Animatics SmartMotor™ Success Checklist

- *Power Supply Selection*
- *Proper Electrical Interfacing*
- *Sizing a SmartMotor for the Application*
- *Thermal Environment*
- *Mechanical & Environmental Implementation*

ANIMATICS®

Defining the Future of Motion Control

Follow these easy rules to assure success in using the Animatics SmartMotor™ to maximize your system's reliability. Please take a minute to see that your system design and implementation passes the test. Keep these pages handy to document your settings and send it along with any motors returned for inspection or repair.

1. Power supply selection is very important.

- ☐ **Use a transformer based power supply, or properly size a switching supply.**
- ☐ **Fuse the connection.**
- ☐ **Provide for a means to keep the SmartMotor's voltage below 48VDC.**
  - ○ using a shunt near the motor or,
  - ○ adding a shunt to a switching power supply or,
  - ○ operating at 42VDC or less and adding a shunt for a Vertical Application.

2. Proper electrical interfacing is essential.

- ☐ **Refrain from creating any ground loops with the communications by…**
  - ○ isolating the ground prong of the host PC for a single motor application or,
  - ○ isolating the motor's power supply for a single motor application or,
  - ○ using a communication's isolation product to protect each axis or,
  - ○ operating only smaller motors at low power, like short SM23s or smaller.
  - ○ Employing no serial communications makes isolation of the communications a moot point.
- ☐ **Refrain from creating any ground loops with the SmartMotor's I/O by…**
  - ○ using the main or 5V power at the motor to operate any sensors or,
  - ○ using an opto-coupler to interface to the inputs or outputs or,
  - ○ using an I/O isolation product or,
  - ○ operating only smaller motors at low power, like short SM23s or smaller.
  - ○ employing no I/O connections makes isolation a moot point.

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3. Properly sizing an Animatics SmartMotor™ for the application is critical.

- [ ] **Determine that the motor selected has the torque to handle the friction.**
- [ ] **Determine that the motor selected has the torque to support any vertical loading.**
- [ ] **Determine that the motor selected has the torque to accelerate the load.**
- [ ] **Determine that the motor's rotor inertia is properly matched to the load.**

4. Considering the thermal environment for the SmartMotor is important.

- [ ] Consider the ambient temperature and avoid applications above 70°C ambient.
- [ ] Maximize the heat sinking capability of the motor's mount to any extent possible.

5. Proper mechanical and environmental implementation is needed.

- [ ] Assure motor shaft loading is within axial and radial limits.

- [ ] Be certain that the motor does not get exposed to fluids or excessive moisture.
- [ ] Insure relative humidity is <30% and non condensing.

1. Power Supply selection is very important.

There is a simple way to compute the required current for a given application. This is useful when choosing a power supply for a given application, but it is also useful when attempting to calculate how many motors can be powered from one supply in low current applications. The peak current can be computed by taking the peak required torque (Tp) and dividing it by the torque constant (Kt) of the motor in question. Example: An engineer has decided on using an SM2337D SmartMotor (Kt = 5.60 oz-in/Amp), and has determined that 100 oz-in of peak torque is required for the application in question. The peak required current would be Tp/Kt, or (100 oz-in)/(5.60 oz-in/Amp), which amounts to 17.9 Amps.

Any voltage between 10VDC and 48VDC will satisfy the requirements of the SmartMotor. Higher voltage, however, will permit the SmartMotor to run faster. Each motor will produce so much RPM per Volt. A voltage should be selected to offer from 50% to 100% more speed than is required by the application. Once a servo reaches its top speed, it can no longer output any torque.

☐ **Use a transformer based power supply, or properly size a switching supply.**

The SmartMotor™ is a switching device that uses PWM (Pulse Width Modulation) to regulate the power of the motor. Based on the application needs, the motor may be drawing just a few dozen milliamps one moment, and then a few dozen amps the next. It may even drive current back into the supply when it is decelerating an inertial load, or lowering a heavy vertical load The absolute best power supply for a servo system is a simple transformer, rectifier and capacitor design, with no active components trying to regulate the voltage. A shunt may also be necessary, but that is addressed in another section.

Many applications benefit, however, from enjoying the smaller form-factor, lighter weight or greater availability of switching power supplies. Be careful! If a SmartMotor draws an excessive amount of current from a non-regulated supply, the voltage will simply sag, however, if it draws even a bit more than the specification of a switching power supply, the power supply will “crowbar”, basically completely letting go of the load at a time when power is needed the most. This will not only fail the application, but you might also damage the SmartMotor. When sizing a switching power supply, you must be sure to size it for the Maximum Possible, peak, current draw of the SmartMotor, not the expected Continuous draw as you could with an unregulated supply.

