

The Science of PVDF Signals when Compared to Conventional Signals

Todd Eiken, RPSGT

Date:

October 14-15, 2016

Location:

Marriott Louisville East



Conflict of Interest Disclosure

Speaker:

Director of Product Development – Dymedix Diagnostics



Polyvinylidene Fluoride

PVDF

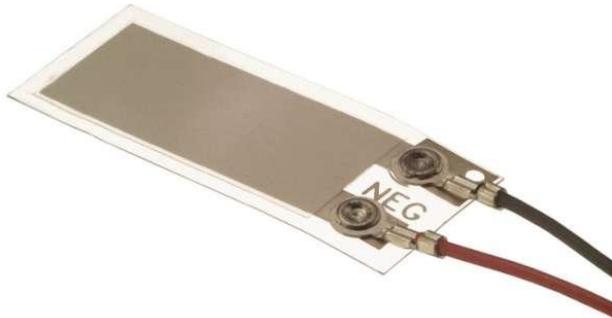
PVDF (polyvinylidene fluoride) film converts one form of energy (heat and mechanical) into another (electrical).

PVDF, is a polarized fluoropolymer whose electrons are aligned (similar to a magnet), and any force that disturbs this alignment causes the film to generate a measurable voltage.

Thus, PVDF exhibits both piezoelectric (responding to mechanical changes) and pyroelectric properties (responding to thermal changes).

Polyvinylidene Fluoride

PVDF



Movement + Temperature + Pressure

PVDF

Common Uses

Roadway Intersection Sensors

Children's LED Shoes

Coin Operated Vending Machines

Stethoscope

Audio Microphones and Speakers



Why Does This Matter to Me?



Nothing New in PSG Sensors for 30 Years

Airflow: NP > Thermocouple > Thermistor > NP

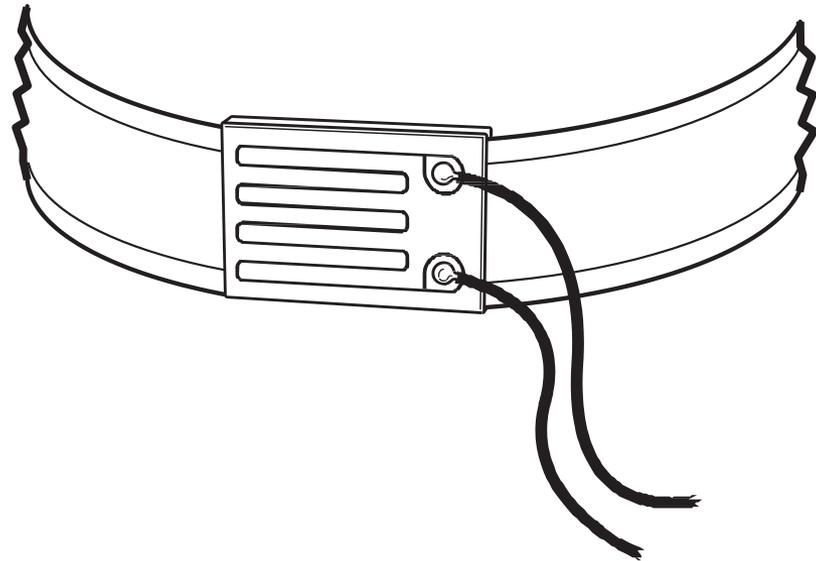
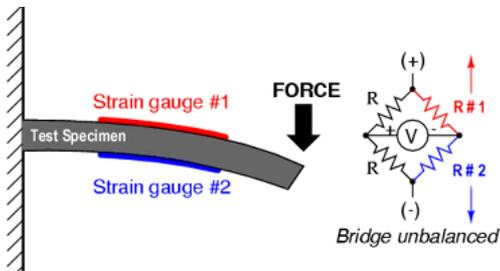
Effort: Strain Gauge > RIP > EP > Piezo Crystal > RIP

