Fujitsu Microelectronics Europe
User Guide

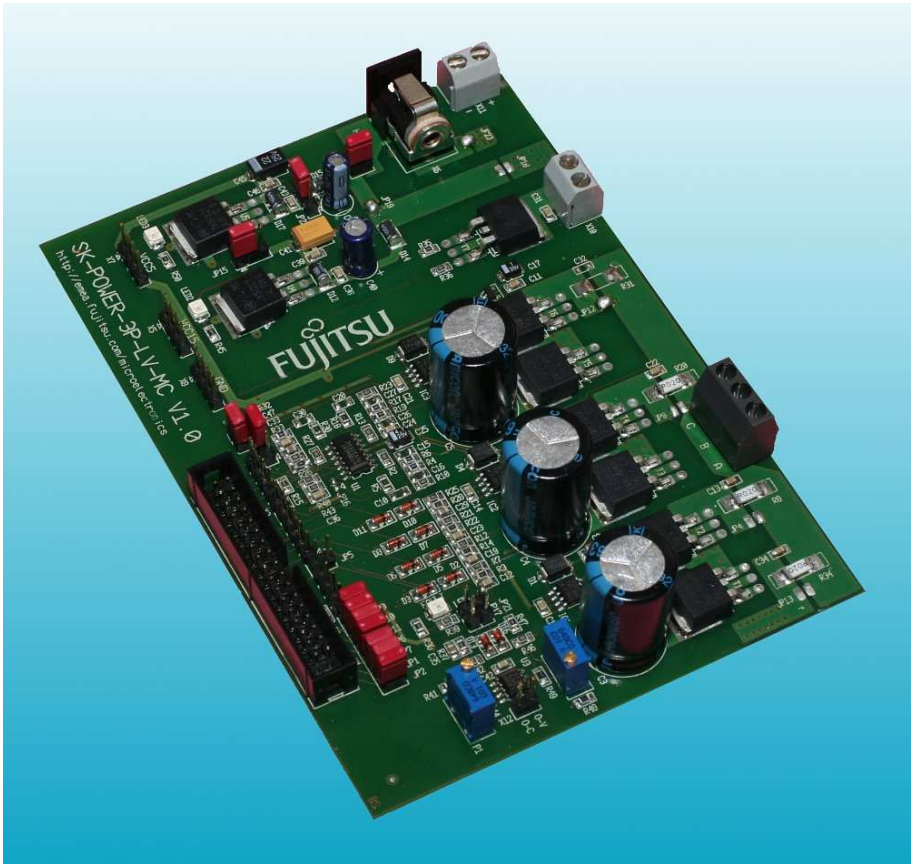
FMEMCU-UG-910068-11

MOTOR CONTROL

EVALUATION BOARD

SK-POWER-3P-LV-MC

USER GUIDE



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Revision History

Date	Issue
2007/11/19	V1.0, CHa, first version
2008/09/05	V1.1, MSc, China-RoHS regulation added

This document contains 23 pages.

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0 Contents

1 Overview

1.1 Abstract

The SK-POWER-3P-LV is an evaluation board for low voltage motor control applications, mainly using BLDC (brushless DC) or PMSM (permanent magnet synchronous) motors.

The board allows the designer immediately to start with the software development and evaluation of low voltage three-phase motor control applications before his own final target system is available. It is directly connectable to the Fujitsu SK-91470-144PMC1-MC Starterkit using the included 34-pin ribbon cable.

1.2 Features

- Low-voltage power stage with gate drivers for three-phase motors
- Directly connectable to MB91470 and MB91480 Series Starterkits with –MC suffix

  (e.g. SK-91470-144PMC1-MC, SK-91F479-144PMC1-MC)
- Flexible power supply voltage system:
  - DC link input (35V 10A max.) for motor current supply
  - Logic supply from DC link or separate input 9-15V
- 10-20V gate driver supply (with optional 15V regulator) and 5V internal logic and analog supply, Power-LED
- Integrated current measurement for two phases and DC link current
- Integrated voltage measurement for all three phase voltages and DC link voltage
- Hardware over-current and over-voltage detection with LED, interfaced to DTTI input of Starterkit
- 34-Pin connector holds all relevant PWM and analog signals
- Chopper transistor + connector for external brake resistor

This board must only be used for test applications
in an evaluation laboratory environment!

