MC 101

Motor Controller Card

USER'S MANUAL

HUMUSOFT®

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1. Introduction

1.1. Product Description

The MC 101 stepping motor control card is designed for the need of controlling the steps, speeds, directions and accelerations of stepping motors using the IBM PC/XT/AT or compatibles. A maximum of three stepping motors can be controlled simultaneously by one MC 101 card. Each of the three channels consists of an 8253 counter/timer controlled by common 8031 microcontroller, which can execute the smart set of commands, compute accelerations, sense emergency switches and interrupt to the PC under certain circumstances. Once the command has been sent from the PC to the MC 101 card, 8031 microcontroller becomes responsible for the motor control and PC is freed for other purposes. 8031 microcontroller has also a buffer so that up to 10 commands can be loaded into MC 101 card and then sequentially executed. In this way computing resources of your PC can be better utilized.

Each of the three channels can be individually reconfigured as a pulse width modulation (PWM) channel and used for controlling DC motors, heat systems, etc.

In addition there are an 8-bit digital input port and an 8-bit digital output port for other versatile applications.

1.2. Features List

The MC 101 allows independent and simultaneous operation of up to 3 stepping motors or PWM channels with following features:

- Programmable step rate from 1 to 8191 pulse per second (pps) or 0.3 to 2700 rpm for a motor with 200 steps per revolution
- Programmable acceleration and deceleration from 100 to 25500 pps per second
- Number of steps per command from -32768 to 32767
- Independent emergency inputs for each channel which allows to stop motors immediately
- Possibility of PWM signals generation with programmable period and pulse width from 0 to 13 ms with 200 ns resolution
- Independent choice of stepping/PWM for any channel
- Jumper selectable interrupt signals
- DIP switch selectable I/O port base address
- Crystal based timing
- 8 digital input channels and 8 digital output channels, all TTL compatible
- IBM PC XT/AT compatible

2. Hardware Installation

2.1. DIP Switch & Jumper Settings

The bank of eight switches (SW1) on the MC 101 specifies the base address of I/O ports on this card. MC 101 occupies four consequent addresses in PC I/O address space. Bit weights of these switches are listed in **Table 1**. According to this table selecting I/O address 310h means that switches 1, 2 and 6 should be switched OFF and all other switches ON. Factory setting of base address is 310h.

Switch no.	OFF	ON
1	**200h**	0h
2	**100h**	0h
3	80h	**0h**
4	40h	**0h**
5	20h	**0h**
6	**10h**	0h
7	8h	**0h**
8	4h	**0h**

Table 1: JP1 - I/O Port Setting

IRQ signal can be selected using jumper JP2. This jumper can be either disconnected (interrupt disabled), or placed to one of the positions marked 2, 3, 4, 5, 6, 7 which will enable selected IRQ signal. On 286 and higher machines placing jumper JP2 to position 2 will enable IRQ9 signal. IRQ jumper settings are listed in **Table 2**.

Jumper position	2	3	4	5	6	7
IRQ selected	2 (9)	3	4	5	6	7

Table 2: JP2 - IRQ Setting

Jumpers JP3, JP4, JP5 are used to select the mode of operation of each channel. JP3 is used for configuration of channel 1, JP4 for channel 2 and JP5 for channel 3. Factory setting is all channels in step mode. See **Table 3**.

Channel	Jumper	PWM	Step
Ch 1	JP3	1-3, 2-4	3-5, 4-6
Ch 2	JP4	1-3, 2-4	3-5, 4-6
Ch 3	JP5	1-3, 2-4	3-5, 4-6

Table 3: PWM/Stepper Setting

2.2. Installation

Once you have properly set all jumpers and switches, you can install the MC 101 card in any free expansion slot of your computer. Follow the steps outlined below:

☞ Turn off the power to the computer system and unplug the power cord.

☞ Disconnect all cables connected to the computer system.

☞ Using a screwdriver (or nut driver), remove the cover-mounting screws. that screws are at the rear side of the PC.

☞ Remove the computer system cover.

☞ Find an empty expansion slot for in your computer. If the slot still has the metal expansion-slot cover attached, remove the cover with a screwdriver. Save the screw to install the MC 101.

