

IMPORTANT PRODUCT INFORMATION

READ THIS INFORMATION FIRST

Product: **Axis Positioning Module; 1 Axis**
 IC693APU301J
 Firmware Version 2.10

General Description

The IC693APU301 one-axis Axis Positioning Module (APM) is a one axis motion control module that is highly integrated with the logic solving and communications functions of the IC693 PLC. Two primary control loop configurations are provided, standard mode and follower mode. Basic capabilities of the APM are described below.

High Performance

- 1 millisecond servo loop update
- Block processing time under 5 milliseconds
- Velocity Feed Forward and Position Error Integrator to enhance tracking accuracy
- High resolution of programming units
 - Position: -8,388,608 . . . +8,388,607 User Units
 - Velocity: 1 . . 8,388,607 User Units/second
 - Acceleration: 1 . . 134,217,727 User Units/second/second

Easy to Use

- Configured with IC641 configuration software
- Simple and powerful instruction set
- Simple one axis motion programs
- Program support for a short motion program (Program Zero) which can be created in the IC641 configuration software (for Standard mode only)
- Non-volatile (flash) storage for 10 programs and 40 subroutines
- User scaling of programming units (in Standard mode only)
- Generic programming using command parameters as operands for Acceleration, Velocity, Move and Dwell commands
- Automatic data transfer between PLC tables and APM without user programming
- Ease of I/O connection with factory cables and standard terminal blocks as well as a serial port for connecting programming devices

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Versatile I/O

- 10 volt Velocity Command analog output
- 12-bit plus sign analog input
- Home and Overtravel switch inputs
- Position Capture Strobe Input (in Standard mode only)
- User-defined control inputs (8) and outputs (4)
- A Quad B Feedback (up to 175 kHz per channel)
- Linear TEMPOSONICS® Feedback

Product Identification:

IC693APU301J

Hardware Identification: AP3A1(44A731628-G01R09 or later)

Software Identification: Firmware version 2.10 (PROM U14, 44P723399-007A2.10)

Replaces

IC693APU301H (firmware version 2.02)

IC693APU301G (firmware version 2.02)

IC693APU301F (firmware version 2.02)

IC693APU301E (firmware version 2.02)

IC693APU301D (firmware version 1.10)

IC693APU301C (firmware version 1.10)

IC693APU301B (firmware version 1.00)

IC693APU301A (firmware version 1.00)

Firmware Upgrade Kit

A firmware upgrade kit, **44A731246-G02 (firmware version 2.10)** is available to upgrade the modules listed above to firmware version 2.10. This update is an optional release. There will normally be a charge for an upgrade to firmware version 2.10. Contact the PLC Hotline for more information if you encounter one of the problems listed in *Problems Resolved*.

Applicable Documents

1. GFK-0840C, *Axis Positioning Module APM Standard Mode User's Manual*.
2. GFK-0781B, *Axis Positioning Module APM Follower Mode User's Manual*.
3. GFK-0664A, *PLC Axis Positioning Module (APM) Programmer's Manual*.

Special Operational Notes

CPU Firmware

Use of APM firmware version 2.10 requires that version 3.52 or higher of the IC693 CPU firmware be installed in the CPU module.

IC641 Programming Software

Use of APM firmware version 2.10 requires that version 6.01 or higher of IC641 programming software be used to configure the host APM module. Earlier versions of IC641 programming software will not be able to configure all the available features of APM firmware version 2.10.

Motion Programmer

Use of APM firmware version 2.10 requires that version 1.50 or higher of the APM Motion Programmer be used to create/edit motion programs 1 - 10.

Resolver and Digital Feedback Types

The *RESOLVER* and *DIGITAL* feedback types which may be configured for the APM via the IC641 configuration software are NOT implemented in this release.

Custom Feedback Types

The *CUSTOM1* and *CUSTOM2* feedback types which may be configured for the APM via the IC641 configuration software are reserved for special applications and should not be selected for normal module operation.

Reversal Error Compensation for the Follower Control Loop Mode

Reversal error compensation can not be configured via the IC641 configuration software when follower mode is selected. No other mechanism is currently supported to allow this parameter to be configured for follower mode.

S-Curve Acceleration for Superimposed Moves in Follower Control Loop Mode

S-Curve acceleration is not supported for superimposed moves in the follower control loop mode. Any moves defined to use S-curve acceleration will instead be executed with normal linear acceleration. No error indicator will be issued to the user should this situation be encountered.

In Zone Status Bit in Follower Control Loop Mode

The *In Zone* %I bit is unconditionally set whenever the follower is enabled. In previous firmware releases, *In Zone* was only set when *Command Move* was off and *Position Error* was less than the configured *In position* value.

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I/O Cables

Four I/O cables are now available for use with the APM, as described below. The IC693CBL311 cable is the original one which has been available for some time.

