

## APPLICATION NOTE: Wye-Delta Energy Savings with the PPL 3SR Motor Controller

The 3SR Motor Controller has the capability to use two different energy-saving algorithms simultaneously. The two methods are referred to as Electronic Power Reduction and Wye-Delta (Y-D) Switching. In situations where both can be used together, the best energy savings generally result. This application note describes how to configure Y-D Switching.

### Requirements for use:

1. An existing Wye-Delta (Star-Delta) soft-starter on the motor system
2. PPL Operator Interface Software
3. PPL control board Rev E or Rev F with Relay K1 populated

Under most circumstances, the Electronic Power Reduction algorithm is solely used. In cases where the above three requirements are met, Y-D Switching may also be used in conjunction.

### The Concept:

A Y-D motor is a special type of AC motor that can operate in two different stator winding configurations: Wye or Delta. The Wye configuration applies a lower voltage across each phase winding so the motor consumes less power - at a price of lower available torque. Conversely, the Delta configuration applies full line voltage across the phase windings, so the motor consumes more power, but provides more torque to the load. External electromagnetic contactors are used to change the windings between the two configurations. A comparison of voltage, current, torque and power for Wye and Delta configurations are shown in Fig. 1.

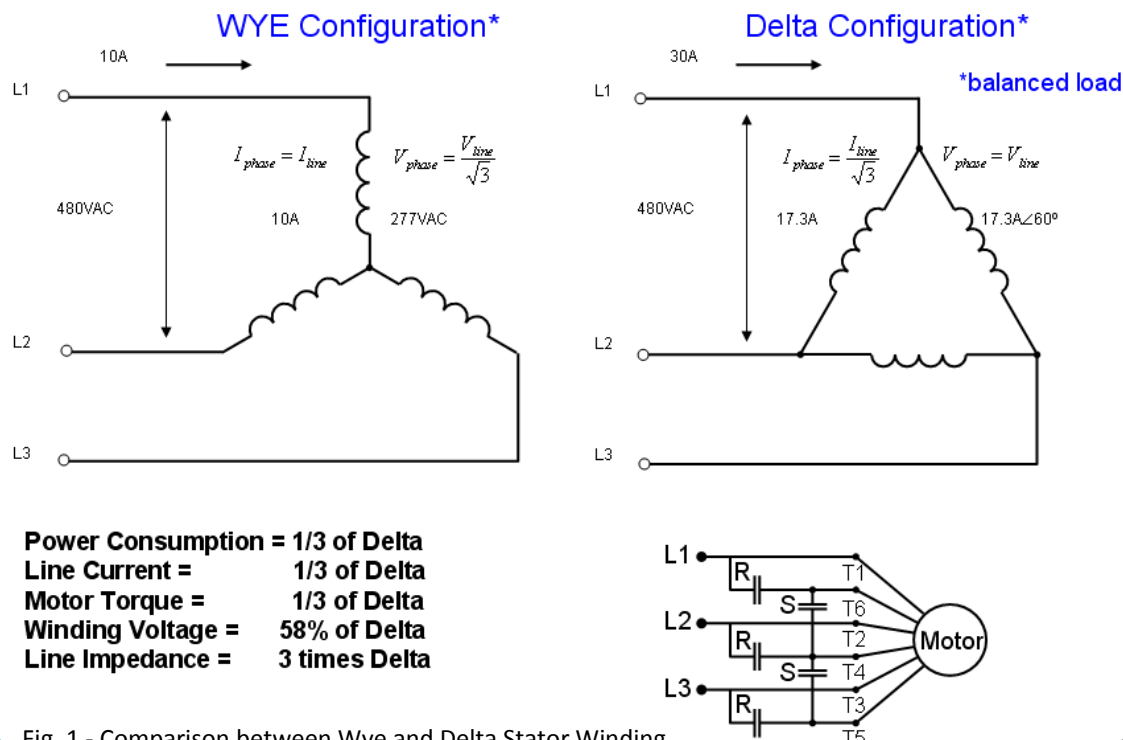


Fig. 1 - Comparison between Wye and Delta Stator Winding Configurations. Note the theoretical power consumption in the Wye configuration is only 33% that of the Delta

of the Wye stator configuration to initially ; from across-the-line starting in Delta. The

motor only remains in the Wye mode for a few seconds, at which point a timer relay switches the contactors to the Delta configuration. The motor then remains in Delta for the duration of its operation.

