Learning Guide and Frequently Asked Questions

Respiratory Inductance Plethysmography (RIP) and zRIP DuraBelt

PHILIPS

RESPIRONICS

sense and simplicity

The advantages of Respiratory Inductance Plethysmography (RIP) over piezo

Respiratory inductance plethysmography (RIP) is not new, but is widely misunderstood as the signals received on the polysomnograph are vastly different than those of piezo signals. The awareness of how different the signals are between piezo and RIP can be compared to when thermal was the only accepted airflow signal and then pressure airflow was introduced. It took several years for the sleep profession to appreciate the benefits and the differences between thermal and pressure airflow. The same educational understanding needs to occur between piezo and RIP.

As airflow is well understood, let's look at ways of measuring airflow as a starting point. We will then apply this understanding to respiratory effort and RIP.
The goal of a sensor is to reflect as accurately as possible physiological changes used to determine the presence of sleep disorders. An absolute measure of airflow would be spirometry, where the volume changes are directly measured and reported as units: milliliters or cubic centimeters. While accurate, spriometry would obviously interfere with a patient's sleep, so other, less exact means are used.

A thermal sensor generates a signal based on temperature changes driven by the warm air of exhalation and the comparatively cool air of inhalation passing over the sensor. There is a limit to how quickly the signal can change, as the sensor actually has to warm and cool from exhalation to inhalation. Therefore, the signal produced by a thermal sensor is more rounded and smooth than the physiological event we are trying to monitor. Pressure-based airflow sensors, such as the Pro-Tech PTAF series, generate a signal in response to changes in pressure in the nasal cannula. The pressure changes are generated by inhalation and exhalation. Because the pressure sensor responds faster than thermal sensor, the waveform can be "blocky" or "spiky." While perhaps not as pretty as a thermal-based flow signal, the shape of a pressure-based flow signal can indicate changes in the upper airway.

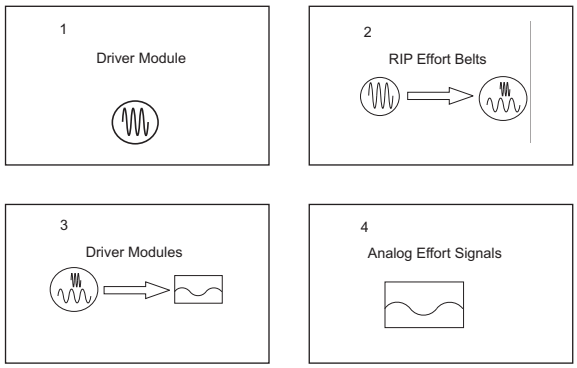
Respiratory effort channels represent changes in volume in the thoracic and abdominal cavities as the patient works to breathe. The piezo sensor represents changes in volume indirectly by capturing strain in an elastic band that is transferred to a piezo sensor. A piezo-electric sensor outputs a signal when the crystal is compressed or stretched generating a voltage. An elastic belt is fastened around the chest or abdomen to measure changes in tension during respiratory effort. If a low signal is detected, the sleep technologist will usually tighten the piezo belt to increase amplitude. Piezo crystal sensors can decrease output amplitude even though patient effort has not decreased ("sensor fatigue"). Piezo belts are subject to "trapping artifact" as the patient turns from side to side, "trapping" the belt under the arms and removing strain from the piezo sensor. This can create a false signal. There are situations, for example when a patient is lying on top of the piezo crystal, where the effort signal can be dampened, not detected, producing erroneous readings or unexplained changes in polarity that look like paradoxical effect.

Due to fundamental differences in electronic principles, RIP effort sensors will not have these misleading signals. RIP relies on the principle that an oscillating current applied through loops of wire generates a magnetic field. Through the RIP module, change in the area enclosed by these loops creates an equivalent change in signal. The signal is designed to be more reliable because the sensor encircles the entire part of the body and is not subject to sensor fatigue. As a result, the shape, phase, and amplitude of the RIP effort waveforms can provide more information than a piezo signal about the patient's breathing. For example, when a RIP effort signal decreases in amplitude, this directly reflects a decrease in movement of the chest or abdomen. As you would expect, when a patient sleeps and breathes more shallowly, the signal amplitude will not be as high as when the patient is awake and breathing normally. The RIP signal does look different from a piezo signal. (See figures 1 – 4) Trying to make a RIP effort signal look like a piezo signal will likely result in frustration. Knowing the differences allows the sleep professional to better understand the patient's respiratory effort.