1.3 General Description

The SK-POWER-3P-LV supports the Fujitsu starter kits with the –MC suffix, such as the SK-91470-144PMC1-MC and SK-91480-100PMC-MC (The MotorKit-91F267-MC is not directly connectable). It is an extension board for these starter kits and serves as power stage (inverter) for brushless motor control applications using Fujitsu's motor control MCUs.

The on-board voltage regulators allow the user to configure the board to fit a variety of situations. The board includes a 15V regulator for the gate drivers, as well as a 5V-regulator for the analog and logic supply. The 15V regulator can be bypassed (JP22) if the source input voltage is in the range of 10-20V. The 5V regulator can use a separate 9-15V input or use the gate drive supply as regulator input. Also, solder jumpers (JP18 and JP19) can be set to supply the DC link from the logic power supply input (X6), e.g. when using a small motor (<3A).

The board includes shunt resistors and signal conditioning for phase- and DC link current measurement. Also voltage dividers for phase- and DC link voltage measurement are provided. A comparator with adjustable threshold can be used to monitor the DC link and generate a fault signal in case of over-current or over-voltage.

A temperature sensor IC is placed between the power transistors to monitor the board temperature. Its analog output signal is 500mV +10mV/℃ and can be routed to the Starterkit.

The board contains three MOSFET half-bridges to drive three-phase motors, such as PMSM (Permanent Magnet Synchronous Motor) or BLDC (Brushless Direct Current) motors. Additionally, a chopper circuit is provided. Together with an external brake resistor, it enables dynamic braking, i.e. limiting the DC link voltage when the motor acts as generator, for example when decelerating a mechanical load.

2 Installation

Carefully remove the board from the shipping carton.

Check if there are any damages before power is applied to the evaluation board.

For the logic power supply a DC input voltage of 9V – 15V is recommended. The positive voltage (+) must be connected to the center pin, and ground (GND) must be connected to the shield of the connector X6!

By default, the DC bus is supplied through the screw terminal X11. Connect to an adequate power supply for the motor in use (35V max.). Be aware that this input is not protected against false polarity. Always connect '+' to the terminal close to the upper board edge, and GND to the one close to X6.

Further, it is strongly recommended to use a laboratory DC power supply with adjustable current limitation with this board. Otherwise, in case of software or hardware malfunctions or false configurations, high currents can flow and damage the power supply and/or the board and lead to overheating by excessive power dissipation.

