ARTISAN®
TECHNOLOGY GROUP

Your **definitive** source for quality pre-owned equipment.

Artisan Technology Group
(217) 352-9330 | sales@artisantg.com | artisantg.com

Full-service, independent repair center
with experienced engineers and technicians on staff.

We buy your excess, underutilized, and idle equipment
along with credit for buybacks and trade-ins.

Custom engineering
so your equipment works exactly as you specify.

- Critical and expedited services
- In stock / Ready-to-ship
- Leasing / Rentals / Demos
- ITAR-certified secure asset solutions

Expert team | Trust guarantee | 100% satisfaction

All trademarks, brand names, and brands appearing herein are the property of their respective owners.

Find the *GE Fanuc IC693APU302* at our website: ***Click HERE***

August 12, 1996
GFK-1317B

IMPORTANT PRODUCT INFORMATION

READ THIS INFORMATION FIRST

Product: **Power Mate APM Module; 2 Axes**
IC693APU302K
Firmware Version 2.50

General Description

The IC693APU302 two-axis Power Mate APM (PM-APM) is a two 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 Power Mate APM are described below.

High Performance

- 2 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 or two axis motion programs with synchronized block start
- Program support for a short motion program (Program Zero) which can be created in the IC641 configuration software
- 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

Versatile I/O

- 10 volt Velocity Command analog output
- 12-bit plus sign analog input

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

- 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
- Digital Interface to Power Mate J Digital Servo Interface module

Product Identification:

IC693APU302K

Hardware Identification: AP3A1(44A731628-G01R11 or later)

Software Identification: Firmware version 2.50 (PROM U14, 44P723399-008C2.50)

Replaces

IC693APU302J (firmware version 2.11)
IC693APU302H (firmware version 2.10)
IC693APU302G (firmware version 2.02)
IC693APU302F (firmware version 2.02)
IC693APU302E (firmware version 2.02)
IC693APU302D (firmware version 2.02)
IC693APU302C (firmware version 2.01)
IC693APU302B (firmware version 1.50)
IC693APU302A (firmware version 1.50)

Firmware Upgrade Kit

A firmware upgrade kit, **44A731242-G05 (firmware version 2.50)** is available to upgrade the modules listed above to firmware version 2.50. This update is an optional release. There will normally be a charge for an upgrade to firmware version 2.50. Contact the PLC Hotline for more information if you have encountered one of the problems listed in *Problems Resolved.*

Note

Digital servo control using the Power Mate J Digital Servo Interface module is only allowed with Power Mate APM hardware revision R11 and later.

Applicable Documents

1. GFK-0840D, *Power Mate APM for Series 90™-30 Standard Mode User's Manual.*
2. GFK-0781C, *Power Mate APM for Series 90™-30 Follower Mode User's Manual.*
3. GFK-0664A, *PLC Axis Positioning Module (APM) Programmer's Manual.*

® TEMPOSONICS is a registered trademark of MTS Systems Corporation.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Special Operational Notes

CPU Firmware

Use of APM firmware version 2.50 requires that version 3.52 or higher of the IC693 CPU firmware be installed in the CPU module.

IC641 Programming Software

Use of Power Mate APM firmware version 2.50 requires that version 6.01 or higher of IC641 programming software be used to configure the host Power Mate APM module. Earlier versions of IC641 programming software will not be able to configure all the available features of Power Mate APM firmware version 2.50.

Motion Programmer

Use of Power Mate APM firmware version 2.50 requires that version 1.50 or higher of the Power Mate APM Motion Programmer be used to create / edit motion programs 1 - 10.

Resolver Feedback Type

The *RESOLVER* feedback type which may be configured for the Power Mate APM via the IC641 configuration software is NOT implemented in this release.

Custom Feedback Types

The *CUSTOM1* and *CUSTOM2* feedback types which may be configured for the Power Mate 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 may 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

When the Follower Mode is selected, the *In Zone* %I bit indication operates as follows:

1. When Follower is NOT enabled, the *In Zone* indication works exactly like it does in Standard Mode.
2. In previous firmware release 2.11, the *In Zone* indication was forced ON when the Follower was enabled and no internal move commands were generated. When an internal move command was generated, the *In Zone* indication would turn OFF during the move and will turn ON as soon as the command was completed without waiting for the axis position to be within the configured *In Position Zone* value.

In this release and all releases prior to 2.10, *In Zone* is only set when *Command Move* is off and *Position Error* is less than the configured *In Position Zone* value.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

I/O Cables

Four I / O cables are available for use with the Power Mate 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 PM-APM connector)
- IC693CBL319: 1 meter (3 feet) I/O cable (frame ground provided at PM-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 2.50)

Follower Ramp Feature Could Not Be Configured to Specify *No Distance* Make Up correction.

