4I27 MOTOR CONTROLLER - PWM

VERSION 1.1

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WARNINGS

SERVO WARNING

Large servo motors are capable of inflicting serious injury both to people and to mechanisms associated with the servo system. In addition, some motors use potentially lethal supply voltages.

When a servo control system is first configured, unpredictable behavior should be EXPECTED. First time checks of basic servo operation (such as motor position versus drive) should be checked with the motor power leads disconnected.

Never depend on software commands to the 4I27 to disable the motor when you or others would be exposed to a hazard should the motor start unexpectedly. Motor power should always be removed when working on mechanical parts of the servo system.

STATIC ELECTRICITY

The CMOS integrated circuits on the 4I27 can be damaged by exposure to electrostatic discharges. The following precautions should be taken when handling the 4I27 to prevent possible damage.

A. Leave the 4I27 in its antistatic bag until needed.

B. All work should be performed at an antistatic workstation.

C. Ground equipment into which 4I27 will be installed.

D. Ground handling personnel with conductive bracelet through 1 megohm resistor to ground.

E. Avoid wearing synthetic fabrics, particularly Nylon.

INTRODUCTION

GENERAL

The 4I27 is a low cost, LM629 based 2 axis DC servo motor control system implemented on a stackable PC/104 bus card. The 4I27 is designed for high performance positioning systems using DC servo motors with quadrature shaft encoders.

The per axis output of the 4I27 is an 8 bit sign-magnitude PWM signal that can drive H-bridge type servo amplifiers directly.

There are different models of the 4I27 with different encoder and index inputs. Quadrature encoder and index inputs can be either TTL for short distances and smaller motor, or RS-422 where long encoder cables are required. TTL inputs are conditioned with RC filters and Schmitt triggers for noise immunity.

Control signals for each axis include 3 auxiliary I/O bits. These I/O bits are used for over-temperature shutdown detect and H-bridge enable when the 4I27 is used with the 7I25 H-bridge. The enable bits are used by the 7I27 H-Bridge. Eight general purpose I/O bits are available for any application use.

The LM629's used on the 4I27 are high performance digital processors specifically designed for motion control. The LM629 can execute a ramp-up, slew, and ramp-down motion sequence without host processor intervention.

Host interrupts can be generated at end of motion, position breakpoints, index pulse, or in response to various error conditions. Interrupts are or'ed on the 4I27 card, so that only one system interrupt is used. The IRQ line used can be software selected from any of the 11 available AT bus interrupts.

A digital PID filter is used to set loop feedback parameters for stability and optimum performance. Velocity, target position and filter parameters may be changed during motion. The clock speed of the LM629's can be lowered to accommodate large motors that require lower PWM chopping frequencies.

Demonstration software includes examples of 2 axis position mode operation, velocity mode operation, and a simple filter tuning program that allows dynamic filter coefficient modification while providing a graphic display of the servo system step response. Source code is provided for all demonstration software.

An analog output version of the 4I27 is available as the 4I27A.

HARDWARE CONFIGURATION

GENERAL

The 4I27 has only two hardware configurable options, the I/O port address, and the LM629 clock speed.

The options are selected with shorting jumpers placed on three pin headers. In the following discussions, when the words "up", "down", "right", and "left" are used it is assumed that the 4I27 card is oriented with its bus connectors J1 and J2 at the bottom edge of the card (nearest the person doing the configuration).

DEFAULT CONFIGURATION

The 4I27 card is configured in the following manner when shipped from the factory.

FUNCTION	DEFAULT	JUMPERS	POSITION
PORT ADDRESS	0200H	W1,W2,W3	DOWN,DOWN,DOWN
LM629 CLOCK	8 MHZ	W4	LEFT

Demonstration programs shipped with the 4I27 depend on the port address being left at the default setting

