

Dust Collection Systems Sequence of Operation & Technical Description

Ecogate, Inc.

Version 4 (general greenBOX® Nxt, Max, and Master system for a factory, shop or school)

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Introductory Notes

This document describes the dust collection system sequence of operation managed by the Ecogate greenBOX® control system in Automatic Mode. System functionality includes Automatic Start and Automatic Stop triggered by workstation activity sensors. The system is designed to be fully automated, so users are expected to just use their workstations. External status light informs users about normal operation, warning, or system error. Ecogate greenBOX® controls minimum and maximum airflow in ten duct zones and minimum and maximum airflow in the main duct.

1. Automatic System Stop

- If no workstation activity sensors at workstations are active (i.e. all are inactive) the system will stop the main ventilation fan via Variable Frequency Drive (Power MASTER VFD) after a user adjustable delay¹.
- The Power MASTER VFD will also stop the dust collector via a free STOP contact (NC).
- The greenBOX® control unit will open all the workstation gates for safety reasons² (this option can be switched off by user).
- Automatic Stop and closing unused ventilation drops results in reduced noise levels in the factory, reduces the amount of required makeup air (if used) and significantly reduces dust collection system electricity consumption.

2. Automatic System Start

- If a user starts a workstation, the greenBOX® will leave the workstation gate open, start the ventilation fan via the Power MASTER VFD, start the dust collector (via relay contacts), and close most of the other workstation gates³.
- Gates at some non-active workstations (or bleed gates if used) will remain open to maintain minimum required air flow in the duct system and in the ventilation fan.
- Turning ON further workstations will open the corresponding workstation gates, and at the same time close some gates previously used for maintaining minimum airflow to compensate for the additional air volume.
- If the feature that control maximum airflow per duct zone and per system is active greenBOX will stop opening the gates above maximum airflow level and will issue warning for users via orange status light, warning text on greenBOX display, and relay contact will activate for customer preferable action.

¹ The fan off delay is adjustable in the range of 0...999 minutes.

² Should anybody override the VFD controls and start the fan with gates closed, the duct system could collapse.

³ If bleed gate(s) are used in the duct system, they will be opened to maintain minimum airflow.

- Turning workstations OFF will similarly close the appropriate gates (each gate can close with a programmable delay of up to 999 seconds) while opening other gates for minimum airflow if necessary.
- The drop air velocity (air volume) is adjusted by the greenBOX® control system. The user can check air velocity/air volume/pressure at each drop, at branches, and main duct on the greenBOX® control unit screen (or via remote access).
- Closing gates at workstations that are not in use reduces noise in the factory, ventilation fan consumption and makeup air volume.
- greenBOX is equipped by output for LED status light with green, orange, and red lights; green light is on if system operates OK (ventilation is correct), orange light means warning (for example filter differential pressure reaches warning limit set by user), and red light is on if there is system error (ventilation cannot reach design values, if fan or filter pressure is too high that the duct system could collapse etc).
- greenBOX is equipped by digital inputs, and dry contact relay outputs, both digital inputs and contact outputs functionality can be set by user.
- Full version of the greenBOX® and Power MASTER VFD User Guides are available from Ecogate.
- greenBOX Nxt can control up to 75 workstation gates, greenBOX Max up to 150 gates, and greenBOX Master up to 225 gates. Number of the dust collecting systems is not limited per greenBOX, but power supply size is limiting how many gates can be connected to each greenBOX (Nxt, Max, Master).

3. greenBOX® Control System Technical Details

[What does the Ecogate greenBOX® do?](#)

The greenBOX® control unit manages the entire dust (fume, mist) collection system. It opens and closes workstation gates, starts and stops ventilation fan, adjusts the fan speed via Power MASTER VFD, and maintains minimum transport air velocities in the duct system. The greenBOX® control system is based on Ecogate Next Unit of Computing (standard developed by Intel Industrial Corp.). This is a standardized commercial product (i.e. not custom made on project-to-project basis), installed with the same software in hundreds of locations. This means the software is fully tested and does not need any last-minute improvisations or commissioning delays. The fan and duct system models are built-in greenBOX software – setup of the system is very simple and fast. The communication with gates and VFD is via Modbus RTU over RS485. The gates Modbus addresses are assigned automatically during setup to simplify and speedup the system installation.

