Microbridge Airflow Sensors

High Flow Capability
Bypass Design Considerations – Note #2

Many users would like to take advantage of the cost-effective, high-performance characteristics of the microbridge mass airflow sensor. Some of these applications require the ability to measure flow ranges higher than the capability of existing microbridge sensors. Others may simply wish to take advantage of the flow range capability of the high-flow AWM5000 series, but require the small size and fast response times of the AWM2000/ AWM3000 series.

One way to achieve higher flow range capability is through the use of a bypass configuration. This provides a higher main flow channel than the lower bypass (sensor) flow channel. In this configuration, only a sample of the total flow actually gets directed through the bypass channel and the sensor. The amount of flow directed through the microbridge device is determined by the ''bypass ratio.'' The smaller the ratio, the more predictable and stable the sensor output throughout the measured flow range.

Simple bypass configurations can be easily incorporated into most applications. The bypass ratio can be calculated by determining the cross sectional area of the flow channel above the microbridge chip compared to the cross sectional area of the main flow channel at its point of greatest restriction. The cross sectional area above the microbridge chip is determined according to the internal design of the sensor flow tube (See Table 1).

Figure 1 Typical bypass design

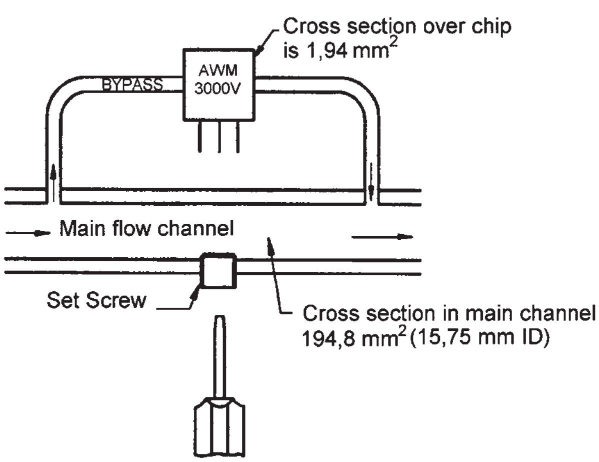

Figure 1 is a typical bypass configuration. In this design, the main flow channel has an ID of 15,75 mm which results in a cross sectional area of 194,83 mm². The cross sectional area above the microbridge chip is 1,95 mm². This yields an approximate bypass ratio of 100 to 1. This design incorporates a variable flow restriction (set screw) that can be used to calibrate a specific bypass ratio.

Applications that incorporate bypass designs with ratios of 100 to 1 or greater may experience noticeable errors near zero flow. Large bypass ratios require a larger pressure drop to adequately direct flow to the sensor. Under very low flow conditions, there may not be sufficient pressure drop to drive flow through the bypass (sensor) flow channel. There may also be considerable variation in performance due to variety of bypass channel designs and geometries. In addition, device-to-device variation may be amplified when used in conjunction with high bypass ratios.

For example, an application that needs 5 SLPM flow measurement capability could potentially use an AWM3300V (1,000 sccm flow range device). This would simply require the use of two T-connections and a bypass flow channel using 1/8 inch ID tubing. This is the same tubing size recommended for connecting the sensor. With this configuration, the bypass ratio is 4 to 1. This will allow 4 liters of flow through the bypass channel with 1 liter of flow through the sensor channel, permitting a total of 5 liters of flow through the system.

The same size tubing, 1/8 inch ID, to bypass an AWM5000 series sensor would provide a 1 to 1 bypass ratio, thus doubling the flow capability of this sensor. Further, using a 3/8 inch ID tubing to bypass the AWM5000 series would provide a 3 to 1 bypass ratio, thus quadrupling the flow range capability for the AWM5000 sensor. This 3 to 1 bypass configuration used with an AWM5104VN (20 SLPM flow range) would provide flow measurement capability up to 80 SLPM.

Table 1 Cross-sectional area above microbridge chip

Catalog Listing	Area*
AWM2100V	1.57 mm²
AWM2300V	1.94 mm²
AWM3100V	1.57 mm²
AWM3300V	1.94 mm²
AWM42150VH	1.75 mm²
AWM42300V	1.75 mm²
AWM43300V	1.75 mm²
AWM43600V	12.07 mm²
AWM5000 Series	45.60 mm²

* All values are approximate.

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In applications where the desired flow rate exceeds the flow specifications for standard MICRO SWITCH products, a bypass flow channel (see Figure 2.) can be configured. A bypass (appropriately sized) consists of a Microbridge sensor on parallel with the main flow channel. In this configuration, only a portion of the total flow rate will pass through the bypass channel and sensor, while the majority of the total flow passes through the main flow channel. Below is an example of calculations needed to properly size the bypass configuration and help select an appropriate Microbridge Sensor.

In this example, a multi-channel bypass with a Microbridge Sensor is configured for 100 liter/min flow rate.

Step 1: Convert desired flow rate from liters/min to m^3/sec by the following formula:

Enter Desired Flow Rate = 100 liters/min

liter/min X .00001666667 = $\boxed{0.001666667}$ m^3/sec

Enter the above calculated value into INPUT area below as the Total Volumetric Flow (Q_{total}).

