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USER MANUAL

Accessory 28A

4 Channel A/D Conversion Board

3Ax-602236-xUxx

October 15, 2003

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INTRODUCTION

PMAC's Accessory-28A Analog-to-Digital Conversion board provides four channels of high-speed high-resolution analog input capability to the PMAC controller. The input voltages, in the range of ±10V, are converted to 16-bit signed values, at a rate of 18-KHz (55-μsec conversion). This input can be used for servo position feedback, as from an LVDT or potentiometer, or for general-purpose use (e.g., to monitor process variables, to allow analog speed control, or to monitor motor currents).

The resolution of the A/D conversion can now be selected via jumpers. In addition, the ACC-28A benefits from a design improvement aimed at substantially reducing the noise signals and the cross-talk signals among the four analog input channels. It achieves this by trading off resolution to gain substantially improved cross-talk elimination. Also, an improved sample-and-hold circuit design reduces noise and enhances the accuracy of the analog-to-digital conversion process.

PMAC Analog to Digital Converter Accessories

PMAC has three accessories that it can use to read analog signals. These entire interface boards may be used for either servo loop feedback or for data acquisition. ACC-28B is Delta Tau's most accurate analog to digital converter, featuring separate A/Ds per channel and can be used with either PMAC1 or PMAC2. Both ACC-36 and ACC-28A have multiplexed A/Ds on board. ACC-28A is an externally mounted board with a 16-bit resolution and a **higher** conversion rate than ACC-36 (12 bit). ACC-36 must be located immediately adjacent to PMAC while ACC-28A or ACC-28B may be placed up to 2 feet away from PMAC. The three A/D boards are summarized below,

ACC-36 is a 16-channel 12-bit resolution analog to digital converter board.

ACC-28A is a 4-channel 16-bit resolution analog to digital converter board.

ACC-28B is a 2-channel 16-bit resolution analog to digital converter board (most accurate).

Notes:

PMAC-STD may use only ACC-28A to read analog inputs.

ACC-28A may not be used with PMAC2.

Ordering Your Accessory 28A

Option 2 is a DIN railmount for stand-alone use. Option 2A has the DB-15 pin analog input connector. Option 2B uses the 12-pin terminal block instead.

The default option for ACC-28A is Option 2B, which orders a DIN railmount for ACC-28 with the 12-pin terminal block connector used for analog input signals and analog power supply.

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SETUP

Connectors

J1 brings the converted digital signals from the ACC-28 to a DSPGATE on PMAC or the ACC-24 Axis Expansion board through its JS(x) connector. It also provides the power for the digital section of the ACC-28 board.

J2 (obsolete)

J3 (Option 2A only) provides the input connections for the analog signals and the power input for the analog circuits.

TB1 (Option 2B only) provides the input connections for the analog signals and the power input for the analog circuits.

Connecting Your Accessory-28

The analog signals are wired into the ACC-28 through the TB1 terminal block (12 terminals), or through the J3 connector (a DB-15 connector), whichever is present on your board. Each input has a primary line and a complementary line. If you are providing differential analog input, use both of these. If you are providing single-ended inputs, connect the complementary pin to the ground of your analog source. The pins for each input are:

	Terminal Block		DB-15 Connector	
Signal	**Main Pin**	**Comp. Pin**	**Main Pin**	**Comp Pin**
ADC1	1	2	1	9
ADC2	3	4	2	10
ADC3	5	6	3	11
ADC4	7	8	4	12

The analog signals are passed through differential amplifiers, anti-aliasing filters, a multiplexer, and a serial analog-to-digital converter. The serial data stream from the converter is then passed through optical couplers (for noise immunity) and sent to shift registers in DSPGATE ICs through ACC-28's J1 connector and the provided 16-pin flat cable. This cable can be plugged in on the other end to one of four possible connectors, either on the main PMAC board or the ACC-24 Axis Expansion board. The connector is used on the other end determines in which A/D registers the information will be available:

Connector	A/D Registers
PMAC JS1	ADC Registers 1-4
PMAC JS2	ADC Registers 5-8
ACC-24 JS1	ADC Registers 9-12
ACC-24 JS2	ADC Registers 13-16

Thus, ACC-28 analog inputs 1 to 4 map into PMAC ADC registers 1 to 4, 5 to 8, 9 to 12, or 13 to 16, depending on which JS connector is used.