Signal generation by the RIP system

The Driver Module generates an oscillating signal (figure 1). The signal is sent into the effort belts where the frequency is changed (modulated) by the movements of breathing (figure 2). The wire must go around the patient completely as it is measuring the area inside the belts, unlike piezo which measures the tension on the belts.

The changed signal comes back into the Driver Module. There it is de-modulated into the analog signal representational of the efforts of breathing (figure 3). The signal is then output by the Driver Module to the recording system (figure 4).



As mentioned previously, there is an oscillating signal of a known frequency going through the belts. The frequency is altered by a change in the inductance field around the belts. The field is changed when the area underneath the belts, or enclosed by the belts, changes in volume. The RIP module uses the electronic principles of this field to generate the effort signal.

Because the belts measure changes in volume, the changes in the shape and amplitude of the RIP chest signal can mimic the pressure transducer signal. The pressure flow signal expresses flow from pressure and both are volume dependant. As upper airways narrow, the same volume is being pushed through the smaller opening. This prolongs flow with decreased pressure beyond the restriction and results in the flattened pressure flow signal signifying Upper Airway Respiratory Syndrome (UARS). Because this also delays the volume change in the chest, the RIP belt will show this as a signal similar to the pressure flow signal.

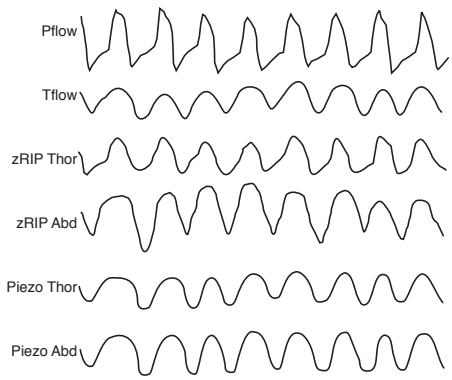
- RIP is designed to be accurate because it uses magnetic fields and electronics to produce signals according to established principles.
- The use of RIP technology does not require a detailed knowledge of these fields, electronics, or principles.

The difference in RIP waveform and piezo

As you look through the following waveform examples you will see differences between the RIP effort signals and the piezo signals. RIP comes from changes in volume; piezo comes from strain or tension on the belt. If you are familiar with the difference between a thermal and pressure-based nasal flow signal, you will see a similar difference between piezo and RIP-based effort signals.

Normal

This example shows that the RIP thoracic channel is more similar to the PTAF signal than to the other effort channels. A longer Time Constant or lower Low Frequency Filter allows the thoracic belt signal to display more information, not unlike the PTAF flow signal. RIP signals are unlike piezo signals in that often RIP signals appear somewhat spiky whereas piezo signals appear smoother.

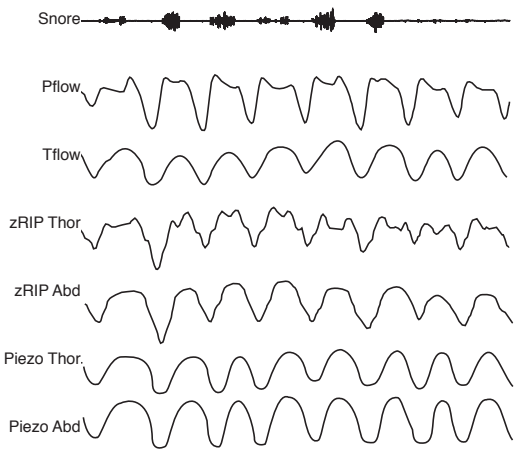


Note: The example above is of Pro-Tech zRIP effort channels.