Step 2: Calculate Reynold's number for desired volumetric flow. It is important that desired volumetric flow is in the laminar flow range. This means that the Reynold's number must be 2000 or less. Enter desired volumetric flow in INPUT area below. Make adjustments in INPUT area to diameter (D) and quantity (N) of flow channels for a Reynold's number (Re) of 2000 or less (Laminar Flow):

$$Re = \frac{4 * \rho * Q / N}{\pi * D * \mu} = \frac{0.000347826}{1.80539E-07} = \boxed{1926.59302}$$

Table 1

Parameter	Definitions		Input Range	Constant @ 20°C	Metric Units
ΔP =	Delta Pressure	=	—		N/m^2
μ =	Viscosity Air	=	1.81E-05	—	$(N*s)/m^2$
ρ =	Density Air	=	1.20	—	kg/m^3
π =	PI	=	—	3.141592654	—
D =	Diameter of Single Flow Channel	=	0.003175	—	m
N =	Number of channels	=	23	—	—
L =	Length of By-Pass	=	0.0508	—	m
Q_{total} =	Total Volumetric Flow Rate	=	0.001666667	—	m^3/sec
K_{inlet} =	Inlet Loss Coefficients	=	0.5	—	—
K_{outlet} =	Outlet Loss Coefficients	=	1.0	—	—
g =	Acceleration of gravity constant	=	—	9.806	m/sec^2

Step 3: Calculate approximate pressure drop across Laminar Flow Area (due to flow). Use the following equation:

$$\Delta Pflow = \frac{128 * \mu * (Q/N) * L}{\pi * D^4} = \frac{8.52851E-09}{3.19246E-10} = \frac{26.71 \ N/m^3}{\boxed{0.107} \ ''H^2O}$$

Step 4: Calculate approximate pressure loss at inlet and outlet. Use the following formula:

first, calculate velocity: $V = \frac{4 * Q}{\pi * N * D^4} = 9.2$ m/sec

next, use calculated velocity (V) in equation below and calculate Inlet and Outlet pressure loss:

$$\Delta P_{inlet/outlet\ loss} = \frac{(K_{inlet} + K_{outlet}) * V^2 * \rho}{2} = \frac{75.39 \ N/m^2}{\boxed{0.303} \ ''H^2O}$$

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Step 5: Calculate approximate Total Pressure drop across Laminar Flow Area. Use the following formula:

$$\Delta P_{total} = \Delta P_{inlet/outlet\ loss} + \Delta P_{flow} = \underline{102.11}\ N/m^2 \quad \boxed{0.41}\ ''H^2O$$

Note: ΔP_{total} is an approximate value. Testing or further analysis is needed for each specific design.

Step 6: Select appropriate Microbridge sensor that has a full scale pressure drop that is equal to or greater than calculated Total Pressure Drop (ΔP_{total}) using Table 2 below:

Table 2

Product	Rated Flow	Rated Pressure	Output Type	Select by Typical Full Scale Pressure Drop
AWM2100V	±200 sccm	N.A.	±44.5 mv	.20 ″H_2O or 49.8 N/m^2
AWM2150V	±30 sccm	N.A.	±14 mv	.20 ″H_2O or 49.8 N/m^2
AWM2200V	N.A.	0-2 ″H_2O	±31.75 mv	2.0 ″H_2O or 498 N/m^2
AWM2300V	0-1000 sccm	N.A.	±55.5 mv	1.3 ″H_2O or 324 N/m^2
AWM3100V	0-200 sccm	N.A.	1-5 Vdc	.20 ″H_2O or 49.8 N/m^2
AWM3150V	0-30 sccm	N.A.	1-5 Vdc	.20 ″H_2O or 49.8 N/m^2
AWM3200CR	N.A.	0-2 ″H_2O	4-20 mA	2.0 ″H_2O or 498 N/m^2
AWM3201CR	N.A.	0-0.5 ″H_2O	4-20 mA	.50 ″H_2O or 125 N/m^2
AWM3200V	N.A.	0-2 ″H_2O	1-5 Vdc	2.0 ″H_2O or 498 N/m^2
AWM3300V	0-1000 sccm	N.A.	1-5 Vdc	1.3 ″H_2O or 324 N/m^2
AWM42150VH	±25 sccm	N.A.	±8.5 mv	.20 ″H_2O or 49.8 N/m^2
AWM42300V	0-1000 sccm	N.A.	±55.5 mv	.90 ″H_2O or 224 N/m^2
AWM43300V	0-1000 sccm	N.A.	1-5 Vdc	.90 ″H_2O or 224 N/m^3
AWM43600V	0-6 slm	N.A.	1-5 Vdc	8 ″H_2O or 1992 N/m^4

In this case, using the By-Pass Configurations for flows up to 100 LPM with a ΔP = 0.37 ″H_2O, the following listings would work: AWM2200V, AWM2300V, AWM3200V, AWM3300V, AWM3200CR, AWM42300V, and AWM43600V depending on desired outputs and flow ranges.

Figure 2

BY-PASS CONFIGURATION DRAWING