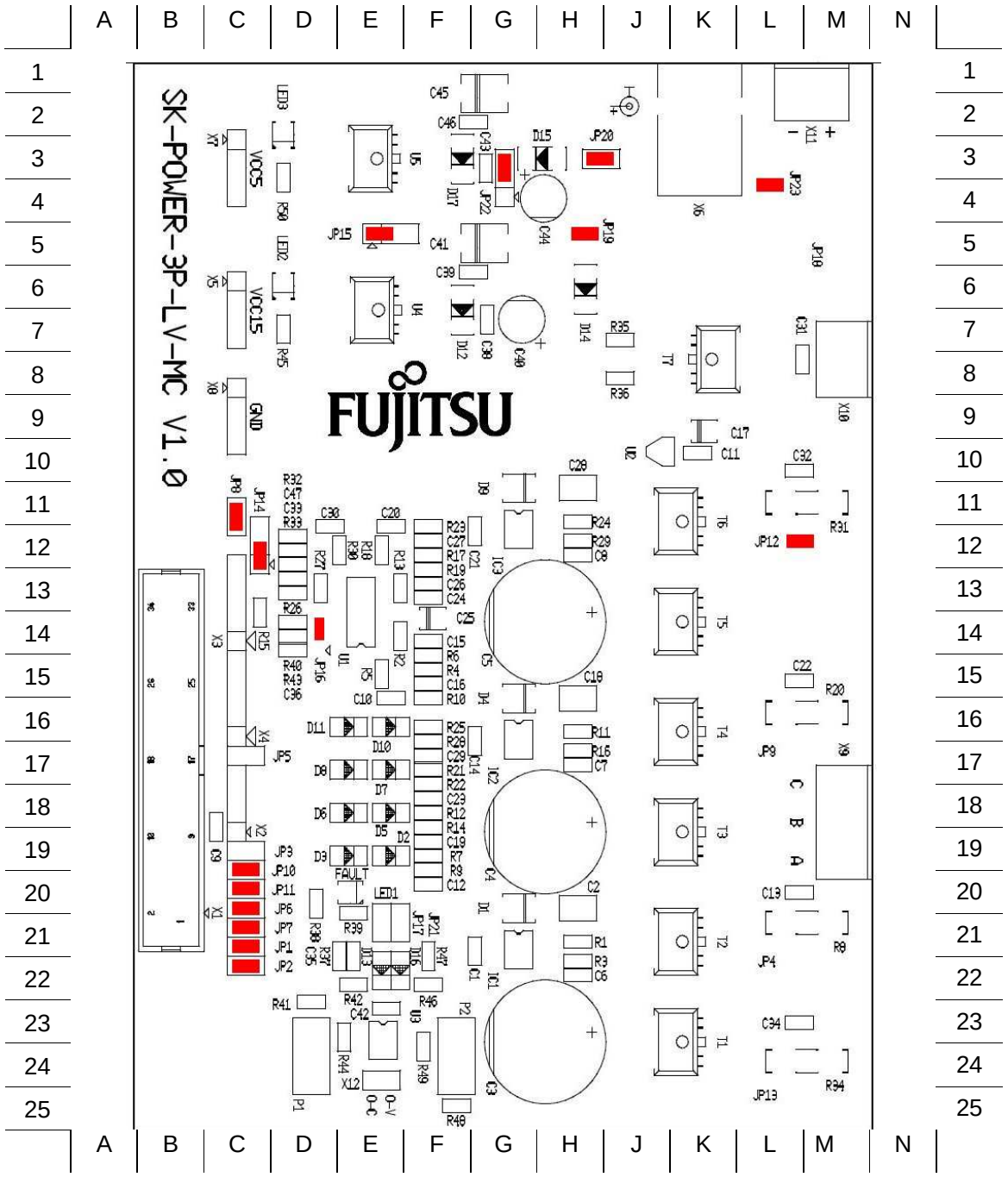
After power-on, the power-on LEDs (LED2 and LED3) should be on, depending on the configuration of the corresponding jumpers. If the LEDs do not light up, switch off the power supply and check the jumper settings according to the desired configuration.

Depending on the power supply used for the DC link input, it might be necessary to protect the power supply against reverse current. This can occur when shutting down the power supply with the board attached, or when an attached motor is externally accelerated or quickly decelerated and thereby works as a generator. This protection can be done by a diode of sufficient current capability. Since many power supplies are vulnerable to this issue, inserting a diode is recommended.

The board is shipped with power transistors in a D2PAK package. For additional flexibility, there are also soldering options for power MOSFETS in TO-220 packages, which can be mounted on external heat sinks. In this case, probably also the current measurement shunts should be replaced with a smaller value or bypassed to reduce heat.