Limb Movement: EMG > Piezo Crystal > EMG

Actually, we have gone backwards

Early Technology

Effort - Strain Gauge



Early Technology

Effort - RIP

Respiratory Inductance Plethysmography

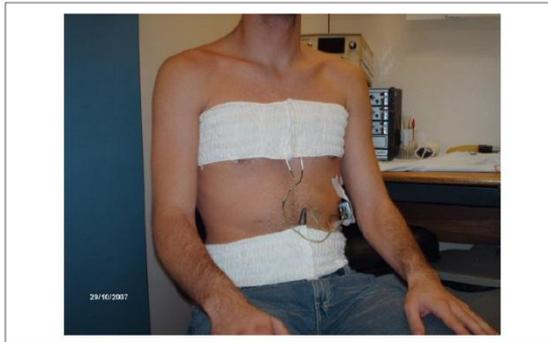
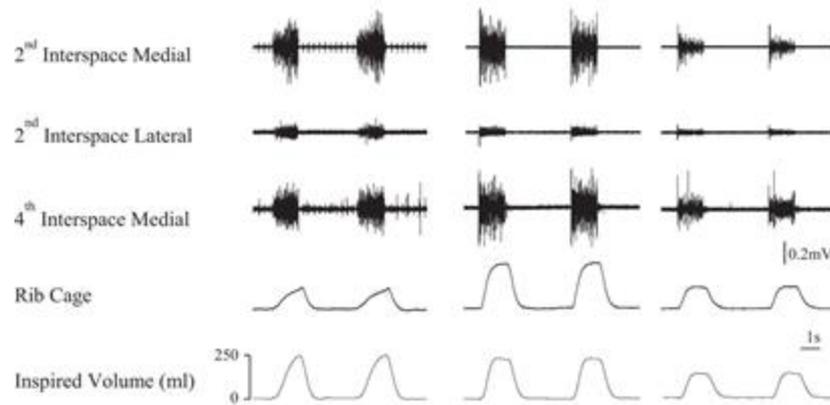