☞ Hold the MC 101 firmly at the top of the board, and press the gold edge connector into an empty expansion slot.

☞ Using a screwdriver, screw the retaining bracket tightly against the rear plate of the computer system.

☞ Replace the cover of the computer, and plug in the power cord.

☞ Reconnect all cables that were previously attached to the rear of the computer.

3. Programming Guide

3.1. Port Description

I/O space of the MC 101 card consists of four registers immediately following the base address selected by SW1. I/O ports are listed in **Table 4**. The meaning of individual bits in particular registers are listed in **Table 5** and **Table 10**, list of commands for command register is in **Table 6**.

addr.	R/W	Name	Purpose
Base+0	W	Data register	Data for MC 101
Base+0	R	Status register	Status of MC 101
Base+1	W	Digital output	8 bit TTL digital output
Base+1	R	Digital input	8 bit TTL digital input
Base+2	R	Communication register	Communication status
Base+3	W	Command register	Control commands

Table 4: I/O Port Description

Important notice: *For correct operation of MC 101 card it is necessary to perform IC (F2h) and EC (05h) commands before any other communication with this card. Using any other commands*

except of these described above may cause incorrect operation of the card.

bit	Value and Meaning
7	1 = Input ready
6	1 = Input ready interrupt enabled
5	1 = Status change
4	1 = Status change interrupt enabled
3	1 = Interrupt request
2	1 = Run, 0 = Reset requested
1	Reserved for future use
0	1 = Command, 0 = Data in data register

Table 5: Communication Register

3.2. Programming concepts

For programming of MC 101 a set of simple commands is used. Each of these commands consists of a command code byte followed by 0 to 5 data bytes. Number of data bytes is determined by the used command code. Both command code bytes and data bytes are passed to MC 101 through common Data register (Base+0). To determine whether command code or data are currently stored in this register, bit 0 of Communication register (Command/Data) is used. Command/Data bit set to 1 determines that command code is present in Data register, while Command/Data bit set to 0 determines data in Data register. This bit is set using CF (Command follows) and reset using DF (Data follows) control commands.

Command	Value	Name
IC	F2h	Initial configuration
CF	01h	Command follows (in data reg.)
DF	00h	Data follows (in data reg.)
IRE	0Dh	Input ready interrupt enable
IRD	0Ch	Input ready interrupt disable
SCE	09h	Status change interrupt enable
SCD	08h	Status change interrupt disable
EC	05h	Enable card
DC	04h	Disable card (reset)

Table 6: List of Commands

Command and data flow from host computer to MC 101 is under automatic handshake control. Immediately after writing any byte to Data register bit 7 of Communication register (Input ready) is reset to 0. While Input ready is 0 neither write to Data register nor change of Command/Data bit should be performed. After the data are accepted by the microcontroller on the MC 101, Input ready is set to 1 and next byte can be written to MC 101 through Data register.

The whole transfer of a command to MC 101 looks like the following example:

- Wait until Input ready bit is 1
- Send CF control command
- Write command code to Data register
- Wait until Input ready bit is 1
- Send DF control command
- Write first data byte to Data register
- Wait until Input ready bit is 1
- Write second data byte to Data register

After receiving the whole command and data the command is either immediately executed or stored in MC 101 internal buffer in case that the particular channel is busy at the moment.

3.3. Initialization

After hardware reset of MC 101 card which can be caused by switching on the computer or pressing RESET button on the computer it is necessary to initialize the

card before you execute any other commands. At first it is necessary to write IC (Initial configuration) and EC (Enable card) control commands to Command register (Base+3) and then set desired mode of operation using control commands.

Software reset of MC 101 can also be performed in several ways. First possibility is to perform DC (Disable card) control command, wait until bit ERR of status register is 1 (Reset accepted) and then enable card with EC control command. This will cause cold start of the 8031 microcontroller and ends execution of all commands. The same situation can be achieved by Init command 00h (with no data).

If it is necessary to initialize single channels individually, Init command should be used. This command has no data and its structure is shown in **Table 6**.

