Three-Phase Induction Motor Drive Starter Kit MC3PHAC (Ver.2)



MJ-IMD-LC20-LC21

http://www.motorjock.com/

The 220 Volts 3 Amperes Three-Phase Induction Motor Drive, developed with a particular focus on reliability, robustness and low cost.

Features

- Complete 220V-3A power inverter solution
- V/f Control method implemented by MP3PHAC from Freescale
- Independent motor supply: 0 to 250V AC or direct DC at 0 to 350V DC
- Output current up to 3A
- Input inrush limiter based on 3.5A NTC resistor
- Overtemperature, overvoltage and overcurrent protection
- Compact design
- Test points available to test and further evaluation
- Available for Personal Computer and Stand-Alone operation mode
- Opto-isolated USB connection to host computer for control and monitoring
- Implemented as a two independent PCB: Control Board and Power Stage
- Two board implementation allow further evaluation
- Presetting for PWM frequency 5, 10, 15 and 20 kHz

Applications

- Washing machine
- Air conditioner
- Fan
- Pump

Functions:

- Sensorless Speed Control

Description

The purpose of the MJ-IMC-LC20-LC21 demonstration board is to present a universal, fullytested design consisting of a 3-phase inverter bridge based on the small intelligent smart power module FNB41560 and the MP3PHAC MCU.

The MJ-ACMC-LC20-LC21 consists of two boards: Power Stage Board (LC20) and Control Board (LC21). The Power Stage Board LC20 can be used with different (compatible) Control Boards and Control Board LC21 can be used with different Power Stage Boards. It can be helpful for new design equipment debugging and testing.

The Power Stage Board LC20 consists of short-circuit rugged IGBT's with negative temperature coefficient. Additional auxiliary functions are undervoltage lockout and smart shut-down.

The Control Board LC21 can operate in standalone mode (control buttons, the «Start / Stop» «Forward / Reverse») and can be connected to personal computer via opto-isolated USB port.

Components

MCU: MC3PHAC (Manual and Communication software available at <u>http://www.freescale.com/</u>)

USB: FT232R (Manual and Virtual COM driver available at <u>http://www.ftdichip.com/</u>)

POWER: FNB41560 (Manual and Mounting Guidance available at <u>http://www.fairchildsemi.com/</u>)

Connector Description



Fig. 1. Connector description

Wiring

Wiring diagram represents at fig. 2.



Fig. 2. Wiring

The Power Stage Board LC20 contains the 9-pin screw connector for Motor, Power and Braking resistor connection. The Control Board LC21 contains the 6-pin screw connector for External Control panel connection (which include just two variable resistors 10 kOhm and two push buttons) and standard mini-USB connector for Personal Computer connection.

Motor connection

Motor have to be connected to corresponding pin **[U V W]** on the Power Stage Board LC20 (refer silk screen in the bottom of the board)

Power Connection

Power Stage Board LC20 has two independent power input for motor [MOTOR POWER] and control circuit [AC220] (refer silk screen in the bottom of the board).

Braking resistor connection

If Motor operate at hard Start-stop mode important to use Braking resistor to avoid overvoltage alarm during motor deceleration. The Resistor have to be connected to corresponding pin **[Brake]** on the Power Stage Board LC20 (refer silk screen in the bottom of the board). Value and Power of Braking resistor have to be select due to application requirements. **Note.** For operating show it is possible to use incandescent lamp (about 60..200 Watt) as a Braking resistor

External pushbuttons and variable resistors connection

It is possible to use internal variable resistors (RV105: "Speed" and RV106: "Acceleration") and buttons (S102: "START/STOP", S103: "FORWARD/RESERVE") for control motor speed, acceleration, On/Off status and motor direction or connect external pushbuttons and variable resistors 10 kOhm to the Control Board LC21 via 6 pin screw connector (refer Fig. 2). If external pushbuttons and variable resistors are used, the jumpers JP113 and JP114 are must be remove.

Personal Computer connection

Connection to PC is available via opto-isolated USB port which located at Control Board LC21 (Fig. 2). It is possible to use 'USB type A to Mini-B' standard cable.

