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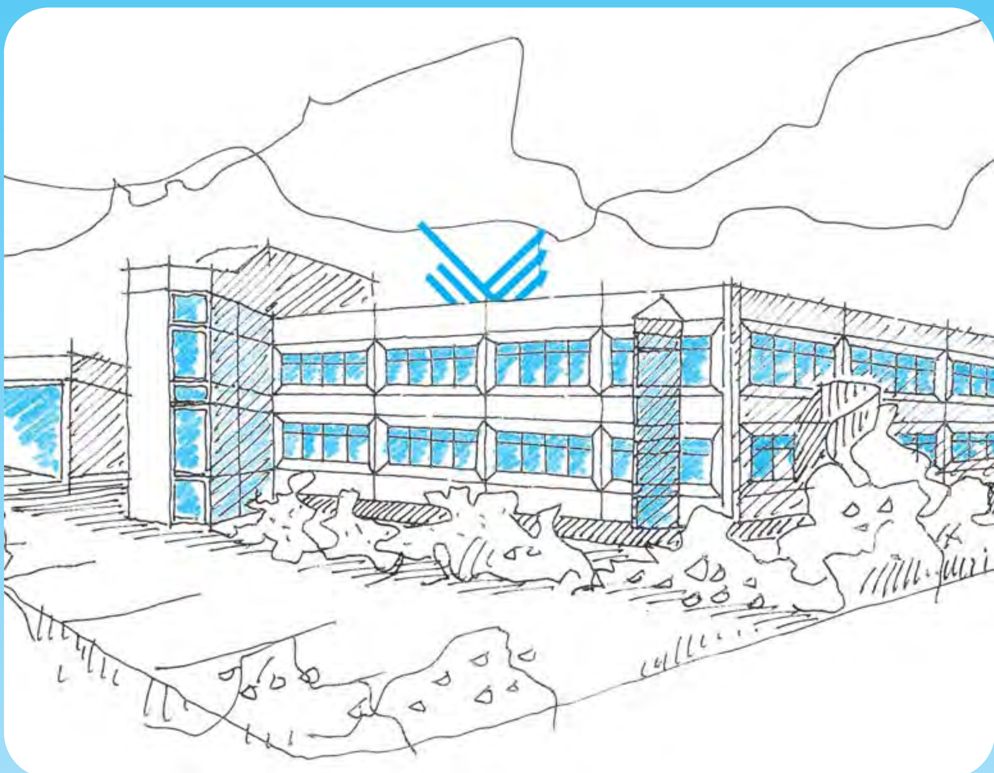

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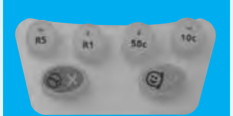
Keypads



DSL

DSL

CONTENTS

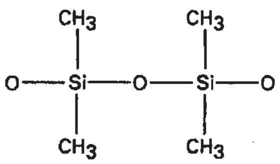
RUBBER KEYPADS

MATERIALS / MANUFACTURING

SILICON RUBBER

FEATURES

Silicone rubber is a synthetic rubber compound that possesses the most desirable properties of both organic and inorganic materials. It has a man made chain of siloxane linkages Si-O detailed below:



CHARACTERISTICS

The data in the tablebelow is representative of standard performance material used in the manufacture of conductive rubber keypads.
Contact us for more information on high performance material if your application requires higher grade material than what is listed.

Physical Mechanical and Electrical Characteristics of Silicone		
Physical Characteristics		
	Conductor carbon pill	**Insulator silicone**
UL Flammability Rating		94 HB
Specific Gravity at 25C	1	1.1 - 1.4
Durometer (Shore A)	65 ±5	40 - 80 ±5
Tensile Strength (Kg/cm^2)	70	55-75
Compression Set %*	20	11-22
Insulation Breakdown		26k v/mm
Volume Resistivity	5	$3x10^{14}-10^{15}$
Mechanical Characteristics		
Key Stroke	0.0 - 5.0 mm	
Actuation Force	20 - 500 grams	
Operating Life	500K actuations (typical)	
Operating Temperature	-20 +70°C**	
Storage Temperature	-40 + 250°C**	
Electrical Characteristics		
Contact Resistance	<200 ohms***	
Insulation Resistance @ 500 VDC	>100 Mohms	
Contact Bounce	<12 msec	
Contact Rating	30mA @ 12V DC. 5sec.	
Dielectric Strength	>1 min. @ 500 V RMS	

* After 22 hours at 175°C

** To convert degrees Fahrenheit to degrees Centigrade use formula: $\frac{^\circ F-32}{1.8}$

*** Based on gold or nickel-plated printed circuit board.

KEYPADS

Manufacturing Process

- All of conductive rubber keypads and switches are compression-molded in precise carbon sreel tools using highly elastic, non-toxic silicone rubber compounds.
- After molding, all keypads are subjected to a two-hour post-curing cycle at a temperature of 200°C. Post curing is essential to the manufacturing process because it removes catalyst and oxidant residue retained by the keypad during the molding process, stabilizes the physical properties of the silicone and increases thermal stability.