Bit	Symbol	Name	Value and Meaning
7	0		
6	0		
5	M3	Channel 3 Mode	0 - Step, 1 - PWM
4	M2	Channel 2 Mode	0 - Step, 1 - PWM
3	M1	Channel 1 Mode	0 - Step, 1 - PWM
2	E3	Channel 3 Enable	0 - disable, 1 - enable
1	E2	Channel 2 Enable	0 - disable, 1 - enable
0	E1	Channel 1 Enable	0 - disable, 1 - enable

Table 7: INIT Command Structure

This command is used for initialization of single channels and determining the mode of operation of each channel. Command is valid for channels with Enable bits set to 1. The mode of operation of initialized channel is determined by Mode bit of the channel. This command can be used for initialization of a single channel, two channels or all three channels by one command. For example command 00100101 (25h) causes initialization of channels 1 and 3, channel 1 in Step mode, channel 3 in PWM mode, while channel 2 is left uninitialized. Desired mode of operation of each channel must also be set by jumpers. Default mode of operation of all channels after reset is the Step mode.

3.4. Commands for Step Mode

For channels in Step mode a set of powerful commands can be used to set desired number of steps, direction, maximum speed and acceleration. Step command structure is shown in **Table 8**.

Bit	Name	Value and Meaning
7	1	
6	EX	Execute 1 = Command is executed 0 = Data are accepted without execution
5	A	Acceleration data flag (1 byte of data follows)
4	SP	Speed data flag (2 bytes of data follow)
3	ST	Step data flag (2 bytes of data follow)
2	E3	Channel 3 Enable 1 = Enable, 0 = Disable
1	E2	Channel 2 Enable 1 = Enable, 0 = Disable
0	E1	Channel 1 Enable 1 = Enable, 0 = Disable

Table 8: Step Command Structure

Enable bits determine which channels should accept this command. Step, Speed and Acceleration flags determine which data will follow this command. If the Execute bit is set to 1, command will be executed. If this bit is reset to 0, data are loaded into internal registers without execution.

If Step flag ST is set, two data bytes containing desired number of steps will follow the command code. Number of steps is a two's complement 16 bit integer number. Lower byte should be passed first to the Data port. Possible number of steps ranges from -32768 to 32767.

If Speed flag SP is set, two data bytes containing desired maximum pulse

frequency will follow the command code. Pulse frequency is a 16 bit integer value. Lower byte should be passed first to the Data port. Possible pulse frequency is from 1 to 8191 pulse per second.

If Acceleration flag A is set, one data byte containing desired acceleration will follow the command code. Acceleration is an 8 bit integer value. Possible acceleration is from 1 to 255. This number means the increase of pulse frequency per 10 ms. If Acceleration equals to 0, no acceleration control is provided and the pulse frequency is the maximum from the beginning.

Command code is followed by data in this order: step number low byte, step number high byte, max. speed low byte, max. speed high byte, acceleration.

For easy understanding there is an example of MC 101 programming:

We want to move stepping motor on channel 2 4096 steps clockwise with maximum speed 1000 pulse per second. Desired time to reach full speed is 1 s. Command code for this action is 11111010 (FAh). Following data are: 00h (step number low byte), 10h (step number high byte), E8h (max speed low byte), 03h (speed high byte), 0Ah (acceleration byte). After this action we want to move the same motor 4096 steps back to the initial position. As max. speed and acceleration have been set by previous command, it is not necessary to set them again. So the command code for this action is 11001010 (CAh) followed by data: 00h (low byte of -4096 steps), F0h (high byte of -4096 steps).

3.5. Commands for PWM Mode

For channels in PWM mode a set of commands is similar to the set of commands for Step mode. Parameters for PWM are period of output signal and duration of logical one on the output. PWM command structure is shown in **Table 9**.

Bit	Name	Value and Meaning
7	1	
6	1	
5	0	
4	DUR	Duration data flag (2 bytes of data follow)
3	PER	Period data flag (2 bytes of data follow)
2	E3	Channel 3 Enable 1 = Enable, 0 = Disable
1	E2	Channel 2 Enable 1 = Enable, 0 = Disable
0	E1	Channel 1 Enable 1 = Enable, 0 = Disable

Table 9: PWM Command Structure

If Period flag PER is set, two data bytes containing desired period duration will follow the command code. Period duration is a 16 bit integer value. Lower byte should be passed first to the Data port. Possible value is from 1 to 65535, unit is 200 ns.