It is very easy to determine if an existing Y-D soft-starter is present on the motor. As shown in Fig. 2, there are two additional contactors and a timer relay dedicated to this purpose. The Wye contactor is particularly easy to spot, as it will have three terminals shorted together.

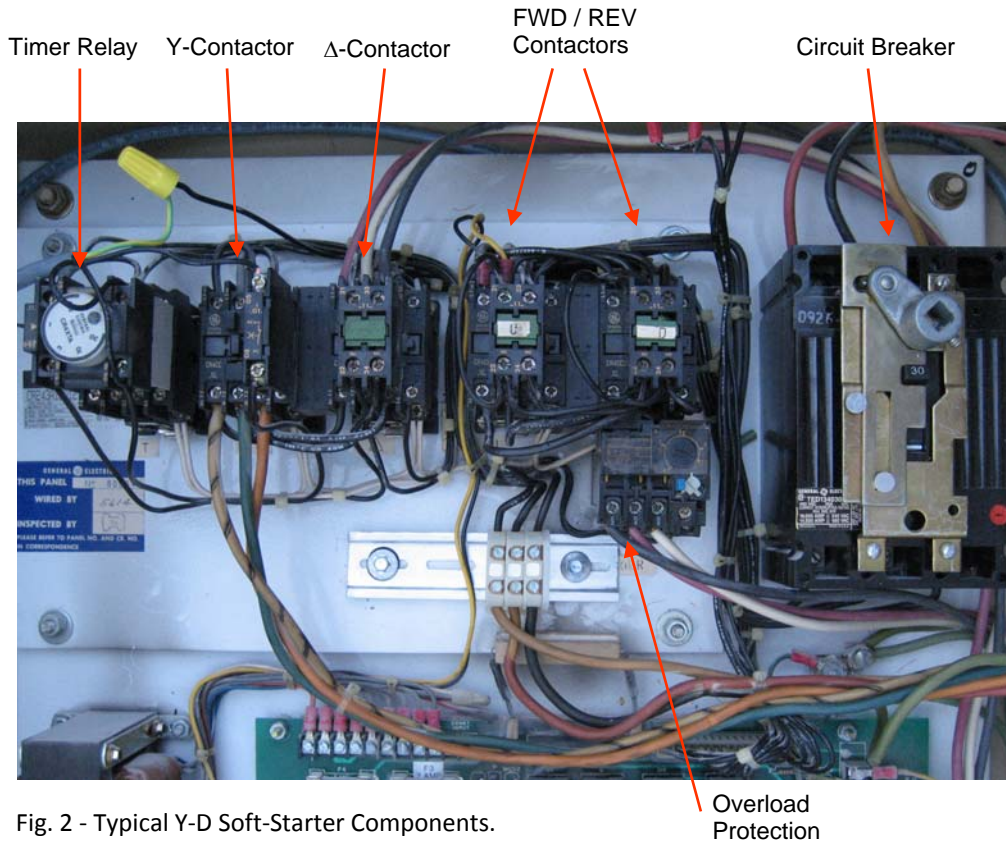


Fig. 2 - Typical Y-D Soft-Starter Components.

The PPL 3SR controller provides intelligent control of these contactors to allow the motor to also *run in the Wye configuration under low load*. This is the basis of the Y-D energy savings method. The motor consumes much less power while zero harmonics are produced (by operation in Wye). Operation in the Wye configuration will not harm the motor nor will the motor be at risk of stalling because the 3SR controller will not allow the motor to operate under a heavy load while in the Wye configuration. In other words, the controller will only allow the motor to operate in the Wye mode only when the torque demand is low.