Dimensions & Weight

greenBOX Nxt: Dimensions: W=17.2" x H=10.2" x D=4.5", weight 20 Lb.; the greenBOX® should be installed on a wall with the LCD screen at eye level. Max. power consumption is 350 W at 115V AC. greenBOX Nxt can control up to 75 workstation gates.

greenBOX Max: Dimensions: W=17.2" x H=10.2" x D=4.5", weight 20 Lb.; the greenBOX® should be installed on a wall with the LCD screen at eye level. Max. power consumption is 720 W at 115V AC. greenBOX Max can control up to 150 gates.

greenBOX Master: Dimensions: W=17.2" x H=10.2" x D=4.5", weight 20 Lb.; the greenBOX® should be installed on a wall with the LCD screen at eye level. Max. power consumption is 1,440 W at 115V AC. greenBOX Master can control up to 225 gates.

Setup File

Specifics of particular system are entered to the control system via simple, smartphone like user interface (gate diameters, design drop air velocity, order of gates in branches, branch diameters, main duct diameter, minimum transport air velocity etc.). User specific setup is stored in internal database. All user configuration is managed through a user interface on 10" built-in touchscreen or via connected device (smart phone, tablet, or computer). The setup file is copied to the Ecogate Cloud, via the internet connection, for backup.

greenBOX is Industrial Control System

The greenBOX® is using Linux operating system with built-in web server. The greenBOX® should be connected to the internet via Ethernet LAN port. The internet connection allows access on local network (just type greenBOX IP address to browser on any device), and via ERAS – Ecogate Remote Access Server. All internet communication is end-to-end encrypted, and there are no open ports at greenBOX. The networking security whitepaper is available from Ecogate.

Diagnostics & Usage Data

Diagnostic and usage data are sent to the Ecogate Cloud regular time intervals. With a Service Agreement, the user can access this data using a web browser, download the data in CSV format (reporting system function, fan and filter pressures, fan power, system air volume and air velocity, gate air velocities, workstation utilization, electricity savings).

Internet Connection via Ethernet/LAN Port

The internet connection is optional, but highly recommended. It enables system backup, remote access & diagnostic and usage data collection. Connection to the internet not require any special configuration of customer firewall but must allow internet protocols at ports as described in the white paper provided by Ecogate and based on greenBOX® LAN port MAC address.

Building Automation Control System Connection is Supported

The greenBOX® have a connection to a Building Automation Systems (BAS) or Process Control Systems via Modbus RTU gateway. The status of all connected devices (systems, gates, VFDs) are available, and also data measured by greenBOX are available to Building Automation

systems. The white paper provided by Ecogate describes details of this communication to “higher Level Control system”.

4. Power MASTER VFD Technical Details

What does the Ecogate Power MASTER do?

- The Ecogate Power MASTER VFD starts, stops, and adjusts speed of the ventilation fan. Additionally, the Power MASTER protects the duct system against implosion collapse⁴, starts the dust collector via free START contact (NO) and stops the dust collector via free STOP contact (NC)⁵.
- The Power MASTER “Enable” Input is used to confirm to the Power MASTER that the dust collector is operating normally (i.e. no error). If there is any dust collector error (for example airlock is not working, cleaning is not working etc.) the dust collector’s PLC should open Enable input of the Power MASTER. The Power MASTER will stop the main fan to protect the dust collector⁶.
- This VFD is a commercial product (i.e. not custom made on a project to project basis), installed with the same settings & software in hundreds of locations. This means that the software is fully tested and requires no last-minute parameter changes or commissioning delays.