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Analog Bias Adjustment

Each analog input has an offset potentiometer that may be used to adjust the zero level of the input. The potentiometers match analog input channels as follows:

ADC Input	Pot Number
1	R22
2	R21
3	R11
4	R10

In addition, R1 allows a board level zero offset adjustment for the ADC circuits.

These pots may be adjusted interactively by monitoring the input voltage and querying for the M-variable value of the digital register (see below).

General Program Use

Since PMAC automatically brings the information into its registers, using the information is just a question of accessing those registers and processing that information as you see fit. The registers used for the converted analog information are:

Channel	PMAC	Turbo PMAC
ADC1	Y:$C006	Y:$78006
ADC2	Y:$C007	Y:$78007
ADC3	Y:$C00E	Y:$7800E
ADC4	Y:$C00F	Y:$7800F
ADC5	Y:$C016	Y:$78106
ADC6	Y:$C017	Y:$78107
ADC7	Y:$C01E	Y:$7810E
ADC8	Y:$C01F	Y:$7810F
ADC9	Y:$C026	Y:$78206
ADC10	Y:$C027	Y:$78207
ADC11	Y:$C02E	Y:$7820E
ADC12	Y:$C02F	Y:$7820F
ADC13	Y:$C036	Y:$78306
ADC14	Y:$C037	Y:$78307
ADC15	Y:$C03E	Y:$7830E
ADC16	Y:$C03F	Y:$7830F

These registers are 24 bits. Only the top 16 bits carry the converted data. The data is in signed (two's-complement) form if ACC-28 Jumper E1 is in the default setting. See Section 8 of PMAC User's Manual (Gate Array Registers).

Usually these registers are accessed in software through the use of M-variables, which point to a register. M-variables are first defined to location and size; then they can be used as any other variable (although these are read-only variables by the nature of the registers). Typical definitions for PMAC (non Turbo) would be:

PMAC	Turbo PMAC	Description
M201 -> Y:$C006,8,16,S	M201 -> Y:$78006,8,16,S	ADC1: 8-bit offset, 16-bit width, signed
M202 -> Y:$C007,8,16,S	M202 -> Y:$78007,8,16,S	ADC2: 8-bit offset, 16-bit width, signed
M216 -> Y:$C03F,8,16,S	M216 -> Y:$7820F,8,16,S	ADC16: 8-bit offset, 16-bit width, signed

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These M-variable definitions, once made, are stored indefinitely in battery-backed RAM. Once they have been made, you are free to use the variables in expressions in your motion and/or PLC programs.

Examples:

```
F(M201*P1)       ; This makes move speed proportional to voltage
X(M202*P2)       ; This makes location proportional to voltage
IF (M203<8192)   ; This makes action conditional on voltage level
```

Feedback/Handwheel Use

The ADC registers can also be used as position registers for either servo feedback or master control of an axis. You must simply create an entry in the Encoder Conversion Table (see PMAC main User's Manual section on "Encoder Conversion Table"). By creating an entry for an ADC register you are, in effect, telling PMAC to process an ADC register (instead of the standard encoder feedback) as your feedback or master register. Once created, the appropriate motor I-variable(s) should be modified from their default values. For position feedback, Ix03 must be modified for velocity feedback. Ix04 must be modified also. If the ADC is used as Master (Handwheel) register, then Ix05 must be modified.

Detailed instructions for the setup of the Encoder Conversion Table are given in PMAC main User's Manual (under "Feedback Features") or in the Turbo PMAC Software reference manual. Summarizing briefly, the Y-word (setup word) of the table entry is a 6-digit hex value. The first two digits specify the type of conversion, and should be set to 10 (hex) for ADC conversion. The last four digits contain the Y-word address of the ADC register. Then a typical non-Turbo entry such as $10C007, provides for the conversion of the ADC 2 register.