DIMENSIONAL TOLERANCE

- Great care should be exercised when a keypad is designed using silicone rubber because it is a highly elastic material subject to manufacturing variations. Tolerances for silicone rubber, by nature, need to be considerably larger than those for less-elastic materials because silicone tolerances are affected by variances in shrink rates, molding conditions and material compounds.

Dimensional Tolerance*	
Dimension	
0.0 - 10.0 mm	± 0.10 mm
10.1 - 20.0 mm	± 0.15 mm
20.1 - 30.0 mm	± 0.20 mm
30.1 - 40.0 mm	± 0.25 mm
40.1 - 50.0 mm	± 0.30 mm
50.1 - 100.0 mm	± 0.35 mm
100.1 mm and up	± 0.5%

Angular dimension ±1 degree

* Contact us to determine if more precise tolerances are available for your design.

ACTUATION FORCE TOLERANCES

- The membrane shape and size of all rubber switches can be designed so that almost any actuation force and tactile feelcan be realized. Most applications require positive tactile feel with relatively long life, so an actuation force of approximatly 125 - 150 grams is typically recommended with an accompanying snap ratio of approximately 40-60%.

Actuation Force Tolerances**	
Design Force	
50 g	± 15 g
75 g	± 20 g
100 g	± 25 g
125 g	± 30 g
150 g	± 35 g
175 g	± 40 g
200-250 g	± 50 g
250.1 g and up	± 30%

** Typical tolerance for actuation force is ± 25g. Optimum actuation force for best key performance is 80-150 g. Conductive rubber switches can be successfully designed and manufactured with actuation forces ranging from a minimum of 20 g to a maximum of 500 g.

DESIGN RECOMMENDATIONS

SNAP RATIO

- The snap ratio (or click ratio) of any conductive rubber keypad directly affects the tactile feel realized by the operator. Keypads with snap ratios of 40-60% have excellent tactile feel and relatively long life, while keypads with snap ratios below 40% have relatively weak tactile feel, but longer life. Dual-durometer keypads also improve tactile feel.

- The snap ratio of any keypad can be calculated by working with the formula below where F1 = actuation force and F2 = contact force.

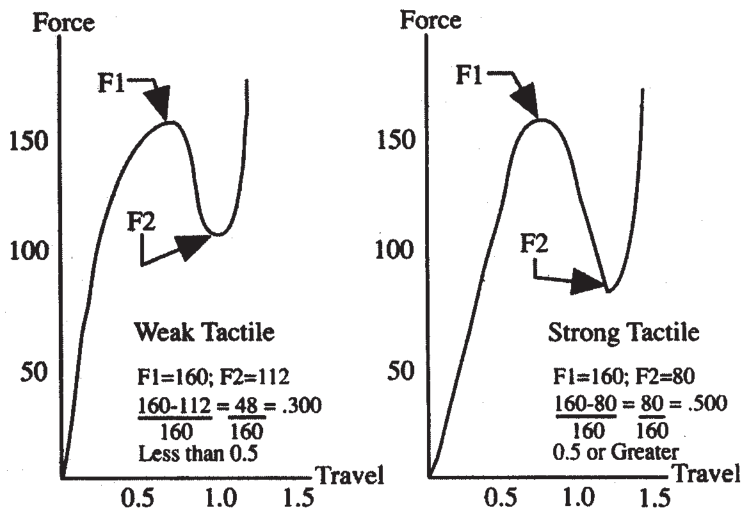
$$\frac{F1 - F2}{F1}$$

- It is very difficult to recommend specific guidelines for creating best tactile feel. However, if actuation force and stroke are identi fied for a given application, it is possible to design a keypad s switch membranes precisely to realize the identified parameters. A very general guideline that can be followed for developing good tactile feel is to specify higher actuation forces for keypads with large keys than those with small keys. This rule also applies to key heights: tall keys require higher actuation forces than short keys.

- Another typical guideline for actuation force is to specify a minimum actuation force of 80 - 100 grams for keys with heights of 10 - 15 mm and a minimum actuation force of 150-175 grams for keys with heights of 15 - 25 mm.

- Care should be taken when designing tactile feel so a minimum return force of 30 grams is realized. This minimum return force will help greatly to eliminate the potential problem of sticking keys, as will proper bezel design. (see page 10 Figure 2).

Tactile Feel



TYPES OF CONTACTS

- There are several different types of contacts available for rubber switches, each with its own unique electrical characteristics. The following information should be carefully considered when choosing the contact type for your application.

