epec | build to print electronics

RUBBER KEYPAD COMPARISON - CONDUCTIVE AND NON-CONDUCTIVE CONSTRUCTION DIFFERENCES

By Paul Knupke – Epec Engineered Technologies

Molded silicone rubber keypads have been used in the electronics industry for over thirty years. Rubber keypads offer a 3-dimensional operating surface that appeal to end users. Original Equipment Manufacturers (OEMs) still have complications when trying to specify features that make sense for their requirements. This article goes into detail about the range of design features available while comparing and contrasting the differences between the two basic styles.

Keypad designers need to understand the various features and trade-offs to choose the best design style for their application.

Molded Silicone Rubber Keypads Come In Two Basic Styles:

1. Conductive rubber keypad with an integral semi-conductive pill or puck on the back side.
2. Non-conductive rubber keypad that presses against a metal snap dome switch.

The term rubber keypads can refer to just the molded silicone rubber part or the entire keypad assembly including the supporting printed circuit board, and sometimes a decorative bezel. The molded rubber part is a component of a larger keypad assembly and needs to be understood as part of an assembly rather than a stand-alone component.

Common Features For Molded Silicone Rubber Keypads

Rubber keypads are a single piece of high-grade molded silicone rubber incorporating visible keytops into a base mat that rests against a printed circuit board and a thin web of rubber between the keytops and base mat (Figure 1).

Figure 1. Molded silicone rubber keypads.

Most molded rubber keypads are manufactured using a low-pressure compression molding process. There are a few molders who use a higher pressure liquid injection molding process. Molded rubber keypads can be a solid color, different solid colors within isolated areas, translucent, or a combination of translucent and solid colors.

Keytop legends can be achieved with screened silicone ink or laser etched on translucent silicone rubber that has been spray painted with one or more coats of silicone paint. The vast majority of silicone rubber keypads are not rated for UL 94V0 flammability because the rubber is somewhat flame retardant but does not meet stringent UL 94V0 requirements. UL 94V0 rating is available for silicone rubber but the raw rubber has to be special ordered with a large minimum buy. Very few silicone rubber keypads need the UL 94V0 rating, saving extra lead time and large minimum buy.

Front surfaces of the rubber keytops can be coated with a wear-resistant coating similar to polyurethane. Coating textures include gloss, satin, or matte. Other aesthetic surface treatments that are available include dual-durometer keytops and epoxy tops. Surface treatment options are only aesthetic and do not affect the core discussion of design or operating parameters.

Conductive Rubber Keypads – Construction

Conductive rubber keypads contain a semi-conductive pill or puck that is pre-molded with a mixture of carbon particles and silicone rubber (Figure 2). The mixture contains enough carbon particles so that the surface is somewhat conductive but with enough silicone rubber to hold the carbon particles together. The pill or puck is permanently attached to the bottom of the keytop at each switch location during the final molding operation. The pills are placed in the mold in a similar fashion to insert molding used for molding terminals in electrical connectors.

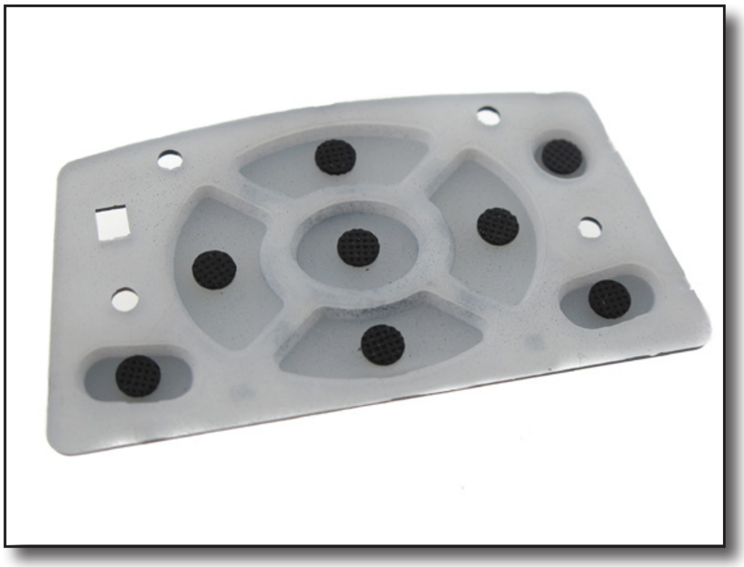

Figure 2. Conductive rubber keypads with a semi-conductive pill or puck.

Conductive rubber keypads form an electrical switch closure when the keytop is pressed and the semi-conductive pill comes in physical contact with exposed inter-digitated conductors on a printed circuit board. The switch closure is made at the very end of the keytop travel and the pill surface must be parallel to the printed circuit board to provide switch closure.

