VAV CHILLED BEAMS Pi FUNCTION

DESIGN GUIDE

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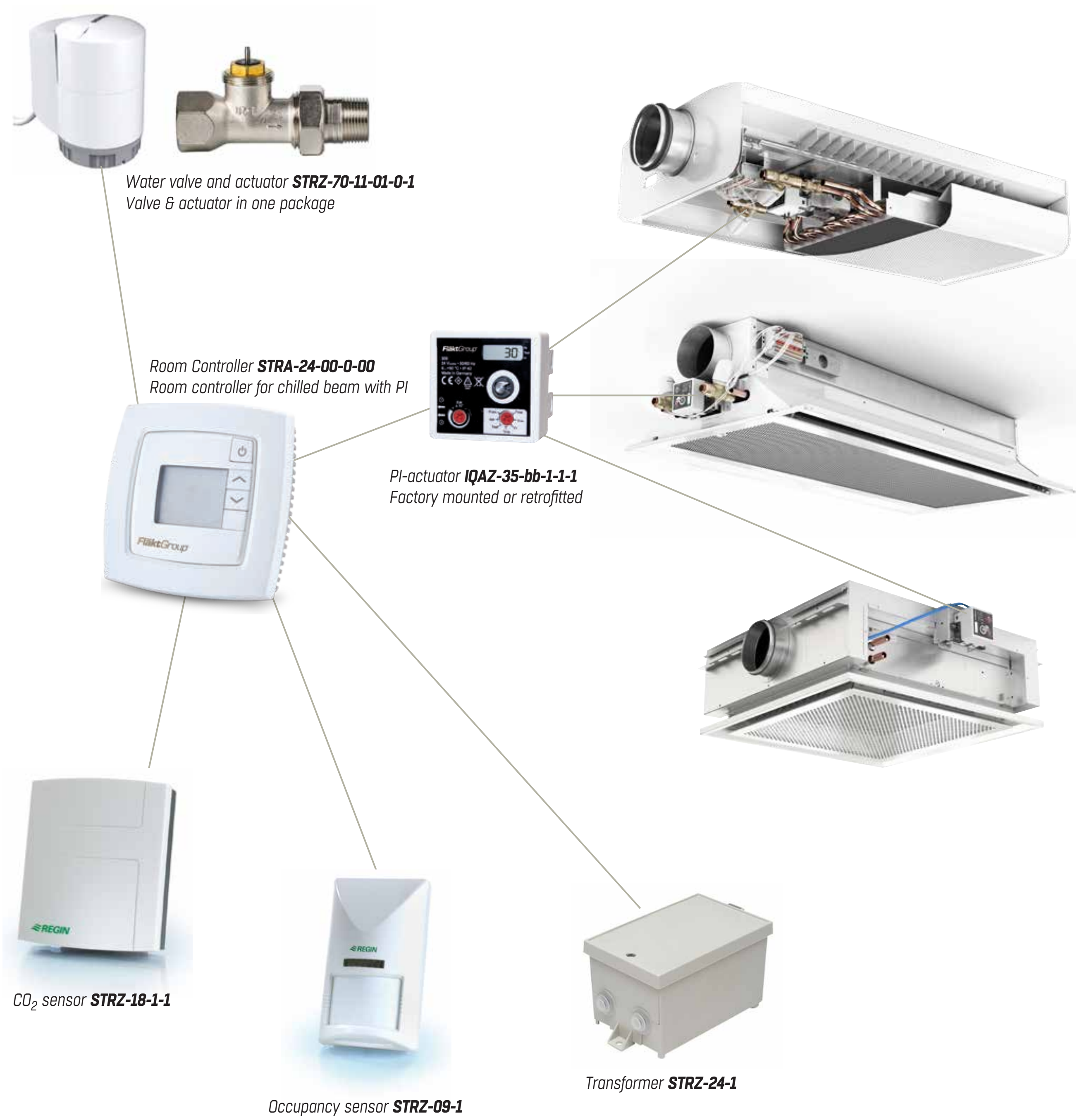
DIMENSIONING OF VAV CHILLED BEAM

FUNCTION PI

PI-function is an actuator connected to a chilled beam to vary the airflow based on temperature, CO_2 and occupancy and it is done independed from pressure before chilled beam.

Picture below shows a system with components for a PI-function installation.



OPERATION LEVELS

The PI-actuator mounted on chilled together with STRA-24 operates with 3 airflow levels.

- V_0 - Non occupancy airflow
- V_{min} – Minimum occupancy airflow
- V_{max} – Maximum airflow

The airflow in a chilled beam with PI-actuator is controlled based on Occupancy sensor, Temperature sensor (included in STRA-24) and CO_2-sensor. When non-occupancy is detected in the room, airflow level is set to V0 and will be kept independent from pressure to the chilled beam.

When occupancy is detected, airflow setpoint is increased from V_0 to V_{min}. From airflow level V_{min}, the airflow setpoint is changed dependent on cooling need and CO_2-level in the room.

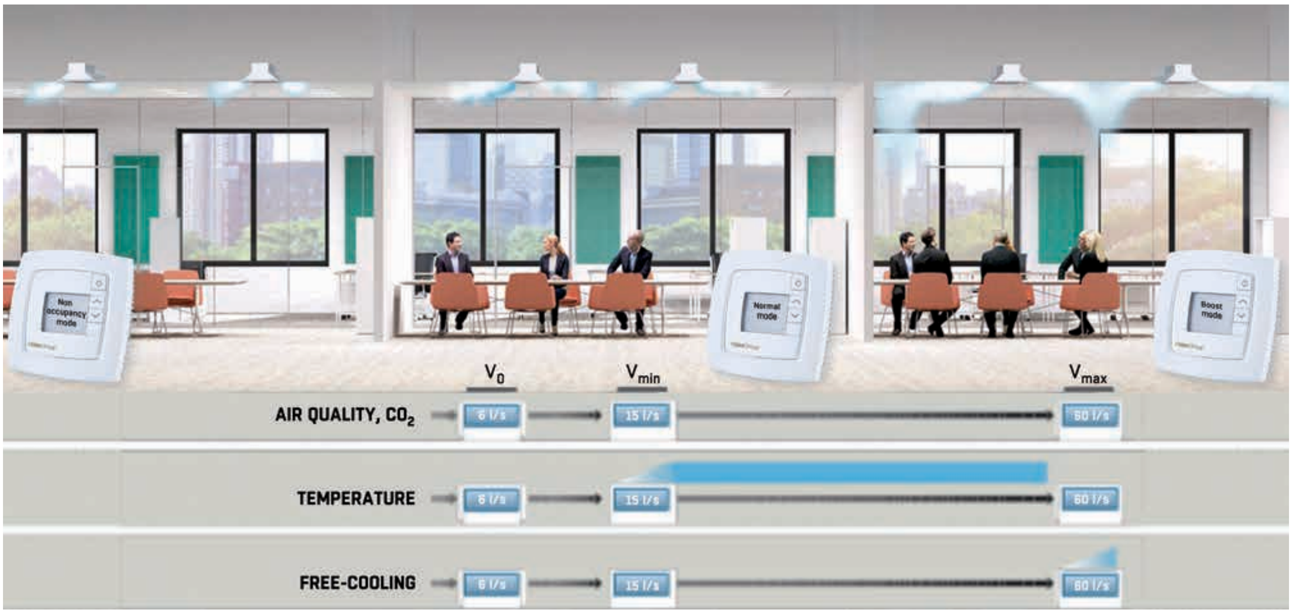
The cooling sequence in occupancy mode works in 2 steps. The first step of cooling is waterflow. When more cooling is need, the water flow is increased to get more cooling power. The second step of cooling is increasing airflow. If water valve is fully open and still there is a need for increased cooling power, the airflow will increase from V_{min} to maximum V_{max} to reach the desired temperature in the room.