To use this information as position feedback for motor #2, set I203 and I204 to point to the address of this entry in the Encoder Conversion Table. This causes the motor to use the x-word of the same table entry (the processed ADC register) as the feedback signal for servo loop closure. This setup procedure is required only once if saved using PMAC's "SAVE" command. This simple procedure for the above example is as follows:

PMAC	Turbo PMAC	Description
WY$0728,$10C006	I8008=$178006	Set 9th ECT Entry for ADC
I203=$0728	I203=$3509	Position feedback from 9th ECT entry
I204=$0728	I204=$3509	Velocity feedback from 9th ECT entry

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RESOLUTION SELECTION

Although PMAC reads the content of the ADC registers as 16-bit 2s complement values, the maximum resolution of ACC-28A is now 15 bits. The resolution may be further reduced down to a minimum of 8 bits by the appropriate installation of jumpers E5 to E8. Note that the least significant bit should be ignored in the 15-bit operational mode; and the least significant two bits should be ignored in the 14-bit operational mode and so on. The table below shows the jumper selection for the various resolutions of ACC-24A:

Resolution Selection Jumpers

Resolution	E8	E7	E6	E5
8-bits	ON	OFF	OFF	OFF
9-bits	ON	OFF	OFF	ON
10-bits	ON	OFF	ON	OFF
11-bits	ON	OFF	ON	ON
12-bits	ON	ON	OFF	OFF
13-bits*	ON	ON	OFF	ON
14-bits	ON	ON	ON	OFF
15-bits	ON	ON	ON	ON
*Default factory setup is for 13-bit operation with both 20 and 30 MHz versions of PMAC. *For the 30 MHz PMAC, if a resolution higher than 13-bits is desired, then the jumper E98 on the PMAC board should be installed between pins 2 and 3.*				

Interpretation of Converted Analog Data

PMAC's 16-bit 2's complement read of the ADC registers using the M-variable format would yield a number in the range in between 2^{15}-1 (representing nominally +10V) to -2^{15} (representing nominally -10 volts). With ACC-28A, the resolution ranges from 15-bits to 8-bits. This means that the actual converted data resides in the *most significant* 15-bits to the *most significant* 8-bits, respectively. As an example:

Assuming 13-bit resolution (default jumper setup)

```
M201->Y:$C006,8,16,S (PMAC)
```

; M201 is addressing ADC1 with the usual; format (8-bit offset, 16-bit width; signed). As defined, the value of M201; may range between +32767 to -32768; representing +10V to -10V respectively; However due to the default jumper setup ;on ACC28A (see above) the least; significant three bits of the number are to; be ignored.

```
M201->Y:$78006,8,16,s (Turbo)
```

Note:

It may appear that reducing the effective resolution of the A/D converters is unwarranted. However, in the original 16-bit operation mode of ACC-28, the cross talk and noise often covered a voltage range which was equivalent to several of the least significant bits. In ACC-28A, the reduction in the effective resolution is overcompensated by the extra signal-to-noise ratio improvement.

Absolute Power-On Position

PMAC allows you to acquire power-on position automatically if you set up Ix10 for the PMAC or Ix10 and Ix95 for the Turbo PMAC. Starting with PMAC firmware version V1.14, it is necessary to use motor setup variable Ix10 to get the absolute power-on position from an analog sensor brought in through an ACC-28A. All firmware versions of the Turbo PMAC are capable of reading absolute power-on position.

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Ix10 specifies the register to read for absolute power-on position, and how to read the data in that register. If Ix10 is set to 0, PMAC will set the power-on position for that motor to 0, even if an absolute position device is used for the motor.

Ix10 must use the raw data register for the sensor, not the processed data register in the conversion data. For the ACC-28A interface, the values of Ix10 to use are shown on the following table.

For the Turbo PMAC Ix10 specifies the register you are going to use to obtain power-on position and Ix95 tells the PMAC how to process the data. Non-Turbo PMACs used one register for both functions.