The Follower Ramp feature, which was introduced in firmware version 2.10, did not provide a configuration value to specify a *no distance* make up correction (that is, to ignore any lost master counts during the acceleration ramp). In firmware version 2.50, specifying a make up time of zero allows the Follower Ramp feature to operate without making up for master counts lost during acceleration.

In Zone Forced ON When the Follower Mode is Enabled and Command Move is OFF

In firmware version 2.10 and 2.11, In Zone was forced ON when the Follower was enabled and Command Move was OFF. This precluded using the Integrator mode *in zone* selection (became like continuous mode). *In Zone* is no longer forced ON when Follower is enabled. In addition, when Follower is enabled PMOVE command completion no longer requires that the *In Zone* indication be set.

Most Negative Valid Value for Home Position / Position Offset Treated As Invalid

If a configuration value of –8,388,608 was defined for either the Home Position with Encoder feedback selected or the Position Offset with Linear feedback selected, the Power Mate APM would reject the configuration as invalid. Firmware version 2.50 will allow configuration of this value for these two configuration fields.

Commanded and Actual Position Not Set to Zero After High/Low Count Limit Error

If the High and Low Count Limits were set such that 0 was not within the count limit range and the Power Mate APM subsequently encountered either a High Count Limit error (58) or a Low Count Limit error (59), the commanded and actual position was not set to zero as expected. Instead, they were set to unexpected values. This problem has been corrected in firmware version 2.50.

Linear Transducer Position Offset Treated as Counts Instead of User Units

Firmware version 2.11 erroneously treated the configured Linear Transducer Position Offset as counts instead of user units when (a) the counts : user units ration was not 1:1 *and* the position offset was not zero. This problem has been fixed in firmware version 2.50.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Linear Feedback Position Offset Validated Against EOT+ and EOT– in Linear Mode

If the End Of Travel + and End Of Travel – limits were configured such that the Linear Feedback Position Offset was outside those limits, firmware version 2.11 would incorrectly issue either an error code of 03 or 04 rather than the correct error code of 58 or 59. Firmware version 2.50 now reports the correct error code in this situation.

Cannot Execute Motion Program After *Abort All Moves*

If a program was aborted during or after execution of a PMOVE command and the servo did not pull the axis into position (*In Zone* remained off), another program could not be executed until the *In Zone* condition was achieved. Firmware version 2.50 will now allow another program to execute after an Abort whether or not the *In Zone* condition has been realized.

Problems Resolved by Previous Upgrade (Version 2.11)

Follower Ramp Erroneous Velocity Limit Error

During the ramp distance make up a follower velocity limit error (F2) would be erroneously reported for certain velocity and acceleration combinations. This has been corrected in firmware version 2.11.

Follower Enabled %I Status Not Turned Off

If the *Drive Enable* and *Enable Follower* %Q bits were both turned off on the same PLC sweep, the *Follower Enabled* %I indication would be left on. This behavior has been corrected in firmware version 2.11.

Follower Analog Master Input Does Not Work

The analog master input function did not work properly in firmware release 2.10. The analog input %AI data was valid but the analog input did not produce any commands for the follower master axis. This feature again functions properly in firmware version 2.11.

Problems Resolved by Previous Upgrade (Version 2.10)

Multi-Axis Synchronization

Under certain circumstances multi-axis programs would fail to synchronize properly at a synch block. The problem would occur when there was an absence of motion for one of the two axes within the block being synchronized, as shown in the following example program segment:

```
3X      ACCEL   2, 1500
        VELOC   2, 15000
        PMOVE   2, +106000

4X      ACCEL   1, 1500
        VELOC   1, 1000
        PMOVE   1, +2000

5               :
```

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Note that for synchronization block 3, only motion commands for axis 2 appear. Similarly, for synchronization block 4, only motion commands for axis 1 appear. When this program segment executed, the motion for axes 1 and 2 would synchronize at block 3 as expected, but then blocks 3 and 4 would both simultaneously execute as opposed to synchronizing at block 4 as expected. The workaround for this problem in firmware versions prior to 2.10 was to place a *DWELL 1, 0* command in block 3 and a *DWELL 2, 0* command in block 4. This workaround is no longer required in firmware version 2.10.

CMOS Outputs

When the PLC CPU transitioned to stop mode, the Power Mate APM's CMOS outputs were left in whatever state they happened to be in. Firmware version 2.11 now turns the CMOS outputs ***OFF*** whenever the Power Mate 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.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

New Features and Functionality for This Upgrade (2.50)

Support for Digital Servos Via Digital Servo Interface Module

Digital servos may now be interfaced to the Power Mate APM module via a second companion module, the Digital Servo Interface module. Together, these two modules constitute a Power Mate J system. The Power Mate APM module must be configured for *digital* feedback mode. Only the Standard control loop mode is supported (Follower mode is not supported).