PORT ADDRESS

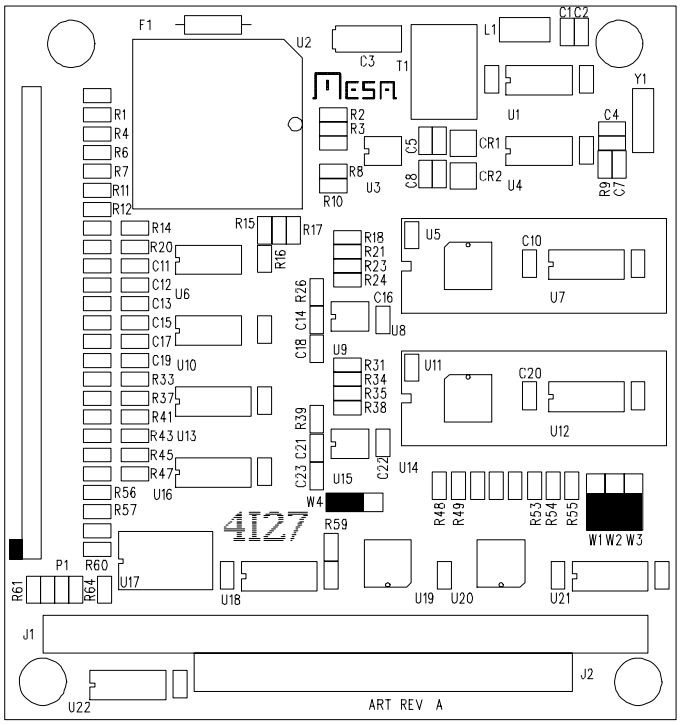
The 4I27 occupies 16 contiguous locations in I/O space. The base address of the 4I27 card can be any of eight different locations. These locations are selected with shorting jumpers placed on jumper blocks W1,W2, and W3.

The following table shows the I/O base addresses selected by these jumpers:

ADDRESS	W1	W2	W3
0200H	DOWN	DOWN	DOWN
0210H	DOWN	DOWN	UP
0220H	DOWN	UP	DOWN
0230H	DOWN	UP	UP
0240H	UP	DOWN	DOWN
0250H	UP	DOWN	UP
0260H	UP	UP	DOWN
0270H	UP	UP	UP

HARDWARE CONFIGURATION

PORT ADDRESS AND CLOCK SPEED JUMPERS



HARDWARE CONFIGURATION

LM629 CLOCK

The LM629 motor controller chip on the 4I27 normally use a 8 MHz clock. This clock can be set to 4 MHz if desired. This can be useful when driving larger motors that require slower PWM chopping frequencies. Lowering the LM629 clock to 4 MHz lowers the PWM chopping frequency to 7.8 KHz instead of the standard 15.6 KHz. The maximum quadrature input rate will be reduced to 500 Khz when the 4 MHz clock option is selected.

INTERFACE CONNECTOR

GENERAL

The I/O interface connector on the 4I27 is a 50 pin header. The suggested mating connector is AMP PN 1-746285-0. There are two 4I27 models with different connector pinouts, A model with TTL encoder inputs, and a model with RS-422 encoder inputs. The TTL encoder input model pinout matches the MESA 7I25 dual H-bridge motor driver, allowing a single 50 conductor flat cable to connect between the two. The RS-422 input model is intended for applications where electrical noise is a problem, or long encoder cables (>10 ft) need to be accommodated.

I/O CONNECTOR ORIENTATION

The 50 pin connector on the 4I27 has the pin one end marked with a white square on the circuit card. This corresponds with the red stripe on typical flat cable assemblies. If more positive polarization is desired, center polarized IDC header connectors should be used. These connectors will not fully mate with the pins on the 4I27 if installed backwards. A suggested center polarized 50 pin IDC header is AMP PN 1-746285-0.

TTL INTERFACE CONNECTOR PINOUT

PIN#	SIGNAL	PIN#	SIGNAL
1	MOTOR1QA	25	/MOTOR1 OVERTEMP
3	MOTOR1QB	27	/MOTOR0 OVERTEMP
5	MOTOR0QB	29	MOTOR1SENSE
7	MOTOR0QA	31	MOTOR0SENSE
9	MOTOR1IDX	33	BIT 7
11	MOTOR0IDX	35	BIT 6
13	MOTOR1PWM	37	BIT 5
15	MOTOR0PWM	39	BIT 4
17	MOTOR1DIR	41	BIT 3
19	MOTOR0DIR	43	BIT 2
21	/MOTOR1ENA	45	BIT 1
23	/MOTOR0ENA	47	BIT 0

Even numbered pins 14 through 50 are grounded. Even numbered pins 2 through 12 are open. Even pins 2..12 can be grounded at the source end of the interface cable if interleaved grounds are desired for the encoder inputs. They are grounded at the 7I25 end of the interface cable when a 7I25 is used. The /MOTORxOVERTEMP bits apply to the 7I25 H bridge driver and indicate that the H bridge driver has shut down due to a >145°C temperature in the H bridge driver chip.