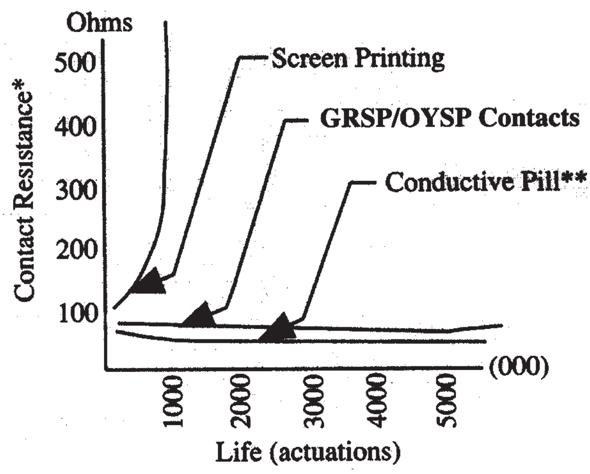
- The **carbon pill** is the contact most frequently used in conductive rubber keypads and switches, primarily because of its long life and low contact resistance. The average life for carbon pills exceeds 5 million actuations, and contact resistance is typically less than 200 ohms. Carbon pills are usually circular shaped and available in one-half sizes ranging from 2.0 - 8.0mm. The typical thickness of a carbon pill is 0.4 - 0.5mm; this should be taken into consideration when the stroke of the switch is determined. We also offer several different sizes of oval-shaped pills which are also considered "standard" because they do not require any type of special tooling charge. The oval-shaped pill sizes are available as below:

Oval-Shaped Conductive Pills			
1.5 x 5.0	2.5 x 5.0	4.0 x 7.0	4.0 x 16.0
2.0 x 3.5	2.5 x 11.0	4.0 x 8.0	4.5 x 8.0
2.0 x 4.5	3.0 x 5.5	4.0 x 11.0	5.0 x 7.0
2.0 x 5.0	3.0 x 8.0	4.0 x 14.0	5.0 x 14.0
2.0 x 12.0	4.0 x 6.0	4.0 x 15.0	6.0 x 10.0

- The second most commonly used contact type is **silk screened or conductive ink.** Screened contacts are available in any shape or size and allow great design flexibility because of the manner in which they are printed on switch-contact areas. Their biggest drawbacks, however, are shorter life and higher contact resistance compared to carbon pills. Screened contacts are typically only 10-20 microns thick, hence the shorter life and eventual climbing contact resistance. It is not uncommon for screened contacts to realize contact resistance of approximately 1,000 ohms over the life of the keypad. Careful attention must be given to the keypad's electrical requirements when this contact type is selected.

- A third contact type, **GRSP/OYPS**, is unique because it combines the advantages of the carbon pill and silk-screened contacts. GRSP/OYPS contacts utilize a special low-resistance conductive ink that is not applied in the conventional silk-screen manner. As a result, the ink layer on the switch-contact area is thicker than silk-screened contacts (15-30 microns); therefore, it has a lower contact resistance (less than 200 ohms) over an excess of 5 million actuations. Contact us for more information about GRSP/OYPS contacts.

Average Life / Contact Resistance



* Based on gold or nickel-plated printed circuit board with an applied load of 200 grams.

** Typical thickness of a conductive pill is 0.4 - 0.5mm; typicai thickness of screen printing is 10 - 20 microns.

Environmental Test Conditions						
Test Conditions*	Contact Resistance in Ohms (before test)			Contact Resistance in Ohms (after test)		
Contact type	Pill	Ink	GRSP/OYPS	Pill	Ink	GRSP/OYPS
Low temp. (-35ºC x 10 days)	50.0	51.0	50.0	50.0	51.0	54.0
High temp. (100ºC x 10 days)	106.0	104.0	106.0	108.0	105.0	109.0
Ozone resistance 60 ppm (60ºC x 10 days)	82.0	84.0	83.0	82.0	84.0	83.0

