


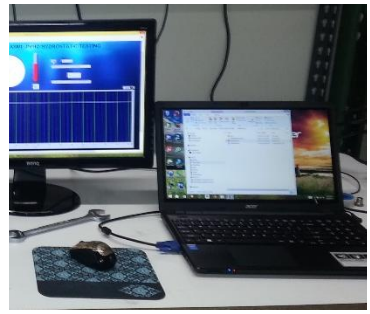
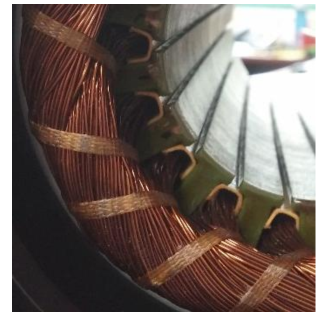

BDC ELECTRIC MOTOR SYSTEM SELECTION PROCESS

1. MECHANICAL SYSTEM PARAMETERS

The first step in any motor selection is the mechanical power requirements demanded by the load; ie propeller, hydraulic pump, winch drum, valve control.... Different loads have different load patterns that must be matched by the motor, according to the torque profile and shaft RPM.

The first reference graph shows the relationship of output shaft HP as a function of motor torque and shaft speed (RPM). By definition HP = Torque Speed and is shown in Figure 1 below for specific HP levels. For any given shaft HP, the motor torque required decreases the shaft RPM increases. This is how a very small motor can produce a lot of HP. The motor torque is low but the shaft speed is allowed to go very high. The advantage is the small footprint, however this also imposes higher wear loads on the system that affect the life of the motor. Conversely, motors with high torque at low speeds provides low wear on the bearings but the high torque output can require larger dimensions or high currents which will also affect the stress on the electric system.