#### **Control Board Configuration for Y-D Switching Control:**

1. Relay K1 must be populated. Specify K1 when ordering the controller.
2. On Rev. F control boards, the Y-D jumper needs to be installed (Fig. 3)  
On Rev. E control boards, the 4-position slider switch should be in the second position (Fig. 4)
3. All three DIP switches in down (OFF) position

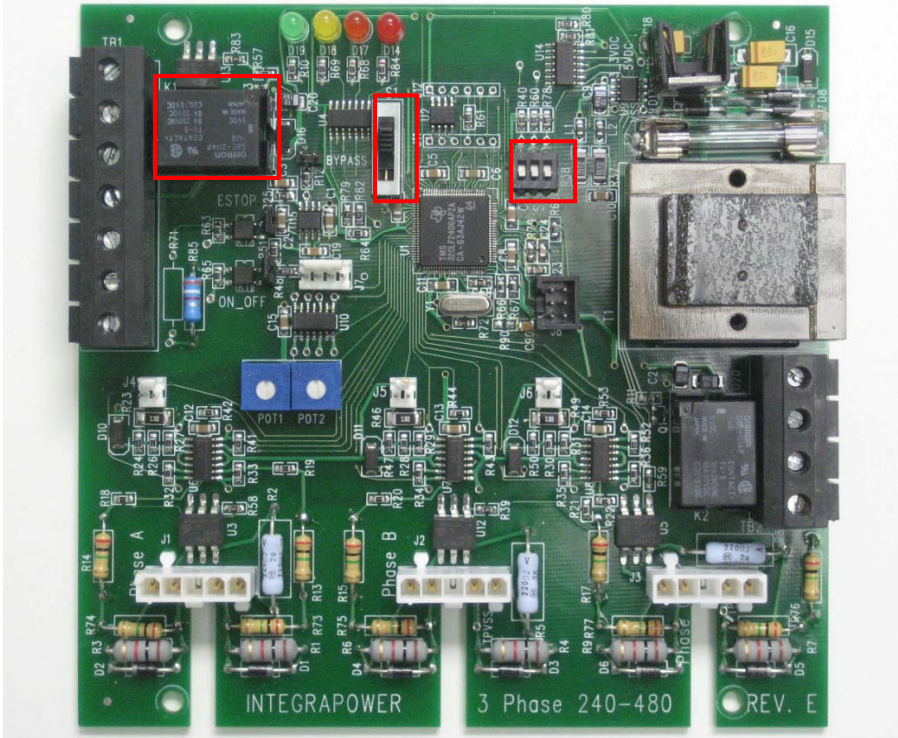


Fig. 3 - Rev. E Control Board Configuration for Y-D Switching

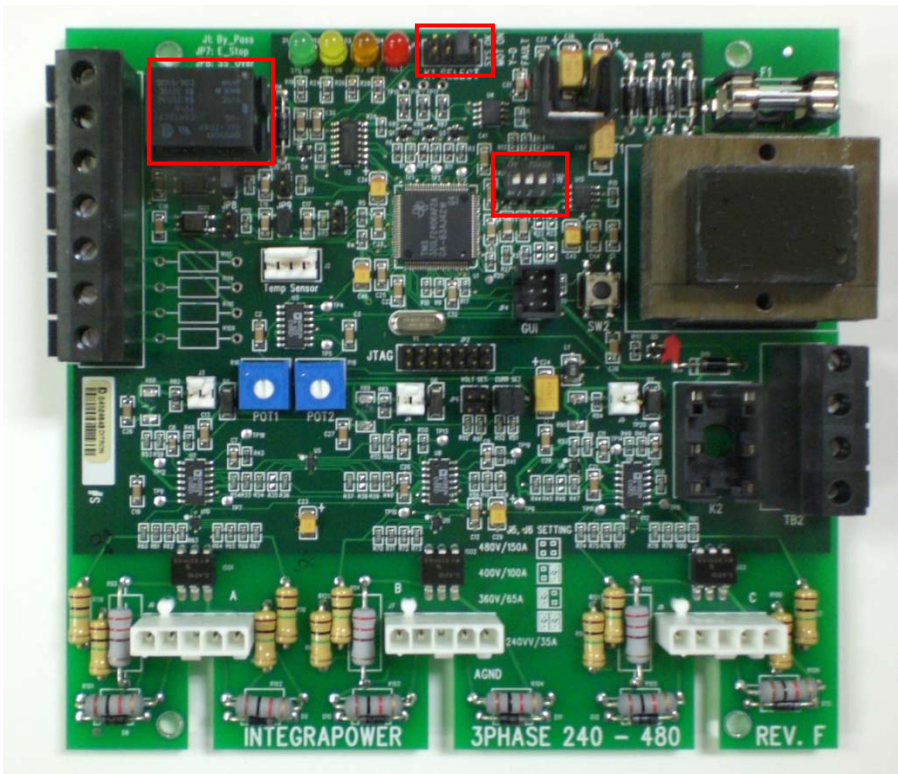


Fig. 4 - Rev. F Control Board Configuration for Y-D Switching

**Installation:**

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 14201 N Hayden Rd  
 Scottsdale, AZ 85260  
 480.268.2393

Installation of Y-D Switching consists of two parts:

1. Motor power connections, and
2. Y-D contactor connections to enable computer control

These basic connections are shown in Fig. 5

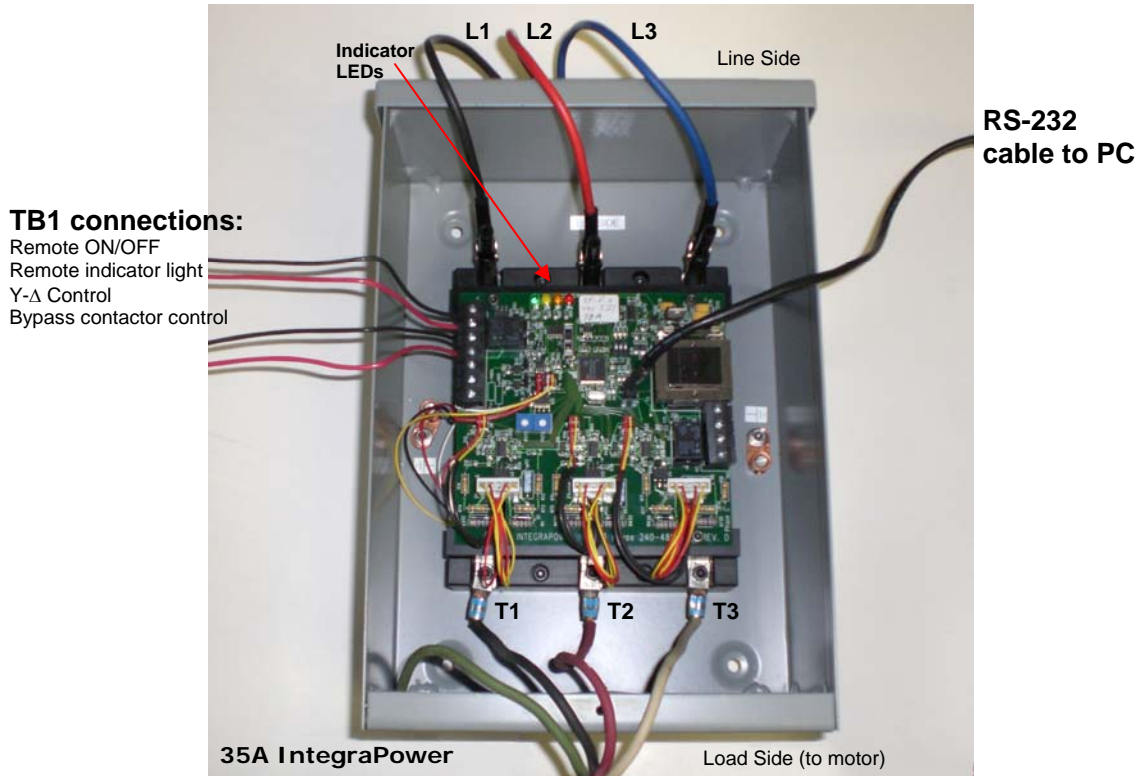


Fig. 5 - Basic connections for Y-D Switching control. Motor power is provided via L1, L2, L3 and T1, T2, T3. Contactor switching control is sourced from TB1 using the top four screw terminals (Wye pins 1 and 2; Delta pins 3 and 4)

Y-D motors may have 6, 9 or 12 leads. Figure 6 shows a 6 lead motor with Y-D contactors. Regardless of the number of leads, the concept is the same. There will be three main power lines leading to the motor from the controller and two contactors - Y or "Start" and D or "Run".

The three power lines are connected to the 3SR controller and the remaining motor power lines connecting to the contactors should be left as they are configured.

NOTE: If a system has a Y-D starter, and it is desirable to utilize the existing soft-start without using Y-D Switching for energy savings, just make the three power

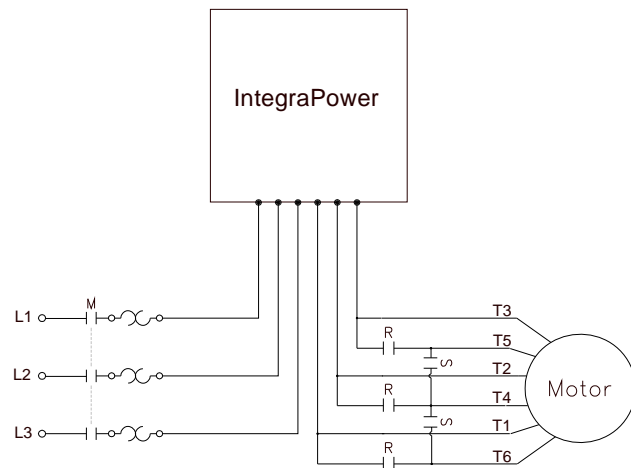


Fig. 6 – Basic 6-wire installation with Y-Δ starting. L1, L2 and L3 are connected to the input terminals of the controller and connections to T1-T6 are made as shown. NOTE: The connection order must be maintained as shown or the motor will rotate in the reverse direction.

connections to the motor, disable the 3SR voltage ramp soft start using the Operator Interface software and neglect the control connections to TB1 (Not recommended).

**Installation Procedure:**

1. Turn off power at the breaker
2. Connect the power lines L1, L2 and L3 to the input terminals of the 3SR controller
3. Connect the three output power lines (T1, T2 and T3) to the motor, being careful to maintain existing downstream connections to the motor (Figs. 5 and 6)