Absolute Position Table

Channel	Connector	PMAC Ix10 Value	Turbo PMAC Ix10 Value	Turbo PMAC Ix95 Value
ADC1	PMAC JS1	$B1C006	$78006	$B10000
ADC2	PMAC JS1	$B1C007	$78007	$B10000
ADC3	PMAC JS1	$B1C00E	$7800E	$B10000
ADC4	PMAC JS1	$B1C00F	$7800F	$B10000
ADC5	PMAC JS2	$B1C016	$78106	$B10000
ADC6	PMAC JS2	$B1C017	$78107	$B10000
ADC7	PMAC JS2	$B1C01E	$7810E	$B10000
ADC8	PMAC JS2	$B1C01F	$7810F	$B10000
ADC9	ACC-24 JS1	$B1C026	$78206	$B10000
ADC10	ACC-24 JS1	$B1C027	$78207	$B10000
ADC11	ACC-24 JS1	$B1C02E	$7820E	$B10000
ADC12	ACC-24 JS1	$B1C02F	$7820F	$B10000
ADC13	ACC-24 JS2	$B1C036	$78306	$B10000
ADC14	ACC-24 JS2	$B1C037	$78307	$B10000
ADC15	ACC-24 JS2	$B1C03E	$7830E	$B10000
ADC16	ACC-24 JS2	$B1C03F	$7830F	$B10000

The B1 in the first two hexadecimal digits of Ix10 for non Turbo PMAC or Ix95 for the Turbo, specifies that this is a 16-bit register in the high 16 bits of the 24-bit word being read, interpreted as a signed value.

For absolute position on power up, I14 must also be enabled for the non-Turbo PMAC only. I14 is the 'auto position match on run enable' parameter. With I14 set equal to 1, PMAC will execute the PMATCH function on any Run or Step command to make sure that the axes in the motion program have the proper starting-position information.

Analog Power Supply and Opto-Isolation

To achieve the opto-isolation features of ACC-28, you **must** bring in separate analog power supplies either through the Terminal Block (TB1) or through the connector J3. In addition, jumpers E2, E3 and E4 should not be installed.

