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AC INVERTER

Application Note:

RCU Series Regenerative Converter Unit – Estimating Energy Savings

Please refer also to the relevant Inverter Instruction Manual

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Background

Regeneration occurs whenever the load on a motor's shaft tries to turn the motor shaft faster than the inverter's output frequency is trying to drive it. This is referred to as "overhauling", and can occur when trying to decelerate a load, or when something on the load equipment is adding mechanical energy to the system. An example of the latter would be a load being lowered on a hoist; a downward inclined conveyor carrying a heavy load; or a fully loaded passenger elevator moving downward. In these situations, the inverter is really acting to restrain the motion of the load, and this causes regeneration.

During the normal course of operation of such equipment, the inverter will sometimes be driving the load, and sometimes regenerating. The intensity and frequency of regeneration is determined by a number of factors, including most significantly the operating profile of the equipment, meaning how often it starts and stops, how quickly it ramps up and down in speed, how long it dwells at constant speeds or at stop, hot often the load torque and shaft torque are in the same direction, etc. The inertia of the load, friction, and other factors come into play as well.

Regeneration causes the inverter's DC bus voltage to rise. Unchecked, this will eventually cause the inverter to trip. The traditional method of coping with this problem has been siphoning off this energy via dynamic braking resistors and dissipating that energy as wasted heat.

The RCU replaces a conventional dynamic braking arrangement, and converts this regenerated energy back into AC power. It feeds that energy back into the power mains as three-phase AC instead of wasting it as heat. In so doing, it offsets power that would have had to come into the system from the electric utility, and reduces the kW-h consumption and therefore the power bill. So in essence, the RCU is like another generator installed on the utility grid, feeding power into it by synchronizing to it.

Estimation of Energy Savings

The RCU will feed regenerated power back to the grid under the same conditions that a dynamic braking system would activate and convert that energy to heat. For that reason, the first step to determining potential energy savings is actually the same as the first step for sizing and selecting a dynamic braking system. Namely, the required braking torque and braking duty cycle must be determined.

From this data, the total amount of energy regenerated over a given time period can be calculated. The RCU converts 95% or more of this back into reclaimed power. This provides all the factors needed to calculate the kW-hr reclaimed per hour, day, week, month, etc. Knowing the electric demand rate, this can be converted into dollars and hence a payback period.

Example: Passenger Elevator

Typical passenger elevators are rated for 150% motor rated torque at a 20% braking duty cycle. From these two pieces of information alone, we can deduce that the RCU will reclaim 150% x 20% x 95% = 28.5% of whatever power it consumes. This value range has been confirmed in a number of actual elevator applications, by installing power meters in the input lines of the inverter and the output lines of the RCU, and measuring actual power consumed and power regenerated. Actual savings from 20% to 30% have been measured in these test systems.

Knowing the actual cost of elevator operation makes the rest of the calculation simple. It means that if the elevator costs $100 per month to operate, $100 x 28.5% = $28.50 per month will be recouped. Based on the RCU purchase cost, you can then calculate your payback period.

If you don’t have that data, calculating the cost of operation requires making some educated guesses. Just because the elevator is rated for 150% braking torque at 20% duty cycle, that does not mean the elevator is operating at that capacity 24 hours a day, 7 days a week. This is just a worst case assumption for the busiest time of the day when operation is nearly continuous. The rest of the day, operation is more sporadic. So for the purposes of our example, let’s assume that the elevator only operates 25% of the time at this capacity, and the rest of the time is totally idle. If the elevator has a 20 hp motor (15 kW), and assuming the electric power cost is 10 cent/kW-hr, the savings in a year can be estimated as follows:

15 kW x 8750 hr/yr x 25% operation x 150% torque x 20% regen duty cycle x $0.10/kW-hr = $984/yr

Depending on the particular RCU model selected, this could represent a payback period of 2 years or less, based on the RCU savings alone. This is appropriate in the case of an existing inverter with DB already installed, where the RCU will replace that existing DB solution.

With a brand new installation, it must be remembered that the RCU will ***eliminate the need*** for a DB system, so the price of the DB chopper and resistors is avoided from the outset. In such systems, if an RCU is not used, a DB system will be required anyway. So in this case the cost of the DB solution must first be subtracted from the initial cost of the RCU. This difference is then used to calculate the payback and justify the additional investment. In such scenarios, paybacks well under a year are not unusual.

Summary

Obviously, the most accurate way to determine energy savings achieved with the RCU is by actually metering of the regenerated power relative to the power consumed. This is simply not practical in most cases, so estimated savings must be calculated based on a number of key system characteristics. The accuracy of such estimates is highly dependent on how precisely the operating parameters of the system can be defined.

Ultimately, justification of the cost (or added cost) of the RCU vs. a traditional DB system is based on the savings anticipated vs. the installed cost, just like any other capital item.