When using a switching power supply, it is most desirable to operate the SmartMotor from a switching power supply that is loaded by many other, more or less constant current devices, where the SmartMotor doesn’t overwhelm the total power budget.

Also, it can be even more important to use a shunt (a device that burns off excess power resulting from motor back-drive) with a switching power supply for two reasons. First, because of its tight regulation, you may get a switching supply set to a voltage very near the SmartMotor’s limit, leaving little budget for a voltage spike. Second, a switching power supply will not accept current driven back to the supply, so current sent back to the supply from a motor being back-driven will end up pouring charge into its own capacitors, and the small capacitance in the output stage of the supply, driving the supply voltage up beyond the SmartMotor’s limit, causing damage.

So, please use a transformer based power supply, or pay close attention to properly sizing a switching supply to provide a foundation to enjoy the SmartMotor’s industry leading longevity.

☐ **Fuse the connection.**

Each SmartMotor should have its power separately fused in a single, serviceable location. A slow-blow fuse rated above the continuous current requirement of the application will protect the motor under most circumstances, and yet survive the inrush current that occurs during power-up due to the SmartMotor’s internal capacitance.

Continued on next page.

- [ ] **Provide for a means to keep the SmartMotor's voltage below 48VDC.**

Over-voltage can occur due to voltage spikes entering the power supply, by abrupt decelerations of the motor with a heavy inertial load or by the back-driving of the motor due to a falling vertical load that changes the motor into a generator. Another common cause of over-voltage arises when the unloaded voltage level of a power supply goes overlooked. It is not uncommon, for example, for an unregulated "48 Volt" power supply to actually put out 55 Volts or more when unloaded, or lightly loaded, as would be the case of a SmartMotor that is not moving or holding. Operating at 42VDC or less as nominal is an excellent way to help protect the SmartMotor from damage due to inadvertent over-voltage. Having the additional 6 Volts of headroom is usually enough to protect against all of these conditions, except for the falling vertical load.

- ○ Using a shunt near the motor provides the best protection for over-voltage arising from virtually any circumstance. The key word is "virtually". As an example, 10 feet of 14 or 16 gage wire is "near" the motor. 100 feet of wire, of any gage, is far away. At this distance, the wire experiences a significant voltage drop when current flows and isolates the SmartMotor from the voltage protection that the shunt is supposed to offer.
- ○ Adding a shunt to a switching power supply will prevent at least one of the failure modes known to be associated with the use of switching power supplies in servo applications - back drive or "regeneration".
- ○ Operating at 42VDC or less and adding a shunt for a Vertical Application is the safest way of handling voltage regulation problems. The added 6 Volts of margin combined with the shunt protection will maximize the reliability of the SmartMotor in an application that due to gravity or other influence, can be back-driven by the load itself.

2. Proper electrical interfacing is essential.

☐ **Refrain from creating any ground loops with the communications.**

When multiple devices exist within the same system, they often need to communicate to one another. For signal connections to be made, it is quite often necessary for the devices to share ground connections as well. This can create problems when these devices are operating from different power supplies and those supplies are connected to power sources referenced to differing potentials. Current can actually flow from one ground connection to another, causing the resistance in the wiring to allow the current to flow and votlage to drop. Isolation is the solution to these problems. Power can be isolated with transformers and signals can be protected with, among other things, OPTO-Isolators.

- ◯ Isolating the ground prong of the host PC for a single motor application is the simplest way to avoid a ground loop and associated damage. Unfortunately, it presupposes that the application has only a single axis. In a multiple axis application, the issue of isolating each axis from the other still exists.
- ◯ Isolating the motor's power supply for a single motor application is another way to avoid ground loops, note this only applies to the simplest of applications. Most power supplies either completely isolate the output from the input, or at least offer that provision. If isolation is done, it is further necessary to connect the host device to the SmartMotor directly. Avoid taking Transmit and Receive, for example, from the motor, but ground from the power supply. This mistake would expose the host computer to voltage spikes across the SmartMotor's power supply ground wire. If the motor's power is isolated, it should be enough to run the host device's Transmit, Receive and Ground wires directly to the associated pins on the SmartMotors main connector.
- ◯ Using a communication's isolation product to protect each axis in multiple axis applications is one of the best solutions. These are featured in the SmartMotor catalog and are designed to be very simple and effective solutions.
- ◯ Operating small wattage motors, such as a size 17 or 23 at low power can eliminate ground "bounce". If this is the case, then interfering electrical noise, one of the two problems associated with isolation, is averted. The other problem with a ground loop is that two devices connected to the loop may, themselves, be at different potentials. For example if a host PC is connected to a power source that exists, for whatever reason, at a different level than the SmartMotor's power supply, large currents will flow through the ground wires. A warm or melted RS-232 cable is a sure sign that this problem exists! Isolating the host device or power supply can solve this issue and the simple fact that the motors are small and don't draw much current can solve the issue of electrical noise without isolating each and every axis. Greater success with this approach can be achieved by using very heavy gage (~14 gage) ground wire from motor to motor. Operating without isolation in the communications when using small motors, but at maximum torques, will probably not work reliably.
- ◯ Employing no serial communications makes isolation of the communications a moot point.