4. Connect the GUI isolation cable between the controller and a PC. Start the Operator Interface software.
5. Turn on the breaker (**CAUTION - the motor may start**) and enable the GUI mode by selecting the "Enable GUI Control" checkbox in the software. Power must be supplied to the control board to enable communications between the PC and the 3SR controller. In cases where remote power is supplied to the control board via terminal TB2, this should be specified when ordering the controller (so the correct power transformer is included).
6. For the initial system check, use the following GUI settings:
  - On the "Power Savings" tab, select "Bypass"
  - On the "Motor Controls" tab,
    - de-select the "Y-D Active" check box
    - de-select the "Soft Start On" check box
    - de-select the "Kick Start On" check box
7. Start the motor using GUI control (if it is off) and verify the rotation direction and motor operation are normal. At this point, the motor should start and stop under GUI control and the motor should otherwise operate as if the controller were not in the system. Calibrate the controller by selecting "Calibrate" from the Tools menu and enter the requested values. Verify the "Data Feedback" feature (on Data tab) is showing values in the data fields on the GUI. If not, re-check the connections and settings. These tests will verify the basic connections are correct prior to running the Y-D Switching.
8. Again turn off the breaker. Connect the four contactor control wires as described in figure 7. Make sure to label any of the original control wires that are disconnected from the contactors or timer relay, so they can be restored later if needed.
9. Turn the motor power back on and reconnect the GUI. Stop the motor using the "Motor Off" GUI control, but keep power applied to the controller. The next section will describe the Y-D software settings.