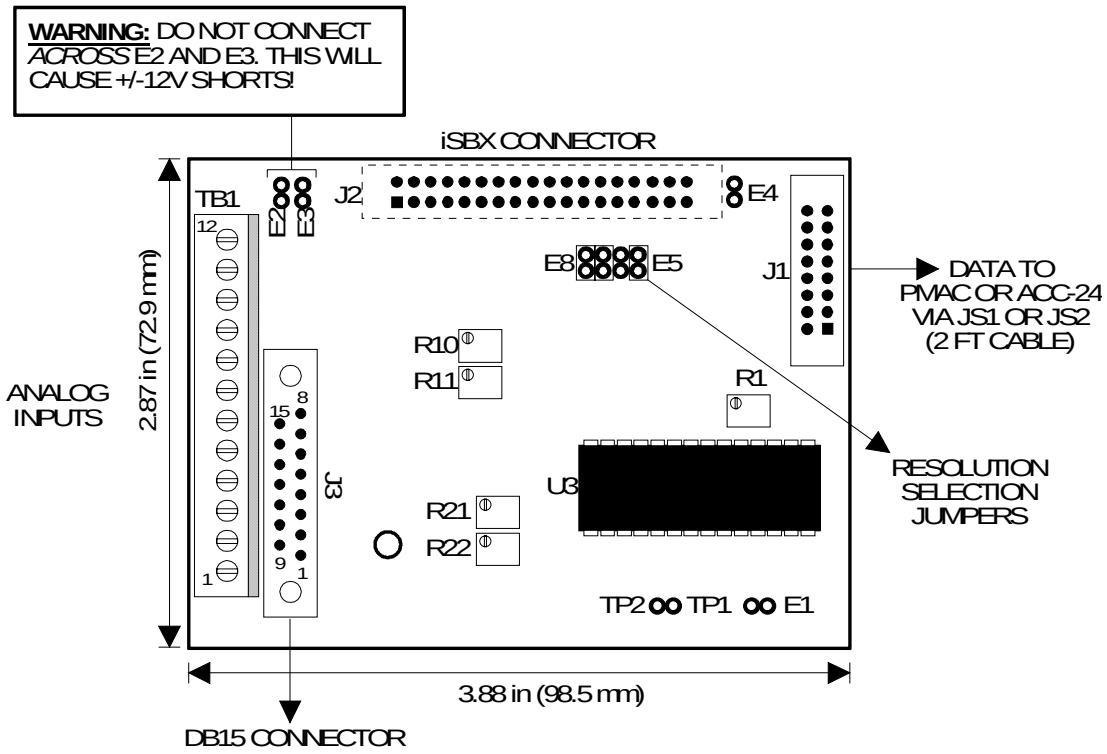
Power Requirements

5V	12V	-12V	Other 24V etc.
	250mA	100mA	N/A

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BOARD LAYOUT

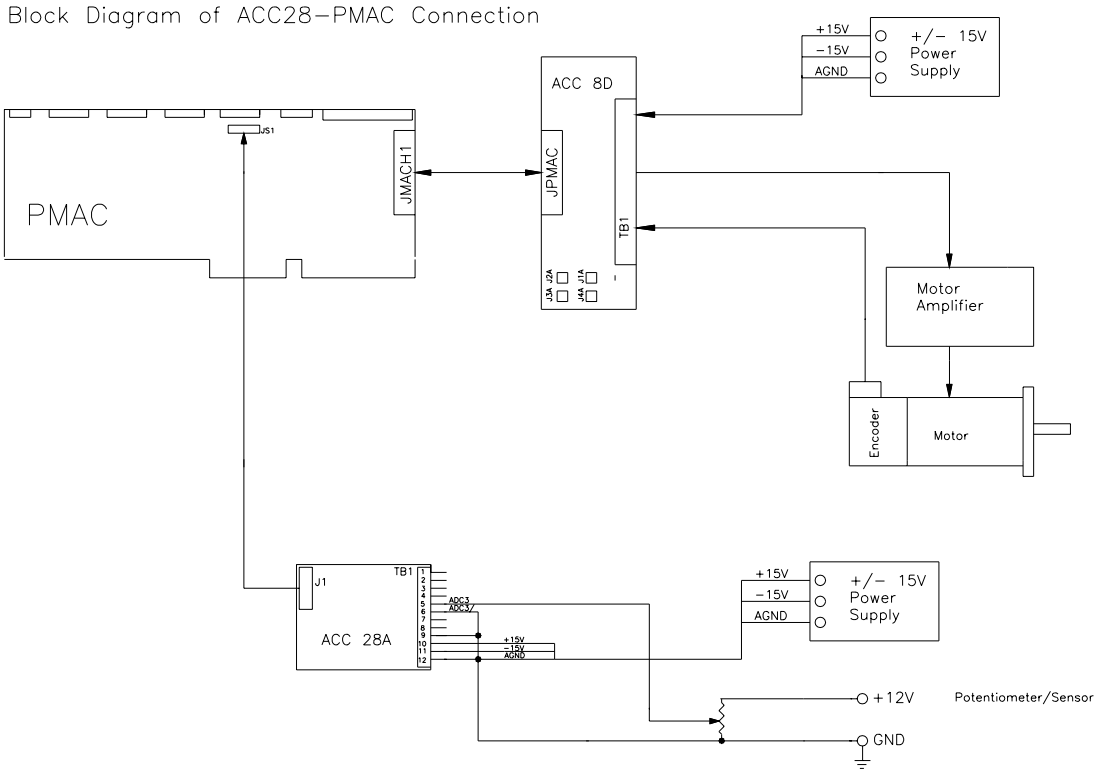
ACC-28A
4 CHAN., 16 BIT, A/D CONVERTER



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Connecting to PMAC

The following diagram shows how to connect an analog sensor or potentiometer to ACC-28A to use as a Master/Handwheel device. In this diagram we are connected to ADC3. Although the variable voltage source is a single ended input, we connected the complementary signal to analog ground as stated earlier. In higher precision applications, a separate supply may be desired for each circuit as shown below. Please call the factory if you have any questions.