This cooling sequence can be swaped if you have “free” cooled air and then start by increasing the airflow before water flow. But normal procedure is to first use water and then air in the cooling sequence.

The second parameter that controls the airflow level in occupancy mode is CO_2-level. When ppm-level increases above lower limit, the airflow increases to reduce the CO_2-level. The airflow increases up to maximum V_{max} when ppm level is equal or higher then high ppm limit. The high and low ppm-limits are set in the STRA room controller.

When there is a need for heating, the heating valve for the water increasing the water flow to get more heating power. The airflow does not increase in same way as in cooling sequence, if increased water flow does not give enough heating capacity.

The airflow will in heating sequence stay at V_{min} (if not heating PI is chosen, see below) as long as CO_2-level does not request for more airflow.



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HEATING WITH PI-FUNCTION

Naturally, warm air rises and remains at ceiling level when the heating function of a chilled beam is used and can therefore result in an unbalanced temperature gradient within the room. However, using a chilled beam with PI-function means that you can create stable ventilation whilst in heating mode. This is achieved by increasing the airflow when the demand for heating grows.

When there is a demand for more heating the airflow is increased causing it collide with walls or other airstreams in the room and is then directed downwards to the occupied zone. The level of increased airflow in heating mode is an adjustable parameter in STRA-24 (parameter 49).

DIMENSIONING OF CHILLED BEAM

To dimension a VAV-chilled beam you need requirement in terms of application, airflow need, cooling need and dimensioning pressure. Typical application for a VAV-chilled beam is meeting room.

SELECTION OF V_0

V0 is the airflow used in non-occupancy mode and there for is the airflow level designed to do ventilation of the building. The lowest allowed ventilation is depending on legislations in your country but it can be around 0.35 $l/s/m^2$. So for a room with 15 m^2 the airflow would be around 5 l/s. At this mode there are normally no demands for cooling capacity but it is of course important chilled beam can handle the normal load thus it does not always increase airflow just because it is a need for more cooling capacity.

Compared to competitors, FläktGroup chilled beams provides better comfort and more cooling power in this mode since all available pressure is used in chilled beam to create induction, where competitors have very pour cooling power due to lost pressure drop before nozzles.

SELECTION OF V_{MIN}

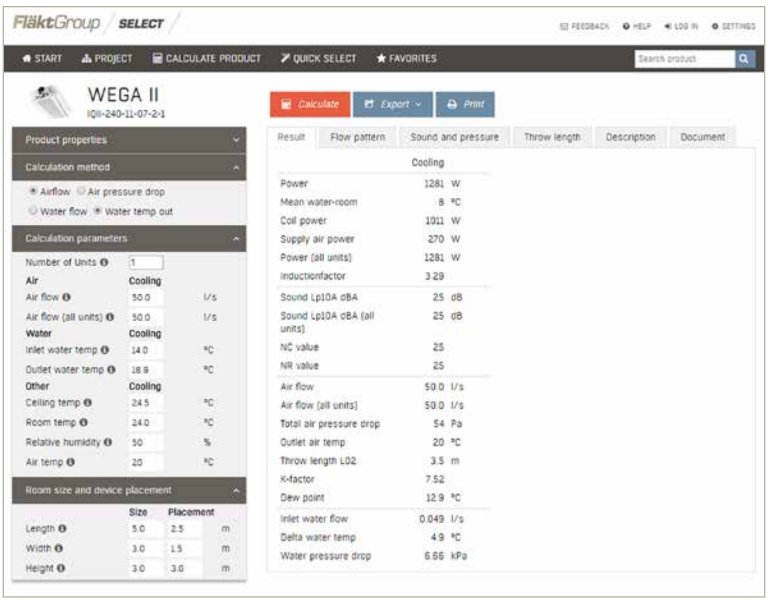
Vmin is the minimum airflow used in occupancy mode. In a conference room it would typically be the air volume of one or two persons in the room. Air volume required for a person is depending on your legislation in your country but is typically around 10 l/s per person. If it is a normal office, the airflow for V_{min} is typically 10 l/s. At this airflow level you should also consider the cooling capacity.

At normal usage with internal load and dimensioning pressure, you should with Vmin airflow achieve cooling capacity to handle normal load (not peak load). Because this is an airflow level which is the most frequently used, it is important to select a size of chilled beam and size of coil to handle normal load with V_{min} airflow to get an energy efficient system.

If you have heating in the chilled beam, V_{min} is the airflow used in heating mode, if not the CO_2 level tells the airflow to increase. This means that you need to consider that the heating power from the coils is enough at V_{min} airflow.

SELECTION OF V_{MAX}

The selection of Vmax is the airflow level to cover the ventilation need for maximum number of persons in the room. If it is a room maximum for 6 persons, the maximum airflow should probably be around 60 l/s which should be possible to supply at dimensioning pressure. At this level it should also being able to handle the maximum heating load in the room at dimensioning pressure. All these 3 selection of airflows can be simulated in SELECT.



VARIATION OF PRESSURE

The PI-function is, as described before, pressure independent which means it supplies the right airflow independent of pressure before the chilled beam by adapting the nozzle opening to the available pressure. This means it utilize all available pressure to distribute the air and get good coanda effect and induction rate all over the airflow range from 0 l/s up to maximum airflow of the chilled beam. Although if the pressure is changing, the amount of induced air is changing hence, the cooling power at certain airflow is changing. What need to be considered is how much can the pressure decrease, in order to still get the maximum required airflow and maximum required cooling power.

If you have made you design at 100 Pa and you can get your maximum airflow and cooling power down to 50 Pa. Then this 50 Pa is an input to the duct design (see below), and in this case make the design of the duct system to not go lower than 50 Pa. Since maximum load not appear many days in a year you may allow the design in this case to go even lower 50 Pa since it is a very worst case that maybe never appear.

DUCT DESIGN

Even if the chilled beam with PI-actuator is pressure independent, it is important to have a pressure variation to the chilled beam which is within certain levels. To get a good working chilled beam, the pressure to the chilled beam should between 40 - 140 Pa. If you go lower than 30 Pa, you will probably loose coanda effect and will get very pour comfort in the room. It could work if you have high airflow but generally 40 Pa is a good rule of thumb. Then you should not go higher than 140 Pa in the chilled beam. If that occurs it may be noise problems and that is from the comfort point of view not to recommend. As discussed in section above, you also have a lower limit where you may don´t achieve required cooling capacity or airflow. If this lower limit is 50 Pa, the design of ductwork should be made to keep the pressure to each of the chilled beam within 50 - 140 Pa to get good comfort and performance from you system.

If there is a ventilation system with many chilled beams, you may need to use constant pressure dampers (EMPA) in the system to serve a floor or a section of the system with constant pressure. How many chilled beams or rooms which can be used without using a constant pressure damper, is up to the duct design and airflow variation. But up to 20 chilled beams with PI-actuator can be used in a section, as a rule of thumb, without any constant pressure damper. Below you see an example of a branch of chilled beam with constant pressure damper in begin of the branch.