Figure 2 - Thorax and abdominal bands in the sitting position



Early Technology

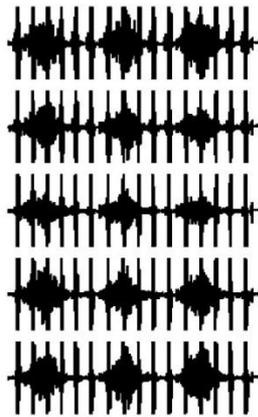
Effort - Intercostal EMG



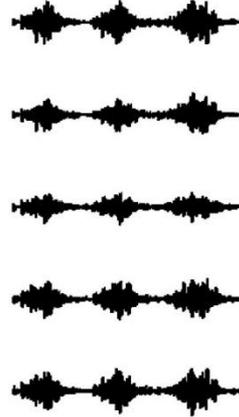
Good for Centrals

Early Technology

Effort - Intercostal EMG



Diaphragm EMG contaminated by ECG

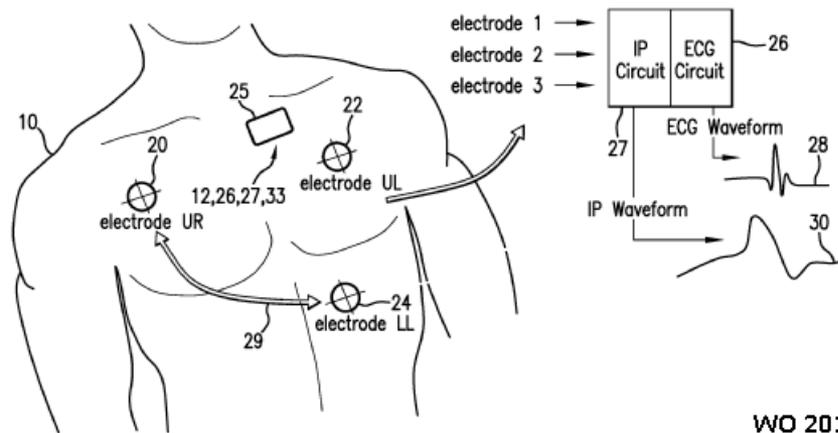


Diaphragm EMG after deletion of ECG

Excessive ECG artifact
Excessively obese patients

Early Technology

Effort - Impedance Pneumography

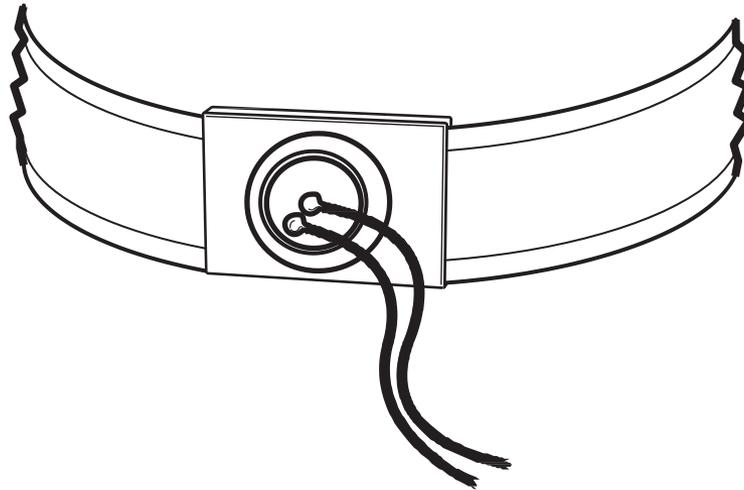


WO 2011/032132

Bedside monitors
Infant apnea monitor

Early Technology

Effort - Piezo Crystal



This was an innovation - Very Popular
Effort and Extremity Movement
Eventually not recommended by AASM

Early Technology

Airflow - Thermistors and Thermocouples



Early Technology

Ear Oximetry



Example of continually advancing technology

Where are We Today?



Airflow

Conventional Airflow

Thermistors and Thermocouples



Thermal – Respond to Temperature Change Only

Conventional Airflow

Thermocouple



Two Dissimilar Metals

Wires Expand and Contract to Temperature Changes

Voltage Changes

Conventional Airflow

Thermistor



Signal Similar to Thermocouple

Conductive Plastic / Glass Bead

Bead Expands and Contracts Due to Temperature Change

Changes in Resistance

“Wheatstone” Bridge

Conventional Airflow

Thermistors and Thermocouples

Technical Limitations:

Slow Response Time

Measures Only Temperature Changes

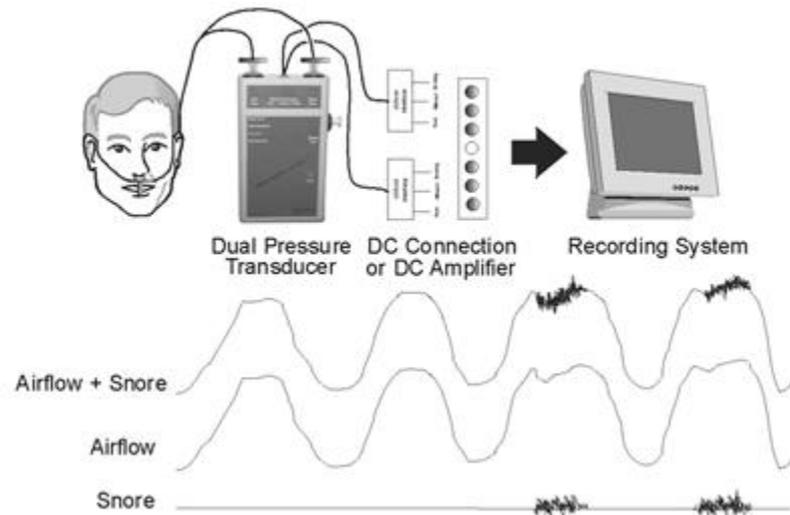
Signal Degrades with Higher PAP pressures

External Power Source Requirement

AASM Recommended Change to Nasal Pressure for Hypopnea

Conventional Airflow

Nasal Pressure



Conventional Airflow

Nasal Pressure

Measures inspiratory and expiratory pressure fluctuations

Utilizes a nasal / oral cannula and pressure transducer

AC or DC signal amplification

AASM Endorsement



Conventional Airflow

Nasal Pressure

Technical Limitations

Nonlinear (Hypopnea = Apnea)

