WARNING Important Information, please read carefully

Class 5 SmartMotor™ servos may be used as upgrades to replace older Class 4 series SmartMotor Servos. However, there are some syntax differences . The SMI software has a code converter that will convert Class 4 code for you. However, it may require manual editing to maintain proper distances, velocities and accelerations.

Additionally it may require changes to following error limits and PID tuning parameters. Please consult the User's Guide and help files as necessary.

NOTE: It is not recommended to mix Class 4 and Class 5 motors on the same serial daisy chain.

Do not run Class 4 motors in Contouring Mode with Class 5 motors on the same daisy chain. It WILL NOT WORK.

SmartMotor Hardware and Control Limitations

Each SmartMotor is an integrated motion controller, drive amplifier and motor.

As with any motion controller, care should be taken with regard to connections, communications, and control. Proper grounding and shielding techniques should be observed and utilized.

Standard SmartMotor Controller & Drive Specifications:

All standard SmartMotor servos should be powered from 18VDC to 48VDC. Under no circumstances should they be allowed to run off of any higher voltages. Lower voltages could cause a brownout shutdown of the CPU or what would appear as a down power reset under sudden load changes. If power is reversed on any standard SmartMotor, immediate damage WILL occur and the SmartMotor will no longer operate.

NOTE: During hard fast decelerations, a SmartMotor can pull up supply voltages to the point of damage if a shunt resistor pack is not used.

NOTE (FOR M-STYLE MOTORS):

Drive Power and Control Power are Separate Inputs. Control power is rate max range of 18 to 32VDC.

Drive Power is from 18 to 48VDC max.

The drive stage stage of D-style motors should not be powered through pin 15 of the DB15 connector under any circumstances. Doing so can cause damage to the internal circuitry.

CPU Power:

All SmartMotor servos have an internal 5VDC power supply to run the internal CPU. This supply can be easily damaged if an external voltage source of a higher potential is applied. Do not exceed 5VDC on and I/O pin or 5VDC pin on any SmartMotor.

I/O Restrictions and Limitations:

Each on-board I/O pin has a minimum amount of protection consisting of a 100-Ohm current limit resistor and a 5.6VDC Zener diode. Each I/O pin also has a 5Kohm pull-up resistor. When assigned as outputs, they act as a push-pull amplifier that drives hard to either the positive or negative 5VDC rail. This means they are not open-collector I/O pins. Each I/O pin can sink and source up to 25mA. Exceeding this could result in damage to the I/O port.

Communications:

Each SmartMotor has a 2 wire RS-232 port. This port meets IEEE standards with full +/- 12VDC potential on the transmit line. Proper serial ground signal referencing and shielding techniques should be used. Under no circumstances should the shield of a cable be used for the RS-232 ground reference. This could result in noise or corrupt data as well as ground loops that could damage the serial port chip set.

Each SmartMotor boots up default to the ECHO_OFF state. This means that nothing received is transmitted or echoed back out.

This is important to remember in serial "daisy-chain" set-ups. They also boot-up defaulted to base address zero meaning they will listen and respond to any incoming valid SmartMotor commands.

Hardware Protection Faults:

All Class 5 SmartMotor protection faults (over Current and over Temp) result in dynamic braking on error. This means the windings are shorted out to dissipate power as fast as possible.

WARNING

All motors WILL trip on thermal limit at 85°C. They will not reset until cooled back down below 80°C. The SmartMotor should be operated between 0 and 85°C, and stored between -10 and 85°C, non-condensing. In other words, reaching dew-point can cause moisture to condense on the encoder disk causing loss of integrity of position feedback. The SmartMotor should not be started up cold below 0°C.

Software Protection Faults:

Limit switch inputs and position error limits are both "software" protection faults. This means they are not firmware unchangeable. The effects of Limit Switches and Position Error can be changed via valid software commands or set-up parameters.

Position Error is predicated by a value set by the user and can drastically effect SmartMotor response under varying load conditions and tuning. Limit switches can be set up to cause the SmartMotor to servo in place instead of free wheel. Refer to specific firmware addenda for various limit switch options and capabilities.

Motor Torque Limits: AMPS Command and T (Torque) Command

Motor T (torque) command is only for use in Mode Torque (MT). It has no effect on motor operation outside of Mode Torque.

The AMPS command has effect over all other modes of operation. It limits absolute maximum power available from the drive amp to the motor windings as a function of percent duty cycle of PWM (Pulse Width Modulation). The AMPS command should be used when it is desired to limit motor torque to a sensitive or torque input limited load. It may also be used to reduce the chance of reaching peak over current errors on high acceleration applications.