Using MJ-IMD-LC20-LC21 with personal computer

The MJ-IMD-LC20-LC21 can be used in "Standalone Mode" or can be connected to Personal Computer and operate in "PC master Software Mode".

To switch mode necessary to set jumpers JP108, JP109, JP110, JP111 as:

1-2: "Standalone Mode"

2-3: "PC master Software Mode"

Jumper JP107 make switching analog signal "A_Speed" and "A_Temperature" (Refer Circuit diagram)

1-2: "Speed" (measure analog signal from Speed set variable resistor)

2-3: "Temperature" (measure analog signal from temperature sensor inside IGBT module U203)

It is recommended to set jumper JP107 to 1-2: "Speed" position when used "Standalone Mode" for motor speed control from variable resistor RV105, and to set jumper JP107 to 2-3:

"Temperature" position when used "PC master Software Mode" for real time IGBT module U203 temperature monitoring via analog input SPEED (MC3PHAC, pin 26).

Switching of jumpers in "Standalone Mode" and "PC master Software Mode" represents at fig.3 and fig.4.



Fig. 3. 1-2: "Standalone Mode"



Fig. 4. 2-3: "PC master Software Mode"

By default jumpers JP107, JP108, JP109, JP110, JP111 set in position 1-2: "Standalone Mode" (Fig. 3). To use MJ-IMD-LC20-LC21 with personal computer jumpers must be switch to position 2-3: "PC master Software Mode" (Fig. 4).

Software

Before plugging USB cable to PC important to install Virtual COM Port (VCP) driver from FTDI website <u>http://www.ftdichip.com/</u>

For control and manage Control Board LC21 from personal computer possible to use FreeMASTER (refer "FreeMASTER Application Installation" on Freescale website <u>http://www.freescale.com/</u>).

Demo MC3PHAC FreeMASTER (also known as PC-Master) application software is available at <u>http://www.freescale.com/</u> (refer AN2202: "Creating a Graphical User Interface (GUI) for the MC3PHAC" and AN2202SW software zip-file)

Virtual COM port setup installation

The Starter Kit MC3PHAC (Ver.2) connect to personal computer via USB. The Starter Kit use IC FT232RL - USB UART from FTDI, therefore it is necessary to install drivers of the virtual COM port (VCP Driver) or D2XX Driver, if user will use port via Windows USB Stack and DLL. last version of drivers it is possible to download from www.ftdichip.com.

After VCP drivers installation will complete a new virtual COM port will appear in Windows Device Manager (Fig. 5).



Fig. 5. FTDI VCP at Device Manager.

It is possible to use this port (for example COM5 as a represent at Fig.5)to connect Starter Kit to any PC application.

"FreeMASTER" installation

Freescale company, as a manufacturer of IC MC3PHAC at the

<u>www.Freescale.com/FreeMASTER</u> web site represents software: "FreeMASTER", well known before as a "PCmaster".

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	welcome screen			
	welcome screen	Value	Unit	Period

Fig. 6. FreeMASTER main window.

It is possible to download "FreeMASTER" description and help files for free from www.Freescale.com after registration.

The "MC3PHAC_PCMasterSoftware_Demo" project

FreeMASTER is a user-friendly real-time debug monitor and data visualization tool that you can use for any application development and information management. FreeMASTER supports completely non-intrusive monitoring of variables on a running system. You can display multiple variables changing over time on an oscilloscope-like display, or view the data in text form. As well, FreeMASTER supports additional capabilities and targets with an on-target driver for transmitting data from the target to the host computer.

Freescale company at website <u>www.Freescale.com</u> also represents a demo-project for FreeMASTER: "MC3PHAC_PCMasterSoftware_Demo", refer to "Creating a Graphical User Interface (GUI) for the MC3 PHAC": AN2202.pdf.

Important to note MC3PHAC_PCMasterSoftware_Demo needs to set the PWM polarity signal parameters and Dead Time value. If this parameters will set wring, the Starter Kit MC3PHAC (Ver.2) can be damage. To avoid this problem use the customized version of MC3PHAC_PCMasterSoftware_Demo.