INTERFACE CONNECTOR

RS-422 INTERFACE CONNECTOR PINOUT

PIN#	SIGNAL	PIN#	SIGNAL
1	MOTOR1QB	2	MOTOR1/QB
3	MOTOR1QA	4	MOTOR1/QA
5	MOTOR0QB	6	MOTOR0/QB
7	MOTOR0QA	8	MOTOR0/QA
9	MOTOR1 IDX	10	MOTOR1/IDX
11	MOTOR0 IDX	12	MOTOR0/IDX
13	MOTOR1PWM	15	MOTOR0PWM
17	MOTOR1DIR	19	MOTOR0DIR
21	/MOTOR1ENA	23	/MOTOR0 ENA
25	MOTOR1SENSE1	27	MOTOR0SENSE1
29	MOTOR1SENSE0	31	MOTOR0SENSE0
33	BIT 7	35	BIT 6
37	BIT 5	39	BIT 4
41	BIT 3	43	BIT 2
45	BIT 1	47	BIT 0
49	+5 volt power		

Even numbered pins 14 through 50 are grounded. RS-422 differential pairs are on odd and even successive pins, for example: MOTOR0QB and MOTOR0/QB (pins 5 and 6 respectively) comprise a RS-422 differential pair (the B quadrature encoder input for motor 0). All RS-422 inputs on the 4I27 are terminated at the 4I27 card with 136 Ohm resistors.

INSTALLATION

GENERAL

When the 4I27 has been properly configured for its application, it can be inserted into a PC/104 stack. The standoffs should then be tightened to secure the 4I27 in its place. When the 4I27 is secured in the stack the I/O connector can be plugged in from the side.

OPERATION

REGISTER MAP

The 4I27 occupies 16 contiguous I/O port locations starting at the user selected base address.

BASE +00H	82C55 Port A	(must be output)
BASE +01H	82C55 Port B	(must be input)
BASE +02H	82C55 Port C	(user defined)
BASE +03H	82C55 Control port	
BASE +04H	Motor 0 Command/Status port	
BASE +05H	Motor 0 Data port	
BASE +06H	Motor 0 Command/Status port (duplicate)	
BASE +07H	Motor 0 Data port (duplicate)	
BASE +08H	Motor 1 Command/Status port	
BASE +09H	Motor 1 Data port	
BASE +0AH	Motor 1 Command/Status port (duplicate)	
BASE +0BH	Motor 1 Data port (duplicate)	
BASE +0CH	Motor 0 and Motor 1 Command/Status port	
BASE +0DH	Motor 0 and Motor 1 Data port	
BASE +0EH	Motor 0 and Motor 1 Command/Status port (duplicate)	
BASE +0FH	Motor 0 and Motor 1 Data port (duplicate)	

PARALLEL PORT

A 82C55 parallel port is supplied to control various bits for motor control and to provide an 8 bit general purpose input or output port. The motor control bits are designed to interface with the Mesa 7I25 H-Bridge driver and the supplied software, otherwise these bits can be used for any purpose. The motor control bits are active low, and have pullup resistors, so that they are inactive on power up. All bits not mentioned are not used and should be set high.

OPERATION

PARALLEL PORT BITS

82C55 PORT	BIT	PIN	FUNCTION
A	0	23	/Motor 0 enable
A	1	21	/Motor 1 enable
A	2	N/A	ISEL0
A	3	N/A	ISEL1
A	4	N/A	ISEL2
A	5	N/A	ISEL3
A	6	N/A	IMODE0
A	7	N/A	IMODE1
B	0	31	Motor 0 sense (general purpose bit)
B	1	29	Motor 1 sense (general purpose bit)
B	2	27	/Motor 0 overtemp
B	3	25	/Motor 1 overtemp
B	4	11	Motor 0 index (also connected to LM629)
B	5	9	Motor 1 index (also connected to LM629)
C	0	47	Bit 0 (general purpose bit)
C	1	45	Bit 1 (general purpose bit)
C	2	43	Bit 2 (general purpose bit)
C	3	41	Bit 3 (general purpose bit)
C	4	39	Bit 4 (general purpose bit)
C	5	37	Bit 5 (general purpose bit)
C	6	35	Bit 6 (general purpose bit)
C	7	33	Bit 7 (general purpose bit)

OPERATION

PARALLEL PORT OPERATION

The parallel ports on the 4I27 use a standard 82C55 PIA. The user accessible I/O lines have 3.3K pullup resistors to simplify interfacing to contact closure, opto-detector or open collector outputs.

