Modular Damper Overview

April 24, 2021

Developed By:

Utah State Smart Vent Design Team.

Sponsor: Manhattan 2, Glenn Weinreb, gWeinreb@manhattan2.org

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I. Project Overview

More Control

One can reduce HVAC energy consumption with more control. One can get control with $3 microcontroller IC's in physical devices networked together with reliable communication. Devices include:

- motorized dampers inside ducts
- motorized dampers at vent openings
- fans inside ducts
- motorized valves at radiators
- pumps that moves 60°F water from ground source into radiators and heat exchangers
- pumps that move water from thermal storage tank in basement into radiators and heat exchangers (water heated or cooled via solar when sun shining)
- sensors (occupancy, indoor/outdoor temperature, sun, wind pressure)

With the above technology, one can:

- more precisely control airflow from central HVAC fan
- move air from one room to another room while HVAC is off (e.g. move cool air from basement to warm office on 2nd floor without turning on central HVAC)
- route ground source 60°F water as needed
- route thermal storage water as needed
- integrate large appliances, thermal storage water, ground source 60°F water, and central HVAC

Devices with processors exist, yet we are not doing the above due to:

- a standard way to electrically plug the above devices into a building does not exist
- a common operating system for all devices that supports plug and play and reliable integration does not exist
- standard physical plug-in modules with fans and dampers does not exist

Researchers are working on the first two obstacles (standard electrical cable and operating system). For details, see: https://www.manhattan2.org/smart-building.

In this document we focus on the last remaining obstacle, which is a proposed standard for a replaceable standardized plug-in fan.

Standardization reduces cost via commoditization. Plug and play reduces cost via less design and installation labor.

One would want a system whose additional cost is paid for with reduce energy bills within a reasonable period of time. If one can do this, then mass adoption becomes feasible.

The good news is development costs are low, and a decent amount has already been completed. Perhaps the hardest part is the operating system (i.e. BuildingBus); however, this has already been coded and is available to others free and open. This means anyone can copy and modify at no cost.

Standard Plug-In Fan

If one places a proprietary damper or fan in a duct and it fails every 15 years while the building lasts 100 years, and the manufacturer stops production after 5 years, then the building will degrade in value due to difficult to obtain replacement parts. The only way to resolve this is to make use of standardized plug-in modules at vent openings.

For example, to replace a fan or motorized damper within a duct, one would remove the vent cover, reach into the duct, remove ~4 bolts, unplug the module, remove through vent opening, and replace with new standardized module, plug-and-play.

Students at Utah State University, set up by Dixon Nielson, developed this this. All design work is free and open, which means anyone can copy and modify at no cost. For details, see: https://www.manhattan2.org/fan-and-damper.

II. Modular Damper Overview

System Overview

The Modular Damper is a plug-and-play HVAC inline damper concept. The damper is designed to be fully enclosed inside a duct, allowing the damper to be easily installed and replaced through a vent opening. Figure 1 shows the Modular Damper inside a section of custom duct.