2.1 Jumper settings

Jumper	Description / Function	Type	Default	Coordinates
JP1	PWM1H	Jumper 2 pin	closed	C21
JP2	PWM1L	Jumper 2 pin	closed	C21
JP3	BRAKE	Jumper 2 pin	open	C19
JP4	PHASE A SHUNT BYPASS	Solder JP 2 pin	open	L21
JP5	TEMPERATURE	Jumper 2 pin	open	C17
JP6	PWM2H	Jumper 2 pin	closed	C20
JP7	PWM2L	Jumper 2 pin	closed	C20
JP8	AGND	Jumper 2 pin	closed	C11
JP9	PHASE B SHUNT BYPASS	Solder JP 2 pin	open	L16
JP10	PWM3H	Jumper 2 pin	closed	C19
JP11	PWM3L	Jumper 2 pin	closed	C19
JP12	PHASE C SHUNT BYPASS	Solder JP 2 pin	closed	L12
JP13	DC BUS SHUNT BYPASS	Solder JP 2 pin	open	L24
JP14	I DC BUS FAST / SLOW	Jumper 3 pin	1-2	C12
JP15	VCC15 SOURCE	Jumper 3 pin	1-2	E5
JP16	OFFSET	Solder JP 3 pin	2-3	D14
JP17	OVER-CURRENT DTTI	Jumper 2 pin	open	E20
JP18	P_CONNECT	Solder JP 2 pin	open	L5
JP19	P_CONNECT	Solder JP 2 pin	closed	H5
JP20	POWER	Jumper 2 pin	closed	H3
JP21	OVER-VOLTAGE DTTI	Jumper 2 pin	open	E20
JP22	5VREG_SOURCE	Jumper 3 pin	2-3	G3
JP23	GND_CONNECT	Solder JP 2 pin	closed	L4



3 Jumpers and Switches

This chapter describes the jumpers and potentiometers to configure the various features of the evaluation board. The default settings are shaded in the following tables.

3.1 **Power Supply** (JP: 15, 18, 19, 20, 22, 23)

The evaluation board supports a variety of different input voltage combinations. The analog and logic regulator input supply can be provided either by a separate power input (X15), by the gate driver supply voltage or it can be connected directly to the DC link. The supply voltage for the gate drive circuits must be in the range of 10-20V and can be derived either from the DC link input (X11) or X15. A 15V voltage regulator can be inserted in case the used input voltage is higher than 20V.

JP15 VCC15V Source

This jumper selects whether the gate driver supply voltage is fed from the 15V voltage regulator or directly from the DC input voltage

JP18 DC link power connect

This jumper connects the DC link voltage input X11 with the logic and gate driver supply. To vary the DC link voltage from 0-35V independently of the other supply voltages, open JP18 and supply the logic input voltage by X15.

JP19 This jumper can be used to connect the DC link and/or gate driver supply to the supply input X15. This can be useful when a small motor is used and the entire system is powered by X15 (JP18 closed), or when JP18 is open, it is also possible to supply the gate driver from X15 and the DC link by X11 (default setting).

JP20 Power

This jumper can be used to switch the logic supply on and off.

JP22 5VReg_source

This jumper selects whether the input for the 5V regulator is X15/JP19 or the gate supply input voltage. In case the voltage at X15 is higher than ca. 18V, it is recommended to set the 15V regulator as gate supply source and input to the 5V regulator.

JP23 GND_connect

This jumper connects the power ground with analog ground.

Jumper	Setting	Description
JP15	1 - 2	Bypass 15V regulator (Source voltage 10-20V)
	2 - 3	Insert 15V regulator (Source voltage >18V)
JP18	Closed	connect DC link voltage to logic and gate driver
	Open	X11 supplies only the DC link
JP19	Closed	common inputs for 15V and 5V regulator
	Open	separate inputs for 15V and 5V regulator
JP20	Closed	Logic supply input enabled
	Open	Logic supply input disabled
JP22	1-2	5V regulator input connected to VCC15
	2-3	5V reg. input connected to X15 and/or 15V reg. input
JP23	Closed	Power ground and logic ground are connected
	Open	Power ground and logic ground are not connected

By default, the board is configured for DC link voltage 0-35V and separate logic supply input (X15) 10-20V (12V recommended)

WARNING: There is no protection diode between the DC link input (X11) and the DC link. Applying a voltage with reverse polarity can cause damage to the power stage.

Always connect '+' to the terminal close to the upper board edge, and GND to the one close to X15.

Always use a laboratory DC power supply with adjustable current limitation with this board. Otherwise, in case of software or hardware malfunctions or false configurations, high currents can flow and damage the power supply and/or the board and lead to overheating by excessive power dissipation.

