The form of motor control we all know best is the simple manual station with up and down pushbuttons. While these stations may still be the perfect choice for certain applications, a dizzying array of more sophisticated controls is also available. This article addresses the basic electrical requirements of the motors and user interface issues you will need to address before specifying, building or buying winch controls.

To begin with, the manual control stations should be of the hold-to-run type, so that if you take your finger off of the button the winch stops. Additionally, every control station needs an emergency stop (E-stop) that kills all power to the winch, not just the control circuit. Think about it—if the winch isn’t stopping when it should, you really need a failsafe way to kill the line power. It’s also a great idea to have a key operated switch on control stations, especially where access to the stations is not controlled.

Safe operation by authorized personnel must be considered when designing even the simplest manual controls.

Treating Fixed Speed Motors

The actual controlling device for a fixed speed winch is a three phase reversing starter. The motor is reversed by simply switching the phase sequence from ABC to CBA. This is accomplished by two three-pole contactors, interlocked, so they can’t both be closed at the same time. The NEC requires both overload and short circuit protection. To protect the motor from overheating due to mechanical overloads a thermal overload relay is built into the starter. This has bimetallic strips that match the heating pattern of the motor and trips contacts when they overheat. Alternatively, a thermistor can be mounted in the motor winding to monitor the motor temperature. Short circuit protection is generally provided by fuses rated for use with motors.

A separate line contactor should be provided ahead of the reversing contactor for redundancy. This contactor is controlled by the safety circuits: E-stop and overtravel limits.

This brings us to limit switches. When you get to the normal end of travel limit the winch stops and you can only move it in the opposite direction (away from the limit). There also needs to be an overtravel limit in case, due to an electrical or mechanical problem, the winch runs past the normal limit. If you hit an overtravel limit, the line contactor opens so there is no way to drive off of the limits. If this occurs, a competent technician needs to fix the problem that resulted in hitting the overtravel limit. Then, you can override the overtravels using the spring return toggle switch inside the starter—as opposed to using jumpers or hand shooting the contactors.

Variable Speed Requirements

Of course, the simple fixed speed starter gets replaced with a variable speed drive. Here’s where things start to get interesting! At the very least you need to add a speed pot to the control station. A joystick is a better operator interface, as it gives you a more intuitive control of the moving piece.

Unfortunately, you can’t just order any old variable speed drive from your local supplier and expect it to raise and lower equipment safely and reliably over kids on stage. Most variable speed drives won’t, as they aren’t designed for lifting. The drive needs to be set up so that torque is developed at the motor before the brake is released, and (when stopping) the brake is set before torque is taken away.

For many years DC motors and drives provided a popular solution as they allowed for good torque at all speeds. The large DC motors required for most winches are expensive, costing many times what a comparable AC motor costs. However, the early AC drives were not very useful, as they had a very limited speed range and produced low torque at low speeds. More recently, as the AC drives improved, the low cost and plentiful availability of AC motors resulted in a transition to AC drives.

There are two families of variable speed AC drives. Variable frequency inverters are well known and readily available. These drives convert AC to DC, then convert it back to AC with a different frequency. If the drive produces 30 Hz, a normal 60 Hz motor will run at half speed. In theory this is great, but in reality there are a couple of problems. First, a typical 60 Hz motor gets confused at a line frequency below 2 or 3 Hz, and starts to cog (jerk and sputter), or just stops. This limits you to a speed range of as low as 20:1—hardly suitable for subtle effects on stage! Second, many lower cost inverters are also incapable of providing full torque at low speeds. Employing such drives can result in jerky moves, or a complete failure to lift the piece—exactly what you don’t want to see when you are trying to start smoothly lifting a scenic element. Some of the newer inverters are closed loop (obtain feedback from the motor to provide more accurate speed control) and will work quite well.

The other family of AC drives is flux vector drives. These units require an encoder mounted on the motor shaft allowing the drive to precisely monitor the rotation

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of the armature. A processor determines the exact vector of magnetic flux (thus flux vector drive) required to rotate the armature the next few degrees at a given speed. These drives allow an infinite speed range, as you can actually produce full torque at zero speed. The precise speed and position control offered by these drives make them a favorite in high performance applications.

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Circuit). When multiple winches are used to carry a single piece, the winches must be perfectly synchronized, or the load can shift so that an individual winch can become dangerously overloaded. The control system must be able to keep selected winches in synch or provide a rapid, coordinated stop if a winch is unable to stay in synch with the others. With a typical top speed of 240 fpm and a requirement to keep the winches within a 1/8” of each other, you have less than three milliseconds to recognize a problem, attempt to correct the errant winch’s speed, determine that you’ve failed and initiate a coordinated stop of all the winches in the group. This takes a lot of computing, fast I/O, and well-written software.

There are two very different approaches to large rigging control systems. Originally, a single console was used, with the usual problem of where it should be located for the operator’s optimum view. Unfortunately this can change not only from show to show, but also from one cue to the next. This dilemma has been partially addressed by using video cameras at different locations in conjunction with 3D screen graphics that allow the operator to view the expected rigging motion three dimensionally from any viewpoint. This allows the operator to view the on screen movement of the rigging from a viewpoint that matches his actual view of the stage, or the actual view of a closed circuit camera. For complex moves with inter-related pieces this makes the control and understanding of what is happening much simpler.

The other approach is a distributed system, with several portable consoles. This allows different operators to control different aspects of the rigging, in the same manner we have done with manual sets. A dramatic example of this approach is used by the Royal Opera at Covent Garden, where there are ten consoles controlling a total of 240 motors. Each console has five playbacks, and is set up so that each motor is assigned to a single console. One operator and console could control everything, but frequently one console may be running stage lifts, another the onstage rigging, and a third is being used backstage to move stored drops.

PLC Based Systems

A PLC is a programmable logic controller. First developed to replace the relay based industrial control systems of the ’50s and ’60s, these controls are at home in rugged, industrial environments. These are modular systems with a great variety of I/O modules allowing semi-custom hardware configurations to be assembled easily at a reasonable price. These include position control modules, counters, A/D and D/A converters and all sorts of solid state or hard contact closure outputs. The great variety of I/O components and the modular nature of the PLC make this an effective way to build custom and semi-custom control systems.

The greatest drawback to PLC systems is the lack of really great displays to tell you what they are doing or to help you program them. Monochrome and medium resolution color displays are the norm, as the primary use for these components in on a factory floor.

One of the first major PLC systems used in a large entertainment venue is the complex lift and wagon system at the original MGM Grand (now Bally’s) in Las Vegas. Several manufacturers offer standard PLC-based systems and a host of semi-custom acoustic banner, shell, and lift control systems is also available. The ability to build custom systems from standard building blocks is the greatest strength of PLC-based controls.

High End Controllers

The most sophisticated rigging controllers go well beyond speed, time, and position control. They include the ability to write complex cues, record profiled moves, and manage multiple cues running at once.

Many of the larger opera houses are moving toward point hoist systems, where there is a separate winch for each lift line (the rigging equivalent of dimmer per circuit).
Conclusion

The tremendous variety of rigging control systems currently available ranges from the pushbutton station to complex multi-user computerized control system. When shopping for rigging control systems you generally get what you pay for. The most important features are safety and reliability. These are features with real value, and you should expect to pay a fair price for this security. Work with an established manufacturer who can show you working installations and who will put you in contact with users who have requirements similar to yours.

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