Error Handling, Motor Status Bits & Internal Conditions:

SmartMotors have many 16 Bit status words that contain interrupt registers triggered by selected events. These events include Position Errors reached, Over Current reached, Limit Switch

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conditions, Syntax errors and so on. In addition, in the newer SmartMotor servos, Bus Voltage, Drive Current, and SmartMotor Temperature are also available. By proper use of these status bits very simple and very flexible error handling can be achieved. Motors can be made to respond under varying load conditions in different ways and recover from any given software or hardware fault in a controlled manner.

Switching Power Supplies:

Most switchers will go into an OFF state on over-voltage. Few of them have a buck-regulator that prevents over-voltage. The ones that do are very costly and large. Always use a Shunt when using a switching power supply to aid in suppression of bus overvoltage. Switching power supplies should be sized to provide maximum expected current for the entire motor system under the worst load considerations. This is because switchers have no "reserve" like linear power supplies do. When they reach maximum current, they shut down or reset.

WARNING: Improper Power Supply Sizing may result it Motor Position Error Faults, Motor Resets, and Machine Faults

Mechanical Brakes:

Any time the load can be easily back driven or is in a vertical orientation, an electromechanical fail-safe brake is highly recommended. Under no situation should a PLC or external controller be used to control a fail-safe brake on a servo. The response time will be diminished to the point of defeating protection. Instead, use the SmartMotor interrupt control features stated here:

Use the EOBK( ) command in conjunction with the BRKTRJ or BRKSRV commands:

```
EOBK()  command can assign the brake function to any
        I/O pin. value is -1 to disable.
BRKENG  - engage brake immediately, disable drive
BRKRLS  - release brake immediately. Warning: motor
        may freewheel.
BRKTRJ  - motor engages brake at end of trajectory.
        Releases when new move started.
BRKSRV  - motor engages brake when drive turned off
        due to OFF command or fault.
```

In making use of selected commands from above, the brake will get a signal to engage (be de-energized) within 250 to 500 microseconds of its trip condition. Using the PLC will cause a delay of anywhere from 4 to 10 milliseconds due to scan time, process time and brake release time. By then, the current in the control could have already well exceeded limits.

Position Error Limits:

Let's suppose you have a maximum allowable position error limit of 1000 encoder counts. The SmartMotor can hit a hard stop and go up to 999 encoder counts into position error before a trip condition is met.

The time it takes to get to that position error may be slow or fast depending on the speed you are moving.

Set "EL" to the lowest value possible to allow continued machine operation without spurious position error faults occurring.

Amplifier Tuning:

Let's suppose you have "tight" tuning of KP>3000 or so and KD>20000 or so. This is just an example of slightly tight tuning, but not too high. The higher the numbers, the faster motor current will rise under a given increase in position error. Collectively, with the above mentioned facts about "E" maximum allowed position error, the current may rise much faster. It is best to ratio acceptable tuning values with good Position Error values so as to maintain the lowest running position error with the lowest value of "EL" possible. The ironic thing here is that usually to get decrease following error implies increasing tuning. This is true, but for example: KV (velocity feed forward) and KA (acceleration feed forward) are better means to achieve this goal.

These tuning values lower position error while moving without increasing motor current because they shift the motor position command forward in the trajectory for the entire move, compared to during the dynamics of changes in moves. As a result, you get lower peak currents in the motor.

Power Supply Voltage Levels:

The higher the voltage, the faster the motor can move and the faster it can accelerate. This is a good thing, but in conjunction with faster acceleration, the higher the voltage, the closer to a peak voltage for over-voltage breakdown of the controller. Also, the higher the voltage, the faster a rate of change of current can occur. It is a risk with any application to get faster response by moving towards a higher voltage. Typically speaking, it is the dynamics of sudden changes that increases risk by a "x^2" factor whereas the continuous load risk is only a direct ratio increase. This is because rate-of-change in current is proportional to acceleration which is the square of velocity, i.e. x^2. For safety sake, a 42VDC supply for a 48VDC system gives good margin with little speed losses.

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Firmware Safety Control Options:

The firmware has the ability to suppress Back-EMF voltages any time the calculated trajectory has been exceeded by actual motor motion. In other words, the processor is looking at where it should be compared to where it actually is. Any time the motor exceeds dynamic position per calculated trajectory, the drive amplifier shunts power to maintain dynamic position control. As a result, excessive currents are suppressed at a rate of response of ~250 micro seconds.

Additionally, if the motor faults out for either Position Error, Travel Limit, or Thermal Limits, it will automatically short out the windings and dynamically stop the shaft.