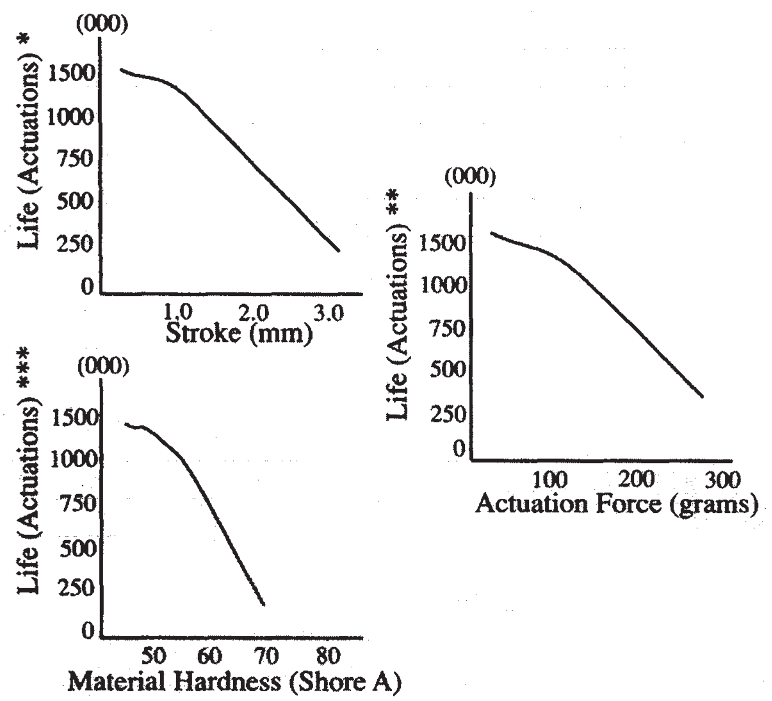
* Low temperature: Raise to 25°C for 24 hours, then lest. High temperature: Lower to 25°C for 24 hours, then test.
Ozone resistance: Remove from test condition and lower to 25°C for 24 hours, then test.

SWITCH LIFE

- Switch reliability and life depend on the membrane style chosen and the durometer and quality of the material selected. Actuation force, snap ratio and stroke also influence life, as does a proper post-curing cycle. All other things being equal, switch life is reduced when higher durometer silicone is selected for the base material of the keypad, actuation force is increased or stroke is elongated.

- A minimum membrane thickness of 0.40mm is usually required to realize an average life cycle of 1 million actuations. Refer to the graph below for other typical switch characteristics as one or more of the previously cited parameters are changed.

Typical Switch Characteristics



* Assumes actuation force of 125 -150 grams
** Assumes key travel of 0.8 - 1.0mm.
*** Assumes actuation force of 125 -150 grams and key travel of 0.8 -1.0mm.

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PRINTED CIRCUIT BOARD DESIGN

- Conductive rubber keypads are very reliable, but the environment in which they are used should be considered very carefully when the printed circuit board is designed. In order for any keypad to provide trouble-free operation, it is imperative that all components be designed properly, particularly the printed circuit board.

- Printed circuit boards can be supplied with several different types of plating; the only type that is specifically not suitable for use with conductive rubber switches is tin-lead solder boards. Gold plating over nickel on the printed circuit board offers the lowest possible contact resistance (less than 100 ohms) for any keypad application, and a minimum layer of 30-50 micro inches of gold over 100-200 micro inches of nickel is recommended for best switch performance. The width of gold traces typically ranges from 0.25-0.40mm, while the minimum distance between them is typically 0.30mm and the maximum is usually 0.40mm.

- Nickel plating, like gold, is extremely reliable and relatively inexpensive when compared to the cost of gold-plated boards. Contact resistance for nickel-plated boards is typically less than 100 ohms, and nickel has an excellent track record in even the most severe environmental conditions. If nickel plating is used without gold, a minimum plating thickness of 200 micro inches is recommended for best overall performance. Most keypad applications utilize nickel-plated boards because of their high reliabi lity and low cost.

- Silk-screened carbon boards can also be used with conductive rubber switches, but should only be selected when contact resi stance between 500-1,000 ohms can be tolerated. If screened carbon boards are used, the minimum distance between the traces should be 0.50mm, and the overall size of the electrode should be greater than 5.0mm.

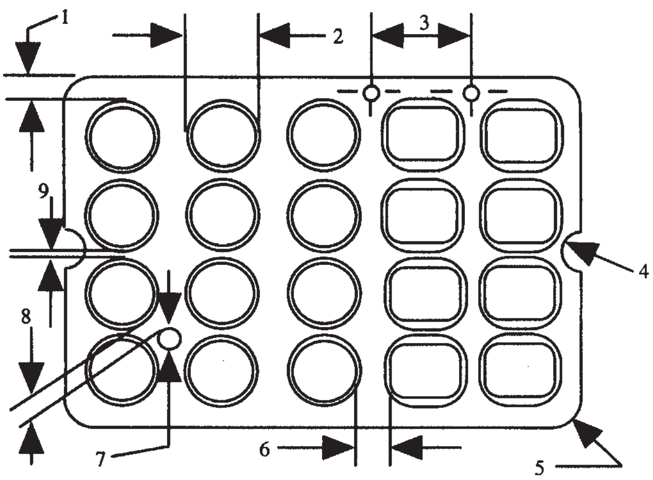
- It should be noted that there is not a single recommended pad pattern for use with rubber keypads. Printed circuit board electrode design should be developed carefully taking all switch characteristics into consideration. The most important single objective to be considered in designing any pad pattern is to provide as many shorting paths as possible so best switch operati on can be realized when the button is actuated. Several common contact patterns are shown below for reference purposes only.