- IC693CBL311: 3 meter (15 feet) I/O cable (frame ground provided at APM connector)
- IC693CBL319: 1 meter (3 feet) I/O cable (frame ground provided at APM connector)
- IC693CBL317: 3 meter (15 feet) I/O cable (external frame ground provided via 8" pigtail for improved noise immunity).
- IC693CBL320: 1 meter (3 feet) I/O cable (external frame ground provided via 8" pigtail for improved noise immunity)

Problems Resolved by this Upgrade (Version 2.10)

CMOS Outputs

When the PLC CPU transitioned to stop mode, the APM's CMOS outputs were left in whatever state they happened to be in. Firmware version 2.10 now turns the CMOS outputs **OFF** whenever the APM senses that the PLC CPU has transitioned to stop mode.

Position Increment Immediate Command (21h)

This command would not always produce the correct position increment unless the user units to counts ratio was 1:1. This problem has been corrected in firmware version 2.10.

New Features and Functionality for this Upgrade (2.10)

Superimposed Point-to-Point Moves on Follower Motion

The follower mode of operation has been enhanced to allow execution of a standard motion program created by the APM Motion Programmer. All the existing program commands will apply to the follower axis, but for this release, only the linear acceleration mode may be used. This enhancement allows the following two types of operation in follower mode:

1. A slave motion can execute a stored motion program in addition to following the master input command. Programmed move commands to the slave, consisting of both velocity and distance, will be superimposed upon the commands from the master source. Provisions have been made for an input trigger signal that can enable the follower axis in synchronism with a moving object so programmed moves can be executed relative to the object as it moves along at a rate controlled by the master input command to the follower axis.
2. The axis can be commanded solely from the stored program data if there is no master command or if the follower is not enabled. When commanding the axis solely from a stored program the axis basically behaves as if it were configured for Standard mode rather than Follower. However, the following restrictions apply when an APM is configured for follower mode:
 - All programmed motion uses Linear acceleration only (no S-curve).
 - Only motion programs 1 - 6 are allowed (programs 0 and 7 - 10 are unavailable).
 - No user unit scaling; User Unit/Counts ratio fixed at 1:1.
 - Strobe inputs are not available.
 - Axis has a *Drive OK* input instead of *Overtravel Limits* inputs
 - Software *End of Travel Limits* are not available
 - *Feedhold %Q* bit and *Rate Override* are not available

Single Magnet Linear (TEMPOSONICS) Feedback

For the standard control loop (only) the Linear Feedback type selection has now been implemented. The Linear Feedback selection has been available in the IC641 configuration software since release 4.02, but has not been supported by the APM until this firmware release (2.10). The basic features of the Linear Feedback type are:

- A 16.896 MHz clock rate and a 16-bit count resolution.
- Configurable recirculation factor which allows rod position resolution to be multiplied by the recirculation factor at the expense of slower update rates.
- Error detection for loss of feedback.
- Position strobe for each axis.
- Find Home command is disabled because the Linear Feedback transducer provides an absolute position.
- Configurable position offset allows the user to adjust the absolute position reported by the transducer.

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CMOVE Enhancement

The standard CMOVE command is useful for applications where the velocity programmed for the succeeding move is attained at the end point of the current move. The CMOVE command has been enhanced to provide support for those applications that require that the velocity change not start until the present CMOVE position has been reached. This delay in servo velocity change is specified by programming an incremental CMOVE command with an operand of 0 (CMOVE INC 0). This command does not cause any extra motion; it only serves to modify the behavior of the succeeding move command. By selectively placing CMOVE INC 0 commands in the program you can determine when particular velocity changes will occur, allowing entire CMOVE commands to be executed at a constant velocity.

The program segment below illustrates a typical use of CMOVE commands prior to APM firmware release 2.10.

<i>VELOC</i>	<i>1, 10000</i>	<i>Set velocity of 1st move = 10000</i>
<i>CMOVE</i>	<i>1, 15000</i>	<i>Reach velocity of 2nd move at position = 15000</i>
<i>VELOC</i>	<i>1, 20000</i>	<i>Set velocity of 2nd move = 20000</i>
<i>CMOVE</i>	<i>1, 30000</i>	<i>Reach velocity of 3rd move at position = 30000</i>
<i>VELOC</i>	<i>1, 5000</i>	<i>Set velocity of 3rd move = 5000</i>
<i>PMOVE</i>	<i>1, 45000</i>	<i>Final stop position = 45000</i>

With the commands listed above, the servo would initially accelerate to a velocity of 10000. Next, the servo would accelerate to a velocity of 20000 and reach that velocity at a position of 15000. After running at a velocity of 20000, the servo would decelerate to a velocity of 5000 and reach that velocity at a position of 30000. Finally, the servo would run at a velocity of 5000 and stop at a position of 45000.