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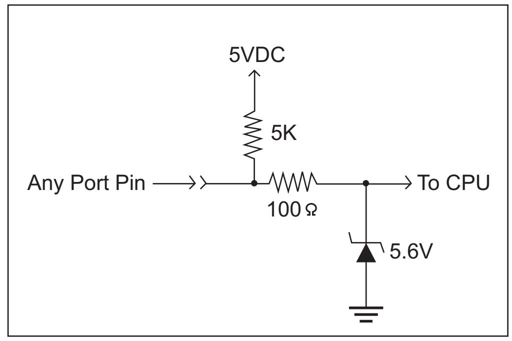
☐ **Refrain from creating any ground loops with the SmartMotor's I/O.**

The SmartMotor's I/O is TTL level (0 to 5V) and can be damaged if not used properly. Each I/O point has multiple functions. All I/O points enter the CPU in two places, one as a digital input and another as an analog input. This means that no matter how you are using the I/O point, you can read back the analog value and learn a lot about how it is performing. For example, if the E and F inputs are being used as an RS-485 port, the analog reading capability can reveal whether the signals are properly biased when inactive. Refer to the Internal Port Schematic on the right to predict how the SmartMotor's I/O may influence external circuits.



SmartMotor™ Internal Port Schematic

- ○ Using the main or 5V power at the motor to operate any sensors is the best way to eliminate ground loops from I/O. That is why the power is there. If power goes from the SmartMotor's I/O connector, to the sensor and the signal comes back, then there are no ground loop issues. In rare applications where the sensor cable travels a long distance through an electrically noisy environment there may be a noise issue to contend with. Even still, proper shielding would most likely address this issue without engaging further circuitry for the purpose of isolating the signal. If the sensor requires 24 Volts, rather than 5, and a 5 Volt alternative is not available, then this can be solved by operating the SmartMotor itself at 24 Volts and pulling power for the sensor, AT the motor. Absent that alternative, another option must be selected. Also, if a signal is not coming from a sensor, but rather from another motor or PLC, then this solution does not apply.
- ○ Using an opto-coupler to interface to the inputs or outputs involves a few parts, but solves the problems of ground loops and electrical noise.
- ○ Using an I/O isolation product is a simple and clean way of solving the problem of isolation. Many isolating I/O products can be found in the SmartMotor catalog. These offer the additional benefit of interfacing 24 Volt I/O to the SmartMotor's I/O.
- ○ Operating size 17 or short stack 23 motors at low power can create an environment where the TTL signals of the SmartMotor's I/O connector are adequate. The I/O signals can travel short distances, ten feet or less, from motor to motor without a problem, provided the cables are thoroughly shielded. Greater success with this approach can be achieved by using very heavy gage (~14 gage) ground wire from motor to motor. Operating without isolation for the I/O when using small motors, but at maximum torques, will probably not work reliably.
- ○ Employing no I/O connections makes isolation a moot point.

3. Properly sizing a SmartMotor for the application is critical.

- [ ] **Determine whether the motor selected has the torque to handle the friction.**

A little friction in a SmartMotor's load can be quite good for added stability. A lot of friction will require that you consider the frictional load when sizing the motor. A 20% to 50% safety margin should be applied to an overall system, but where the frictional load is concerned, measurements should be taken to verify expected values under worst case scenarios. The actual friction of a system should be measured over both temperature extremes the machine is specified to operate under. A sampling of multiple units is also advisable to eliminate any anomalies.

- [ ] **Determine whether the motor selected has the torque to support any vertical loading.**

○ Calculating the torque applied to the motor due to a hanging load will produce a value that must be handled entirely by the motor's continuous torque capability, unless there is a brake in the system or some other device that would relieve the motor from the constant burden of this otherwise ever present load.

