Flying Start
PowerFlex 755 AC Drives

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Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.

**IMPORTANT**
Identifies information that is critical for successful application and understanding of the product.

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Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you:
- identify a hazard
- avoid a hazard
- recognize the consequence

**SHOCK HAZARD**
Labels may be located on or inside the drive to alert people that dangerous voltage may be present.

**BURN HAZARD**
Labels may be located on or inside the drive to alert people that surfaces may be dangerous temperatures.
Intro Steps
Before you begin

Please review the following information before starting this lab.

About this lab

This session provides you with an opportunity to explore the Flying Start features of the PowerFlex 755 AC Drive. In this session you will:

- Demonstrate a scenario in which Flying Start is not used
- Explore Flying Start Enhanced mode
- Explore Flying Start Sweep mode

This lab takes approximately 40 minutes to complete.

Lab Objective

At the end of this lab you will be able to:

1. Configure the drive for Flying Start – Enhanced
2. Configure the drive for Flying Start – Sweep

Tools & Prerequisites

Software programs required
- Connected Components Workbench v9.01
- RSLinx Classic v3.80.00

Hardware devices required
- PowerFlex 755 DHQ Demo Box (PN-39023)
  - PowerFlex 755 AC Drive (20G11-N-B-DM1AA6K32V8) – v12.001
- Ethernet patch cables
- Motor with flywheel attached
Network Setup

Set IP Address of PowerFlex 755 to **192.168.1.30** by setting the IP address switches.

Motor with Flywheel attached
About the PowerFlex 755 DHQ Demo Box

- Safe-off
- Analog I/O
- Aux Encoder Handwheel
- Ethernet Port Connector (behind cover)
- Drive Power
- Configurable I/O
- 24VDC Control Power
- Enabling Grip Switch
- Reset
- Door Interlock Switch
- Safe Limited Speed Select
Drive Setup – Reset Defaults

Use the steps below to reset the drive to its default settings.

1. Press the ‘Folders’ button 📚 on the HIM keypad.
   The button is located on the bottom row of the HIM Keypad (shown circled in the left image below). Pressing the ‘Folders’ button changes the HIM screen display to the Folders screen (see right image below).

2. Use the **Enter** key 📊 located in the center of the HIM keypad to select **00 PowerFlex 755**.

3. Now, use the left 🆕 or right 🔄 arrow keys to navigate to the **Memory** heading, then select **Set Defaults**.

4. Select **This port only**, then select the **All** option using the **Enter** key.
   At this time the drive may display **Fault 58**, which is expected.

5. **Clear** the fault using the **Red** stop key (if necessary), then **Confirm** the reset.

6. Press **ESC** twice to return to the main display.
Drive Setup – Auto Tune and Configuration Parameters

Use the settings below to auto tune the drive, and configure certain parameters for the lab.

Connect to the Drive using Connected Components Workbench

1. Open Connected Components Workbench using the icon on the desktop.

2. In the Device Toolbox expand Discover, then click Browse Connections in the Device Toolbox to open the Connection Browser.

   CCW will now connect to the drive, showing its information in the main pane of the software window.
Configuring Drive Parameters

1. Select the **Parameters** button to view the parameters for the PowerFlex 755 drive.

2. Using the **Group** drop down list, expand **Motor Control** and select **Motor Data**.

3. Fill in the following parameters with the values found on the motor nameplate at this station.
   - Motor NP Volts
   - Motor NP Amps
   - Motor NP Hertz
   - Motor NP RPM
   - Motor NP Power

   **Be sure to press Enter after filling in each value to be sure the entry is confirmed.**

4. Next, select **Mtr Ctrl Options** from the **Group** drop down list, and change the following parameter, being sure to press Enter after the change:
   - Motor Control Mode – Induction FV
5. In the **Group** drop down menu, expand **Drive Cfg** and select **Preferences**. Change the following parameters:
   - 300 – Speed Units – RPM
   - 301 – Access Level - Expert

6. In the **Group** drop down menu, expand **Speed Control**, select **Speed Reference** and change the following parameters:
   - 545 – Speed Ref A Select – Port 0: Preset Speed 1 (Picture A)
   - 571 – Preset Speed 1 – 1400 (Picture B)

7. In the **Group** drop down menu, select **Speed Regulator**, and change the following parameter:
   - 636 - Speed Reg BW – 5

8. In the **Group** drop down menu, expand **Drive Cfg**, then select **Braking Features**, and change the following parameter:
   - 409 - Dec Inhibit Act – Ignore
Auto Tune

Follow the steps below to Auto Tune the Drive.