EXHAUST SIDE

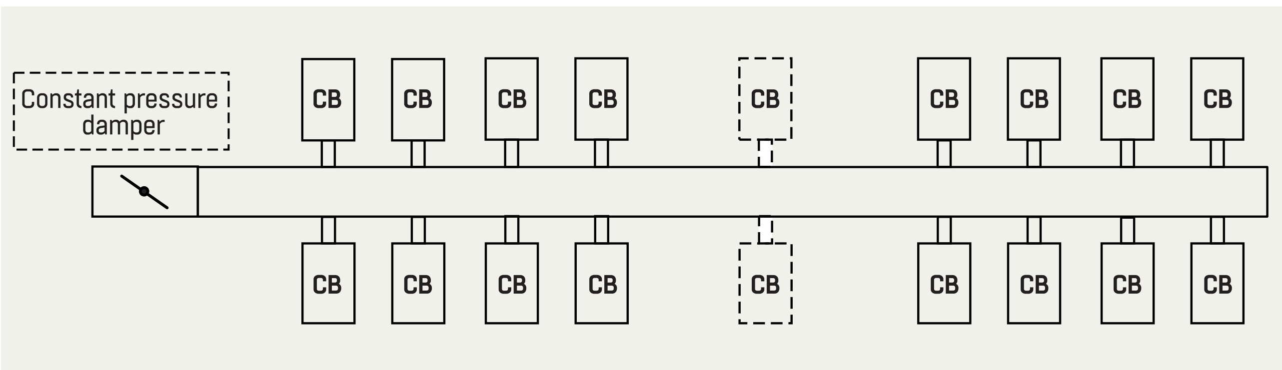
To handle the variation of airflow on Exhaust side, an Ultra Sound (ULSA) VAV-box is used. It can then be controlled by the analogue feedback signal from PI-actuator. The feedback signal from PI-actuator is scaled from 0 - 10 V where 0 V= 0 l/s and 10 V = V_{max} (CB) for the chilled beam.

If one VAV-box is serving the exhaust from one chilled beam, the Vmax (VAV) on the VAV-box is set equal to V_{max} (CB) and V_{min} (VAV) is set to 0.

If one VAV-box is serving the exhaust air from more than one chilled beam which are controlled by same room actuator, the V_{max} (VAV) on the VAV-box is set equal to $\Sigma(V_{max}$ (CB)) and V_{min} (VAV) is set to 0.

Another way to handle the exhaust side is through IPSUM. The PI-actuator has Modbus communication and IPSUM can then sum up the different airflows and through Modbus and control the VAV box on the Exhaust side.

On the following pages are different examples how to control the exhaust side together with PI-chilled beams.



EXAMPLE 1 – WEGA II, NOVA II & LYRA II WITH VAV WITHOUT IPSUM

Pressure is kept constant from AHU.

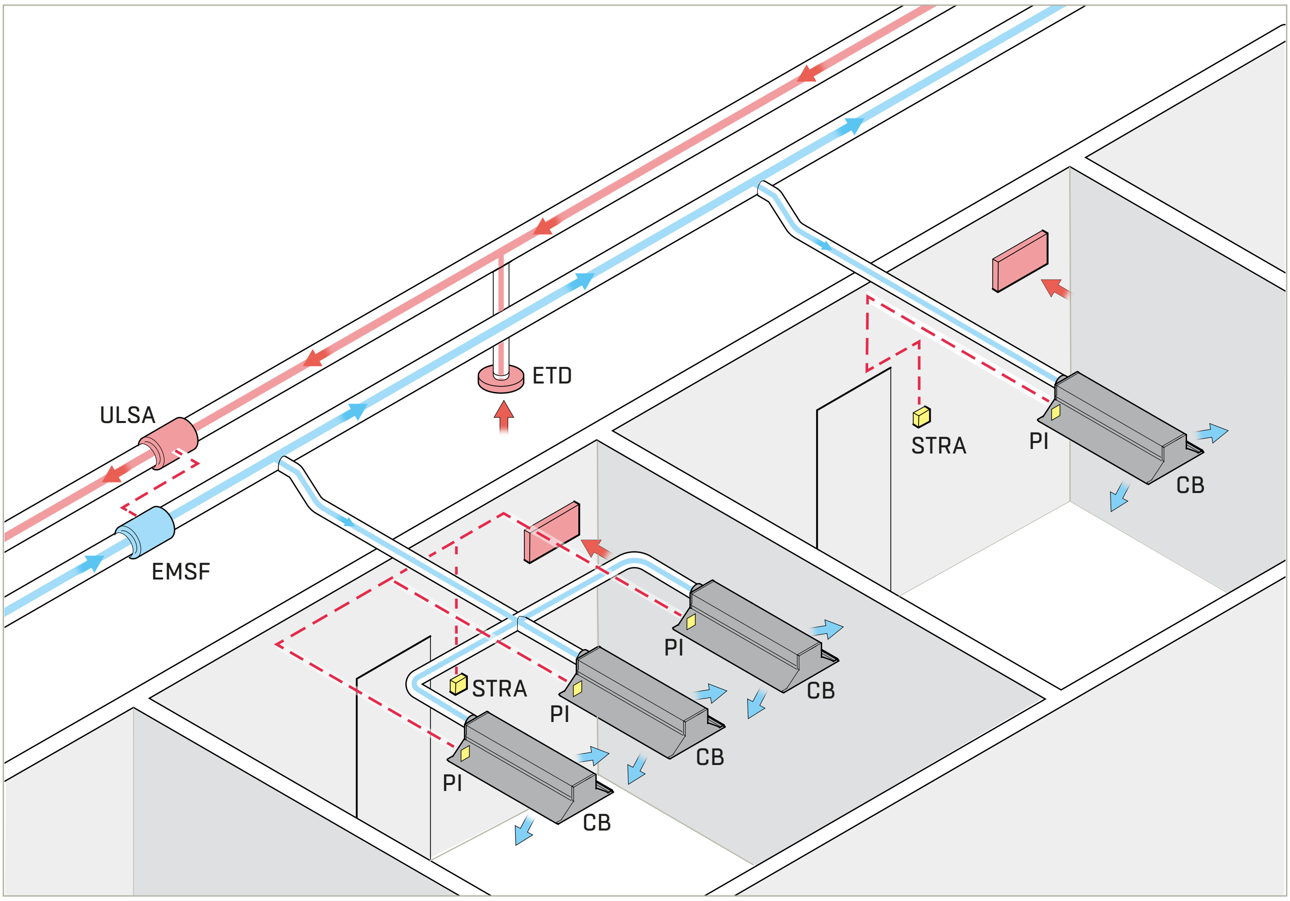
Pressure variation to chilled beams are with desired limits to achieve cooling capacity and noise level.

Airflow in each of the rooms are controlled with STRA-24 which is giving the set point to the chilled beams.

Airflow in to a control zone is measured with EMSF which is sending the set point signal to Utra Sound (ULSA) which is controlling the airflow on the exhaust side.

This solution is suitable for small or medium buildings where IPSUM is not used. Need to make sure that the pressure to the chilled beams does not vary too much.

If pressure vary too much one EMPA can be used per zone on supply side to make the pressure variation in each zone is more constant.



ULSA = Optivent Ultra Sound VAV
EMSF = Optivent Air flow measuring VAV
STRA = Room controller
PI = PI-actuator
CB = Chilled beam
ETD = Extract air Terminal device

EXAMPLE 2 – WEGA II, NOVA II, LYRA II WITH PI AND WITH IPSUM

Pressure is optimized from AHU in order to save energy.

EMPA is used on supply side to control the pressure level to each of the zones thus pressure variation to chilled beams are with in desired limits to achieve cooling capacity and noise level.

In smaller system this EMPA is not needed and the constant pressure from AHU is enough to pressure control the system.

Airflow in each of the rooms are controlled with STRA-24 which is giving the set point to the chilled beams.

