stalling or still, then press the RESET switch on the MCU board.
- If the above mentioned conditions are repeated despite pressing reset switch, switch OFF the power supply, check if all the connections are made and are intact. Verify the Jumper position.
- If the problem is not solved after all the above mentioned steps then contact support team.

8.0 Programming MCU board

- Remove the power to Inverter power board. Connectors J1/J16 should be unpopulated.
- Connect the power to MCU board. Connect X15 with 12V power supply.
- Switch **SW8** is to be set in PROG mode in MCU board.
- Jumper **JP41** to be in ADPT DC IN position on MCU board.
- Connect UART0 of MCU board with a RS232 connector/cable and the other end should be on the PC side.
- Run the Fujitsu Flash Programmer software and program the hex file.

9 Jumpers and Connector Summary

9.1 MCU board

Component	Description/Operation (**MCU Board**)
JP41	This Jumper selects power for MCU board either form DC Adapter or form the external DC power source (I.e. From inverter board) Pin 1 & 2 Short : Power from DC Adapter Pin 2 & 3 Short : Power form external DC source
JP25	Enables External reset when connected
JP2 JP3 JP4	Connects RS232 transceiver to UART0 when shorted
JP12 JP14 JP15	Connects RS232 transceiver to UART1 when shorted
JP17 JP18 JP19	Connects RS232 transceiver to UART2 when shorted
JP49	This Jumper selects power for MCU board either form Voltage regulator on MCU board or form USB Pin 1 & 2 Short : Adepter or external DC power (Through voltage regulator) Pin 2 & 3 Short : USB power
JP1 JP5 JP8 JP10 JP11 JP38	Enables the switches when shorted
JP6	Enables common interrupt when shorted
JP44	Enables GND to be connected to X12 Connector when shorted
JP45	Enables LED18 when shorted
JP42 JP37	For connecting signals form X12 to MCU
JP40	Enables PWM LEDs when shorted.
JP7 JP13 JP16	Enables Potentiometer to be connected to MCU when shorted
SW14	For motor selection
JP20 JP21 JP22	Connects Hall/Zero crossing signal to MCU
X12	This connector carries signals between MCU to Inverter board This connector includes signals for interfacing Inverter board as follows Pin 1 GND Pin 2 GND Pin 3 PWM H1 Pin 4 PWM L1 Pin 5 PWM H2 Pin 6 PWM L2 Pin 7 PWM H3 Pin 8 PWM L3 Pin 9 GND Pin 10 GND Pin 11 VCC_MCU Pin 12 VCC_MCU Pin 13 FAULT/Enable

	Pin 14 NC Pin 15 NC Pin 16 NC Pin 17 NC Pin 18 TEMP signal Pin 19 FAULT Pin 20 NC Pin 21 GND Pin 22 NC Pin 23 GND Pin 24 NC Pin 25 GND Pin 26 NC Pin 27 GND Pin 28 ITrip Pin 29 GND Pin 30 PCU Pin 31 GND Pin 32 PCV Pin 33 GND Pin 34 PCW
X8	Hall/Zero crossing signal interfacing connector Pin 1 : VCC Pin 2 : GND Pin 3 : Hall 1 Pin 4 : Hall 2 Pin 5 : Hall 3
J7	EXOR signal interfacing connector Pin 1 : GND Pin 2 : EOR
LED26	ON when Adapter power is pluged
LED17	Power ON indication
LED16	ON when RESET switch is pressed

9.2 Inverter board

Component	Description/Operation (Inverter Board)
J8 J9 J10	selects Either zero crossing signals when Pin 1 & 2 short or Hall signals when Pin 2 & 3 short
J11 J12 J13 J14	Selects the signal for MCU Interrupt generation when shorted
J4	For Enabling power supply for MCU board Shorted : Enables supply Open: Disables supply
J3	For Enabling power supply for IGBT module Shorted : Enables supply Open: Disables supply
J6	Hall sensor interface connector (Motor) Pin 1 : VCC Pin 2 : GND Pin 3 : Hall 1 Pin 4 : Hall 2 Pin 5 : Hall 3
J7	Hall sensor interface connector (MCU board) Pin 1 : VCC Pin 2 : GND Pin 3 : Hall 1 Pin 4 : Hall 2 Pin 5 : Hall 3
J15	For connecting EXOR signal to MCU board
J5	This connector carries signals between MCU to Inverter board
J1	12V Power supply input through standard power adapter
F1	Fuse 1A
J2	Motor connector Pin 1: Phase U Pin 2 :Phase V Pin 3 :Phase W
D1	Error Indication LED.
D2	Power ON Indication

9.3 Motor Connector

9.3.1 BLDC Motor

Function	Wire Color
A Phase	Brown
B Phase	Orange
C Phase	White
A Hall Sensor	Blue
B Hall Sensor	Green
C Hall Sensor	Yellow
+6V Logical Supply	Red
GND Logical	Black

9.3.2 PMSM Motor

Function	Wire Color
A Phase	Brown
B Phase	Orange
C Phase	Yellow
A Hall Sensor	Green
B Hall Sensor	Blue
C Hall Sensor	Grey
+5V Logical Supply	Red
GND Logical	Black

10. Recommended Reading

This document describes how to use the Fujitsu Motor Control Kit. Additional technical information can be found on the following documents.

- MB91F479 Data sheet
- Fujitsu motor Control Kit Schematic
- Fujitsu motor control software for BLDC/PMSM motor
- Fujitsu motor control Application Note for Sensored BLDC and sensorless BLDC/PMSM

11. Appendix

11.1 Definitions, Acronyms and Abbreviations

BLDC	:	Brushless DC Motor
BEMF	:	Back Electro Magnetic Force
PWM	:	Pulse Width Modulation
PI	:	Proportional-Integral
IGBT	:	Insulated Gate Bipolar Transistor
PMSM	:	Permanent Magnet Synchronous Motor
FOC	:	Field oriented control for PMSM