Conductive rubber keypads provide tactile feedback or snap feel to the user by a feature called a force cone between the bottom edge of the keytop and the surrounding base. The force cone supports the keytop in the unactuated position.

When the keytop is pressed, the force cone compresses to a point, and then collapses providing the tactile feel. The force cone must be thin to flex and provide the tactile feel. Low durometer or soft rubber must be used for the conductive rubber keypad to allow the force cone to flex many times without tearing or cracking.

Non-Conductive Rubber Keypads – Construction

Non-conductive rubber keypads can have the same visual appearance as conductive rubber keypads but have some significant differences in the rest of the construction. The non-conductive rubber keypad functions as a mechanical actuator pushing against a switch mechanism such as a metal snap dome switch (Figure 3).

Figure 3. Non-conductive rubber keypads with metal snap dome switch.

There is no semi-conductive pill on the backside of the keytop and the tactile feel is provided by the metal snap dome switch instead of a force cone. The keytop is supported with a thicker web of material between the keytop and the base causing it to flex less and ne less prone to tearing or cracking. The keytop has to move but the restrictions of the force cone no longer exist. The durometer of silicone rubber can be and should be higher (firmer) compared to the conductive rubber keypad providing a firmer feel to the end user with much less keytop wobble.

Comparison Of Features Between The Two Styles Of Rubber Keypads

With an understanding of basic construction, features and design parameters can be compared and contrasted between conductive and non-conductive rubber keypads. Each feature is examined separately but it should be noted that some of the features are linked together and cannot be separated.

1. Switch Sealing

The switch cavity is the location of two switch contacts and the immediate air volume surrounding the two contacts. Conductive rubber keypad switch cavities cannot be sealed by design. The volume of air in the switch cavity must be free to move when the conductive rubber keytop is pressed. These keypads can incorporate design features to minimize external contamination from passing through or around the rubber keypad but the switch cavity itself cannot be sealed.

Non-conductive rubber keypad switch cavities can be environmentally sealed as well as incorporating design features to minimize external contamination from passing through or around the rubber keypad. In conductive rubber keypads, the pill located on the rear side of the keytop is a mixture of carbon particles and silicon rubber. Brand new keypads have a switch resistance of less than 50 ohms but the resistance increases over time and use as contamination deteriorates the pill surface. This phenomenon occurs and there are no viable options to eliminate the problem by sealing the switch cavity. However, setting the switch circuit resistance threshold higher such as 1,000 to 10,000 ohms will slow the contamination deterioration over use and time.

In non-conductive rubber keypads, the molded rubber keypad is an actuator against a metal snap dome switch and has no impact on closed circuit resistance. The switch resistance is controlled by the contact surfaces on the dome switch, printed circuit board, and the environmental seal at the switch cavity.

2. Switch Bounce

Conductive rubber keypads can exhibit high switch bounce when pressed which will depend on the applied finger force and how squarely the pill pushes against the printed circuit board. If the keytop is pressed in the center versus the edge or corner, the keytop can rock and lower the contact surface between the pill and the printed circuit board. This condition increases the closed contact resistance and increases switch bounce. Life test data can be easily skewed from real life operation results based on how the keytop is pressed (Figure 4).

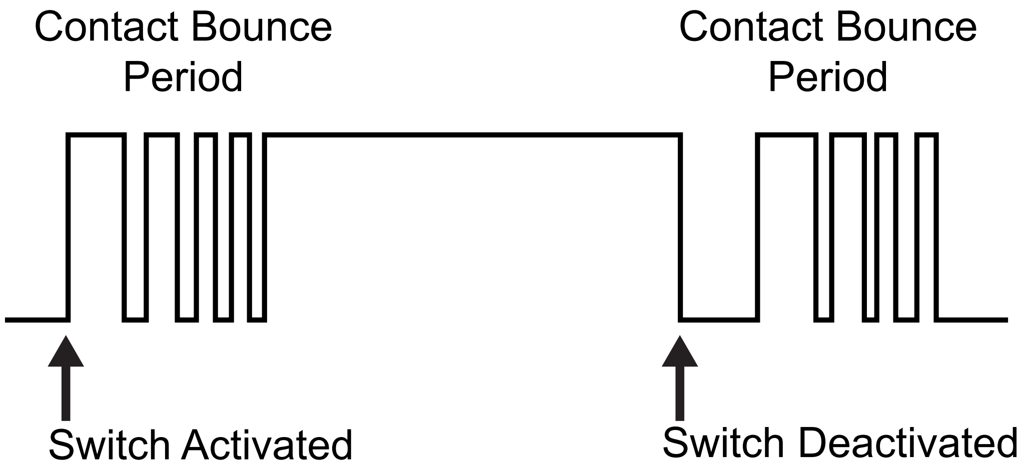

Figure 4. Switch Bounce Diagram

In non-conductive rubber keypads, the switch bounce is controlled by the design of the metal snap dome switch and the contact surfaces of the dome switch and printed circuit board. Dome switches have a much lower closed switch resistance by several magnitudes compared to conductive rubber keypads, lowering the switch bounce even further.