○ Employing a design with no vertical load component at all is ideal. Many applications don't carry this burden and those that do can be assisted with design elements such as spring elements or counter balances. Often, the most reliable solution is simply to use a SmartMotor with plenty of torque to support the constant load or to add a gearhead to a smaller motor.

- [ ] **Determine whether the motor selected has the torque to accelerate the load.**

In most applications, the load's inertia is the greatest component of the motor's loading throughout the motion trajectory. Newton teaches us that F=mA which tells us that it takes a force to accelerate a mass. Common motor sizing programs or simple equations such as this can be used to determine the torque required to accelerate a load.

- [ ] **Determine whether the motor's rotor inertia is properly matched to the load.**

Just because the motor selected can more than handle the friction and the acceleration of a load does not mean the job of selecting a motor is done. Extremely high inertial loads can prevent a servo from every becoming stable. A rule of thumb is to be concerned when the load inertia as felt from the shaft of the motor is greater than 10 times that of the motor's rotor itself. Under this circumstance, there are two saving factors. The first is friction. If there is sufficient friction to the system, then the stability can often be achieved, even with inertial mismatches as great as 100 to 1. The second saving factor lies in the demands of the motion themselves. If it is not required that the load be started and stopped very rapidly, then the little stability actually required by the application may permit similarly high inertial mismatches. Usually, actual experimentation is the only way to produce the answer.

4. Considering the thermal environment for the SmartMotor is important.

☐ **Consider the ambient temperature and avoid applications above 70°C ambient.**

SmartMotors are rated at standard room temperature, 27°C. If the ambient temperature is greater than this, then the full continuous torque rating of the motor should not be expected. Likewise, if the application operates at a lower ambient temperature, then more than the rated torque of the motor is available.

Temperature Variance Chart	
Temperature (in C.)	*TC - Contin. Torque* (in % of rated torque)
0	133%
5	133%
10	133%
15	126%
20	112%
25	100%
30	89%
35	79%
40	71%
45	63%
50	56%
55	50%
60	45%
65	40%

☐ **Maximize the heat sinking capability of the motor's mount to any extent possible.**

Some heat sinking qualities of the motor's mount are expected. The motors are rated on a 10 inch by 10 inch by ¼ inch thick heat sink. If more heat sinking is available then more continuous torque can be generated by the motor and higher ambient temperatures can be better tolerated. Thick, aluminum bulkheads are ideal.

5. Proper mechanical and environmental implementation is needed.

☐ **Assure that the design places no appreciable axial force on the motor's shaft.**

Pressing in on the SmartMotor's shaft can cause damage to the rear bearing and possibly the encoder itself. The SmartMotor is designed to provide torque, not bearing support to an application. Radial force resulting from belt tension from a shaft mounted pulley is designed for. Typically, the SmartMotor's front bearings are so sturdy that the real concern with overloading the shaft with radial force is the bending of the shaft itself.

☐ **Be certain that the motor does not get exposed to fluids or excessive humidity.**

Unless the SmartMotor being used is specially equipped with IP65 protection, it is vulnerable to fluids and even humidity. Measures should be taken to protect the motor from damage associated with such contaminants.

ANIMATICS®

MISSION STATEMENT

- We define the future of motion control by innovation, invention, and a dedication to the highest standards of professionalism and quality in everything we do and in every product that we make.
- We invite quality firms to ally with us and to participate in our inventions and innovations for the benefit of the companies that need and use our advanced technology and products.
- We invite our customers and users to join with us in the joint development of custom products and systems using our technology.
- We commit to providing a fair workplace for our employees.
- We subscribe to the principle of being a good corporate citizen, a good neighbor, and a protector of our environment.

QUALITY STATEMENT

- We define the future of motion control by providing products and services that adhere to the goal of Zero Defects.
- We require that all work done by Animatics Corporation adhere to the policies, practices, and instructions maintained in our Quality System Policy Manual.
- We require that our vendors and sub-contractors have quality programs in effect that adhere to the goal of Zero Defects.
- We meet and confer with our suppliers for the purpose of discussing and monitoring their quality and performance.
- We realize that our goal of perfection is statistically difficult and that some actual or latent defect may exist from time to time. We know that it is important to minimize machine downtime for the users of our products. For those instances we have our “fast track” product replacement program that offers 24 hour replacement of most standard products.

All integrated motor products made by Animatics are covered by patent number 5,912,541.

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