

Replacing Motor-Generator Sets With Modern Static DC Drives

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For many years, high-performance elevator systems utilized an extremely rugged, open frame, brush-type DC motor to power the hoist.

This controlled DC power was generated via an AC motor operating from line power and driving a DC generator -- a classic motor-generator set. This control configuration, known as a Ward Leonard system, basically regulates DC power to the hoist motor armature by controlling the generator field.

Although such relatively low-tech MG systems performed satisfactorily for years, they were not without drawbacks. Some common shortcomings included:

- ◆ *High power consumption:* The combined efficiency of a motor and generator working together to generate DC power is poor. Additionally, an MG set creates a constant and significant power drain -- even at idle speed when the elevator is not in motion.
- ◆ *MG sets require high routine maintenance:* MG sets are normally specified at minimum size and cost, but must rotate at relatively high speeds to meet DC power requirements. As a result, frequent and costly maintenance is a necessity.
- ◆ *Excessive generator brush wear:* Brush wear is a continuing and serious problem. Additionally, the large amount of carbon dust generated can contaminate the machine room, frequently causing failure of other electrical equipment.

Eventually the initial cost, high maintenance and overall wear and tear rendered utilization of MG sets impractical -- even while the rugged, low speed DC hoist motor kept operating as well as the day it was first installed.

Static DC Drives to the Rescue

At the same time, power electronics were providing new solutions to MG set problems by utilizing SCR static switches to directly convert AC line power to DC. This advance virtually eliminated all rotating and high-maintenance components involved in the production of DC power.

Additionally, conversion efficiency was greatly improved and idle losses drastically reduced, resulting in much lower power consumption.

Static components produced remarkable savings on maintenance, making MG set brush wear and carbon dust contamination things of the past. Crowded machine rooms also benefited from the comparatively small size of the static drive.

Today's Advanced, All-Digital Static DC Drives

Incorporation of modern microprocessor-based controllers into today's all-digital elevator drives provides:

- ◆ Minimum installation and operating cost.
- ◆ High reliability to substantially cut passenger entrapments.
- ◆ Exceptional performance to help reduce wait and floor-to-floor times.
- ◆ All digital control to assure repeatability over time and between hoistways.

Issues with early DC drives, including potentiometer difficulties, analog component drift and reliability problems have been virtually eliminated.

Today's DC elevator drives are designed and field-qualified specifically for elevator applications. They have the high lift capacity demanded for minimum floor to floor times and can withstand the rigorous duty cycle associated with high speed hoistways.

In addition, modern software incorporates unique control algorithms to provide optimum performance and a broad spectrum of Input/Output capabilities for car control interface.

DC Drives as MG Set Replacements

Since the introduction of DC static drives, MG sets have essentially disappeared from use in new hoistways. This in turn has caused manufacturers to exit the MG business, resulting in a severe shortage of replacement parts for existing MG set installations.

Thus, more and more MG sets are being replaced with all-digital DC drives as part of modernization programs or simply to reduce maintenance costs.

Application Considerations

There are three major considerations when upgrading a MG set to a digital DC drive. Those considerations are:

- ◆ Input Power,
- ◆ Output Power,
- ◆ Car Control Interface.

Input Power Considerations

Power Feed: Since it converts AC to DC directly, the DC drive will draw approximately 30% more amps from the line during car acceleration. Also, the requirement for peak acceleration amps is immediate, rather than built up gradually as with the MG set. The power line must be able to support these conditions without excessive voltage drop affecting equipment on the same feeder.

Input Voltage: The MG set converted line volts to armature volts via rotating components. The static DC drive does the AC to DC conversion directly via three-phase rectification. If the DC voltage required by a hoist motor is significantly lower than the line input, the drive will lower the input power factor -- which is not normally desirable. Thus, an input voltage conversion transformer is always recommended. As you will see, there are other good reasons for using this transformer.

Power Line Distortion: Static switching draws square wave current from the line and creates a notch when current is commutated from one switch to another. The result is a harmonic distortion on the power line. Potentially harmful effects are generally eliminated by use of an input isolation transformer with good secondary reactance.