1. Using the Group drop down list, expand Motor Control and select Autotune, then change the Autotune value to Rotate Tune.

   ![Autotune screen capture](image)

   Be sure to press Enter to confirm the Autotune value change.

2. Turn to the drive, and press the green Start button.

   The drive will start its auto tune process. Follow its process using the display on the drive HIM module.

Inertia Tune

The motor has a large disk attached to the end of its shaft. By default, the Inertia parameter has a value of 2.00. In order to make sure that the drive’s information is as precise as possible, run an Inertia tune on the drive using CCW to update that value to match the actual Inertia acting on the motor.

1. In CCW, in the Autotune field, select Inertia Tune.

2. Turn to the drive, and press the green Start button.

   Follow the process on the HIM module of the drive.

The drive has now completed its auto tune procedure…. And has updated the remaining parameters determined during the process.

You can now continue to the next section.
**Flying Start**

The Flying Start feature is used to start an already rotating motor. When a drive is started in normal mode, it will apply a frequency of 0 Hz to the motor and then ramp up to the desired frequency. If the motor is already rotating, the drive will try to force the motor to stop, which will generate large currents, which will cause an overcurrent fault.

There are two options to be considered when using the Flying Start feature of the PowerFlex 755 series drive.

- **Enhanced**
- **Sweep**

Use the steps below to configure the drive to allow the motor shaft to continue turning without power, then explore the different options for Flying Start.

**Configuring the Drive Parameters for Flying Start**

The steps below will configure the drive to coast to a stop, configure a switch to determine Forward and Reverse Direction, modify the Motor Control Mode, and modify the data displayed on the HIM module to easily view the changing frequency of the drive.

1. Select the **Parameters** button to view the parameters for the PowerFlex 755 drive.

2. Using the **Group** drop down list, expand **Drive Cfg** and select **Braking Features**.

3. Click the field for **Stop Mode A**, and select **Coast**.

4. Using the **Group** drop down list, expand **Feedback & I/O**, and select **Digin Functions**.
5. For **162 - DI Fwd Reverse**, change the values to the following:
   - Port 7
   - 1
   - 2 – Input 2

![Image showing the configuration of DI Fwd Reverse](image-url)

6. Verify this change on the HIM module, by watching the display while flipping the **IN 2** switch on the demo box. The HIM will display F, then R, as well as an arrow change when flipping the switch back and forth.

7. Make sure the switch is in the **Forward** position before continuing.

8. In the **Group** drop down list, select **Mtr Ctrl Options** found under Motor Control. Change the **35 – Motor Ctrl Mode** value to **Induction SV**.

![Image showing Motor Ctrl Options](image-url)

9. In the **Groups** drop down list, expand **Speed Control**, and select **Slip/Droop Comp**. Change the following parameter:
   - 621 – Slip RPM at FLA – 0

10. Finally, turn to the drive, and on the HIM, select **PAR#** using the soft keys. With **Parameter 1** showing, press the soft key for **Enter**.
    The HIM module will now show the **Output Frequency** value.
Demo

In this demonstration, you will see what happens if a motor that is able to rotate without power is commanded to start by the drive.

1. Press the **Start** button on the HIM module of the drive.

2. Allow the motor to get up to its commanded speed, 1400 RPM.
   This may take a few moments.

3. Now, press the **Stop** button on the HIM module, and allow the motor to coast for a minute or so.
   The drive is no longer controlling the motor – the motor will coast to a stop after a long period of time.

4. Press the **Start** button on the HIM module again.
   The drive will display a fault – HW Overcurrent. This is because the drive will try to bring the motor down to a complete stop before bringing it back up to speed.