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ACC-28 PINOUTS

ACC-28 TB1 (12-Pin Terminal Block)

Pin #	Symbol	Function	Description	Notes
1	ADC	Input	1st Channel Main Input	1
2	ADC1/	Input	1st Channel Comp. Input	2
3	ADC2	Input	2nd Channel Main Input	1
4	ADC2/	Input	2nd Channel Comp. Input	2
5	ADC3	Input	3rd Channel Main Input	1
6	ADC3/	Input	3rd Channel Comp. Input	2
7	ADC4	Input	4th Channel Main Input	1
8	ADC4/	Input	4th Channel Comp. Input	2
9	AGND	Common	Analog Ground	Must use one
10	A+15V	Input	Analog Positive Supply	Must use
11	A-15V	Input	Analog Negative Supply	3
12	AGND	Common	Analog Ground	Must use one

This terminal block is provided only if 2B is ordered.

1 Range is -10V to +10V if single-ended; -5V to +5V if differential.

2 If using single-ended inputs, it is advisable to these pins to AGND for increased noise immunity. If using differential inputs, the usable range is -5V to +5V.

3 Valid power supply range is +/-12V to +/-15V.

ACC-28 J3 (15-Pin Header)

Pin #	Symbol	Function	Description	Notes
1	ADC1	Input	1st Channel Main Input	1
2	ADC2	Input	2ndf Channel Main Input	1
3	ADC3	Input	3rd Channel Main Input	1
4	ADC4	Input	4th Channel Main Input	1
5	AGND	Common	Analog Ground	Must use one
6	AGND	Common	Analog Ground	Must use one
7	A+15V	Input	Analog Positive Supply	Must use one3
8	AGND	Common	Analog Ground	Must use one
9	ADC1/	Input	1st Channel Comp. Input	2
10	ADC2/	Input	2nd Channel Comp. Input	2
11	ADC3/	Input	3rd Channel Comp. Input	2
12	ADC4/	Input	4th Channel Comp. Input	2
13	AGND	Common	Analog Ground	Must use one
14	AGND	Common	Analog Ground	Must use one
15	A-15V	Input	Analog Negative Supply	Must use one3

This connector is provided only if Option 1A or 2A is ordered.

1. Range is -10V to +10V if single-ended; -5V to +5V if differential.
2. If using single-ended inputs, it is advisable to these pins to AGND for increased noise immunity. If using differential inputs, the usable range is -5V to +5V.

3. Valid power supply range is +/-12V to +/-15V.

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ACC-28 J1 (16-Pin Header)

Pin #	Symbol	Function	Description	Notes
1	DCLK	Input	A/D Clock	
2	N.C		No Connection	
3	ASEL0	Input	Channel Select Bit 0	
4	ASEL1	Input	Channel Select Bit 1	
5	CONVERT	Input	Start-Convert Line	
6	ADCIN	Output	A/D Data Stream	
7	N.C.		No Connection	
8	N.C.		No Connection	
9	N.C.		No Connection	
10	N.C.		No Connection	
11	N.C.		No Connection	
12	N.C.		No Connection	
13	N.C.		No Connection	
14	N.C.		No Connection	
15	+5V	Input	Digital Supply	Must use
16	GND	Common	Digital Ground	Must use

ACC-28 Jumpers

E-Point	Physical Layout	Description	Default
E1	1 2	For Future Use Do not install jumper	No Jumper
E2	1 2	For Future Use Do not install jumper	No Jumper
E3	1 2	For Future Use Do not install jumper	No Jumper
E4	1 2	For Future Use Do not install jumper	No Jumper

Resolution Selection Jumpers

Resolution	E8	E7	E6	E5
8-bits	ON	OFF	OFF	OFF
9-bits	ON	OFF	OFF	ON
10-bits	ON	OFF	ON	OFF
11-bits	ON	OFF	ON	ON
12-bits	ON	ON	OFF	OFF
13-bits*	**ON**	**ON**	**OFF**	**ON**
14-bits	ON	ON	ON	OFF
15-bits	ON	ON	ON	ON
*default factory setup is for 13-bit operation with both 20 and 30 MHz versions of PMAC. For the 30 MHz PMAC, if a resolution higher than 13-bits is desired, then the jumper E98 on the PMAC board should be installed between pins 2 and 3.				

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