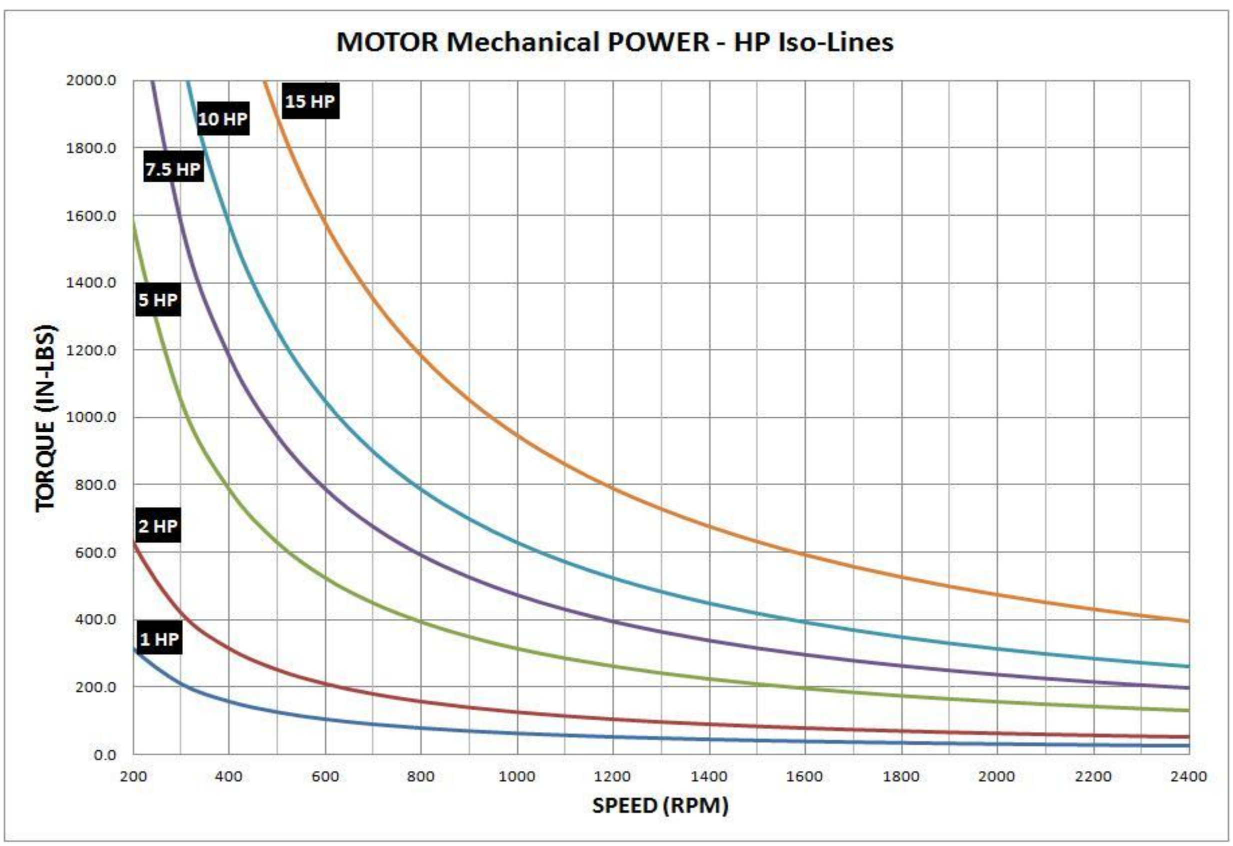

Figure 1 – Motor Shaft power as a function of motor torque and speed

2. ELECTRICAL SYSTEM PARAMETERS

The second step in motor selection is the matching of the desired performance with the system power bus voltage. Alternately, if the power bus voltage is still being determined, several tradeoff decisions are important in producing the most efficient electromechanical drive system.