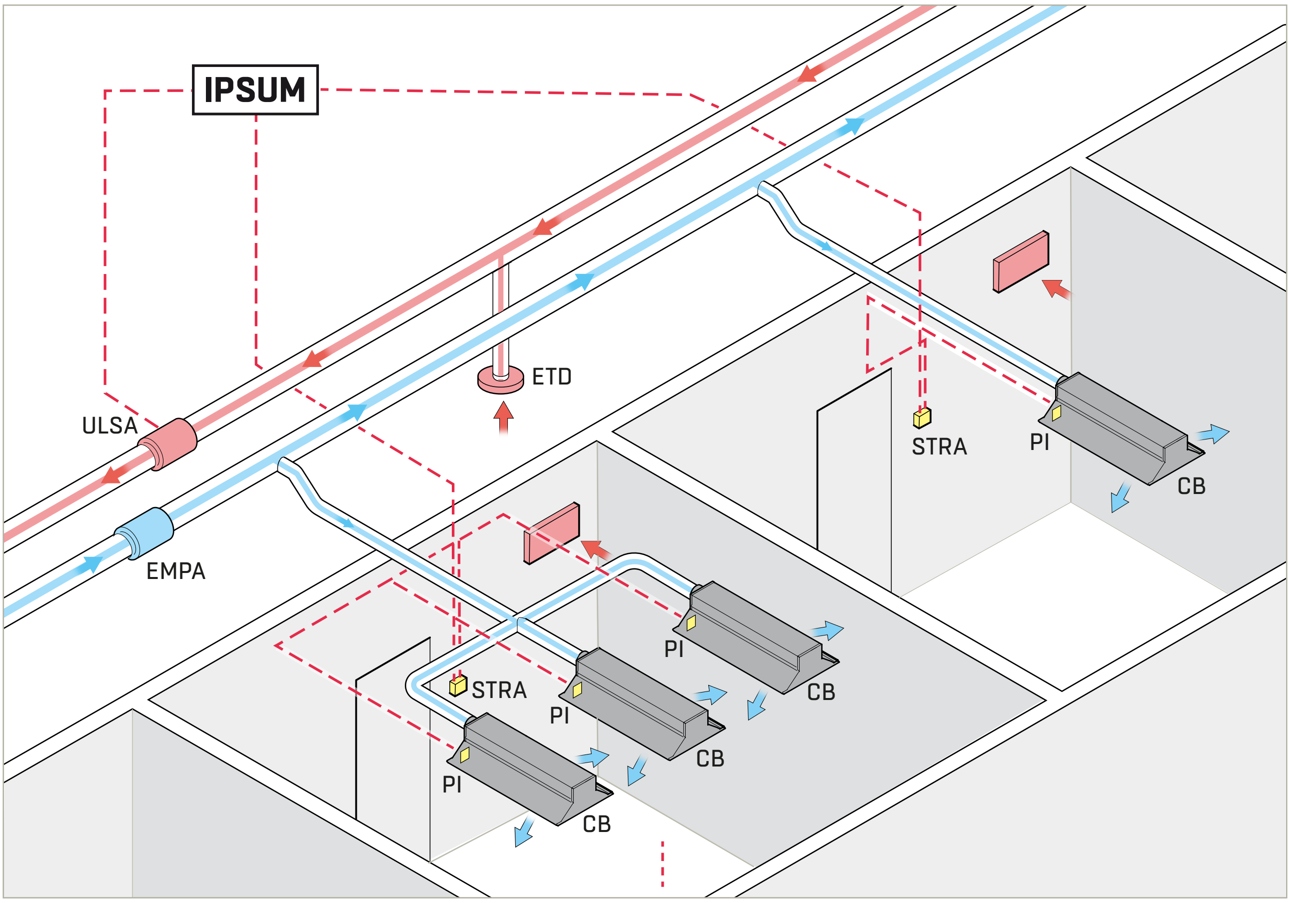
Airflow is measured with each of the PI-actuators and summed up in the IPSUM system. Set point is sent from IPSUM to Utra Sound (ULSA) on Exhaust side to control the exhaust airflow.

The solution requires that each flow in to the rooms are measured with PI-which gives information about supply airflow to IPSUM.

IPSUM sum up the airflow and send setpoint signal for common Utra Sound (ULSA) on exhaust side.

EMPA on zone level can be useful to make sure that the pressure to the chilled beams to vary to much when pressure optimization is made by IPSUM to the AHU

This solution is suitable for medium and big system where IPSUM is used.



IPSUM = VAV Optimization system
ULSA = Optivent Ultra Sound VAV
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ETD = Extract air Terminal device

EXAMPLE 3 – WEGA II, NOVA II, LYRA II WITH PI

Pressure is kept constant from AHU.

Pressure variation to chilled beams are with desired limits to achieve cooling capacity and noise level.

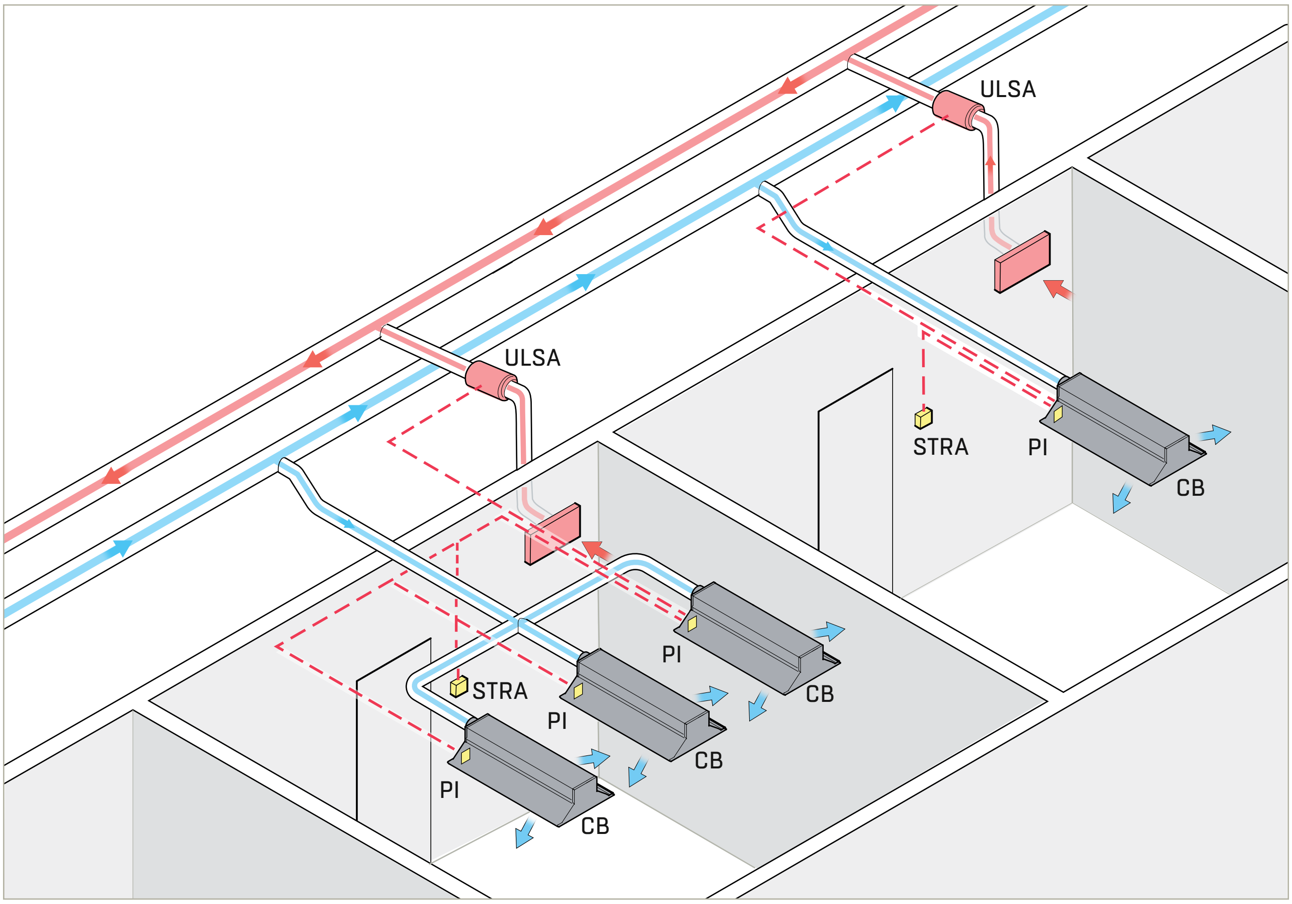
Airflow in each of the rooms are controlled with STRA-24 which is giving the set point to the chilled beams.