Cannula Can Serve as an Obstruction

Oral/Mouth Breathing

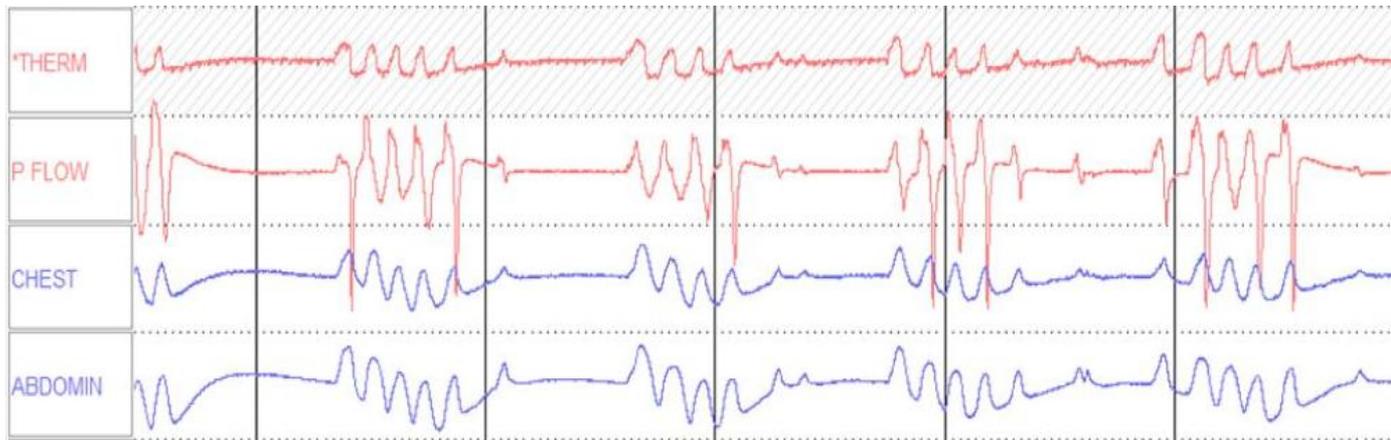
Cannula Can Clog with Secretions

External Power Source Required

Increased costs

Conventional Airflow

Where We Are Today



2 Airflow Channels

Thermal Airflow + Oro-Nasal Pressure

Nothing New in PSG Sensors for 30 Years

Ideal Airflow Sensor

Fast Response Time

Linear to Flow

Low Cost

Compatible with NCPAP

No External Power Source Requirement

Oral / Nasal Combination

No Cannula Requirement

Something New!

PVDF Airflow



Thermal + Movement + Pressure

PVDF Airflow



Very Sensitive (Fast Response Time)