Contact Patterns

- Pads on printed circuit boards should never be smaller than the conductive pill or contact area on the bottom of the rubber switch. It is strongly recommended that the electrode (pad) on the printed circuit board be 1.25 times the diameter of the conductive pill, or at least 1,0mm larger than the overall size of the contact on the bottom of the switch surface.

Figure 1

Design Recommendations



- Figure 1:
  1. Minimum distance from edge of keypad: 1.0mm.
  2. Typical membrane dimension: key size + 2.5mm.
  3. Typical guide hole spacing: 30 - 50mm.
  4. Minimum radius dimension: 2.0mm.
  5. Typical corner radius dimension: =>1.0mm.
  6. Minimum key pitch dimension: 4.0mm.
  7. Minimum guide hole dimension: =:>1.5mm.
  8. Minimum distance from hole to membrane of switch: 1 .Omm.
  9. Minimum membrane spacing dimension: 1.0mm.

Figure 2

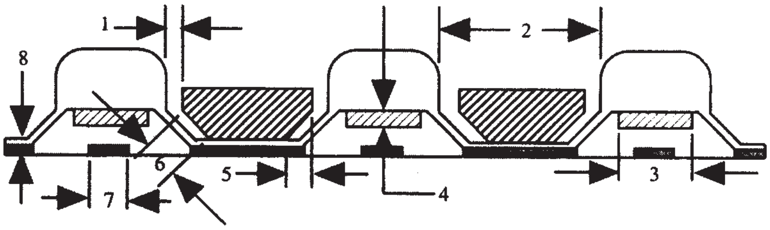


Figure 3

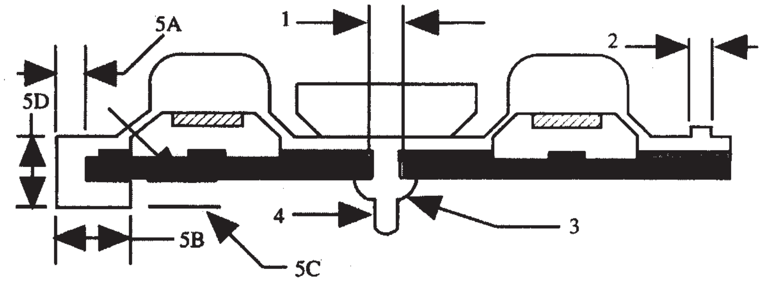


Figure 4

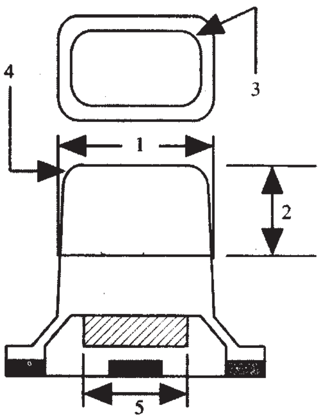


Figure 2:

1. Minimum clearance between bezel and keys: 0.3mm.
2. Minimum key pitch dimension: 4.0mm.
3. Typical pill size dimension (circular pills): 2.0 - 8.0mm
4. Typical pill thickness dimension: 0.4 - 0.5mm.
5. Typical chamfer dimension: 0.5mm.
6. Typical chamfer angle dimension: 45°.
7. Typicai air channel dimension: 2.0 - 3.0mm.
8. Typical base thickness dimension: 1.0mm.

Figure 3:

1. Typical mounting boss hole dimension: 1 .Omm greater than neck of mounting boss.
2. Minimum gasket dimension: width is 1.0mm; maximum height is 1.5 times greater than width.
3. Typical mounting boss dimension: No recommended dimension. One mounting boss required every 50.0mm. Consult GTC for design assistance.
4. Typical mounting boss tail dimension: No recommended dimension. Consult GTCfor design assistance.
5. Typical printed circuit board wrap around dimensions: No recommended dimensions. The following rules apply:

A) Thickness must exceed 1.0mm.
B) Lip length must be =< 2.5mm.
C) Lip thickness must be >1 .Omm and =< wrap around thickness dimension.
D) Height must be <10.0mm. Consult QTC for design assistance.

Figure 4:

1. Minimum Taper Dimension: 1° taper on all keys when button height above switch membrane exceeds 5.0mm.
2. Minimum Pre-molded Keytop Dimension: =>4.0mm.
3. Minimum Side Edge Radius Dimension: 0.2mm on square or rectangular keys.
4. Minimum Top Edge Radius Dimension: 0.3mm for keys requiring a 1' taper.
5. Maximum Contact Size Dimension: -> 2.0mm smaller than minimum keytop dimension for reliable switch closure.