In customized version possible to found file "MotorInitParm.cfg", where parameters of the PWM polarity signals preset:

PWM Polarity B+ T+ 0x1000 0x50 1 Dead Time 0x0036 2000 ns

These lines are set the PWM polarity signal parameters "B+ T+" and Dead Time value "2000 ns" Other parameters can be different, depend configuration.

It is not recommended to manually edit file "MotorInitParm.cfg". Parameters in this file saved from the project.

Open the project MC3PHAC_PCMasterSoftware_Demo: File -> Open Project:

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	File name: MC3PHAC_PCMasterSoftware_Demo.pmp Open Files of type: Project files (".pmp) Cancel Period

Fig. 7. File -> Open Project window

The open project is represents at fig. 8.

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Fig. 8. MC3PHAC_PCMasterSoftware_Demo main window

At the next stage it is necessary to set COM port number for communication (Fig. 9). To set port those: **Project -> Options...**

F MC3PHAC_PCMas	sterSoftware_Demo.pmp - FreeMASTER lorer Item Project Tools Help
텔 MC3PHAC Demo	
	Comm MAP Files Pack Dir HTML Pages Demo Mode
	Communication
	Direct RS232: Port: COM5 Speed: 9600 Timeouts
	C Plug-in Module: COM1
	Connect string COM <x> Configure</x>
	Save settings to project file Save settings to registry, use it as default.
	Communication state on startup and on project load
	C Open port at startup
	Do not open port at startup Stare post at the on put at startup
	Store state to project file, apply is on standp
	OK Cancel Apply Help
	ACMC

Fig. 9. COM port setting

If COM port is change it is necessary to Save project by **File -> Save Project**. Now it is possible to connect to MC3PHAC by pushing red STOP Button. in the result in the bottom of the application data from MC3PHAC will appear (fig. 10):

Name	Value	Unit	Period	*
Commanded Frequency	0	Hz	100	41
Actual Frequency	0	Hz	100	
Modulation Index	0	9⁄0	100	
Bus Voltage	0.0	9⁄0	100	
Dead Time	31.88	uS	5000	
Measured PWM Period	0	uS	1000	
Voltade Boost	0	9⁄0	5000	100
		RS232;COM5;speed	d=9600	1

Fig. 10. Data from MC3PHAC.

Next, press the button **"Press Here to Continue"** and note window will appear (fig. 10). Just close it by pressing **OK**.



Fig. 11. Note window

Next, system will show permission to execute ActiveX, click "Yes":

	Press to Initialize	ACTUAL FREQUENCY	
STOP MOTOR	Press to Stop	MODULATION	
DIRECTION	MOTOR FREQUENCY (Hz)		FORWARD MOTION
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010.6 KHz	D _{60 Hz}	No Current Fault	Event
T F	∢ ►	MOTOR CONFIGURA	TION
COMMAND	RESET MOTOR	CURRENT SETUP Parameter S	ummary

Fig. 12. Permission to execute ActiveX

Before start the system will show one more time all parameters. It is important to check "PWM Polarity: B+ T+" and "Deadtime: 2000 ns" (Fig. 13):



Fig. 13. Parameters window

If parameters are different with described above, it is important to cancel by pressing "No" and set correspond value. Set parameters window represents at Fig. 14.

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PWN FREQUENCY COM 5.3 kHz 10.6 kHz 15.9 kHz SET DEFAULTS/CLEAR SELECTI Default Values	5 Hz/sec IMAND QUENCY (Hz) 51 Hz DN select Controls	Vbus VALUES (%)		
CURRENT SETUP Parameter Summa	ry Write Data to	A INI o File File	TIALIZE MOTOR Return to Motor	
algorithm block description	Value	lint		Pariod
Commanded Frequency	O	Hz	100	renou _
Actual Frequency	0	Hz	100	
Modulation Index	0	9⁄0	100	
Bus Voltage	0.0	9⁄0	100	
Dead Time	31.88	uS	5000	
Measured PWM Period	0	uS	1000	
Voltage Boost	0	1 /0	5000	-
Lone		RS232;COM5;spe	eo=ae00	

Fig. 14. Set parameters window

Set the corresponded parameters (most important to set **PWM Polarity: B+ T+** and **Deadtime: 2000 ns**) and press **"Write Data to File"** in the result this data will write to file "MotorInitParm.cfg" and system will represents resume of all data which sawed in file (Fig. 15).