The difference in RIP waveform and piezo

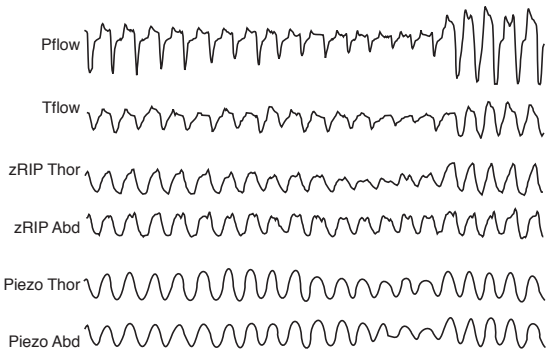
UARS

The example shows a flattening of the PTAF flow signal as a result of narrowing in the upper airways. The chest RIP channel shows signs of UARS signal, becoming jagged as thoracic effort increases. As the zRIP signals become more jagged the piezo signals remain smooth, measuring only the tension on the belt.



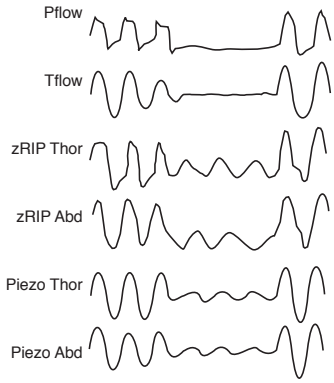
Hypopnea

These RIP signals are "choppy" or more "jagged." The signals are flattening during the hypopneic event, similar to the pressure transducer flow signal.



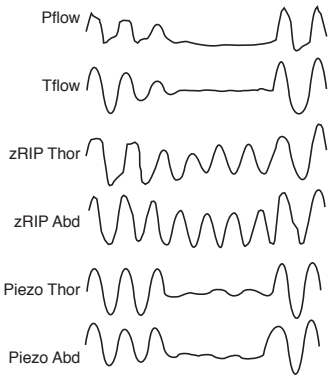
Obstructive apnea

The RIP signals are out of phase and not completely paradoxical; they show the patient's efforts to breathe past the upper airway blockage.



Paradoxical effort

The RIP channels are beginning to go out of phase. The airflow signals are decreasing as the efforts become more paradoxical (until they reach complete paradox and airflow ceases).



Note: The four examples above are of Pro-Tech zRIP effort channels.

RIP	Piezo
Directly reflects breathing activity of a patient.	Indirectly reflects breathing activity of a patient.
Sensor wire wraps around the patient.	Sensor (piezo) most commonly located near the belt buckle.
Belt only needs to be snug on the patient for an accurate signal.	Belt needs to be pulled taut for an accurate signal.
Gain settings do not change during the night when the signal decreases.	Gain settings usually need to be altered during the night to capture the signal.
The signal decreasing reflects true patient breathing effort.	The signal decreasing, or changing can reflect "trapping" or artificial artifact.
Thoracic belt placement is designed to be more precise than piezo.	Belt placement can be anywhere in the thoracic area and pulled tight.

Frequently asked questions regarding zRIP DuraBelt

The Pro-Tech zRIP DuraBelt was specifically designed to support RIP and provide accurate thoracic and abdominal effort movements. Below are a few questions frequently asked by a sleep facility when using a zRIP DuraBelt.

What filter settings do I use for my PSG system (if not an Alice system)?

Low Frequency Filter: 0.16 Hz

High Frequency Filter: 35 Hz

Time Constant: 1 second or longer

Shorter time constants or higher low frequency filter settings will significantly attenuate waveforms. Longer time constants or lower low frequency filter settings will display more information regarding patient effort.

The waveform on my PSG system appears small. What can I do to adjust it?

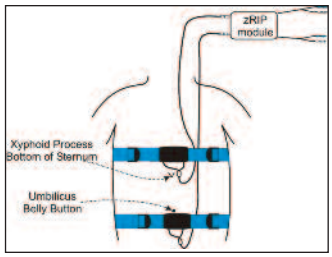
Assuming the placement of the belts is correct, use the controls on the PSG system to adjust the display to your satisfaction. Unlike piezo belts, tightening the zRIP belt will not increase the signal amplitude but it may make the signal smaller.

