Sleep Apnea Machines Using Pressure, Airflow, Humidity Sensors, and Flexible Heaters

BACKGROUND
Sleep apnea is the repeated cessation of breathing during sleep, sometimes hundreds of times during the night and often for a minute or longer. If left untreated, sleep apnea can cause high blood pressure, cardiovascular disease, memory, and weight problems. The resulting lack of restful sleep may also be responsible for job impairment and motor vehicle accidents.

A main treatment option is the use of a Positive Airway Pressure (PAP) machine (Figure 1). The patient wears a mask that uses pressure to send air flowing through the nasal passages so they don't collapse and cause breathing to cease. There are three main categories of PAPs (in order of complexity/cost):

1. **CPAP** (Continuous Positive Airway Pressure) provides a constant pressure to the patient. This positive pressure keeps the throat from collapsing during sleep and allows the patient to breathe freely without worry of episodes of non-breathing.
2. **Auto-PAP** (Automatic Positive Airway Pressure) measures the resistance in a patient's breathing. The amount of continuous pressure delivered to the patient is then automatically tuned to the minimum required to maintain an unobstructed airway on a breath-by-breath basis.
3. **Bilevel-PAP** (Bilevel Positive Airway Pressure) provides two levels of pressure: IPAP (Inspiratory Positive Airway Pressure) and a lower EPAP (Expiratory Positive Airway Pressure).

SOLUTIONS (Tables 2, 3, 4)
Pressure Sensor
Monitors the pressure delivered to the patient in all three PAP machine types.

Airflow Sensors
Monitor the patient's breathing and send an output that reduces the flow of the machine's internal blower fan when the patient starts to exhale. The resulting lowered resistance prevents the patient from feeling as though he is "fighting" against the machine when breathing, reducing discomfort. Machines that use an airflow sensor to detect the breathing cycle are more comfortable for the patient and are more likely to be used regularly than equipment without this feature. Some insurance companies and doctors often prefer this equipment due to greater patient compliance. These sensors are used in Auto-PAP and Bilevel-PAP machines.

Humidity Sensors
Monitor the amount of humidity the patient receives to enhance comfort and to provide adequate air moisture for uninterrupted sleep. Used in all three PAP machine types.

Flexible Heaters
Heat is required to vaporize the water to provide a comfortable breathing environment. There are other ways of generating water vapor such as misting valves, but using heat ensures a uniform, warm, and moist breathing experience most preferred by patients. The heat is generally controlled by an onboard negative temperature coefficient (NTC) thermistor offering variable air temperature that, depending on the OEM, can adjust the vapor/air temperature for optimum patient comfort. Used in all three PAP machine types.

Figure 1. Sleep Apnea Machine Application

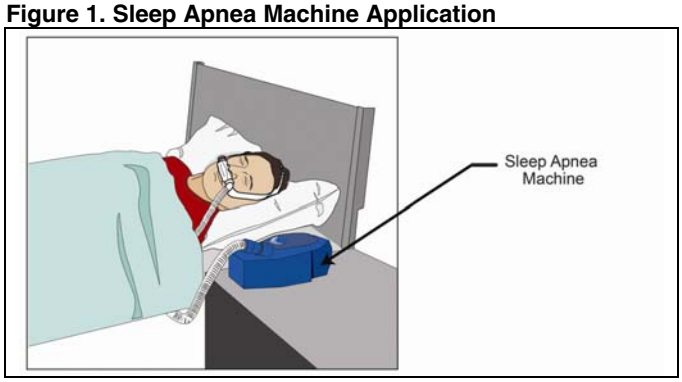

Table 2. Sensors Used in Sleep Apnea Machines

Pressure Sensor (used in CPAP, Auto-PAP, Bilevel-PAP)	Airflow Sensors (used in Auto-PAP, Bilevel-PAP)	
ASDX001D44 (ASDX Series)	**AWM92100V (AWM90000 Series)**	**AWM720P1 (AWM700 Series)**
		
• Customizable calibration • Fully compensated • Available as a bi-directional type for reverse pressure sensing	• Provides true mass flow measurement • Non-compensated (external customer-supplied bypass needed) • 0 SLPM to 200 SLPM flow rate in the application	• Provides true mass flow measurement • Compensated (bypass internal to the sensor) • 0 SLPM to 200 SLPM flow rate

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Table 3. Humidity Sensors Used in CPAP, Auto-PAP, and Bilevel-PAP Sleep Apnea Machines

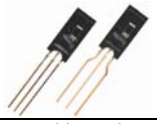
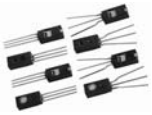
HIH-4000 Series	HCH-1000 Series	HIH-4020/4021 Series	HIH-4030/31 Series
			
• Laser trimmed interchangeability • Low power design • Enhanced accuracy • Fast response time • Stable, low drift performance • Chemically resistant	• Unbuffered capacitive output for a cost-effective solution • Reduced temperature dependence • Low hysteresis • Long-term stability • Enhanced sensitivity/response	• HIH-4021 uses a condensation-resistant filter • Laser trimmed interchangeability • Low power design • Enhanced accuracy • Fast response time • Stable, low drift performance • Chemically resistant	• Multi-layer construction and hydrophobic filter provide resistance to condensation, dirt, dust, oils, and environmental chemicals • Tape and reel packaging • Low housing profile • Low current draw

Table 4. Flexible Heaters Used in CPAP, Auto-PAP, and Bilevel-PAP Sleep Apnea Machines

A3100, C3100, A3200, 3200 Series

• Custom designed for potential OEM applications; polyamide or silicone substrates, or combination (depending on potential application) • Stand-alone heater or a total thermal solution that integrates the heater to the heater plate with brackets, etc. • Agency recognized component • On-board temperature control and thermal runaway safety devices • Uniform temperature distribution

⚠ WARNING

PERSONAL INJURY

DO NOT USE these products as safety or emergency stop devices or in any other application where failure of the product could result in personal injury.

Failure to comply with these instructions could result in death or serious injury.

⚠ WARNING

MISUSE OF DOCUMENTATION

- The information presented in this application note is for reference only. Do not use this document as a product installation guide.
- Complete installation, operation, and maintenance information is provided in the instructions supplied with each product.

Failure to comply with these instructions could result in death or serious injury.

WARRANTY/REMEDY

Honeywell warrants goods of its manufacture as being free of defective materials and faulty workmanship. Honeywell's standard product warranty applies unless agreed to otherwise by Honeywell in writing; please refer to your order acknowledgement or consult your local sales office for specific warranty details. If warranted goods are returned to Honeywell during the period of coverage, Honeywell will repair or replace, at its option, without charge those items it finds defective. The foregoing is buyer's sole remedy and is in lieu of all other warranties, expressed or implied, including those of merchantability and fitness for a particular purpose. In no event shall Honeywell be liable for consequential, special, or indirect damages.

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