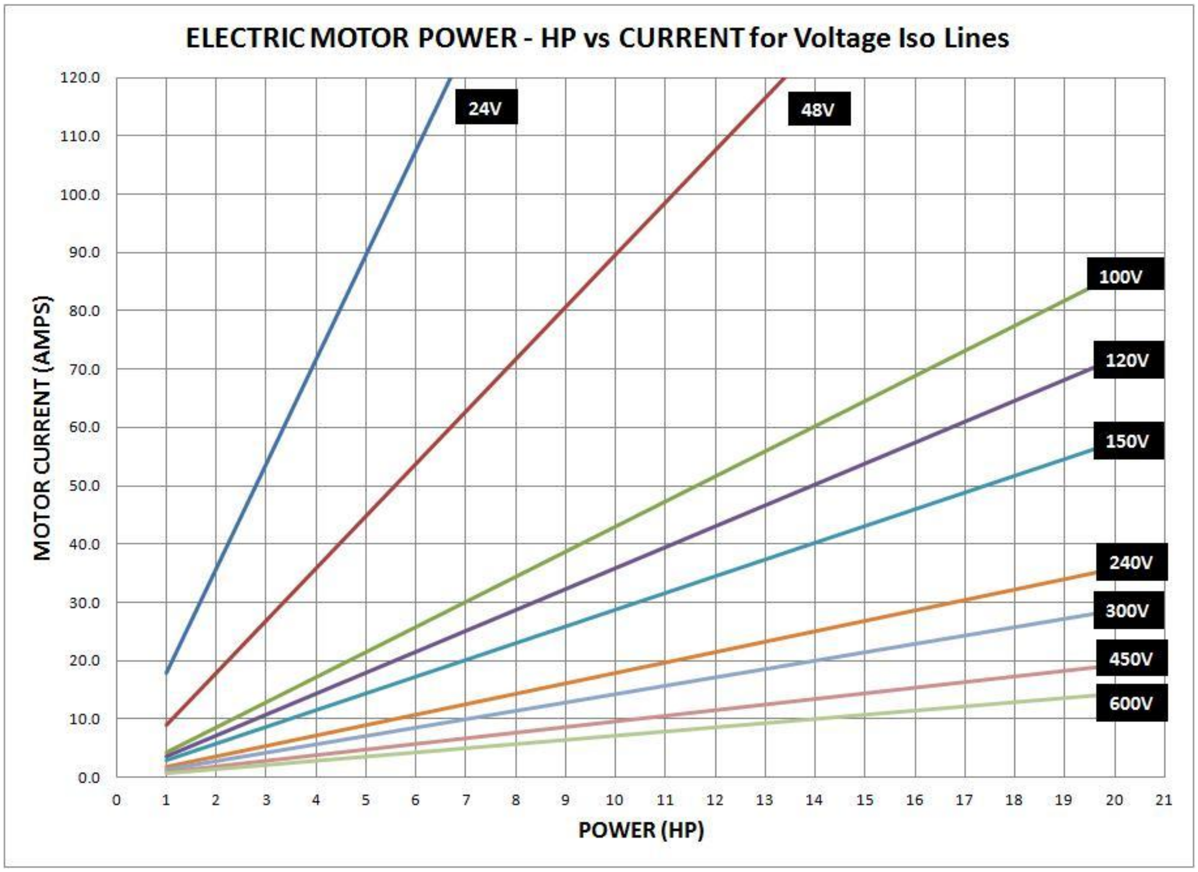

Figure 2 – Motor Current as a function of Shaft Power for set voltages

As shown in Figure 2 above, motor current increases as the power level increases as well as when the voltage decreases. This means that a 10HP motor will require much more current on a 100VDC system than at 600VDC. Likewise, the current level at 24V is off the chart. The important part is to keep in mind that while it is possible to build electronic circuits that can switch large current levels at very high rates to drive modern brushless DC motors, this has a drastic impact on the physical dimensions of the electronics. This is particularly important in underwater vehicle designs where space in electronic bottles is always at a premium. Alternately, ambient pressure electronics are also an option but here again, high current level switching makes this much more difficult.

As a general rule there are four general current levels that are Easy, Moderate, Hard and Very Hard to produce and or to keep compact. Current level:

EASY	15amps or less
MODERATE	30-40 amps or less
HARD	50-100 amps
VERY HARD	100+ amps

This is not a hard and fast rule but provides a useful arms-length guide to the level of complexity of the electronic drivers.

3. MOTOR SIZE & WEIGHT

The third step is to establish the available weight, volume or size available for the motor. Larger power motors are naturally larger and heavier, but for a given HP, higher operating voltage helps reduce the physical size and lower voltage motors at the same HP will grow larger.

Magnetic circuits create more magnetic force by increasing the size of the current coils. This produces more torque at the shaft and increase the torque generating capability of the motor, called the motor Torque Constant, typically called Kt. This same increase in coils, however, also increases the motor's undesired characteristic of generating back EMF relative to RPM. This is called the Back EMF Constant (Ke). This is called a back EMF because the voltage generated by the window directly opposes the input voltage. Consequently, when the back EMF generated by the spinning motor reaches the same level as the input voltage, there is no more current flow going into the motor to generate torque and the motor reaches its maximum RPM. This is why a motor will always be limited to a maximum RPM based on the input voltage. This also means that if a motor is required to spin at high speed for a low voltage system (for example 3000 rpm at 24 VDC), the back emf constant will have to be low, to permit the motor to reach 3000 RPM. This also means the corresponding torque constant will be low which in turn will demand very high input currents to produce the desired torque levels. Since a motor's HP is defined by speed x torque, it is important to define at which speed the torque is required. In a propulsion system, this torque characteristic will depend completely on the propeller design/characteristics. How pumps, it will depend on the displacement of the pump, the flow and the pressure.

This is most important when determining the performance specification over a range of input voltage, such as experienced in a battery-based vehicle. In case of a 150V Battery bank, the voltage can vary from 110VDC to 165 VDC. It is important in the motor design to establish at which voltage the minimum performance must be met. For a set output HP level, meeting the performance at 110VDC will demand higher current levels in the system, while if designed for 150V, the current levels will be lower but the output performance will also drop as the input voltage drops.