Select Return Data Immediate Command

A new %AQ immediate command, 40h, has been added to select what data is actually reported by the Power Mate APM module in the Commanded Position %AI status word for a particular axis. The data to return is specified via the second command byte, as follows:

- 00h: Commanded Position (default at power up and after configuration store)
- 01h: Program Commanded Position (superimposed moves in follower mode)
- 07h: Absolute Feedback Offset (in counts)
- 08h: Parameter Register (specified in second command word as 0–255)
- 10h: Power Mate APM firmware revision
- 11h: Digital Servo Interface module firmware revision

Absolute Feedback Offset Immediate Command

A new %AQ immediate command, 46h, has been added to allow a user to manually enter an encoder Absolute Feedback Offset value (in counts) which will override the offset automatically calculated by the Power Mate APM module following a reset or power cycle condition. The Update Flash Memory immediate command, documented below, can then be used to retain the manually entered value.

Update Flash Memory Immediate Command

A new %AQ immediate command, 4Ah, has been added in support of digital encoder mode. When the Power Mate APM is configured for digital absolute encoder mode, at the end of a Set Position or Find Home command it automatically calculates the correct Absolute Feedback Offset to apply to make the absolute encoder actually report the Set Position or Home Position value. This offset is stored in volatile RAM memory which is lost whenever the Power Mate APM module is reset or power cycled. The Absolute Feedback Offset may be stored to retentive flash memory by way of the Update Flash Memory immediate command. When this is done, the correct encoder Absolute Feedback Offset value will automatically be restored following a module reset or power cycle condition.

Velocity Loop Gain Immediate Command for Digital Servos

A new %AQ immediate command, 2Eh, has been added in support of digital feedback mode. The velocity loop gain for a digital axis is used to match load inertia to the motor inertia, with a value of 16 representing a ratio of 1 to 1. The default velocity loop gain is set using the *Integrator Time Constant* setting in the Configuration Software.

Torque Limit Immediate Command for Digital Servos

A new %AQ immediate command, 2Fh, has been added in support of digital feedback mode. The torque limit command provides a method of limiting the torque produced by a digital servo motor on each axis, across the range of 1–100% in units of 1%. Whenever the Power Mate APM is power cycled or reset, the torque limit is initialized to 100%.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

New Features and Functionality for Previous Upgrade (2.11)

None

New Features and Functionality for Previous Upgrade (2.10)

Superimposed Point-to-Point Moves on Follower Motion

The follower mode of operation has been enhanced to allow each axis to execute a standard motion program created by the Power Mate 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 may be commanded solely from the stored program data if there is no master command or if the follower is not enabled. With this type of operation a stored program may be used to control axis 2 with axis 1 following per the designated ratio. 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 a Power Mate 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.
   - Each axis has a *Drive OK* input instead of *Overtravel Limits* inputs

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 Power Mate APM until 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.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

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 Power Mate APM firmware release 2.10.

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

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:

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

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.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Motor Direction Configuration Setting

The IC641 configuration software version 6.01 now supports the configuration of motor direction for each 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 has been added for a slave axis when the follower is enabled / disabled (respectively) without losing any master counts when the master is enabled. A %I status bit is provided to indicate when the follower axis has achieved master command velocity after being enabled and also to indicate when decelerating after the follower is 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 Power Mate 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 may be changed with immediate commands) will be used for the move. Note that if the move command is executed with the Power Mate 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.

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

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 Power Mate APM which were not directly supported by the IC641 configuration software at the time of the new Power Mate APM firmware release. For release Power Mate 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 Power Mate APM via %AQ immediate commands is stored in volatile memory, unlike standard configuration data which is stored in non-volatile memory. When the Power Mate 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 Power Mate 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 Power Mate APM whenever the status bit is detected as having been cleared.

Restrictions and Open Problems

None

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

Artisan Technology Group is an independent supplier of quality pre-owned equipment

Gold-standard solutions

Extend the life of your critical industrial, commercial, and military systems with our superior service and support.

We buy equipment

Planning to upgrade your current equipment? Have surplus equipment taking up shelf space? We'll give it a new home.

Learn more!

Visit us at **artisantg.com** for more info on price quotes, drivers, technical specifications, manuals, and documentation.

Artisan Scientific Corporation dba Artisan Technology Group is not an affiliate, representative, or authorized distributor for any manufacturer listed herein.

We're here to make your life easier. How can we help you today?

(217) 352-9330 | sales@artisantg.com | artisantg.com

ARTISAN® TECHNOLOGY GROUP