Linear to Actual Airflow

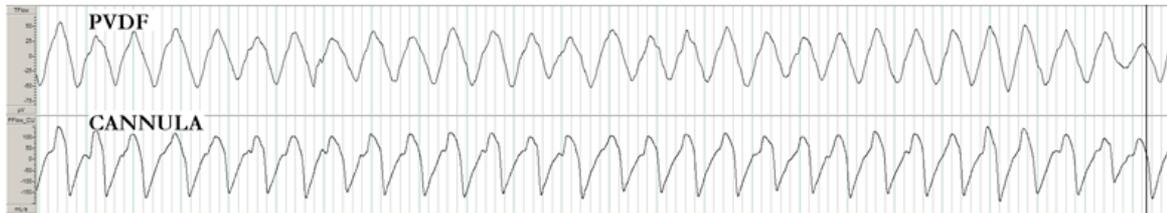
Strong Signal

Temperature and Pressure – 1 Sensor

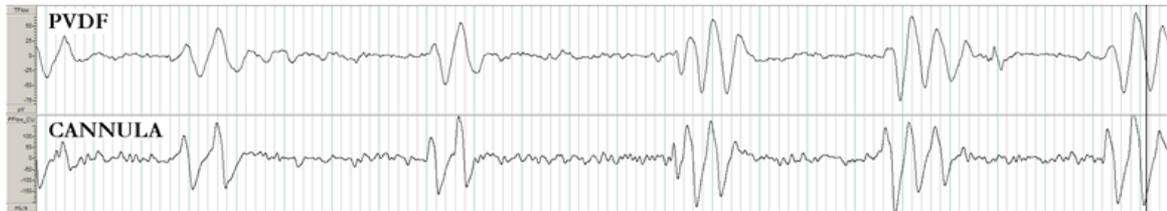
PVDF Airflow

.005 sec Response Time

Normal Breathing Pattern



Apnea Breathing Pattern

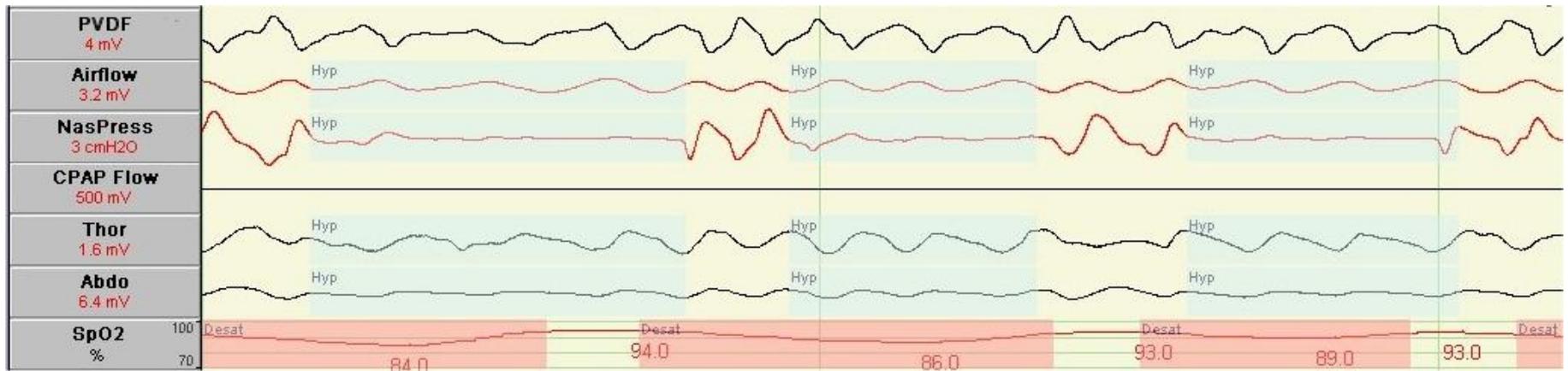


Hypopnea Breathing Pattern



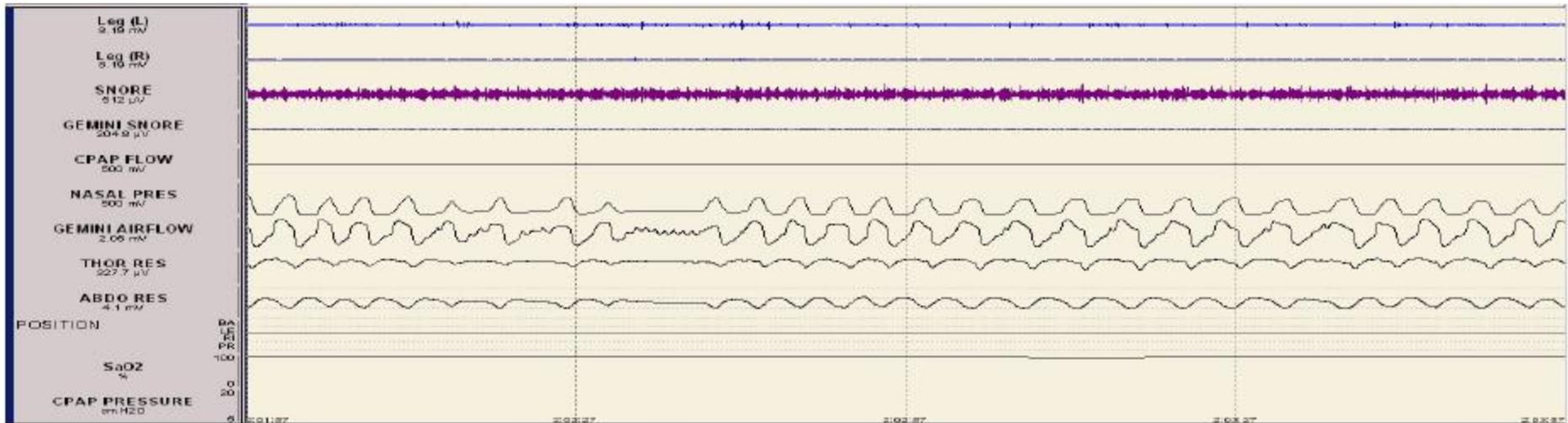
PVDF Airflow

Linear to Airflow



PVDF Airflow

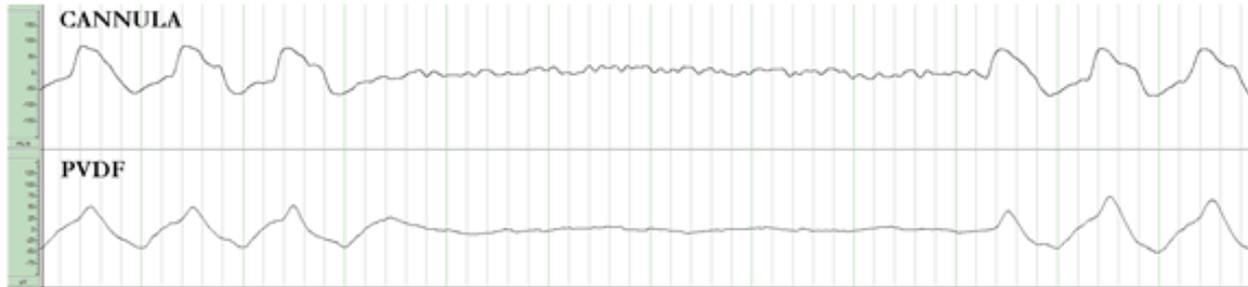
Stronger Signal



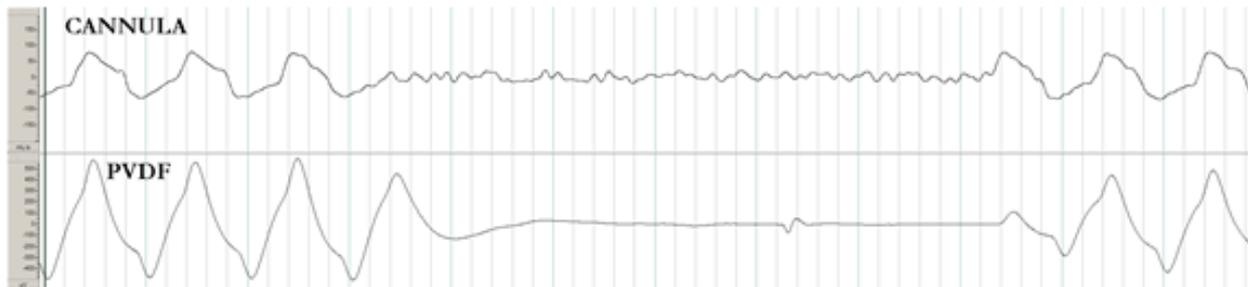
PVDF Airflow

Temperature and Pressure – 1 Sensor

No Heat Applied



With Heat Applied



Where are We Today?



Effort

Conventional Respiratory Effort

Piezo Crystal and RIP



Conventional Respiratory Effort

Piezo Crystal



Ceramic material that is capable of emitting a weak electrical signal when it is flexed.