SCR Switching (commutation): Two conditions must be met to provide proper operation; 1) the AC voltage must be equal to or greater than the DC voltage, and 2) there needs to be 2-4% reactance on the input. Both these conditions can be met with an input transformer.

Transformer Sizing Criteria:

- ◆ Input Primary Voltage must match the Line Voltage.
- ◆ Output Secondary Voltage must equal or exceed DC Armature Voltage. If there is a potential for the line to droop, then a 10 - 20% increase in secondary voltage is recommended as a safety factor .
- ◆ 5% voltage taps are recommended to allow for field conditions.
- ◆ Continuous (rated) secondary amps should equal or exceed $1.05 \times 0.82 \times \text{Full Load DC arm. amps.}$
- ◆ Continuous (rated) KVA rating is $\text{Sec. amps} \times \text{sec. volts} \times 1.732$
- ◆ Transformer must not saturate when Accel Amps are substituted for Full Load Amps in the above formula.
- ◆ The secondary reactance should be 2 – 4%.

Output Power Considerations

These are somewhat more empirical since they depend on both motor and hoistway conditions. Thus, some degree of application experience must be taken into consideration.

DC Motor Armature: Elevator motors almost always have skewed armatures to minimize torque ripple and provide for a smooth ride. This is also the best motor for operation from a static DC drive. It is simply more difficult to obtain the desired performance levels from non-skewed armatures.

DC Drive Output Voltage Ripple: Three-phase rectification produces a 360Hz ripple on DC voltage. This ripple can excite the hoist motor and produce acoustical noise in the motor and mounting structure. This noise, in turn, is transmitted to the hoistway. Thus some type of ripple filter in the DC line is normally desirable.

Ripple Filter Recommendations

It is normally recommended that a ripple filter be added in the DC line from the static drive to the DC motor. The general criteria is:

- ◆ Filter inductance and resistance be approximately equal to motor armature inductance and resistance.
- ◆ Adjustable capacitance and damping resistance be included with the basic design criteria of roll-off starting at approximately 300Hz, and a tuned peak of approximately 100Hz. (Q of 1.2-1.5).
- ◆ The filter should be rated for continuous operation at Full Load Armature Current, and not saturate at Accel amps. Inductance needs to be constant from very low Armature Current through maximum Accel Current.
- ◆ The supplier of this filter must be familiar with its application.

Ripple Filter Adjustment: Most quality manufacturers provide application notes advising on how to measure the actual value of the filter, and how to properly set up the DC drive with the filter.

Acoustical Noise Abatement: Typically a static DC drive used in conjunction with the recommended ripple filter will achieve more than adequately quiet operation. Many times --

almost always for geared machines -- the addition of inductance alone will achieve the desired results. If it does, omission of the capacitors is recommended to minimize future maintenance. In the rare circumstance that unacceptable noise is still present after the filter and drive are properly adjusted, mechanical dampening of hoistway components is required.

Practical Experience: Experience within the industry has shown that a ripple filter consisting of a 5mh inductor with sufficient range of adjustment in the capacitors and damping resistance is broadly effective. But it remains the responsibility of the elevator application engineer and building owner to attain satisfactory results.

Car Controller Considerations

In total modernization projects, a new car controller that includes the drive is always installed. All interfaces with the drive are then either handled or specified by the car controller manufacturer.

If simply replacing the MG set while retaining the existing car controller, then several issues must be considered:

- ◆ An electrical schematic, wiring diagram and operational sequence chart should be generated to assure proper installation and operation.
- ◆ Compatibility of all signal and power supply ratings requires verification. In particular, low level electronic signals interfacing with relays must be controlled via appropriately rated contacts.
- ◆ Older style controls may not have had to consider the susceptibility to electrical noise of today's processor controls. Relay coil switching and contact arcing are significant noise generators that must be isolated from the electronics.
- ◆ A digital drive also generates electrical noise that must be isolated from existing electronic controls. Physical separation of products and wiring is the first step in successfully achieving that.