Airflow is controlled in each room where supply airflow is measured by PI which is sending a setpoint to each Utra Sound (ULSA) on exhaust side for each room.

This solution is suitable for small or medium buildings where IP-SUM is not used and transfer air from room is not applicable.

Need to make sure that the pressure to the chilled beams does not vary too much.

If pressure vary too much one EMPA can be used per zone on supply side to make the pressure variation in each zone more constant.



ULSA = Optivent Ultra Sound VAV
STRA = Room controller
PI = PI-actuator
CB = Chilled beam

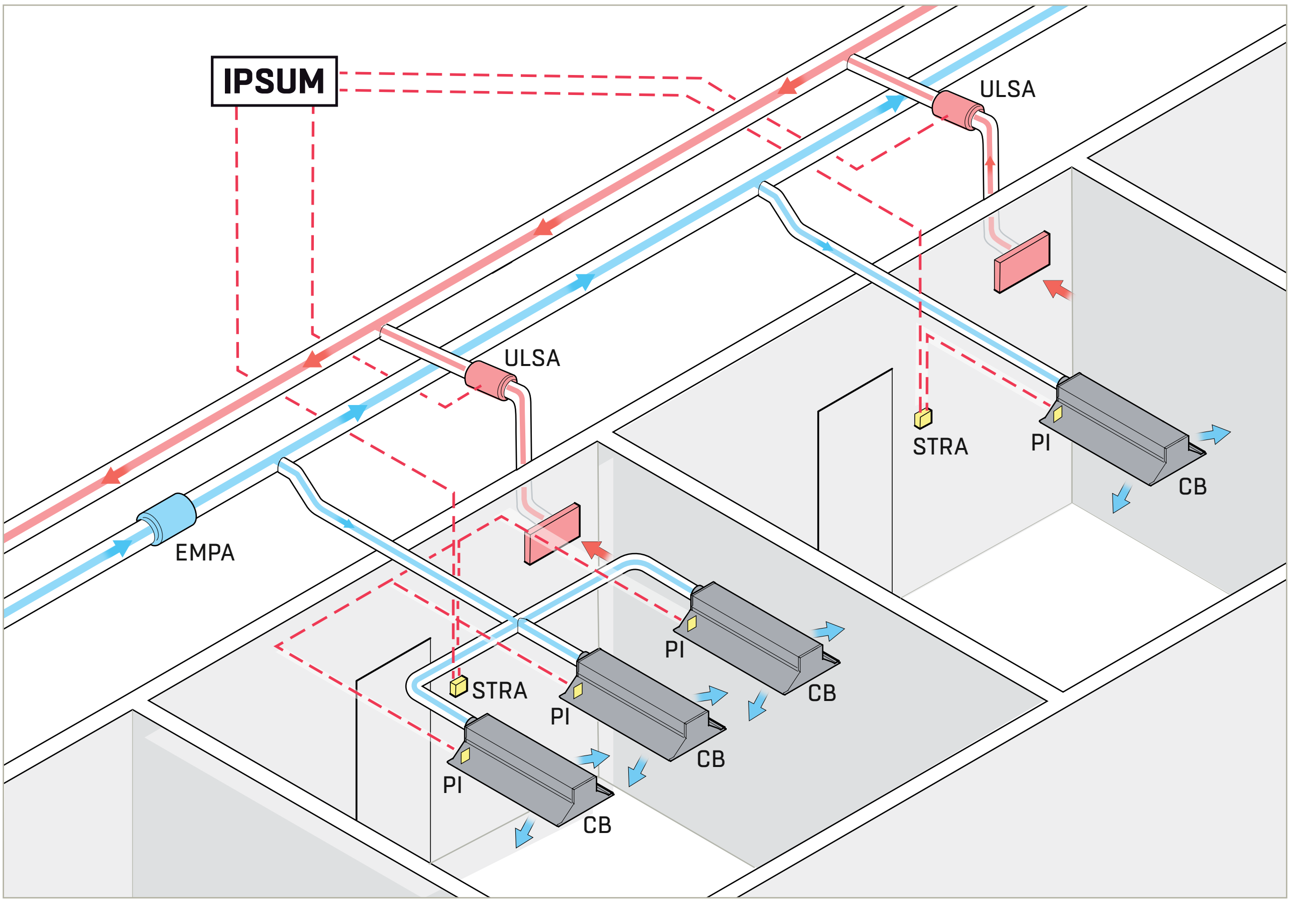
EXAMPLE – 4 WEGA II, NOVA II, LYRA II WITH PI AND WITH IPSUM

Pressure is optimized from AHU in order to save energy. EMPA is used on supply side to control the pressure level to each of the zones thus pressure variation to chilled beams are with in desired limits to achieve cooling capacity and noise level. Airflow in each of the rooms are controlled with STRA-24 which is giving the set point to the chilled beams.

Airflow is measured with each of the PI-actuators and summed up in the IPSUM system. Set point is sent from IPSUM to Utra Sound (ULSA) on exhaust for each of the rooms.

The solution requires that each flow in to the rooms are measured with PI-actuator which gives information about supply airflow to IPSUM. IPSUM sum up the airflow for each room and Utra Sound (ULSA) is used for each room when transfer air is not applicable. EMPA on zone level can be useful to make sure that the pressure to the chilled beams to vary to much when pressure optimization is made by IPSUM to the AHU

This solution is suitable for medium and big system where IPSUM is used and transfer air is not applicable.



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EXAMPLE 5A – WEGA II, NOVA II, LYRA II WITH PI MIXTURE WITH CAV DEVICES WITHOUT IPSUM

UTRA SOUND (ULDA) FOR EACH CAV ROOM

Pressure is kept constant from AHU.