**Fig. 7 - Wye and Delta Contactor control connections.**

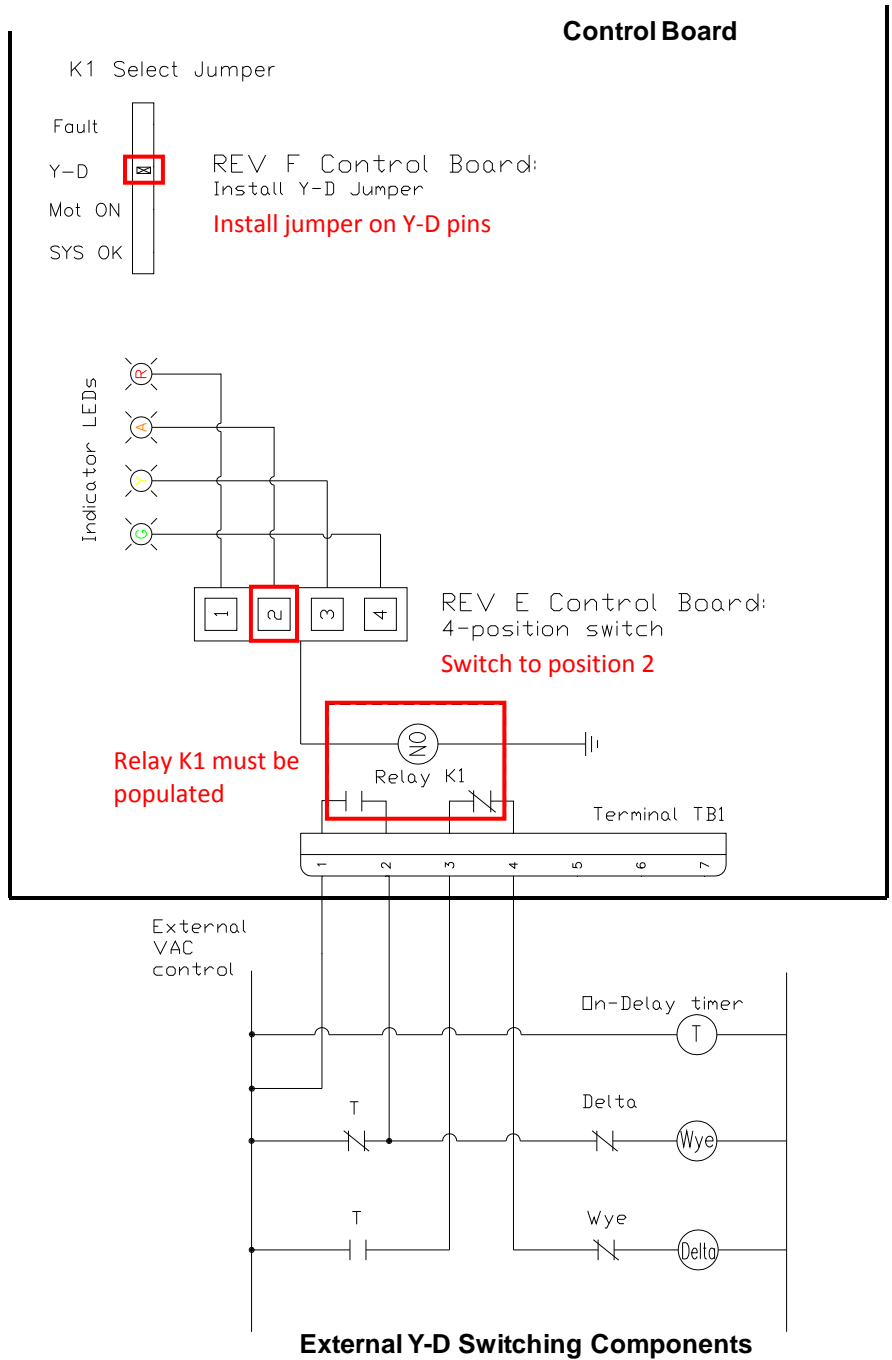
The timer relay (T) may be disconnected from the circuit or left in the circuit. It is normally easiest to leave it in place, as shown. The 3SR computer will bypass the timer relay control.