3.2 Gate drivers (JP: 1, 2, 6, 7, 10, 11)

JP1, JP2, JP6, JP7, JP10, JP11

These jumpers connect the PWM pins of the MotorDrive connector X1 to the on-board gate driver ICs (IC1, IC2, IC3).

Jumper	Setting	Description
JP1	Closed	X1 Pin 3 is connected to the PWM1H gate driver input.
	Open	X1 Pin 3 is not connected to the on-board gate drivers.
JP2	Closed	X1 Pin 4 is connected to the PWM1L gate driver input.
	Open	X1 Pin 4 is not connected to the on-board gate drivers.
JP6	Closed	X1 Pin 5 is connected to the PWM2H gate driver input.
	Open	X1 Pin 5 is not connected to the on-board gate drivers.
JP7	Closed	X1 Pin 6 is connected to the PWM2L gate driver input.
	Open	X1 Pin 6 is not connected to the on-board gate drivers.
JP10	Closed	X1 Pin 7 is connected to the PWM3H gate driver input.
	Open	X1 Pin 7 is not connected to the on-board gate drivers.
JP11	Closed	X1 Pin 8 is connected to the PWM3L gate driver input.
	Open	X1 Pin 8 is not connected to the on-board gate drivers.

The gate drive circuit consists of a drive IC (IR2101) and a bootstrap circuit to provide the high-side floating gate supply. The bootstrap capacitors are charged as soon as the corresponding low-side MOSFET is switched on. To ensure that the high-side MOSFETS are always fully switched on or off, the bootstrap capacitors have to be frequently recharged. Therefore, 100% duty cycle is not recommended for the high-side switches for more than some ms, since the gate voltage might fall and leave the MOSFET in an undefined state.

3.3 Current measurement (JP: 4, 9, 12, 13, 14, 16)

JP14 This jumper can be used to select three different filter characteristics for the DC bus current measurement.

JP4, JP9, JP12, JP13

These solder jumpers can be used to bypass the measurement shunts, when they are not mounted or to reduce the power dissipation when not used by the application.

JP16 This jumper selects an offset defined by R40 and R43 which is added to the internal phase current values (2.5V by default, R99 = R102 = 10k). The default setting (2-3) should usually not be changed.

Jumper	Setting	Description
JP4	Open	Shunt for phase A current measurement used
	Closed	Shunt for phase A current measurement bypassed
JP9	Open	Shunt for phase B current measurement used
	Closed	Shunt for phase B current measurement bypassed
JP12	Open	Shunt for phase C current measurement used
	Closed	Shunt for phase C current measurement bypassed
JP13	Open	Shunt for DC link current measurement used
	Closed	Shunt for DC link current measurement bypassed
JP14	1-2	Fast response RC filter for DC bus current
	2-3	Slow response RC filter for DC bus current
	Open	No RC filtering of DC bus current measurement
JP16	1-2	No offset on phase current values
	2-3	symmetric current measurement, 2.5V offset

Note that the shunt for phase C usually is not mounted, since usually only two currents are measured, and the third one can be calculated. In case of three independent currents, JP12 can be opened and the current can be measured using additional circuitry.

3.4 Over-current / Over-voltage DTTI (JP: 17, 21)

JP17 The over-current detection circuit (U9A) is connected to the MCU DTTI input.

JP21 The over-voltage detection circuit (U9B) is connected to the MCU DTTI input.

Jumper	Setting	Description
JP17	Closed	Over-current detect (DTTI) is enabled
	Open	Over-current detect (DTTI) is disabled
JP21	Closed	Over-voltage detect (DTTI) is enabled
	Open	Over-voltage detect (DTTI) is disabled

The threshold for over-current / over-voltage detection can be set using the precision potentiometers P1 (current) and P2 (voltage).

3.5 Connector X1 options (JP: 3, 5, 8)

JP3 The on-board chopper circuit can be connected to X1.

JP5 The on-board temperature sensor can be connected to X1.

JP8 The ground shield of the cable can be connected to GND.