3. Operate Force

Conductive rubber keypads use a stressed force cone around the edge of the keytop to provide tactile feel and travel. Practical limitations in the force cone prohibit high operate forces with reasonable switch cycle life. Typical operate forces for conductive rubber keypads are in the range of 60 to 200 grams.

Non-conductive rubber keypads are almost passive in operate force adding slightly to the switch's operate force. The effective operate force is the sum of the linear displacement force of the non-conductive rubber keypad and the operate force of a metal snap dome switch. Non-conductive rubber keypad assemblies with dome switches have operate forces in the range of 240 grams to 2,000 grams depending on the dome switch design.

4. Intermittent Switch Operation

Conductive rubber keypads can exhibit intermittent switch operation when the pill becomes coated with non-conductive contamination. The switch cavity where the pill makes contact with the inter-digitated exposed conductors on the printed circuit board cannot be sealed. The volume of air between the bottom of the keytop and printed circuit board has to move so that the keytop and pill can move and not affect the limited amount of tactile snap. Sealing the switch cavity would negate the limited tactile feel. Therefore, any airborne dust or lint sucked into the switch cavity when the keytop is released will accumulate on the exposed contact surfaces of the pill and printed circuit board. Setting the switch circuit threshold resistance higher helps delay the effect of contamination but does not prevent deterioration with use.

Non-conductive rubber keypads rely on the metal snap dome switch for tactile feel and electrical switch closure. The rubber keypad itself is only a mechanical actuator. Metal snap dome switches can be designed to operate in an environmentally sealed switch cavity that eliminates introduction of harmful external communication and eliminates intermittent switch operation.

5. Keytop Travel

Conductive rubber keypads have longer keytop travel required for the force cone to collapse for tactile feel. The combination of limited tactile feel and keytop travel gives the user a sense that the switch has operated. Longer keytop travel reduces the cycle life of the force cone and a shorter keytop travel reduces the user's tactile feel when the keytop is pressed. Typical keytop travel for conductive rubber keypads is 0.03 to 0.07 inches.

Non-conductive rubber keypads have a higher control force and higher tactile snap. The tactile snap is provided by the metal snap dome switch. Travel is limited to 0.022 inches or less depending on the specific dome switch. Compression occurs in the rubber keytop that adds to the travel of the dome switch so that the travel of the keytop will be greater than just the dome switch. Assembly keytop travel can be as much as 0.04 inches depending on selection of a specific dome including diameter, dome operate force, and the rubber actuator design.

6. **Switch Operating Point And Over-Travel**

Conductive rubbers keypads do not make electrical contact until the pill makes physical contact with the exposed conductors on the printed circuit board at the end of travel. The keytop does in fact have some compression when pressed so the user senses a small amount of over-travel after the switch closes. Typically, conductive rubber keypads have an effective switch operating point near 90% of the keytop travel including over-travel. It should be noted that it is possible "tease" the conductive rubber keypad where the user can slowly press the keytop to the point where the force cone collapses (tactile feel) but not far enough that the pill physically touches the exposed printed circuit board conductors (switch closing).

Non-conductive rubber keypads make electrical contact when the metal snap dome switch collapses. The point of collapse is near 70% of travel. Again, the rubber keytop has some compression with pressed and adds to over-travel. Typical effective switch operating point is near 60% of the keytop travel including over-travel. With properly designed non-conductive rubber keypad assemblies with metal dome switches, it is virtually impossible to feel the snap with the dome collapses without an electrical switch closure.

7. **Keytop Wobble**

Conductive rubber keypads have the tendency for the keytop to rock or wobble if pressed off-center. The force cone around the keytop proving the tactile feel can collapse independently of the other parts of the force cone and causes keytop wobble. Keytop wobble can be misjudged by users as switch closure as they can perceive tactile feel even though the switch may not have closed electrically.

Non-conductive rubber keypads are molded with higher durometer rubber and don't incorporate force cones for tactile snap. The keytop motion or wobble when pressed off-center is very limited without the force cone. Pressing a keytop off-center will close the switch. Keytop motion and switch closure ambiguity is eliminated for the user.

Summary

Use of molded rubber keypads offers OEM designers a choice for user interfaces. Knowing more about the construction, features, and limitations provides the tools for making the best selection for specific applications. Viewing the molded rubber keypad as an assembly with interactive components instead of a stand-alone component is the single biggest leap the designer can take.