Enclosure Rating, Door Selector & Indicators

The Power MASTER VFD is based on the ACS880 VFD by ABB in a NEMA 12 rated enclosure (dust proof, for installation inside the building) with a simple door selector (Manual-Stop-Auto mode) and door Indicators (Enabled, Running, Error).

Dimensions

1. **up to 40 HP @ 460V** Power MASTER™ is 27” wide, 43” high, 23” deep; wall mounted (min. distance from ceiling: 8”, min. distance from floor 12” for proper cooling)
2. **50 - 200 HP @ 460V** Power MASTER™ is 35” wide, 48” high, 23” deep; wall mounted (min. distance from ceiling: 8”, min. distance from floor 12” for proper cooling)
3. **250 - 400 HP @ 460V** Power MASTER™ is 33” wide, 92” high, 26” deep; free standing (min. distance from ceiling: 12.5”, min. distance for door opening 32”)

Dimensions for other models (230V, 380V, 600V) are available.

⁴ This requires fan pressure monitoring using a pressure transmitter built into the Power MASTER VFD.

⁵ START (NO – Normally Open) contact of Power MASTER™ simulates pressing the Start button of duct collector PLC and should be wired in parallel to the START button at PLC; STOP (NC – Normally Closed) contact of Power MASTER™ simulates pressing the Stop button of duct collector PLC and should be wired in series with the STOP button at PLC

⁶ If for example the air lock is not working and main fan will continue to run dust collector will be overfilled with dust – this will require production stop and do labor & time expensive cleaning

Installation

Follow Ecogate Power Master VFD User Guide and ABB instructions about VFD installation. The main 3-phase disconnect and fuses are built-in. The 3-phase power input cable and 3-phase power output cable to the ventilation fan motor must be installed in metallic, grounded conduits (never combine the input and output wires in one conduit and never combine wires from several VFDs in one conduit)⁷. Proper grounding of the VFD cabinet, conduits, fan motor must be provided.

Dust Collector Automatic Start and Stop

The Power MASTER™ VFD dry contacts “START” and “STOP” can be used to automatically start and automatically stop the dust collector via dust collector PLC (control system). The ENABLE output of the dust collector PLC must be connected to the Enable input on the Power MASTER™ VFD (this Enable contact should be open if for example airlock of the dust collector is not working or any other part of dust collector functionality to stop main fan).

Ventilation System Enable/Disable, Safety Stop

Three enable inputs are available on the Power MASTER™. The first Enable input is connected to the dust collector PLC. Other inputs can be used to enable/disable the dust collection system using the building automation system or to connect a fire alarm. If a safety stop “mushroom button” is required, it can be connected to the ACS880 VFD STO inputs (Safe Torque Off, see ABB ACS880 manual).

Connection to Control System greenBOX®

The Power MASTER™ VFDs are connected to the greenBOX® by Modbus RTU over RS485. By using Ecogate MASTER cable, 24V DC power is also connected from greenBOX® to serve as backup power for the VFD processor: this allows the greenBOX® to communicate for troubleshooting with the VFD even if the main 3-phase power fails. At the VFD the ACS880 Terminating Resistor DIP switch must be set to ON (the resistor itself is built-in) for trouble-free Modbus communication.

Power MASTER VFD Setup

During the VFD setup, the Ecogate Startup assistant on VFDs LCD control panel is used to configure all VFD parameters. This takes just a few minutes and guarantees proper function both in Manual and Automatic modes. Smart startup logic based on ABB’s Adaptive Programming is used to allow a “grace period” during system start (the dust collector will be directed to start and during the “grace period” the VFD enable input is ignored until the dust collector’s PLC ENABLE signal is confirmed or the grace period expires).

⁷ If cables are not installed in a metallic conduit, a special more expensive inverter rated, shielded cable must be used.

5. Ecogate Gates Technical Details

What does a Gate do?