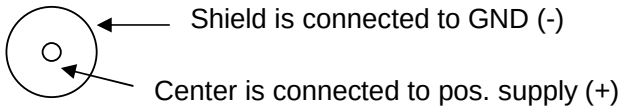
Jumper	Setting	Description
JP3	Closed	Brake chopper transistor is connected to X1 pin 13
	Open	Brake chopper transistor not connected
JP5	Closed	Temperature sensor U2 connected to X1 pin 18
	Open	Temperature sensor not connected
JP8	Closed	Shield ground connected to GND
	Open	Shield ground not connected

4 Connectors

4.1 **Power connector** (X15)

The following figure shows the power connection jack X15. This connector is used to connect an external unregulated DC power supply voltage (9-15V DC, depending e.g. on gate driver configuration) to the evaluation board.

Connector X15:



It is recommended to use 12V input voltage (depending e.g. on gate driver configuration) to keep the power dissipation to a minimum.

4.2 **DC link power connector** (X11)

The DC link power can be supplied either by X15 (when JP18 and JP19 are set and the current is not higher than 3A) or by X11. X11 is a screw terminal for currents up to 15A. Be aware that there is no protection diode for this input on the board. The voltage input range depends on the jumper settings as described in chapter 3.1.

It is recommended to use an external protection diode with sufficient current capability in case the used power supply is not protected against reverse current sourced from the load flowing into the power supply.

Further, it is strongly recommended to use a laboratory DC power supply with adjustable current limitation with this board. Otherwise, in case of software or hardware malfunctions or false configurations, high currents can flow and damage the power supply and/or the board and lead to overheating by excessive power dissipation.

4.3 **Brake resistor connector (X10)**

The board provides a power transistor which can act as braking chopper. This kind of circuit is used to dissipate energy which is generated when the motor works as generator. This can happen, if the motor quickly decelerates with a heavy load or if the motor is moved by the load. In this case, the DC link voltage rises, because the link capacitors have to store the energy. To avoid over-voltage, a resistor can be used to soak this energy from the DC link. The value and power rating depends on the DC link voltage, the possible current generated by the motor and load, and the duty cycle in which braking can occur. The braking current should not exceed 6A in average and 15A peak to limit power dissipation of T7. Also, the switching frequency for T7 should not exceed 2-3kHz to limit switching losses, especially at higher braking currents (low resistance, high voltage). T7 can be driven at 100% duty cycle (no bootstrap circuit).

4.4 Motor connector (X9)

Connect the three phase windings of the motor to this block terminal.

4.5 MotorDrive connector (X1)

This connector holds all control and feedback signals. Use a ribbon cable to connect the inverter board to the starter kit (e.g. SK-91470-144PMC1-MC). The connector has the following pin-out:

X1 pin	Signal	X1 pin	Signal
1	GND	**2**	GND
3	PWM1H	**4**	PWM1L
5	PWM2H	**6**	PWM2L
7	PWM3H	**8**	PWM3L
9	GND	**10**	GND
11	VCC15	**12**	VCC15
13	OPT1 (Brake)	**14**	OPT2
15	OPT3	**16**	OPT4
17	OPT5	**18**	OPT6 (TEMP)
19	Fault	**20**	DC bus voltage sense
21	Shield ground	**22**	Phase A voltage sense
23	Shield ground	**24**	Phase B voltage sense
25	Shield ground	**26**	Phase C voltage sense
27	Shield ground	**28**	DC Bus current sense
29	Shield ground	**30**	Phase A current sense
31	Shield ground	**32**	Phase B current sense
33	Shield ground	**34**	Phase C current sense

Pins 13 -18 are spare pins and not used by default. They are connected to the pin header X2 as well as JP3 and JP5. JP3 can be used to connect OPT1 to control the break resistor circuit by the starter kit. JP5 connects OPT6 to the temperature sensor, so the starter kit can measure the inverter board temperature using an analog input.