5. Clear the fault using the **Stop** button.

Enhanced Flying Start – Forward

Use the steps below to explore the Enhanced option of the Flying Start feature.

1. In CCW, using the **Group** drop down list, expand **Drive Cfg** and select **Start Features**.

2. Change the **356 - Flying Start Mode** parameter to **Enhanced**.

3. Turn to the drive and press **Start**.
   Allow the drive to reach its speed.

4. Press the **Stop** button to stop the drive.
   Allow a minute or so to pass so that the motor begins to coast to a stop.

5. Now, press the **Start** button again.
   Notice that the drive catches the motor right away, and brings it to its commanded speed.
   The Enhanced option utilizes Counter-electromotive force, or CEMF. The drive sends current pulses to the motor to find and calculate the CEMF value, and when it finds that value, it is able to send the appropriate current to the motor to “catch” the motor and then bring it up to the configured speed.
**Sweep Flying Start – Forward**

The Sweep option for Flying Start utilizes a different method of finding the motor’s speed. Use the steps below to configure the drive for this option, then explore the results of that configuration.

1. In CCW, with the motor still turning, change the **Flying Start Mode** parameter to **Sweep**.

![Flying Start Mode Parameter](image1)

2. Change **FS Speed Reg Ki** to **1000**.
   
   This value is being changed to better demonstrate the Sweep Flying Start Mode feature.

![FS Speed Reg Ki Parameter](image2)

3. Press the **Stop** button to stop the drive.

   Allow a minute or so to pass so that the motor begins to coast to a stop.

4. Now, press the **Start** button again, paying attention to the frequency displayed on the drive, and the Analog Output gauge to the right of the drive in the demo box.

![Analog Output Gauge](image3)

Notice that after a few seconds, the drive will catch the motor and bring it up to the commanded speed.

The drive sweeps the output frequency while watching the current in order to find the motor’s speed. It will then apply the appropriate power to the motor, bringing it up to the configured speed.
Sweep Flying Start – Reverse

In some applications, it is possible that the shaft of the motor will be found to be rotating in reverse without power applied. Use the steps below to explore how Sweep Flying Start will address that situation.

1. With the motor still running, flip the **IN 2** switch in the demo box to the right.

   ![Control Panel](image)

   Because the motor was moving in the forward direction, the drive will ramp the motor down to zero, then apply appropriate power to reverse the motor’s direction. This may take a few moments, and the HIM module will display a flashing F and arrow. Once the motor is moving in reverse, the HIM display will show **R** with a reverse arrow.

2. Press the **Stop** button to stop the drive.
   
   Again, allow the motor to coast for a few seconds.

3. Flip the switch to the left, making sure the HIM module is indicating the forward direction.

4. Press the **Start** Button.

   The drive will repeat the Sweep process, starting with the forward direction, and when it has determined that the motor is not moving forward, it will then sweep the reverse direction.

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**FS Speed Reg Ki and Kp parameter values**

The charts below show the frequency and the current being supplied to the motor. The motor is coasting, so when the Start button is pressed on the drive, the drive will output the max forward speed, then start to decrease according to a slope set by parameter 359 (FS Speed Reg Ki). When that frequency matches that of the motor, the current dips, reverses, and the motor is accelerated back to the commanded speed.

The chart below shows the change of the current (blue), and the frequency (pink) as a result of this process when using the default Ki (100) and Kp (75) values.
Changed Ki parameter value

In the chart below, we see that the frequency trace has a more gradual slope (encircled in red). The drive will take more time to detect the motor at this Ki value – 1000.

Changed Kp parameter values
In the chart below, we see two sweep procedures, paying close attention to the current trace in blue. Notice that in the procedure on the left, the Kp value is set to 25, which results in a deeper dip in current when the motor has been detected. In the sweep procedure on the right, the Kp value is set to 500, resulting in a shallower dip of current.

**Reverse Sweep**

In the case of a motor turning in reverse of commanded direction, a flying start in sweep mode will still work. The frequency will sweep in the forward direction first, and if it does not detect the motor, will begin sweeping in the reverse direction. Once the motor has been detected, the drive will safely bring it to a stopped state, then proceed to bring it to its commanded speed.