Ecogate gates are used to close the ventilation drops at workstations that are not in operation. The Ecogate gates use an industrial duty 24V DC gear motor (typical current is 300 mA for gates up to 6" diameter, and about 600 mA for larger gates). The gates are equipped with magnetic limit switches for both the Open and Closed positions. The gate close delay can be set by the user at the greenBOX® to assure that a particular workstation is clean after material cutting (or other dust producing) operations conclude.

Workstation Activity Sensor Input

The workstation activity sensor input is located on the gate control board (24V DC, 10mA, the sensor output should be a dry contact; both NO and NC contacts are supported).

Pressure, Air Velocity, Air Volume Measurements

The gate measures ventilation pressure, air velocity, and air volume. All values are transmitted via Modbus RTU to the greenBOX® including gate power supply voltage, motor current, energy used to open and close gate, open and closed limit switch positions, gate board temperature and more.

Gate Open and Closed Indicators

The gate Open and gate Closed indicators are located on the motor enclosure.

Relay Contact

The gate has one free relay contact that can be utilized for various functions (for example confirmation that gate is open at limit switch, functions are selectable from a list box in the greenBOX® user interface).

How Gates Are Connected to greenBOX® Control System

A 24V DC power supply is provided to the gates by the greenBOX® via the Ecogate MASTER cable. All the gates are connected to the greenBOX® in a Modbus daisy-chain by using Ecogate MASTER cable (with two AWG14 wires for 24V DC power supply, AWG 20 Modbus A, B twisted pair, and shielding). The greenBOX® supports multiple Modbus ports for gates (greenBOX Nxt has 3 Modbus ports, greenBOX Max has 6 Modbus ports, and greenBOX Master has 9 Modbus ports). Because the Ecogate MASTER cable is shielded, it does not need to be installed in conduit. The MASTER cable is typically installed on top of the ducting. At the last gate in the loop, the Terminating Resistor jumper must be installed (resistor itself is at the board) for trouble-free Modbus communication.

Gates Mechanical Installation

For trouble-free gate operation follow Ecogate Recommended Practice instructions on how gates should be installed.

6. Ecogate Workstation Activity Sensors Technical Details

What does a Workstation Activity Sensor do?

As mentioned in the gate description, the workstation activity sensor input is located on the gate control board. This is a way to tell the gate and greenBOX® control system that the workstation needs ventilation (dust/mist/fume collection). It is possible to order a new workstation and specify that it should be equipped with a dry contact output that is closed a few seconds before the workstation needs ventilation and open when workstation no longer needs ventilation. If a workstation has such an output, it is not necessary to use a Workstation Activity sensor. Unfortunately, most existing workstations do not have such an output. In this case we recommend using one of the following workstation activity sensors:

1. **Ecogate AC-DC Volt Sensor** (input detects 24 – 230 V AC or DC)
2. **Ecogate AC Volt Sensor** (input detects 110 – 690V AC)
3. **Hawkeye Current Sensor** (reads current to the cutting motor; not to the overall workstation)
4. **Keyence Laser Sensor** (detects light beam interruption; for example, for material detection or as an occupancy sensor)
5. **Shutoff timer switch** (user can set a timer up to 60 minutes with a wind-up mechanical timer)

How should a Sensor be connected to the workstation?

First, it is necessary to specify which electrical circuit is active a few seconds before the workstation starts producing dust (on a panel saw this would be the circuit that is powering the arm holding material) and connect a VOLT sensor in parallel with this circuit. The output of the sensor is then connected to the gate board sensor input.

6. Automatic Mode Operation Technical Details

The greenBOX® system is designed to fulfill National Fire Protection Association Standard NFPA-660, specifically Operations, System Startup⁸, System Shutdown, System Minimum Conveying Velocity.