During bio-cals the amplitude seemed higher, but once the patient fell asleep the amplitude decreased. Why is this happening?

Some people breathe more shallowly while sleeping which can result in the lower amplitude signals. The signal from a piezo belt can degrade in amplitude through the night. RIP signals may appear small at the beginning of the study but should remain at a consistent level through the test. Be certain that the belts are placed on the patient correctly.

Where do I place each zRIP Durabelt on the patient?

The thoracic belt should be placed to cross on the lower third of the breastbone, below the pectoral muscles. The pectoral muscles will keep the belt from riding up the chest, and the abdomen muscles should keep it from slipping down over the abdomen. The abdominal belt should be placed near the belly button (umbilicus); tape can be placed over the belt to prevent slippage.



For more details on thoracic belt placement, go to this link on the Pro-Tech website: www.pro-tech.com/html/support_main.html. Under the Downloads heading, click on the link titled: Calling for a specific placement.

How tight should each zRIP DuraBelt be on the patient?

Both belts should be snug around the patient before you connect the belt buckles. Put each belt around the patient and adjust the buckle ends until they are three to five inches apart. Then, connect the buckles, plug in the wires, and adjust the belts as needed until they are secure. Over-tightening a belt may decrease the signal.

What is the best cleaning method for a zRIP DuraBelt?

Cleaning the belts:

The recommended method of cleaning a zRIP DuraBelt is to wash it using warm water and household laundry detergent, then air dry. The following cleaning products when used according to manufacturers' instructions should not degrade the belts or shorten their useful life: Amphy Hospital Bulk Disinfectant Cleaner, DisCide ULTRA Disinfectant, CaviCide. Care should be taken to ensure drying of the safety plugs after cleaning.

Cleaning the wireset:

The wireset may be wiped down with soapy water or a bleach or alcohol towelette. Do not immerse the wireset in liquids.

Does a zRIP DuraBelt need to be routinely sterilized or disinfected?

Both belts, in normal use conditions, meet the non-critical item recommendation by the Centers for Disease Control and Prevention (CDC) listed as:

"Noncritical items are those that come in contact with intact skin but not mucous membranes. Intact skin acts as an effective barrier to most microorganisms; therefore, the sterility of items coming in contact with intact skin is 'not critical.'"

Note: This recommendation is listed on page 11 of the CDC document and is available at: http://www.cdc.gov/hicpac
In the Search box, type in: Disinfection_Nov_2008.pdf
Please consult with your institution's infection control officer for specific guidance.

Why isn't the zRIP sum channel module signal twice as big as the other effort signals?

The sum channel adds up the thoracic and abdominal signals, then divides by two to keep it at an amplitude similar to the two effort channels. This is an easy way to see the phase relationship of the effort signals. As the effort signals begin lacking in continuity, or begin to go into paradoxical breathing, the sum channel will diminish in amplitude. The abdominal signal will typically have higher amplitude than the thorax signal because the abdomen is not bound by bones like the thorax and therefore moves more with breathing.

I do not see a signal. What could be the issue?

Check the module to make sure the blue and white leads are plugged into the headbox and the long black leads are connected to the effort belts. Depress the button on the end of the zRIP module to check the batteries. A green light means the batteries are good. If there is not a light, the batteries need to be replaced (use two AAA batteries). Unplugging the abdominal wireset from the driver module will help extend the battery life.

How are the belts connected to the module and how is the module connected to my PSG system?

There are three parts to the zRIP system:

1. Two zRIP DuraBelts (one for the thorax and one for the abdomen).
2. Two wiresets (to connect the belts to the module).
3. The zRIP module.

Three-step connection process:

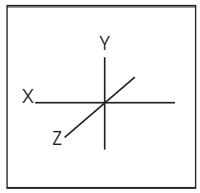
1. Place the two belts on the patient.
2. Connect each wireset to the appropriate belts using the black connectors.
3. Plug the wireset from each belt (white keyhole shaped connectors) into the module. Connect the thorax belt into the thorax input and connect the abdominal belt into the abdominal input.