Ports A and B have predefined functions, while port C is available for general purpose use. Port C has the feature of being splitable into two 4 bit ports to allow both input and output bits on the same port.

Port A is used as an output port. It controls the /MOTOR0ENA and /MOTOR1ENA bits (used by the 7I25 H-Bridge), the ISEL bits which determine the IRQ line driven by the 4I27, and the IMODE bits which control the interrupt driver enable and mode.

Port B is used as an input port, The MOTOR0SENSE, MOTOR1SENSE, MOTOR0TEMP, MOTOR1TEMP, MOTOR0IDX, and MOTOR1IDX bits are read here. The Pascal source code in the file 4I27LOW.PAS has examples of setting up and using the predefined parallel I/O on the 4I27.

INTERRUPT SELECT

When the 4I27 card uses interrupts, the specific IRQ line driven by the 4I27 is determined by the ISEL bits of the 82C55's port A. The four ISEL bits form a binary code that corresponds directly with the IRQ line selected. Since there are other bits on the 82C55's port A, you should always change the ISEL bits by reading the port, modifying the desired bits, and then rewriting the port. The Pascal source code in the file 4I27LOW.PAS has examples of setting the IRQ line.

INTERRUPT MODE

The two IMODE bits on the 82C55's port A determine the 4I27's interrupt mode. The IMODE bits function as follows:

IMODE1	IMODE0	FUNCTION
0	0	Interrupt driver disabled
0	1	Normal interrupt mode
1	0	Shared interrupt mode
1	1	Shared interrupt mode + pull down

The shared interrupt mode uses an active pullup - passive pulldown driver to allow the sharing (logical or'ing) of interrupts between cards. The interrupt can only be shared with other cards that support this mode of shared interrupts.

OPERATION

INTERRUPT OPERATION

The LM629 interrupt outputs are logically ORed by the 4I27 card. This means that an interrupt output from either of the LM629's will can cause a system interrupt. The bus interrupt line is driven by a tri-state buffer controlled by the IMODE bits. The IMODE bits will be in a low state until the 82C55 is programmed. If interrupts are not used, the IMODE bits should be low.

CONNECTING MOTORS

After the 4I27 has been configured and installed in the system, it should be checked for correct operation. The supplied programs 4I27READ, and 4I27TUNE can be used as a quick check of 4I27 functionality.

The first step is to connect the 4I27 to the quadrature encoder(s) and then use 4I27READ to check for functionality and proper count direction (to match the coordinates of your positioning system).

The program 4I27READ simply prints both motor positions (relative to their position at program initialization) continuously until a key is pressed. If the count direction is reversed, switch the encoder A and B outputs to the 4I27. When RS-422 interface encoders are used, make sure not to mix A and B outputs.

For the next step, It is suggested that the motor drive leads be left disconnected, and 4I27TUNE be run. When 4I27TUNE is run, it will check for the presence of the 4I27, and enable motor 0. Motor 0 will be configured for position mode with the home position being set to wherever motor 0 happens to be during program initialization.

The PWM outputs of the 4I27 or the H-Bridge can then be monitored while the motor is manually 'rocked' back and forth from its original position. If the 4I27 is operating correctly, the DIR and PWM outputs should vary with encoder shaft position.

If the 4I27 is used with a 7I25 H-Bridge, the 7I25 output LEDs can be used as indicators of power drive direction and magnitude. A green LED color on a 7I25 indicates a positive polarity on pin 1 of the motor drive terminal strip. In this way, it is possible to determine the correct motor drive polarity.

The motor(s) should be connected such that the motor drive would tend to oppose the hand generated motor motion.