Screw terminals 1 and 2 control the Wye contactor. These two connections should shunt the timer relay Wye control contact, as shown. The motor will start in Wye and only change over to Delta if the load increases above a set threshold - not as a result of the timer relay.

Screw terminals 3 and 4 control the Delta contactor. These two connections may be in series with the Delta control contact or can shunt it altogether - either way, the 3SR computer will control the Delta contactor (once the timer has activated)

Notice that the Wye and Delta contactors are interlocked with two sets of AUX contactors (N.C.). When Wye is closed, Delta must be open, and vice versa. This is an important safeguard.

Also notice that external control power is needed to operate the two contactors. TB1, pins 1-4 contain dry relay contacts only. The maximum current through these terminals should be limited to 1A. If the contactor coils require more current, additional control relays may be needed.



### Y-D Setup with the Operator Interface Software:

Once the wiring connections have been made, as described in the previous section, the Operator Interface software is used to enable and set up the Y-D Switching. See Fig. 8

Apply the following settings in the GUI:

On the Power Savings tab, select Automatic Savings Mode

On the Motor Controls tab, select "Enable GUI Control", "Variable Voltage", "Soft Start On" and "Y-D Active"

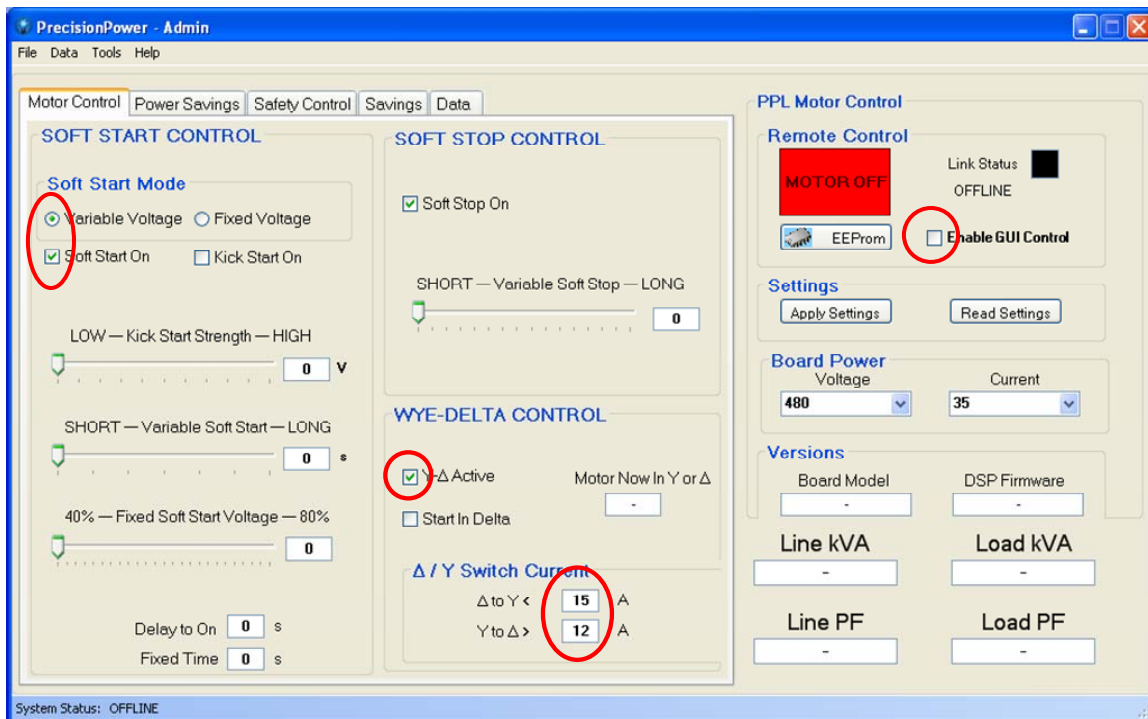


Fig. 8 - Motor Control tab of the GUI showing the settings to establish Y-D Switching Control

### Adjustment of the Y-D Current Switching Threshold Values:

The  $\Delta / Y$  Switch Current deserves special attention, as these settings determine the load thresholds at which the motor windings are switched from Y to Delta and from Delta to Y. Each transition has a separate threshold value that must be entered by the user.

The meaning of the Y-D and D-Y thresholds can be better understood by referring to Fig. 9, which graphically shows Y and Delta motor operation as a function of motor load. Notice that at low loads, the motor should operate in the energy-saving Y-mode. When the load becomes heavier, the motor should switch to and operate in

