**Motor Rewinding mini-Tutorial**

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The way to think about motor rewinding is this: it's just a swap between amps and volts keeping power constant. It's something you can do near the end of a design cycle to match the motor voltage to the drive bus voltage. From a motor designer's point of view *in principle* it's a no brainer, because when the motor is driven at its new rated current every mechanical and thermal parameter of the motor (weight, torque, ohmic loss, magnetic loss) of the motor is unchanged. So as long as the new wire size can be handled by his winding machines, he doesn't care. Well there is a caveat, because wire size is quantized.

Wire are sized ratiometrically. A change of one size (say AWG 33 to AWG 34) always changes copper cross-sectional area (& resistance per unit length) by about 26% since 10^0.1 = 1.259. A change of three wires sizes changes area and resistance (almost) by a factor of two since {10^0.1}^3 = 1.995. A change of ten wire sizes by exactly a factor of 10.

Example, double motor voltage and half motor (rated) current by doubling turns

| | | |
|---|---|---|
| turns | x 2 | |
| wire cross-sectional area | x 1/2 | (wire down three AWG sizes) |
| total wire cross-section | unchanged | |
| EMF | x 2 | |
| torque constant | x 2 | (NM/amp) |
| voltage constant | x 2 | (volt/rad/sec) |
| Resistance | x 4 | (twice # of turns at twice resistance per turn) |
| Inductance | x 4 | (inductance varies as turns squared) |
| Irated new | x 1/2 | (1/2 Irated old) |

At Irated new = 1/2 Irated old

| | | |
|---|---|---|
| torque | unchanged | (x 2 torque constant x 1/2 Irated old) |
| copper loss | unchanged | (amps squared x resistance = 0.5 x 0.5 x 4 =1) |
| magnetic flux | unchanged | (inductance x amps/turns = 4 x 0.5/2 =1) |
| voltage across R and L | x 2 | (x 0.5 current x 4 impedance =2) |
| motor terminal voltage | x 2 | (EMF and voltage across series impedance are both doubled) |

Caveat --- A small tweak in turns is likely to have some effect on efficiency as a wire size change may not be possible. For example, suppose the drive is running out of voltage and you want to lower the motor terminal voltage say 9% with a compensating current increase of 9%. If the motor is wound with 33 turns, this is a change to 30 turns, but probably no change in wire size is possible since the next size up has 26% higher cross-sectional area. The result is EMF, torque constant, and inductance change as expected (EMF and torque constant down 9%, inductance down 18%), but because wire size does not change resistance only goes down 9% rather than 18%. Consequently the 9% higher operating current of the motor causes the ohmic losses to be about 9% higher than before. However, the good news is that magnetic losses don't change so the total increase in motor loss is less than 9%.