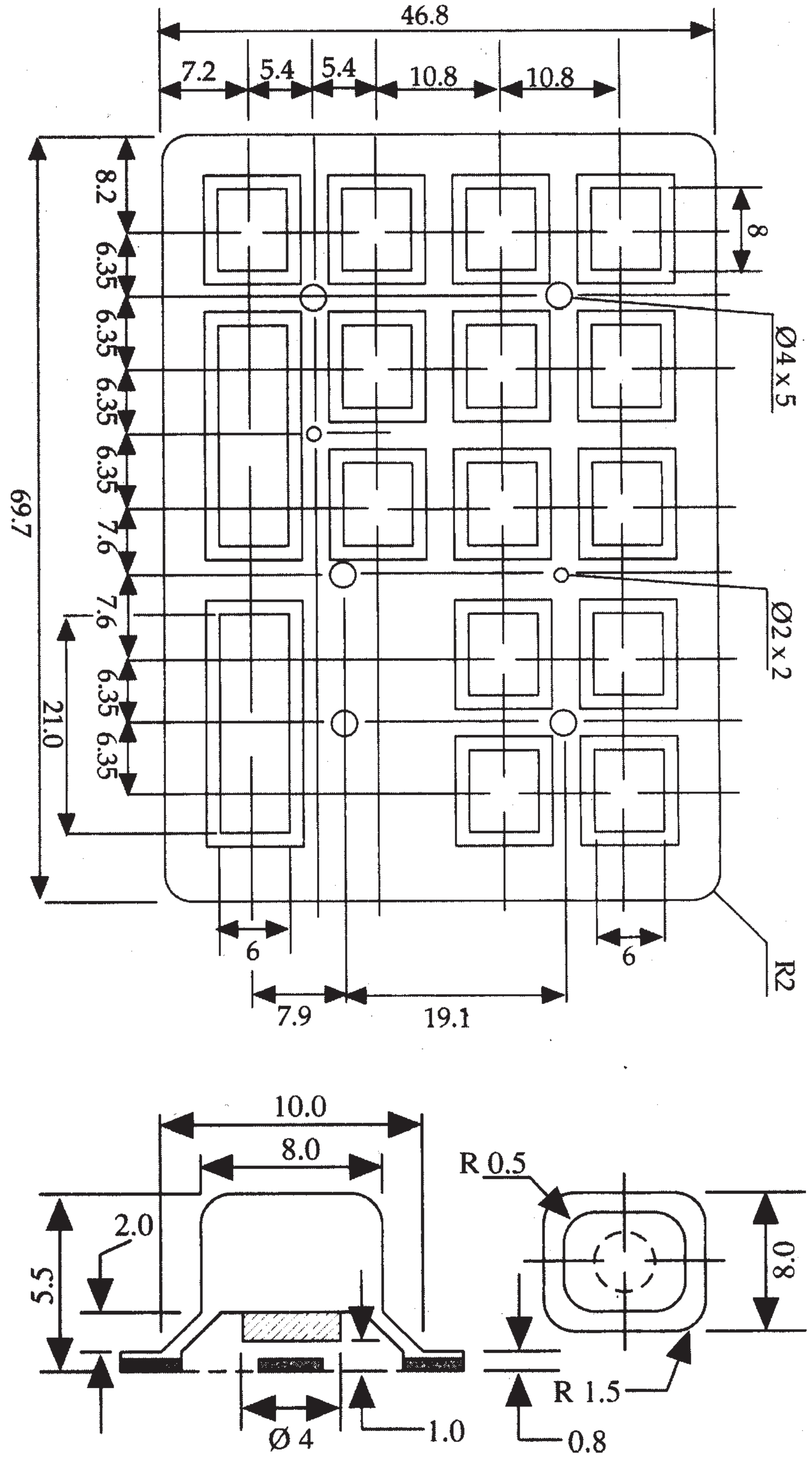
KEYPAD DESIGN GUIDELINES

- The information contained in the following pages provides good general suggestions regarding what types of strokes, actuation forces andtife cycles are typically specified for various types of applications. While these tables may cover most applications, they are not meant to be strict guidelines as each application is unique and may require different design parameters.

Design Application	Typical Stroke (mm)	Actuation Force (grams)	Life Cycle (x 1,000)
Automotive	1.0-2.5	150-300	50-1,000
Calculators	0.2-3.5	30-80	300-1,000
Computer	2.0-4.0	40-90	5,000-10,000
Measuring Equipment	0.3-1.6	30-120	1,000-3,000
Musical Instrument	0.7-3.5	30-100	1,000-3,000
Sound Equipment	0.3-1.5	70-225	1,000-3,000
Telephone	1.0-3.5	70-250	1,000-3,000
Transmitter	0.3-1.5	50-150	300-1,000
TV + VCR	0.6-1.5	30-120	300-1,000
Typewriter	3.0-4.0	40-70	5,000-10,000

Actuation force is usually specified in grams. In the event that this force is expressed in ounces, simply divide the number by 0.0355 to convert to grams (oz/0.0355 = g).