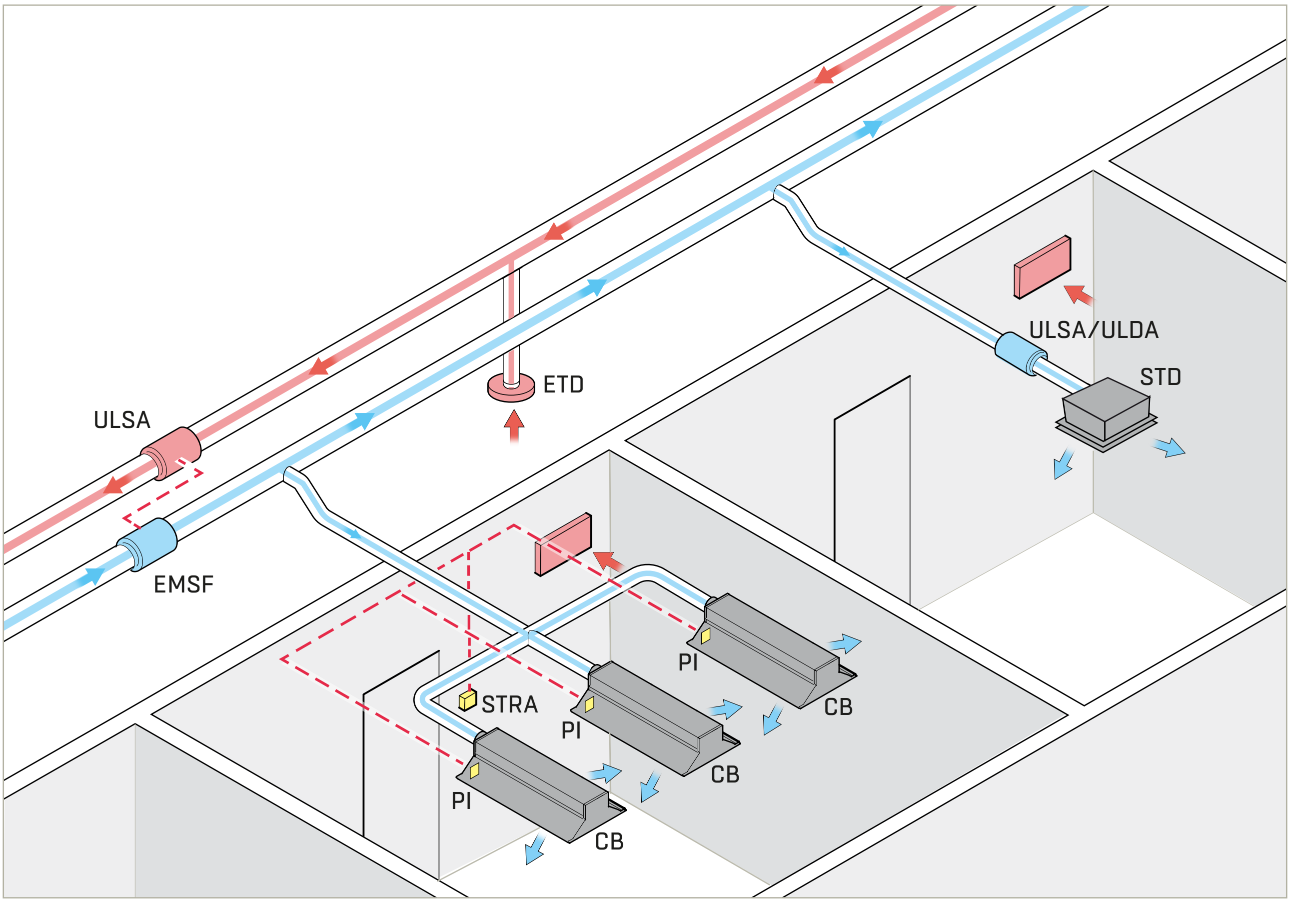
Pressure variation to chilled beams are with desired limits to achieve cooling capacity and noise level.

Airflow in each of the rooms is controlled with STRA-24 which is giving the set point to the chilled beams.

Airflow in to a control zone is measured with EMSF which is sending the set point signal to Utra Sound (ULSA) which is controlling the airflow on the exhaust side.

This solution is suitable for small or medium buildings where IPSUM is not used. Need to make sure that the pressure to the chilled beams does not vary too much.

When pressure vary to much for CAV rooms why one Utra Sound (ULSA/ULDA) of each supply for CAV room is used to keep constant supply air.



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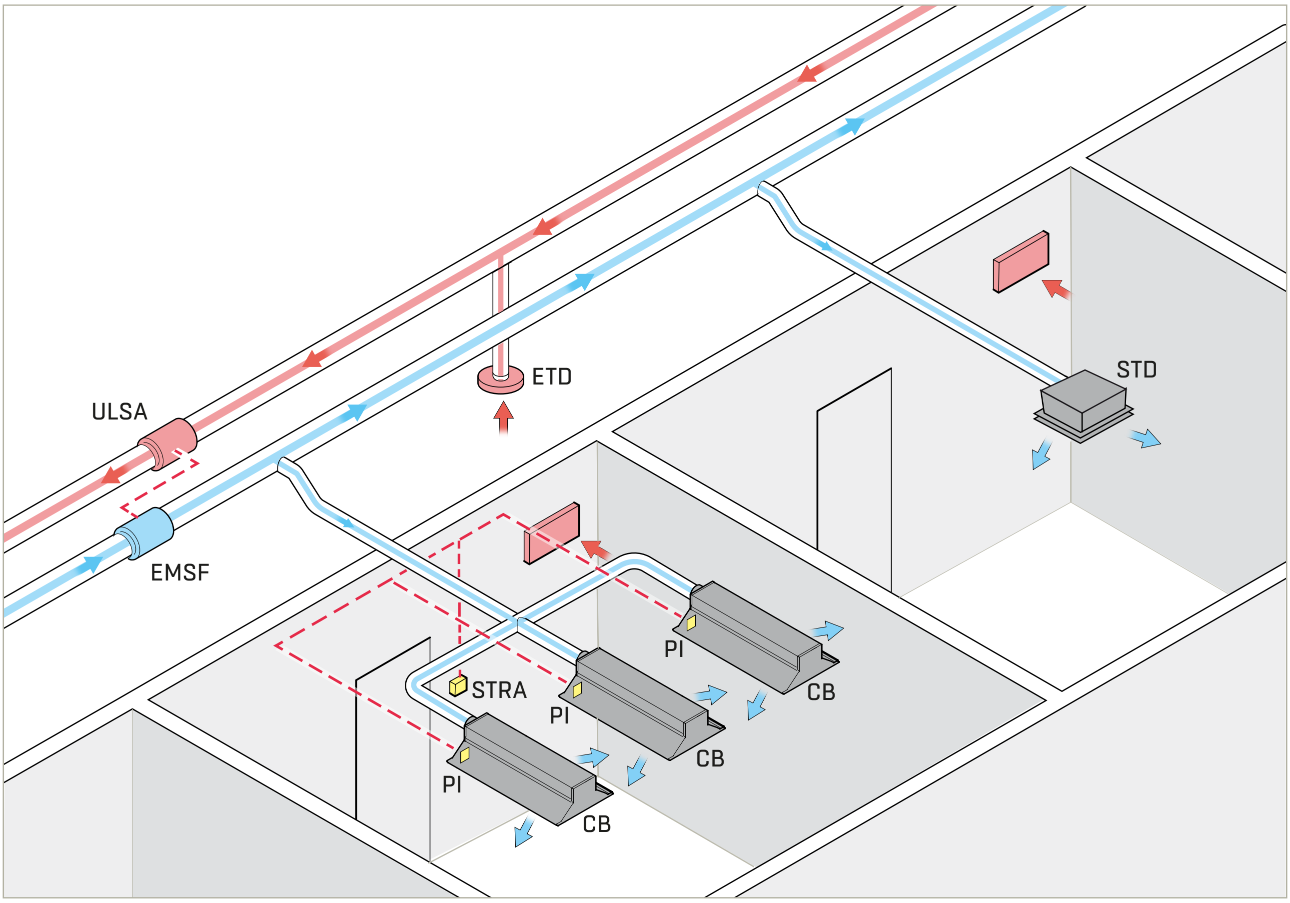
ETD = Extract air Terminal device
STD = Supply air Terminal device

EXAMPLE 5B – WEGA II, NOVA II, LYRA II WITH PI MIXTURE WITH CAV DEVICES WITHOUT IPSUM

WITHOUT UTRA SOUND (ULDA) FOR CAV SUPPLY

Compared to 5A pressure don't vary so much which allow to remove Utra Sound (ULDA) on supply room for CAV rooms.