IOTOR INITIALIZA	TION PARA	METERS			
PWM POLARITY	DEADT (*125	IME ns)		(VOLTAGE (%)	FAULT
BASE FREQUENCY		The initialization pa successfully saved (a summary of the provided below) Saved Motor Confi	rameters were to a file. data saved is puration:) % : BOOST (%)	TIMEOU (second: 2 sec
→ →		PWM Polarity: Dead Time Base Frequency: Acceleration Commanded Frequ PWM Frequency: Volkage Boost Maximum Volkage Fault Timeout Vbus Decel Vbus Rohake Vbus Brownout Vbus Over Volkage	B+ T+ 2000 ns 50 Hz 5 Hz/sec ency 51 Hz 10.6 kHz 10 % 100 % 2 sec 115 % 50 % 115 % 50 %		BROWNOUT
T DEFAULTS/CLEA Defaults Values	R SE	Press 'OK' to Contir	iue.	115 %	: : 50 %
CURR				INITI	ALIZE MOTOR
Param	eter Summary	Wri	te Data to File	Re	turn to Motor

Fig. 15. Saved Data Resume.

Window after data downloading to MC3PHAC represents below (Fig.16):

MC3PHAC Demo 럈 Speed Scope				
	algorithm block description	Value	Unit	Period
	Commanded Frequency		Hz	100
	Actual Frequency	0	Hz	100
	Modulation Index	0	%	100
	Bus Voltage	0.0	%	100
	Dead Time	31.88	uS	5000
				1000
	Measured PWM Period	0	uS	1000
	Measured PWM Period Voltage Boost	0 0	uS %	1000 5000
	Measured PWM Period Voltage Boost Maximum Voltage	0 0 100	uS % %	1000 5000 5000
	Measured PWM Period Voltage Boost Maximum Voltage Fault Timeout	0 0 100 60	uS % % seconds	1000 5000 5000 100
	Measured PWM Period Voltage Boost Maximum Voltage Fault Timeout Vbus Decel	0 0 100 60 110	uS 9% 9% seconds 9%	1000 5000 5000 100 5000
	Measured PWM Period Voltage Boost Maximum Voltage Fault Timeout Vbus Decel Vbus Rbrake	0 0 100 60 110 110	uS 9/0 9/0 seconds 9/0 9/0	1000 5000 5000 100 5000 5000
	Measured PWM Period Voltage Boost Maximum Voltage Fault Timeout Vbus Decel Vbus Rbrake Vbus Brownout	0 0 100 60 110 110 50	US % % seconds % % %	1000 5000 5000 100 5000 5000 5000
	Measured PWM Period Voltage Boost Maximum Voltage Fault Timeout Vbus Decel Vbus Rbrake Vbus Brownout Vbus Over Voltage	0 0 100 60 110 110 50 128	US 0/0 0/0 seconds 0/0 0/0 0/0 0/0	1000 5000 5000 100 5000 5000 5000 5000

Fig. 16. Connect.

At the next window it is enough to press Forward check box for start motor rotation (Fig. 17)