⁸ Requires proper installation of Workstation Activity sensors to allow system start before admission of fumes and dust into system

System Setup

- For each gate a desired air volume is defined in the greenBOX® setup (saved in an internal database) by entering the gate diameter in inches and the desired drop air velocity in FPM (Feet per Minute)⁹ via user interface.
- Each gate is assigned to one of duct branches in the setup along with the order in which the gates are connected to the branches, the branch diameter is also entered.
- The workstation activity sensor should be connected to the gate “SENSOR” input (24V DC, 10 mA is provided by gate board, the sensor output should be dry NO or NC contact). The sensor status (On or Off) is indicated at the gate by a “SNS” indicator and transmitted via Modbus connection to the greenBOX® Nxt control unit.
- The pressure, air velocity, and air volume are measured at each gate¹⁰ and transmitted via Modbus to the control unit greenBOX®.
- For each branch the required minimum air volume is set in the greenBOX® setup.

System Air Velocity and Air Volume Measurements

There are several options how to measure system air velocity and air volume:

1. **By Averaging Air Velocity Sensor** (very precise method where air velocity is measured in entire diameter of main duct). The averaging air velocity sensor must be installed in clean air duct, typically between output of dust collector and inlet of the fan. If the fan is installed on top of the dust collector averaging air velocity sensor cannot be used.
2. **By Summary of Air Volumes of all Gates**. This method can be used if installation of Averaging Air Velocity Sensor is not possible.
3. Based on measured **Fan Power, fan Total Static Pressure, Fan Efficiency “as installed”¹¹**, and the **fan power formula**.

⁹ Also available is metric settings based on greenBOX® localization (EU – metric or US – imperial)

¹⁰ The air velocity and air volume measurement require calibration during system setup and after workstation changes

¹¹ The fan efficiency as installed must be measured during system setup & calibration

7. Ecogate Dust Collector Interface

What does the Ecogate Dust Collector Interface do?

The Ecogate Dust Collector Interface is a sensor suite for monitoring dust collection systems. It is designed for outdoor installation with robust, weather-sealed enclosure that houses **pressure sensors for fan and filter pressures, for cleaning PD pump pressure, and for averaging air velocity sensor**. It has also a **built-in ambient air sensor for automatic anti-freezing mode for winter filter bags**. Connection to the Ecogate greenBOX is straightforward via the Ecogate MASTER Cable which also provides 24DC power supply.

The Ecogate Interface is **designed for convenient installation directly beside the dust collector**. This placement shortens the hoses connecting the fan, filter, and averaging air velocity sensor, resulting in **reduced susceptibility to freezing, and reduction installation costs**.

The Ecogate Dust Collector Interface is built-in a green metal enclosure, measuring 10.7" x 7.7" x 3", that comes with a mounting bracket and weather shield. It operates on a 24V DC power supply from greenBOX, with a maximum consumption of ~ 10W. All measured values are transmitted to greenBOX via Modbus RTU.

8. System Installation

Follow installation guide for greenBOX, for Power MASTER VFD, Best Practice gate installation. Use installation checklist provided by Ecogate.

System Calibration

- During system calibration the “as installed” fan efficiency is measured to calibrate system air velocity and air volume readings, and system air velocity measurements are calibrated
- The gate air velocity readings are calibrated using an external air velocity meter (Fluke 922 with pitot tube and averaging reading in entire duct diameter is recommended)

System Operation

- The system starts and stops automatically based on information from the workstation activity sensors
- greenBOX® control unit continuously calculates the “Required Air Volume” based on the status of the workstation activity sensors, gates open for minimum airflow
- The greenBOX® regulates the fan Air Volume to match the “Required Air Volume” by adjusting the fan motor frequency (speed).
- At each branch the greenBOX® opens additional gates (greenBOX® can use gates installed at workstations or bleed gates¹² (if installed) to reach the minimum air volume defined in setup for each branch

¹² The bleed gates are typically used at branches where gates at workstations cannot be used for minimum airflow (for example at pharmaceutical dust collecting systems)