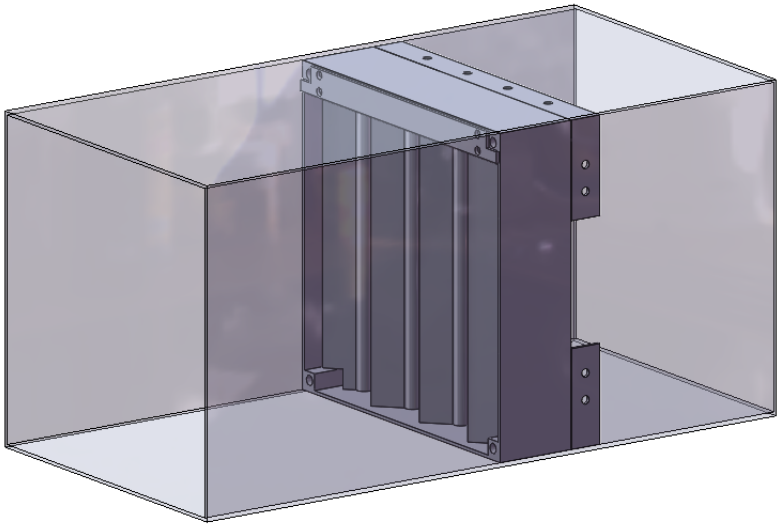
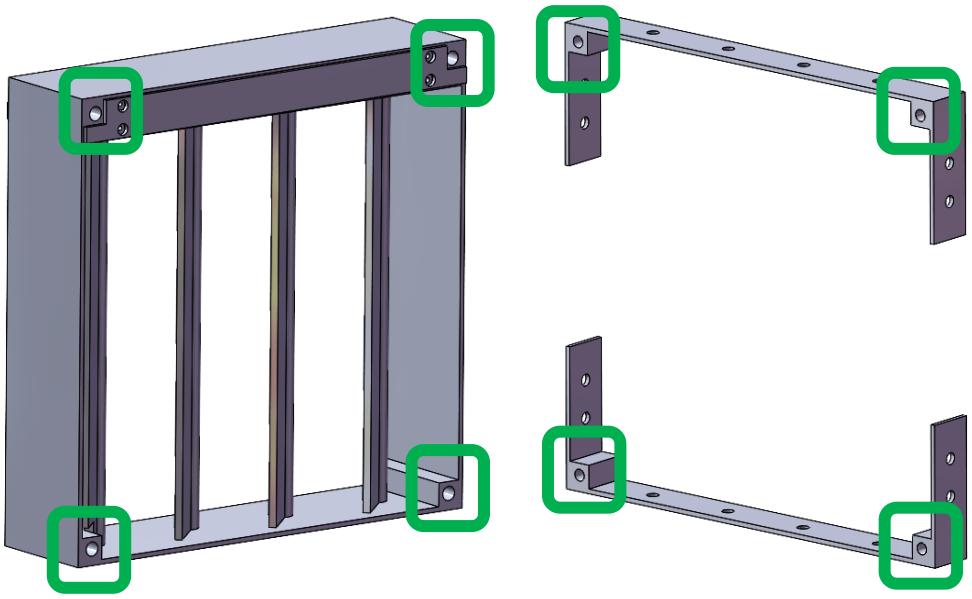


Figure 1. Modular Damper assembled inside a custom duct.

The Modular Damper consists of two separate assemblies. A mounting bracket with standardized bolt locations and a modular damper assembly. The mounting bracket and modular damper assembly are mechanically connected at four bolt locations and electrically connected by a single power and data connection. Figure 2 shows the bolt locations.



a) b)

Figure 2. Bolt (green) locations on the a) modular damper assembly and b) mounting bracket.

Installing the Modular Damper is a simple process. The mounting bracket is permanently installed in the custom duct section by spot welds or duct screws. This duct and mounting bracket assembly is then installed in the HVAC system. The modular damper assembly is then installed in the following steps:

1. Remove vent cover to access the damper location.
2. Insert the modular damper assembly into the duct such that the electrical connector and bolt hole locations are lined up.
3. Install bolts into the four bolt locations.
4. Replace vent cover.

When the modular damper assembly requires maintenance or replacement, the steps above can be reversed to remove the fan from the duct.

System Performance

The purpose of an inline damper is to maximize air flow through the duct when the damper is open and block the airflow when closed. The Modular Damper successfully blocks all the

airflow through the duct when the damper is closed. However, the damper continues to block some of the airflow when fully open. This can be measured by comparing the cross section of the duct without the Modular Damper to a duct with the damper installed. The highlighted area in Figure 3 shows the obstructions to the duct because of the Modular Damper.