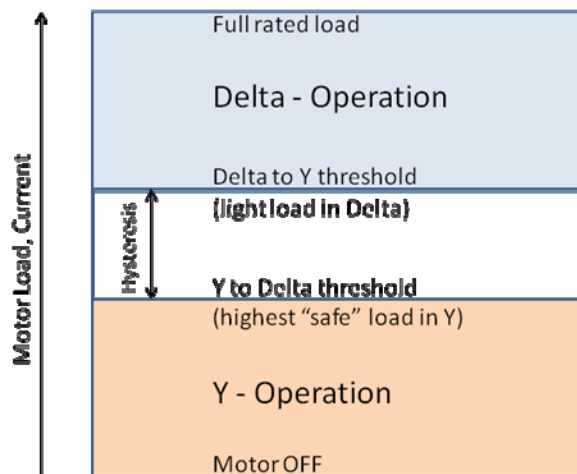


Fig. 9 - The two current thresholds used to control the Y-D Switching. Notice there is an intentional gap between the Y to D and the D to Y transitions. This is important to avoid too many transitions back and forth.

the Delta mode. When the load again becomes light, the motor should then switch back to the Y-mode. This desirable operation is enabled by properly setting the two threshold levels. Some fine-tuning is normally required on each motor to find the best values. A good starting point is to set the D to Y threshold at the current level at which the motor is operating at a low load in the Delta mode. For example, if the motor is operating an escalator, the escalator should be made to operate in a Delta mode with a light load (no people on the escalator). Measure the current under this condition and use that as the initial value for the D to Y threshold.

Notice there is a "hysteresis" or gap between the two modes of operation in Fig. 9. This is to prevent the motor from switching between the two modes too frequently, as this would cause excessive contact wear. A good starting point for the Y to D threshold is 20% below the upper threshold value. Continuing with our escalator example, if the D to Y threshold is set at 5A, then the Y to D threshold would be set at 4A as a initial guess.

In general, if both thresholds are made lower, this is more conservative, as motor operation will favor the Delta mode. The motor will switch from Y to D more frequently and switch from D to Y less frequently. Alternatively, if both thresholds are made higher, the energy savings is better because the motor would, in this case, spend more time in Y as opposed to Delta.

The optimum setting is one that maximizes Y-mode operation time, but does not allow the possibility of overloading the motor in Y-mode operation. Some experimentation is needed to find this balance.