Piezo crystal effort belts create a sine wave when stressed by respiratory movement – elastic strap.

Conventional Respiratory Effort

Piezo Crystal

Technical Limitations

Measures the tension where the crystal is located, a single point, where the band pulls during breathing
Accuracy problems can occur when the patient moves and tension is lost

Output of the piezo crystal is not linear

Conventional Respiratory Effort

RIP



RIP relies on the principle that a current applied through a loop of wire generates a magnetic field normal to the orientation of the loop

A change in the area enclosed by the loop creates an opposing current within the loop directly proportional to the change in the area

Conventional Respiratory Effort

RIP

Technical Limitations

Phase Shift and Paradoxical Breathing

Woven Wire Connection

Proprietary Integrated Circuitry in PSG Systems

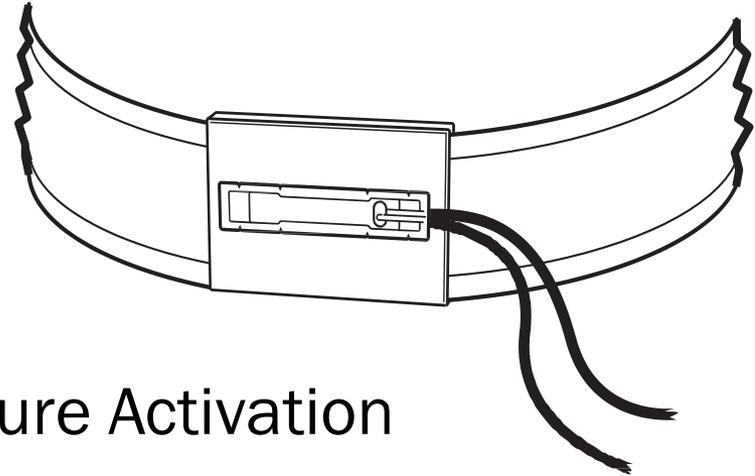
Something New!