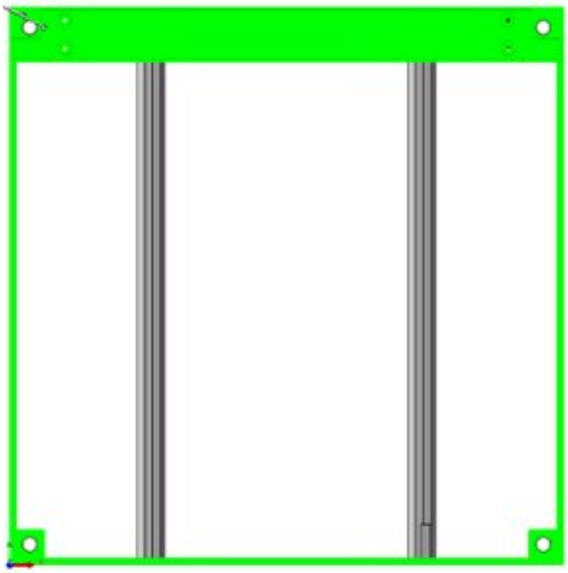


Figure 3. The duct cross section obstructed by an open modular damper is shown in green.

The cross section of a 10 in. square duct is approximately 96.04 in^2 and the area taken up by the Modular Damper when open is 13.23 in^2. This results in a total cross section reduction of 13.78 %.

The modular damper assembly design is intended to vary from different manufactures while the mounting bracket and associated mating features on the modular damper assembly will be standardized across the industry. This allows for a plug-and-play system such that modular damper assemblies from multiple manufactures will be interchangeable.

The Modular Damper can be scaled to fit any standardized duct size. Required bolt locations and damper thicknesses for several duct sizes are listed in the document Modular Damper Standard found at https://www.manhattan2.org/fan-and-damper.

III. Major Subsystem Overview

Mounting Bracket

The purpose of the mounting bracket is to secure the modular fan assembly to the duct wall and transfers loads to the building. The mounting bracket is shown in figure 4.

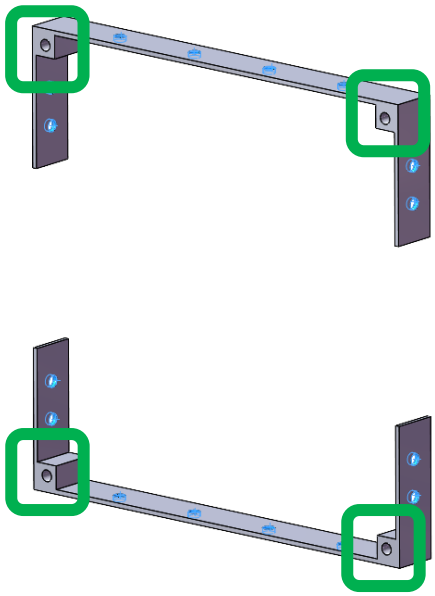


Figure 4. Mounting bracket showing attachment point locations. Mounting bracket to duct are in blue and mounting bracket to modular damper assembly in green.

Located on the mounting bracket are bolt threads for attaching the duct to the bracket and the bracket to the modular fan assembly. The holes highlighted in blue in Figure 4 are for attaching the mounting bracket to the duct.

The location of bolts is highlighted in green in Figure 4. The bolt threads are used for physically connecting the modular damper assembly to the mounting bracket. All the locations in green in Figure 4 are standardized to allow for plug-and-play modules.

The power and data cable must be shielded from vibrations or heat to avoid damaging the wires and causing a short circuit. The cables can enter the duct directly above the connection point on the mounting bracket or can be installed further down the duct and run to the electrical connection point through a conduit.

Modular Damper Assembly

The modular damper assembly consists of a damper housing, damper blades, and mechanical housing that stores the motor, linkages, and electrical connections. The complete modular damper assembly is shown in Figure 5.