OPERATION

SERVO SYSTEM TUNING

A simple manual tuning program, 4I27TUNE, is supplied with the 4I27. This program allows you to manually adjust the digital filter parameters while the selected motor is in operation. In addition, 4I27TUNE can record the step response of the servo system with the current set of filter parameters. 4I27TUNE uses the cursor keys to select the desired parameter, and adjust that parameter. The selectable parameters are as follows:

PARAMETER	DESC.	RANGE	UNITS
KP	gain	0 to 32767	drive/err
KD	damping	0 to 32767	drive/err(n)-error(n-1)
KI	integral	0 to 32767	drive/accum. error
IL	integral limit	0 to 32767	KI contribution limit
SI	sample interval	0 to 255	SP/(SI+1)
STEP SIZE	motor step	100 to 10000	encoder counts
VELOCITY	velocity	0 to 1073741823	encoder counts/SP
ACCELERATION	acceleration	0 to 1073741823	encoder counts/ SP/ SP
MOTOR	selects motor	0 and 1	
TIME / DIV	selects graph	10 to 200	milliseconds/division

SP = SAMPLING PERIOD = 256 uSec * (1+SI) with 8 MHz clock.

The following table shows the 4I27TUNE key functions.

KEY	FUNCTION
UP ARROW	select parameter
DOWN ARROW	select parameter
RIGHT ARROW	adjust parameter up fast (+10%)
LEFT ARROW	adjust parameter down fast (-10%)
PAGE DOWN	adjust parameter up slow (+1%)
END	adjust parameter down slow (-1%)
PAGE UP	draw horizontal timing scale
INSERT	do step and record response
DELETE	clear graph
CTRL HOME	reset parameters to initial values (current motor only)
ALT X	exit program

OPERATION

DEMONSTRATION PROGRAMS

4I27VELO sets motor 0 and motor 1 into the velocity mode and allows you to set their speeds in RPM.

4I27POS1 sets motor 0 to position mode, and does some ramp-up / ramp- down motions. 4I27POS2 sets motor 0 and 1 to position mode, and does a set of coordinated (XY) motions with them. 4I27POS2 will bail out if both motors are not present.

4I27VELO and 4I27POS may need to have their default filter parameters and other constants changed to match your motors and card location before being run.

4I27TUNE is a manual parameter tuning program that allows you to optimize filter parameters while the selected motor is in operation. 4I27TUNE requires an EGA, VGA or Hercules compatible video adaptor card for operation.

All of the demonstration programs are written in Turbo Pascal. The source code for the demonstration programs is provided in the source directory of the 4I27 distribution disk.

REFERENCE INFORMATION

SPECIFICATIONS

	MIN	MAX	UNIT	NOTES
POWER SUPPLY				
Voltage	4.5	5.5	V	
Supply current	---	125	mA	(no ext load)
BUS LOADING:				
Input capacitance	---	15	pF	
Input leakage current	---	5	uA	
Output drive capability	150	---	pF	
Output sink current	12	---	mA	
I/O PORT LOADING:				
Input logic low	-.3	.8	V	
Input logic high	2.0	5.5	V	
Output low	----	.4	V	2.5 mA sink
Output high	3.0	---	V	2.5 mA source
ENVIRONMENTAL:				
Operating temperature range				
-I version	-40	+85	ºC	
-C version	0	+70	ºC	
Relative humidity	0	90	Percent	Non-condensing

REFERENCE INFORMATION

WARRANTY

Mesa Electronics warrants the products it manufactures to be free effects in material and workmanship under normal use and service for the period of 2 years from date of purchase. This warranty shall not apply to products which have been subject to misuse, neglect, accident, or abnormal conditions of operation.

In the event of failure of a product covered by this warranty, Mesa Electronics, will repair any product returned to Mesa Electronics within 2 years of original purchase, provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may at its option, replace the product in lieu of repair.

With regard to any product returned within 2 years of purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident, or abnormal conditions of operation, repairs will be billed at a nominal cost.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED. INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. MESA ELECTRONICS SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

If any failure occurs, the following steps should be taken:

1. Notify Mesa Electronics, giving full details of the difficulty. On receipt of this information, service data, or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the product, in its original protective packaging, transportation prepaid to Mesa Electronics. Repairs will be made at Mesa Electronics and the product returned transportation prepaid.

REFERENCE INFORMATION

SCHEMATICS