Membrane Potentiometers simplify position sensing

*Ultra-flat design enables smart engineering and cost-saving applications*

By Guido Woska

Membrane potentiometers have changed the way engineers think about sensing. With some measuring only 0.5mm [.05cm] thick, ultra-flat membrane potentiometers feature comparable product characteristics to conventional potentiometers, but are liberal with design freedom at significantly lower costs.

Today's membrane potentiometers can be used in the same applications as conventional potentiometers, but can also fit into space-constrained areas. In this case, function can follow form—an uncommon feature of mechanical potentiometers.

Because most producers of membrane potentiometers offer customized products with only small tooling efforts, costs are very competitive, even for small prototype quantities. Three additional advantages are found in the basic construction of the membrane potentiometer: its ability to be fully sealed; the possibility of a hollow shaft design; and numerous wiper options, including operation by hand.

Most membrane potentiometers, like the "Sensofoil" products, can be sealed at up to an IP65 (NEMA4x) rating and beyond. Conventional potentiometers require a difficult assembly of the wiper, particularly in a "hollow shaft" assembly. The "hollow shaft design" of membrane potentiometers, as with "Sensofoil," is more reliable and cost efficient. Because of the simple nature of the membrane potentiometer, such technical adjustments are not required. The wiper for the membrane potentiometer can be as simple as a small plastic knob sliding across the surface; it requires no external electrical contact. Most membrane potentiometers can also be operated by sliding a finger over its surface, and "Sensofoil" is even available in a contactless magnetic version.

**Design characteristics**

In general, a membrane potentiometer is a voltage divider—it is constructed as an open circuit that only gives output when the wiper connects the top and bottom circuits by applying pressure to the membrane surface. The spacing between the top and bottom circuit is constructed mainly of sealant adhesive, allowing it to be sealed against external environmental factors, such as moisture or dust. This spacing adhesive requires a minimum width of 2-3 mm [0.2 – 0.3cm] on all sides of the membrane potentiometer. The ideal width of the resistive active area should be between 3mm and 6mm [0.3cm and 0.6cm], but can also be extended to 10mm [1cm] or even 12 mm [1.2cm]. Linear elements can reach up to 760mm [76cm] in active length, while rotary elements with a central hole can measure from 20mm [2cm] in diameter to approximately 450mm [45cm] in diameter.

The life cycle and operating temperature correspond to those of mechanical potentiometers (e.g. with the Sensofoil Magnet or Sensofoil Hybrid much more than 20 million movements), depending on the design even up to 100 million operations are possible. The operating temperature can range from -40°C [104°F] to 85°C [185°F], and there are even systems in development that can withstand temperatures up to 125°C [257°F].

Due to the design of membrane potentiometers, temperature compensation is not necessary if being operated in a voltage divider mode, and electromagnetic interference will not affect the system.

The standard actuation is made by a wiper or slider. The Sensofoil ® Magnet requires a defined magnet instead of a wiper. For hand tipping actuation, a “SET-function in Z-direction is available as an option.
**Installation process and wiper design**

Due to the flat design of membrane potentiometers, they can be brought close to the motion area of the device which it is measuring, without requiring a lot of installation space. They are adhered to a substrate by simply removing the protective paper and applying it to the surface; other options are snap-in mounting or the use of screws. The wiper can be easily integrated into the application.

With small quantities, off-the-shelf wipers might be the easiest choice, whereas with higher quantities or in cases where space is limited, a custom designed wiper might make more sense. One application might require a spring-loaded screw, while another will require a spring-plate attached to a piece of POM/Delrin plastic. Each application is specific to the requirements of installation space, cost and accuracy.

If lifecycle requirements are very high, a magnetic wiper is recommended for contactless connection. In general, a spherical wiper can be recommended. The typical wiper covers about 10%-50% of the active width. Materials such as steel, brass and hard plastics (e.g. Delron, Delrin) are typical, but depend on the type of membrane potentiometer. Engineers should always seek advice from the manufacturers regarding the right choice of material.

**Surface pressure**

Different surface pressures are defined depending on the application, but in general, a range of 1 Newton (N) to 6 Newtons (N) is recommended for most applications, depending on whether the membrane potentiometer is configured in a standard foil layout or in a hybrid version with additional metal bonds to strengthen the structure. A standard off-the-shelf wiper is usually divided between a 1-3N and a 3-6N range.

**Electrical characteristics**

The electrical characteristics will vary somewhat with the design, but are generally standard, with similar output to that of a conventional potentiometer, e.g. as a voltage divider.

When compared to a conventional precision potentiometer, the most significant difference is the method of achieving linearity. While the conventional potentiometer may use laser-trimming to achieve linearity, membrane potentiometers, which are based on PET-Material, rely on production improvements to improve linearity. Hence, the typical linearity offered is 2% for standard linear potentiometers, although FR4-based membrane potentiometers can reach as little as 0.5% as one option.

But more significant than linearity are repeatability and hysteresis; the accuracy of membrane potentiometers can be as good as 0.01mm [0.001 cm] over a length of 500mm [50cm], but most standard membrane potentiometers range anywhere from 0.05mm [0.005cm] to 0.1mm [0.1cm]. The main impact on all of the electrical outputs is found in the mechanical motion and stability of the wiper. As a benchmark, energy dissipation of up to 1 Watt and a dielectric strength of 500V are standard, with isolation strength of 100VDC also possible.
Applications

A typical application, due to the small height of membrane potentiometers, is the linear measuring of actuators. Control valves are another benefited application, in which currently the standard requires gears and a turning sensor to measure position. The structure required to install and use a membrane potentiometer is much more simple and form-friendly than those used in the large and difficult mounting of certain conventional potentiometers.

Many sensing needs can be solved by using state-of-the-art membrane potentiometers. An improved design, creating linear output signals right next to the motion device, can sometimes increase accuracy over a conventional rotary potentiometer, which is connected by gears far from the actual motion which is being measured. While conventional mechanical potentiometers are cost intense, membrane potentiometers such as “Sensofoil” can reduce these costs significantly.

In many applications, both rotary and linear membrane potentiometers can be used in the same device, e.g. a seat level adjustment requires linear motion, while inclining the seatback angle requires rotary motion. Similar applications are found in automotive interiors, where sliding doors, sun roofs, seat applications and the like require small installation spaces and low weight.

Another simple solution to space problems is to use the PCB, which already exists in many applications as a base for the membrane potentiometer. The printed circuit board can be filled, and afterwards, the membrane potentiometer can be adhered to the board and the connectors can be inserted directly into the PCB. Additionally, very few manufacturers can even print a conductive ink directly onto the FR4 and combine this with the PCB and its components, as they are able to directly assemble the components onto the PCB.

Other applications, which use a membrane potentiometer mainly for cost saving reasons, are string-pots or wire sensors and magnetic tape. Additionally, membrane potentiometers can be fully integrated into a keypad for hand-control. Seamless integration makes the keypad highly innovative and useful for position tracking. The integrated potentiometer can avoid installation holes, as needed by a standard potentiometer and can create a completely sealed and washable front panel surface.

FINAL CONCLUSION

Because of its ultra-flat design and flexible usage, combined with extremely low costs, the membrane potentiometer has opened up sensing possibilities which were not possible before. With new and innovative materials like magnetic operations or hybrid membrane potentiometers (such as the patented “Sensofoil Hybrid” by Hoffmann + Krippner), designers and engineers can use this potentiometer in many applications. Complex sensor constructions can be reduced, simplified and integrated less expensively with modern membrane potentiometers.

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