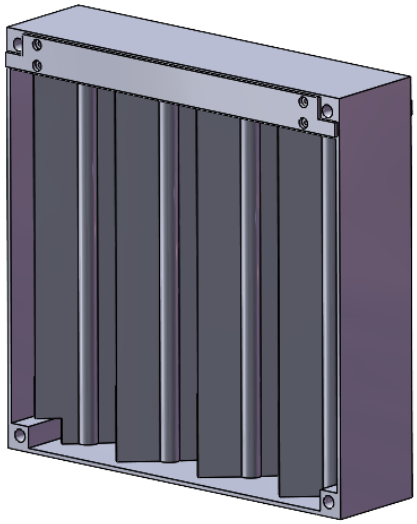


Figure 5. Modular damper assembly.

The damper housing provides strength and support to the modular damper assembly. It encloses the damper blades and mechanical housing in a protective shell around the perimeter. The damper housing also contains the mating surface between the modular damper assembly and the mounting bracket. This mating surface consists of four bolt hole locations as shown in figure 6.

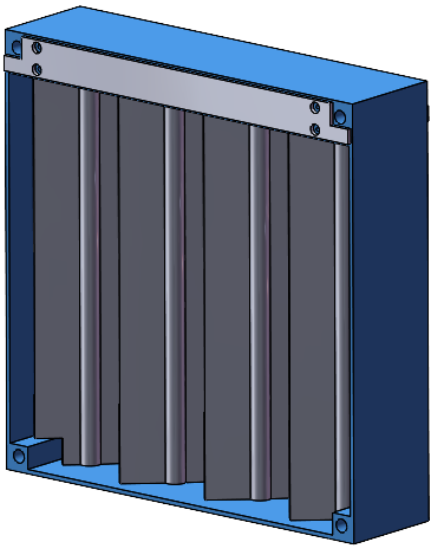


Figure 6. Damper housing is shown in blue.

The damper blades allow the damper to control the airflow through the duct. Figure 7 shows a four-blade configuration; however, the number of blades is not defined by the standards. More blades allow for a smaller modular damper assembly depth but require a more complex linkage system.

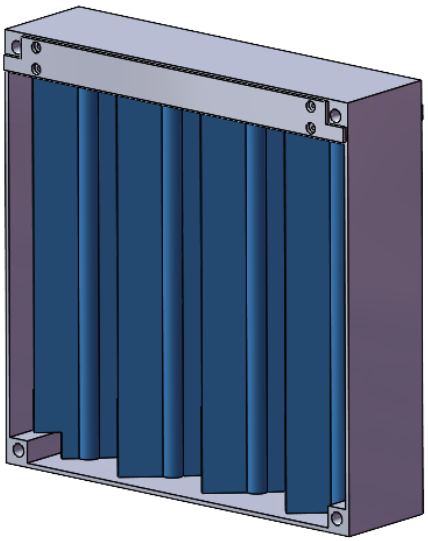


Figure 7. Damper blades are highlighted in blue. Shown is a four-blade configuration.

The mechanical housing protects the motor, linkages, and electrical connections from dust and other damage due to airflow in the duct. The mechanical housing cover can be removed by four screws to service parts inside the housing. The motor and linkages are not defined in the standard, but it is recommended to design the motor and linkages to minimize the cross section of the mechanical housing. The mechanical housing cover is shown in figure 8.

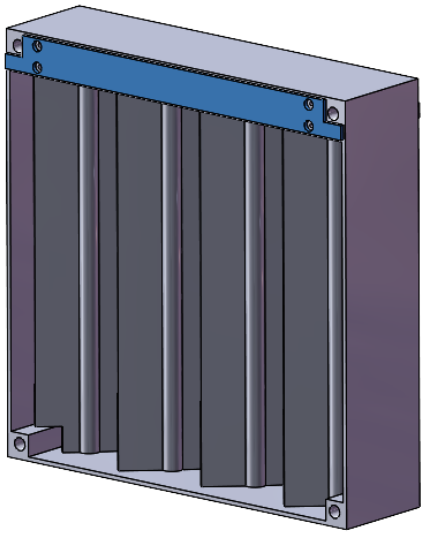


Figure 8. Mechanical housing cover.