PVDF Effort



Strain + Movement + Pressure

PDVF Respiratory Effort



Strain and Pressure Activation

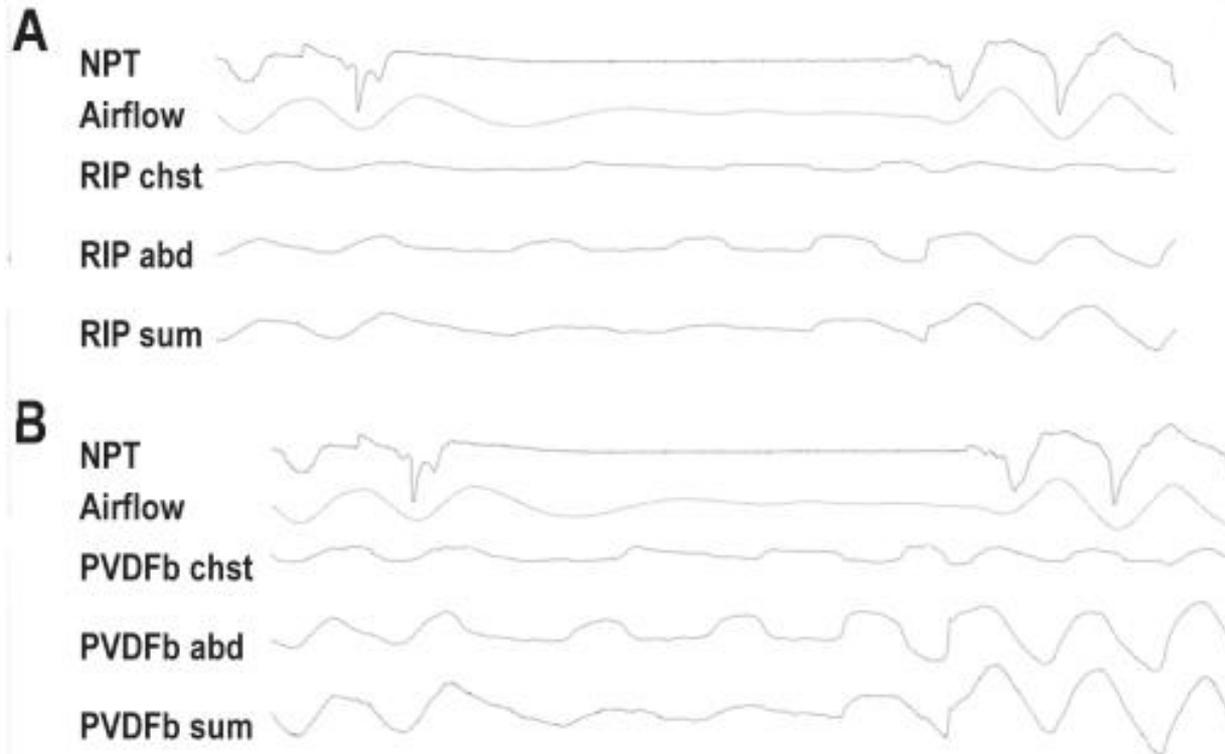
No Phase Shift

No External Power Source

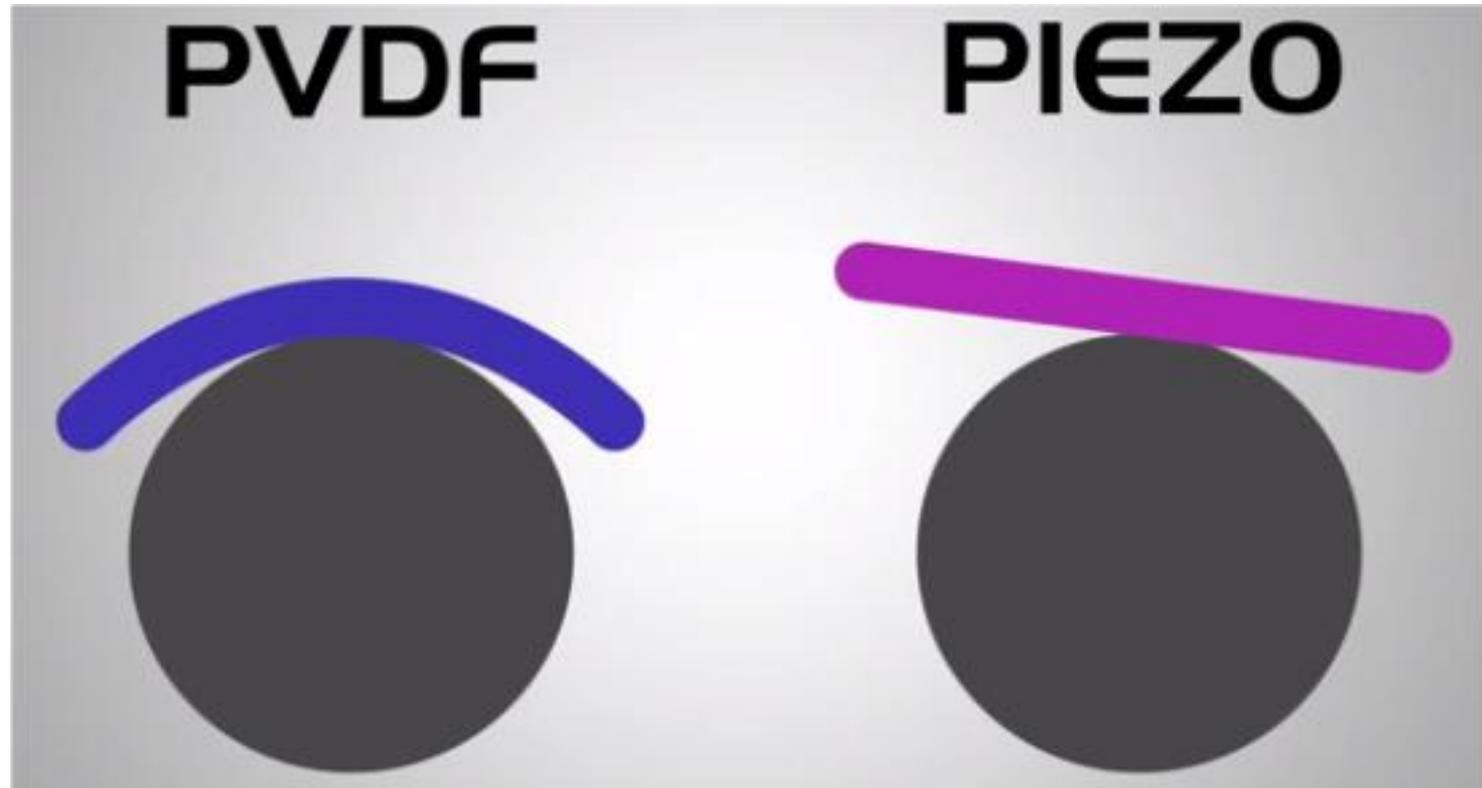
AASM Accepted

PDVF Respiratory Effort

Comparison to RIP



PDVF Respiratory Effort



PDVF Respiratory Effort

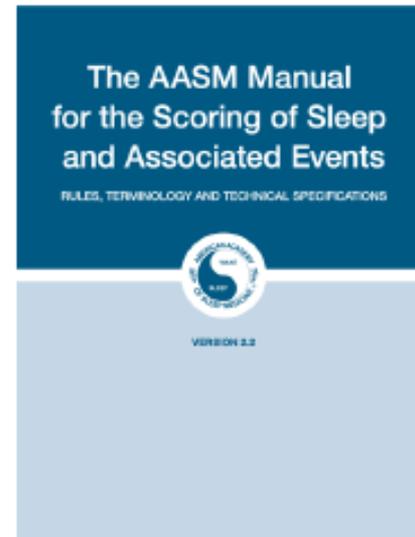
Strain + Movement + Pressure



PDVF Respiratory Effort

AASM Guidelines

- Chapter VIII. Respiratory Rules
 - Part 1: Rules for Adults



6. For monitoring respiratory effort, use one of the following:

- a. esophageal manometry **RECOMMENDED**
- b. dual thoracoabdominal RIP belts (calibrated or uncalibrated) **RECOMMENDED**
- c. dual thoracoabdominal PVDF belts **ACCEPTABLE**

Summary

PVDF – Only Advancement in Sleep Sensors in Over 30 Years

PVDF – Extremely Fast Response Time

PVDF – Thermal + Movement + Pressure

PVDF – Linear Waveforms

PVDF- Provides Own Power Source

PVDF – AASM Compliant

Questions



KENTUCKY
— SLEEP SOCIETY —