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副 MC3PHAC Demo - H部 Speed Scope	МСЗРН		OR CO	NTROL D	EMO	-
	MOTOR CONTR	OLS	REAL	TIME DISPLAY		
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	STOP MOTOR	Press to Stop	MOD	X 98	3 %	
	DIRECTION	MOTOR FREQUENCY (H	z)	CHANGING SPEED	FORWARD MOTION	
			<u> </u>		REVERSE	
		ACCELERATION	HZ		RESISTIVE	
	PWM FREQUENCY □ 5.3 kHz □ 10.6 kHz □ 15.9 kHz ↓ ↓ ↓	(Hz/sec) Setting = 5 Hz BASE FREQUEN		EM FAULTS PC MASTER SW COMM ERROR EXTERNAL FAULT TRIP NO CURRENT FAULT OR CONFIGURA	OVER- VOLTAGE TRIP UNDER- VOLTAGE TRIP EVENT	
	COMMAND	RESET MOTOR	CURRE	NT Parameter S	ummary	
	CLOSE DEMO	Exit Demo	MOTOR	Change Par	ameters	
	algorithm block description					
	Name		Value	Unit		Period
	Commanded Frequency		51	Hz	100	
	Actual Frequency		49	HZ	100	
	Bus Voltage		99	9/0	100	
	Dead Time		2.00	115	5000	
	Measured PWM Period		94.5	uS	1000	
	Voltage Boost		10	9/0	5000	
Done				RS232;COM5;spee	d=9600	

Fig. 17. Motor is Run Forward.

Using an independent Motor and Control Circuit power supply.

Particular feature if the Power Board LC20 is possibility to use independent Motor and Control Circuit power supply connection. It is possible to use same voltage for Control Circuit and Motor IGBT Bridge U203 (refer Fig. 2) or to use separate "AC/DC Motor Power" and "AC Control Power" connection as represents at (Fig. 5)



Fig. 5. Separate "Motor Power" and "Control Power".

"AC Control Power" must be AC voltage 50/60 Hz, 220V, ±10%.

"AC/DC Motor Power" can be AC voltage, in range 0 to 230V or DC voltage in range 0 to 330V. In case of DC voltage "Motor Power" wiring "+" and "-" can be arbitrary because of rectifier D212 is on the board. Variable "Motor Power" useful in case of using motor with operation less than 220 volts or safety during tests and non-standard motor operation modes (like low-speed operation).

The IC MC3PHAC measure Bus voltage "+V_MOTOR" at capacitor C219, via R210, R211, R212, R213, RV201, R214, R215, U202-A формируя аналоговый сигнал "A_VBUS". Signal "A_VBUS" going to IC MC3PHAC via jumper JP106 (position of jumper is 2-3: "Normal Operation"). In case of using low voltage "AC/DC Motor Power" it is necessary to set the jumper JP106 in position 1-2: "Voltage Sensor Emulation". In this case analog signal "A_VBUS" will be set by variable resistor RV101. For adjustment variable resistor RV101 it is recommended to connect Starter Kit MC3PHAC (Ver.2) to personal computer and check value of the "A_VBUS" signal by "Bus Voltage" data at the PC monitor (Fig. 6).

Name	Set va	lue around 10	00%	1.
Commanded Frequency	o by set	ting RV101		
Actual Frequency		04	00	
Rus Voltago	020	0/2	100	
Doad Time	21,88		5000	
Measured PWM Period	0	uS	1000	
Voltage Boost	0	%	5000	
		RS232;COM5;sp	eed=9600	



Set the "Bus Voltage" using variable resistor RV101 around 100%. The adjustment of the variable resistor RV101 it is recommended to implement with disconnected "AC/DC Motor Power". Increasing of the "Bus Voltage" leads to the "BRAKE" signal appear, and further increasing leads to the "FAULT" signal appear. Value of "Bus Voltage" also influence to duty cycle of the PWM for make stable of actual motor voltage due to Bus Voltage changes or voltage ripple.

Important to note, that setting of the jumper JP106 in position 1-2: "Voltage Sensor Emulation" in fact disconnect bus voltage checking by IC MC3PHAC and it is important to be carefully in using of the motor and board. It is recommended to use additional current limiters of fuses in the "AC/DC Motor Power".

Heatsink Mounting

PCB size 100x105 mm

Board must be installed on the Heatsink. Mounting holes location and dimension represents at Fig. 3, Side view represents at Fig. 4.



Fig. 3. Mounting holes location

A = 94.615mm A1 = 36.7 A2 = 41.975 B = 90.17mmB1 = 64.54mm



Fig. 4. Side view

http://www.motorjock.com/