Typical Mechanical Drawing



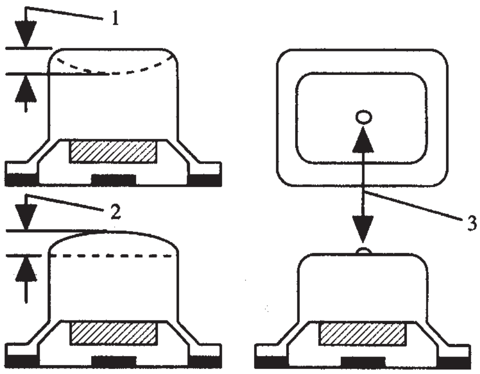
For reference only; Mechanical drawings should include all of the following information:

1. Overall Keypad Size
2. Base Thickness
3. Keytop Outside Dimensions
4. Overall key Height(s)
5. Contact Size(s)
6. Mounting Hole Details
7. Mounting Boss Details
8. Radii Dimensions (keypad and buttons)
9. Keypad/Switch Colors
10. Stroke/Travel
11. Actuation Force (grams)
12. Snap Ratio (force/stroke diagram)
13. Electrical Specifications
14. Material Specifications (durometer)
15. Graphic Color(s)

KEYPAD GRAPHICS

- Almost all keypad graphics, either positive or negative-image, are surface printed using a special silicone ink that is actually bonded to the keypad during the manufacturing process. Graphics are permanently applied to the top surfaces of rubber switches by curing all keypads in high-temperature ovens after printing. Special attention must be given to keytop design if negative-image graphics are desired because printing is difficult on concave and convex keytops. Each graphic color requires its own individual screen, and represents an additional step in the manufacturing process. Pantone numbers are normally used for specifying graphic colors, but color chips can be matched if Pantone numbers are not suitable for a given application.

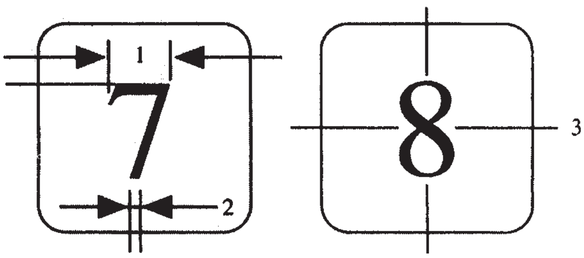
Screen Printing Limitations

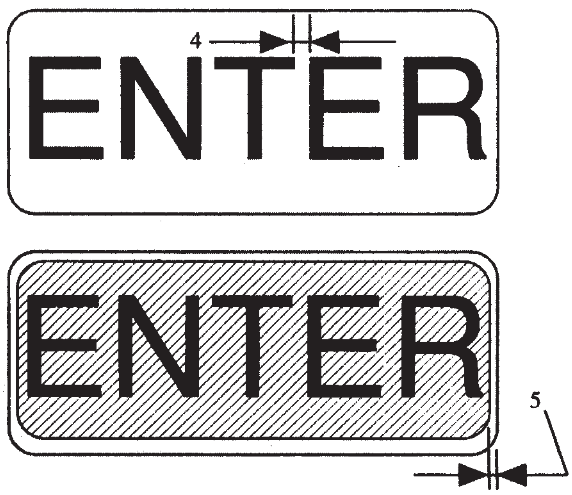


1. Maximum curvature for concave key tops: 0.5mm.
2. Maximum curvature for convex key tops: 0,5mm.
3. Locating dimple: any size possible. Negative image graphics cannot be printed on key surface - positive image graphics only.

- If the keypad graphics are going to be exposed to conditions more severe than normal abrasion (i.e.: operator wearing gloves) or subjected to an excessive number of actuations, they can be coated with translucent ink (matte or shiny finish) to enhance legend life. Overcoating typically doubles the life of silk-screened graphics, and two overcoats of translucent ink can be applied if necessary. However, overcoating does increase the price of the keypad because additional steps are required in the manufac turing process.

Legend/Registration Limitations





1. Minimum legend size: 1 mm square with 0.2mm line widths.
2. Minimum line width: 0.2mm.
3. Registration tolerance: +/- 0.4mm.
4. Minimum line spacing between legends: 0.2mm.
5. Minimum spacing required is the radius +0.3mm.