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ETD = Extract air Terminal device
STD = Supply air Terminal device

EXAMPLE 6 – WEGA II, NOVA II, LYRA II WITH PI, CAV DEVICES AND WITH IPSUM

Pressure is optimized from AHU in order to save energy.

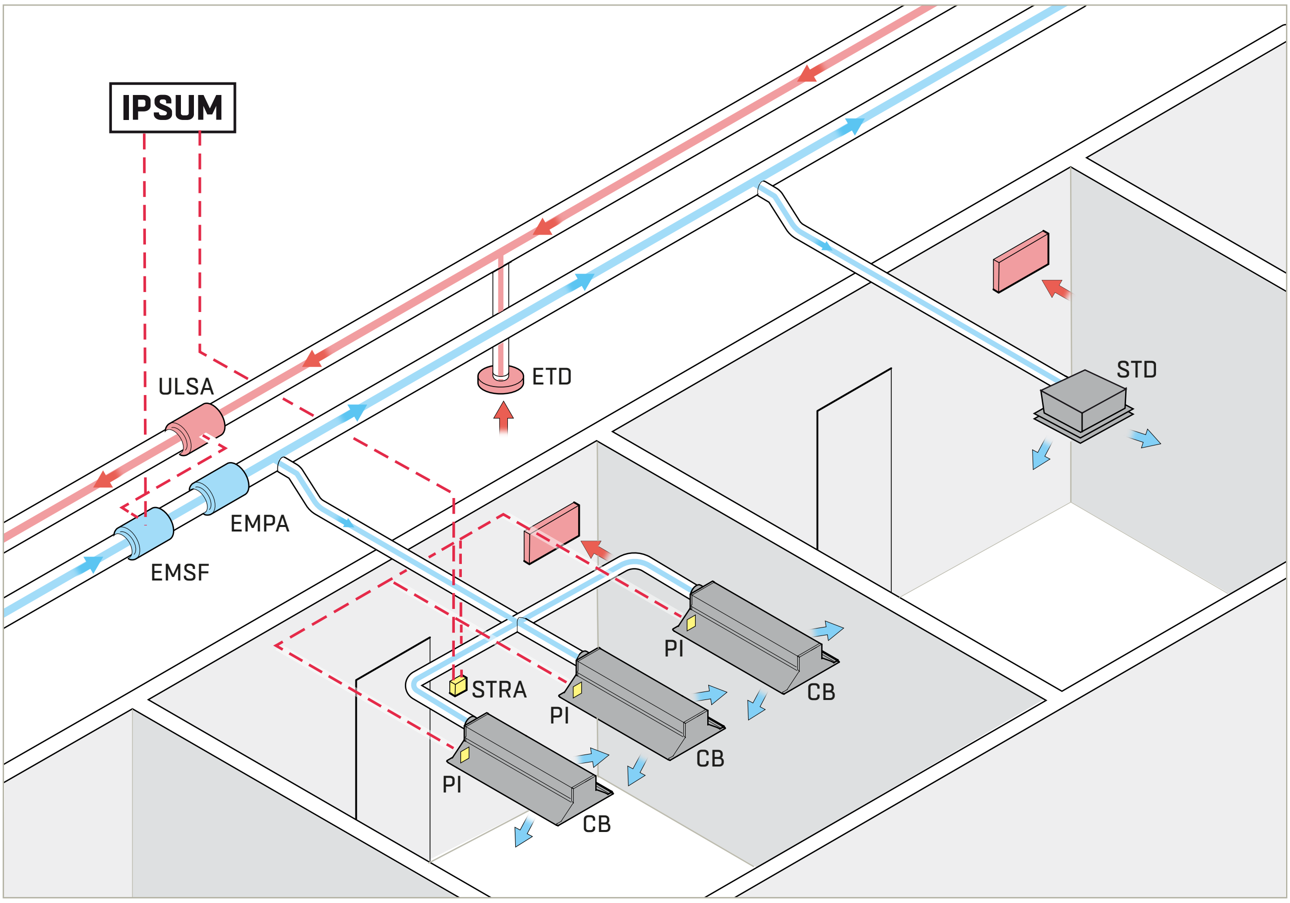
EMPA is used on supply side to control the pressure level to each of the zones thus pressure variation to supply devices may vary much when pressure optimization through IPSUM is performed.

In smaller system this EMPA is not needed and the constant pressure from AHU is enough to pressure control the system.

Airflow in each of the rooms are controlled with STRA-24 which is giving the set point to the chilled beams.

Airflow is measured with EMSF and sent directly to exhaust Utra Sound (ULSA) or through IPSUM to control the exhaust airflow

This solution is suitable for medium and big system where IPSUM is used there is a mixture between CAV and VAV devices.



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STD = Supply air Terminal device

EXAMPLE 7 – WEGA II, NOVA II, LYRA II WITH PI AND CAV, WITHOUT TRANSFER AIR

Pressure is kept constant from AHU.

Pressure variation to chilled beams are with desired limits to achieve cooling capacity and noise level.

Airflow in each of the chilled beam rooms are controlled with STRA-24 which is giving the set point to the chilled beams.

In CAV room Utra Sound (ULSA/ULDA) is used to keep the air volume constant.