Note: the module does not power up until the abdominal (white) keyhole connector is plugged in to this input. The outputs of the module plug into the PSG system abdominal and thoracic inputs (blue is signal [+] and white is reference [-]).

The connector on the zRIP DuraBelt can be placed in the up position (toward the head) or in the down position (toward the feet) or any directional combination.

What is the advantage of the sensor wire being woven on the z axis of the zRIP DuraBelt?

The wire in most RIP belts goes up, down, and across the belt in the X (left to right) and Y (head to toe) axis. The zRIP DuraBelt goes in and out along the Z (toward and away) axis. The Z axis is the axis that the chest wall moves through during respiration, helping to ensure a more accurate signal.



I have an Alice PSG system. Do I set up the zRIP module differently?

No. The effort belt to module setup is the same. Just be sure you are using an Alice zRIP module. The Sleepware gain set at the start of a study should not need to be increased through the night, as is standard for the piezo technology.

Do I have the correct module to use with my PSG system?

There are three modules to be aware of:

A standard zRIP module

The standard zRIP module is for use with most PSG systems and is distinguished by the label on the front of the product.

An Alice zRIP module

The Alice module has a specific label that states Alice on the right hand side and is for use with Alice 3 and 5/LE systems.

A Sum RT module

The Sum RT zRIP module states Sum RT on the label and is for use by labs that request a respiratory effort summing channel.

Standard zRIP Alice zRIP Sum RT

When is a module not necessary?

A module is not necessary if you are using a PSG system that already has an oscillator built into it (such as the Alice PDx). For these type of systems, we offer Pro-Tech sensor-specific wiresets.

Alice PDx and zRIP DuraBelt

Can I use the zRIP DuraBelt with any RIP module?

It depends on the size of the safety connectors. Most RIP modules use 1.5mm safety connectors on their wiresets to plug into the RIP belt. The zRIP DuraBelt was designed to use 1.5mm safety connectors. If your module or wire-set has 1.5mm safety connectors, the belt should work with that system.

Will the zRIP DuraBelt effort system work with my particular PSG system?

To find the appropriate Pro-Tech sensor for your PSG system, go to the "product selector" feature at: www.philips.com/protechsensors. The product selector function will allow you to select a specific PSG system and then see the Pro-Tech sensors supporting that specific system.

How long do module batteries last?

Alkaline batteries have a projected life of 600 hours of continuous use in the zRIP module.

How can I make the batteries last longer?

The module starts using the batteries when the abdominal wireset from the belt is plugged into it. Unplug the belt wiresets from the module between studies. If the wiresets are unplugged after each test, and each test is ten hours long, the alkaline AAA batteries may perform approximately 60 studies.

How do I check the batteries to see if they should be replaced?

Check the battery life by pressing the test button before each study. If the test light illuminates, there should be eight hours of power left in the batteries (when using alkaline batteries). If the light stays dark, check the orientation of the batteries and replace them if necessary.

How should I store the module between studies?

The module should be stored so there is no tension on the output wires.

How should I store the belts and wiresets between studies?

The belts can hang where they were placed to dry, or laid out on a counter or in a drawer. The wiresets also may be hung up or laid out in a similar manner.

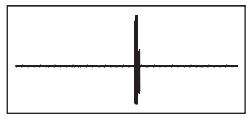
How can the belts be checked for proper function?

You can test the belt with the Pro-Tech ST-3 sensor tester, or an impedance/resistance meter. The resistance reading on an impedance/resistance meter should be less than 3 Ω (ohms). Refer to the sensor manual for the ST-3 sensor tester for detailed directions.

How do I know if the module is connected right and if the module – amp is working?

Press the battery test button. If the test light illuminates, there should be eight hours of power left in the batteries (when using alkaline batteries). If the light stays dark, check the orientation of the batteries and replace them if necessary.

Press and release the battery check button, a spike will appear on all outputs of the module. This is a momentary spike verifying the module is connected properly to the PSG system inputs.



Spike

Verify the module is plugged into the inputs called out in the montage.

I lost my zRIP DuraBelt manual. How can I get another one?

Go to www.pro-tech.com. Click on the "Support" link and then click on "User Guides". There are separate guides for the belt and the module.

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