If Duration flag DUR is set, two data bytes containing desired pulse duration will follow the command code. Pulse duration is a 16 bit integer value. Lower byte

should be passed first to the Data port. Possible value is from 1 to 65535, unit is 200 ns.

PWM commands are not buffered. Any new command for any channel immediately interrupts the channel operation and new values are loaded into the channel. Each channel must be initialized before being used in PWM mode.

3.6. MC 101 Status & Interrupts

Status byte of the MC 101 card can be obtained by reading the Data register (Base+0). Meaning of individual bits in status byte is in **Table 10**.

Bit	Name	Value and Meaning
7	ERR	Card Error 1 = Error (Reset in progress), 0 = MC 101 ready
6	BF	Buffer Full 1 = Buffer full, 0 = Data can be written
5	ES3	Emergency switch 3 1 = ON, 0 = OFF
4	ES2	Emergency switch 2 1 = ON, 0 = OFF
3	ES1	Emergency switch 1 1 = ON, 0 = OFF
2	BUSY3	Channel 3 Busy 1 = channel busy 0 = channel free
1	BUSY2	Channel 2 Busy 1 = channel busy 0 = channel free
0	BUSY1	Channel 1 Busy 1 = channel busy 0 = channel free

Table 10: Status Register Bits

If the emergency switch is switched ON (emergency input forced LOW), ES bit of the corresponding channel is set to 1 and corresponding motor immediately stops. BUSY bits are 1 while the channel executes command and 0 when the channel is idle. The BF bit signals that the command buffer is full and the card is not able to accept more commands. The ERR bit signals either an error or initialization in progress. In either case the card is not active and it is necessary to wait until this bit becomes 0.

Any change of status can cause hardware interrupt to host PC if jumper JP2 is set correctly and status change interrupt is enabled by setting bit 4 of control register to 1. This interrupt request is automatically reset by reading Status byte.

4. I/O Signals

4.1. Output Connector

The MC 101 card is equipped with a 37 pin D-type female connector with pin assignments according to **Table 11**.

GND (CH1)	1	20	DIR (CH1)
PULSE (CH1)	2	21	EXT. VCC (CH1)
GND (CH2)	3	22	DIR (CH2)
PULSE (CH2)	4	23	EXT. VCC (CH2)
GND (CH3)	5	24	DIR (CH3)
PULSE (CH3)	6	25	EXT. VCC (CH3)
EMERGENCY STOP (CH1)	7	26	-12V
EMERGENCY STOP (CH2)	8	27	+12V
EMERGENCY STOP (CH3)	9	28	+5V
GND	10	29	GND
GND	11	30	D OUT 0
D IN 0	12	31	D OUT 1
D IN 1	13	32	D OUT 2
D IN 2	14	33	D OUT 3
D IN 3	15	34	D OUT 4
D IN 4	16	35	D OUT 5
D IN 5	17	36	D OUT 6
D IN 6	18	37	D OUT 7
D IN 7	19		

Table 11: Connector Pin Layout

4.2. Output Signal Description

Five signals are assigned to each channel:

GND   is the ground point for the channel.

DIRECTION   is an open collector with 4k7 pullup resistor output. High
                   level of this signal determines clockwise rotation, low level
                   counterclockwise rotation of stepping motor.

PULSE   is an open collector with 4k7 pullup resistor output. This

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signal is the output of either clock pulses for stepping motor or PWM output.

EXTERNAL VCC   is an input for supplying two internal pullup resistors of each channel. This input can be connected to +5V (pin 28) or +12V (pin 27) or to any external power supply in the range from 0 to 30V. This configuration provides high flexibility in connecting to other devices.

EMERGENCY STOP is a TTL compatible input. Low level on this input causes immediate stop of the motor and a message to host computer. Using DIRECTION output and a simple logic allows to connect two end switches to any channel.

   In addition there are 8 digital TTL compatible inputs D IN 0 to D IN 7 and 8 digital TTL compatible outputs D OUT 0 to D OUT 7 for general purpose use.