4.6 Voltage, current and over-voltage / over-current control points (X3, X4, X12)

X3 holds the signals of the current measurements:

X3 pin	Signal	X1 Pin
1	Current sense phase A	
2	Current sense phase B	
3	Current sense phase C	
4	Current sense DC link	
5	GND	

X4 holds the signals of the voltage measurements:

X4 pin	Signal	X1 Pin
1	Voltage sense phase A	
2	Voltage sense phase B	
3	Voltage sense phase C	
4	Voltage sense DC link	
5	GND	

X12 holds the signals of the over-voltage and overcurrent comparator (active low):

X12 pin	Signal	X1 Pin
1	Overcurrent (Active low)	DTTI
2	Over-voltage (Active low)	DTTI

5 PCB History

Part	Problem	Fixed

6 Related Products

- SK-91470-144PMC1-MC — Evaluation board for the MB91470 Series MCU in the FPT-144P-M12 package
- SK-91F479-144PMC1-MC — Evaluation board with MB91F479 Series MCU in the FPT-144P-M12 package (no MCU socket)
- MotorKit-91F267-MC — Evaluation board with power stage for MB91F267(N)
- Phase3-Kit — Low cost evaluation board for MB91F267(N)

7 Information in the WWW

Information about FUJITSU MICROELECTRONICS Products
can be found on the following Internet pages:

Microcontrollers (8-, 16- and 32bit), Graphics Controllers
Datasheets and Hardware Manuals, Support Tools (Hard- and Software)

http://mcu.emea.fujitsu.com/

Linear Products: Power Management, A/D and D/A Converters

http://www.fme.fujitsu.com/products/linear/start.html

Media Products: SAW filters, acoustic resonators and VCOs

http://www.fme.fujitsu.com/products/saw/index.html

For more information about FUJITUS MICROELECTRONICS

http://www.fme.fujitsu.com/products/start.html

8 China-RoHS regulation

Evaluation Board评估板

Emulation Board 仿真板

根据SJ/T11364-2006

《电子信息产品污染控制标识要求》特提供如下有关污染控制方面的信息。

The following product pollution control information is provided according to SJ/T11364-2006 *Marking for Control of Pollution caused by Electronic Information Products*.

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In order to maintain the declared EFUP, the product shall be operated normally according to the instructions and environmental conditions as defined in the product manual, and periodic maintenance schedules specified in Product Maintenance Procedures shall be followed strictly.

Consumables or certain parts may have their own label with an EFUP value less than the product. Periodic replacement of those consumables or parts to maintain the declared EFUP shall be done in accordance with the Product Maintenance Procedures.

This product must not be disposed of as unsorted municipal waste, and must be collected separately and handled properly after decommissioning.

Please note: The designation of 10 years EFUP is not to be equated with the durability, use-duration or any warranty-claims of the product.

产品中有毒有害物质或元素的名称及含量

Table of hazardous substances name and concentration

部件名称 Component Name	有毒有害物质或元素 Hazardous substances name					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
sk-power-3p-lv-mc	x	o	o	o	o	o

O: 表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T11363-2006 标准规定的限量要求以下

X: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T11363-2006 标准规定的限量要求

- 此表所列数据为发布时所能获得的最佳信息
- 由于缺少经济上或技术上合理可行的替代物质或方案，此医疗设备运用以上一些有毒有害物质来实现设备的预期临床功能，或给人员或环境提供更好的保护效果。

O: Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T11363-2006.

X: Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in SJ/T11363-2006.

- Data listed in the table represents best information available at the time of publication

9 Recycling

Gültig für EU-Länder:

Gemäß der Europäischen WEEE-Richtlinie und deren Umsetzung in landesspezifische Gesetze nehmen wir dieses Gerät wieder zurück.

Zur Entsorgung schicken Sie das Gerät bitte an die folgende Adresse:

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Warehouse/Disposal

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63225 Langen

Valid for European Union Countries:

According to the European WEEE-Directive and its implementation into national laws we take this device back.

For disposal please send the device to the following address:

Fujitsu Microelectronics Europe GmbH

Warehouse/Disposal

Monzastraße 4a

63225 Langen