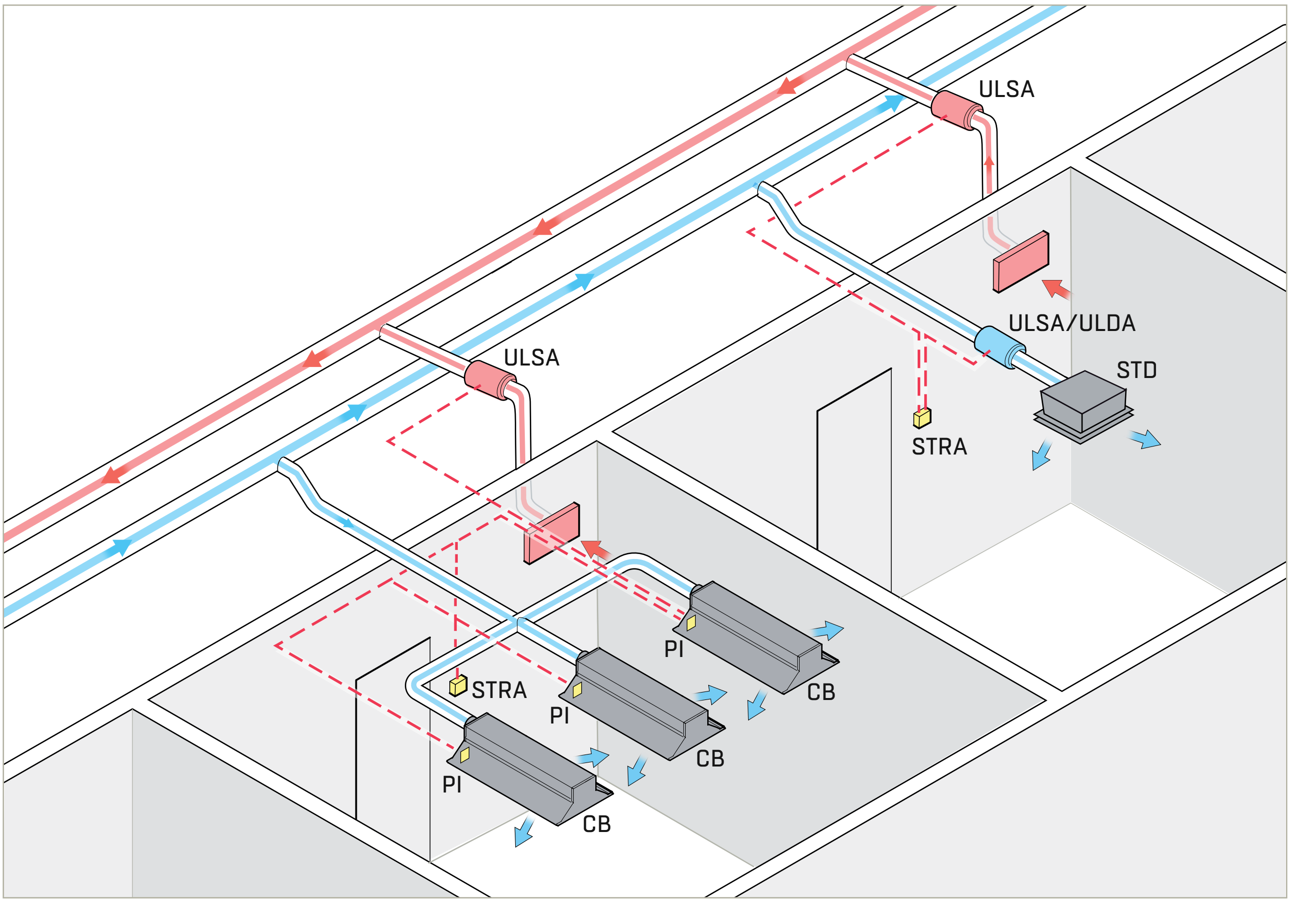
Airflow is controlled in each room where supply airflow is measured by PI for chilled beam rooms which is sending a setpoint to each Utra Sound (ULSA) on exhaust side for each room.

In CAV or VAV with ATD rooms an Utra Sound (ULSA/ULDA) is used both on supply (ULSA/ULDA) and exhaust (ULSA) to control the airflow.

This solution is suitable for small or medium buildings where IPSUM is not used and transfer air from room is not applicable.

Need to make sure that the pressure to the chilled beams does not vary too much.

If pressure vary too much one EMPA can be used per zone on supply side to make the pressure variation in each zone more constant.



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CB = Chilled beam
STD = Supply air Terminal device

EXAMPLE 8 – WEGA II, NOVA II, LYRA II WITH PI AND CAV, WITHOUT TRANSFER AIR AND IPSUM

Pressure is kept constant from AHU.

Pressure variation to chilled beams are with desired limits to achieve cooling capacity and noise level.

Airflow in each of the chilled beam rooms are controlled with STRA-24 which is giving the set point to the chilled beams.

In CAV room Ultra Sound (ULSA/ULDA) is used to keep the air volume constant.

Airflow is controlled in each room where supply airflow is measured by PI for chilled beam rooms which is sending a setpoint to each Utra Sound (ULSA) on exhaust side for each room.

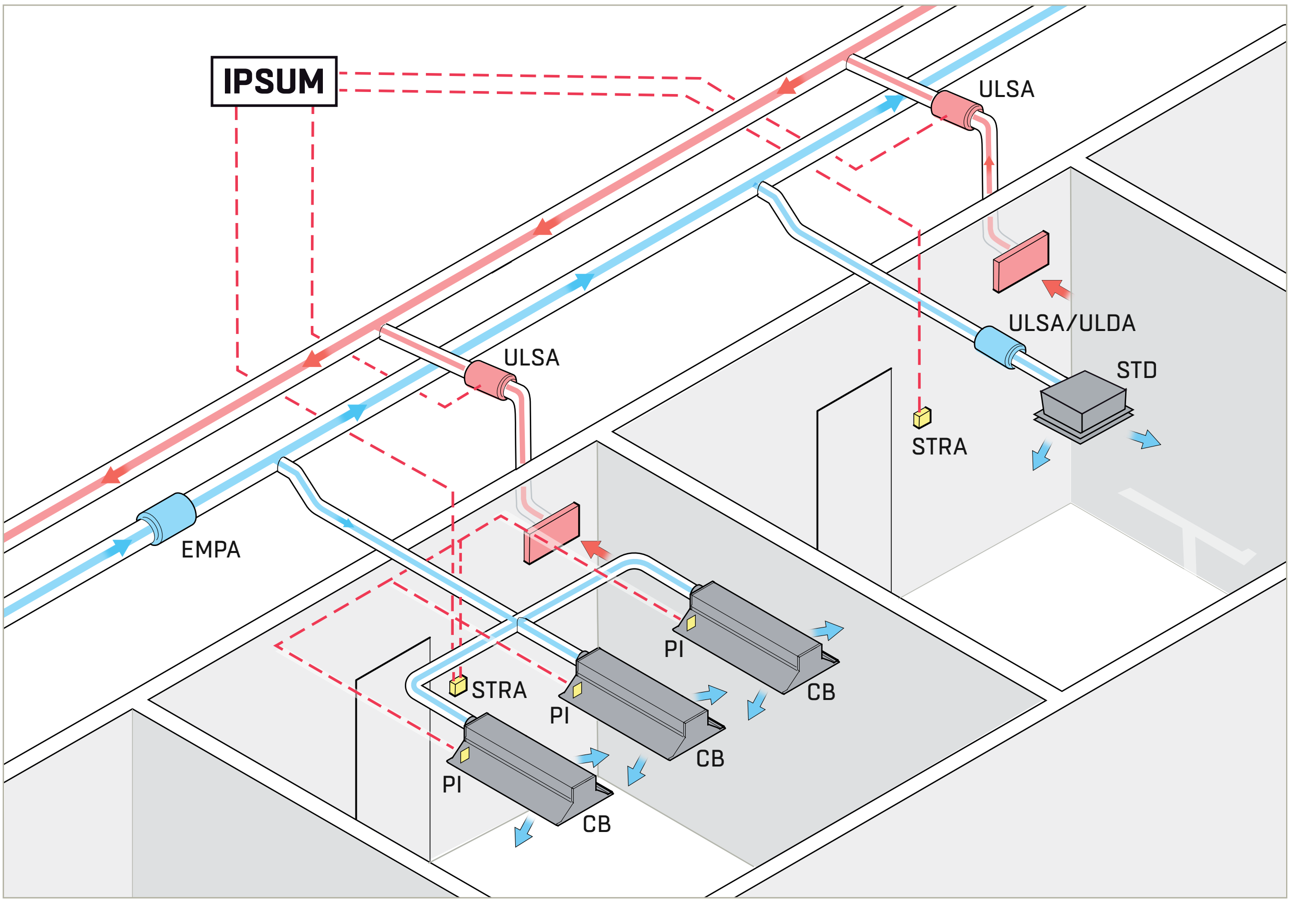
In CAV or VAV with ATD-rooms an Utra Sound is used both on supply (ULSA/ULDA) and exhaust (ULSA) to control the airflow.

Airflow balancing between supply and exhaust can also be handled through IPSUM

This solution is suitable for small or medium buildings where IPSUM is not used and transfer air from room is not applicable.

Need to make sure that the pressure to the chilled beams does not vary too much.

EMPA on zone level can be useful to make sure that the pressure to the chilled beams don´t vary to much when pressure optimization is made by IPSUM to the AHU.



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