Prior to firmware release 2.10, it was not possible to have one of the above CMOVE commands execute at a constant velocity for the entire move. By using the new CMOVE 0 enhancement, a CMOVE command can be made to execute at a constant velocity, as illustrated below:

<i>VELOC</i>	<i>1, 10000</i>	<i>Set velocity of 1st move = 10000</i>
<i>CMOVE</i>	<i>1, 15000</i>	<i>Reach velocity of 2nd move at position = 15000</i>
<i>VELOC</i>	<i>1, 20000</i>	<i>Set velocity of 2nd move = 20000</i>
<i>CMOVE</i>	<i>1, INC 0</i>	<i>Force next velocity change to wait for next Move</i>
<i>CMOVE</i>	<i>1, 30000</i>	<i>Stay at velocity = 20000 until Position = 30000, then change to velocity = 5000</i>
<i>VELOC</i>	<i>1, 5000</i>	<i>Set velocity of 3rd move = 5000</i>
<i>PMOVE</i>	<i>1, 45000</i>	<i>Final stop position = 45000</i>

With the commands listed above, the servo would initially accelerate to a velocity of 10000. Next the servo would accelerate to a velocity of 20000 and reach that velocity at a position of 15000. The servo would continue at a velocity of 20000 until the position of 30000 was reached. Then the servo would decelerate to a velocity of 5000 and finally stop at a position of 45000. The effect of the CMOVE INC 0 command was to make all of the second CMOVE (from a position of 15000 to a position of 30000) occur at a constant velocity of 20000.

Motor Direction Configuration Setting

The IC641 configuration software version 6.01 now supports the configuration of motor direction for the axis, specified as either POSitive or NEGative. A configured motor direction of positive defines the positive axis direction as encoder channel A leading channel B (encoder feedback) or motion away from the feedback transducer (linear feedback). A negative motor direction configuration defines the positive axis direction as encoder channel B leading channel A (encoder feedback) or motion towards the feedback transducer (linear feedback). In practice, the motor direction configuration allows you to reverse the motion caused by all commands without reversing motor or encoder wires.

Acceleration Ramping in Follower Mode

Acceleration and deceleration ramping have been added for a slave axis when the follower is enabled/disabled (respectively) without losing any master counts when the master is enabled. The %I *Command Move* status bit turns on while the axis accelerates to the master command velocity after being enabled. *Command Move* also turns on while the axis decelerates after being disabled. New immediate commands 42h and 45h (see below) are used to configure this feature.

Position Increment with Position Update [Immediate Command 25h]

The new *Position Increment with Position Update* immediate command functions identically to the *Position Increment without Position Update* immediate command [21h] with one exception. In addition to moving the axis by the increment value, both the Actual and Commanded Position (returned in %AI status data) are updated by the increment value. Immediate command 21h does not update either the Actual or the Commanded Position.

In Position Zone [Immediate Command 26h]

The new *In Position Zone* immediate command can be used to set the active In Position zone to a value other than that configured with the IC641 configuration software (that is, it will override the original setting). Note that if the APM module is reset, the original configured value will be restored.

Single Move Motion Program [Immediate Command 27h]

This new command provides a mechanism for executing a single move to the commanded position. The current jog acceleration and velocity settings (which themselves can be changed with immediate commands) will be used for the move. Note that if the move command is executed with the APM configured for follower mode, S-curve acceleration may not be used (only linear).

Enable Follower with External Input [Immediate Command 41h]

Prior to firmware version 2.10, a follower axis could only be enabled by a %Q *Enable Follower* bit. This new command enables the assignment of one of the external faceplate inputs CTL01 - CTL08 to be used as a follower enable trigger. When so configured, the %Q *Enable Follower* bit is used to enable the external faceplate trigger input. The %Q *Enable Follower* bit must be ON and the external trigger must transition from OFF to ON for the axis to begin following the master input.

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Follower Acceleration Ramp Distance Make-Up Time [Immediate Command 42h]

When the Follower Ramp feature (see above) has been selected and the follower is enabled, the following axis is ramped up to the Master velocity at the current jog acceleration rate without losing any of the master counts during ramp up. The following axis must then move faster than the master axis command until the master counts accumulated during the acceleration ramp have been made up. This command allows the specification of how much time should be used to make up the accumulated master counts.

Configuration Modes [Immediate Command 45h]

The Configuration Modes command is used to configure certain features of the APM which were not directly supported by the IC641 configuration software at the time of the new APM firmware release. For APM release 2.10 these include:

1. Select *Program Command Position* to be reported in the %AI *Commanded Position Location* as opposed to the default *Commanded Position*.
2. Select that acceleration ramping should be applied whenever the Follower axis is enabled or disabled (default is to not use acceleration ramping).

Configuration Complete Flag [Immediate Command 49h]

Configuration data provided to the APM via %AQ immediate commands is stored in volatile memory, unlike standard configuration data which is stored in non-volatile memory. When the APM module is reset or reconfigured, configuration data provided via the %AQ immediate commands is lost. To provide a mechanism to detect this, %AQ configuration command 49h has been added to set the APM's 25th %I bit as a *configuration complete* flag. Once set, this status bit is only cleared by a module reconfiguration or reset. The PLC CPU logic can monitor this bit, and resend any configuration data to the APM whenever the status bit is detected as having been cleared.

Restrictions and Open Problems

None