Off-The-Shelf

Single-Position Switches & Conductive Rubber Keypads

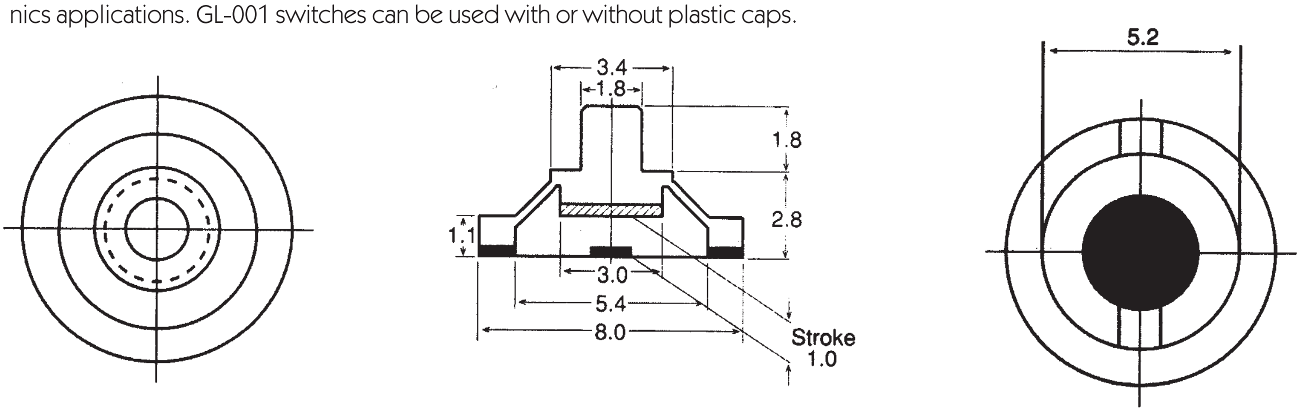
- Reliable
- Economical
- Durable
- Practical
- Convenient

STANDARD PRODUCT GL-001

Mechanical Characteristics		
Actuation Force (grams)	Typical Stroke (mm)	Snap Ratio
80 ±20	1.0	20 - 30%

FEATURES / APPLICATION

- This conductive-rubber button has been designed to operate as a single position switch and is ideal for use in consumer electro nics applications. GL-001 switches can be used with or without plastic caps.

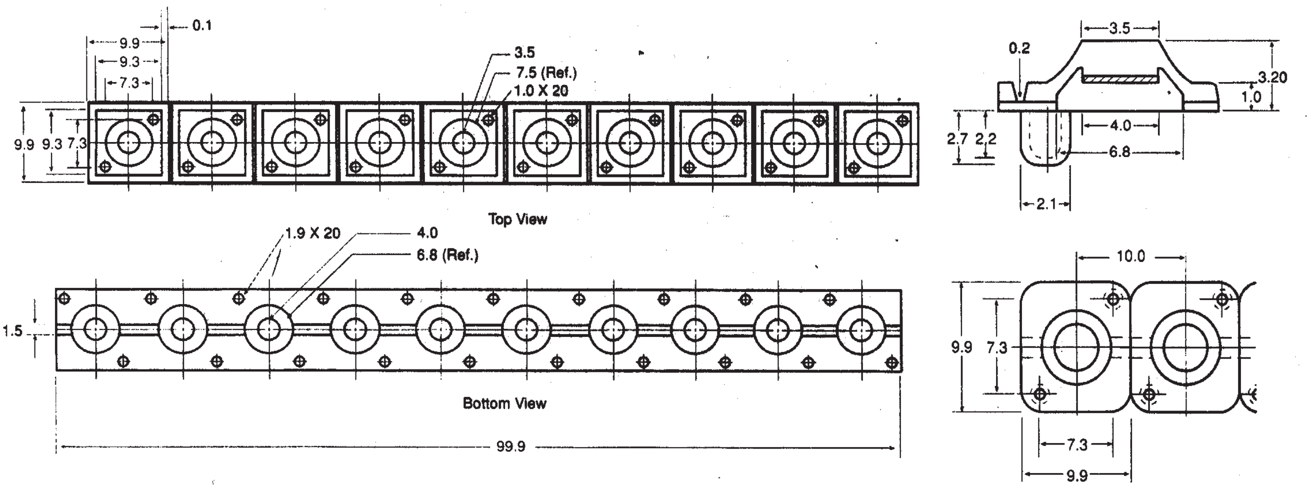


STANDARD PRODUCT GL-002

Mechanical Characteristics		
Actuation Force (grams)	Typical Stroke (mm)	Snap Ratio
80 ±25	1.0	25 - 35%

FEATURES / APPLICATION

- This conductive-rubber button has also been designed for use as an individual switch or as a series of switches. Tear lines bet ween switches permit effortless separation of keys, and mounting bosses on the bottom of all switches promote easy printed circuit board insertion. GL-002 switches are ideal for use in sound equipment and other consumer electronics applications.

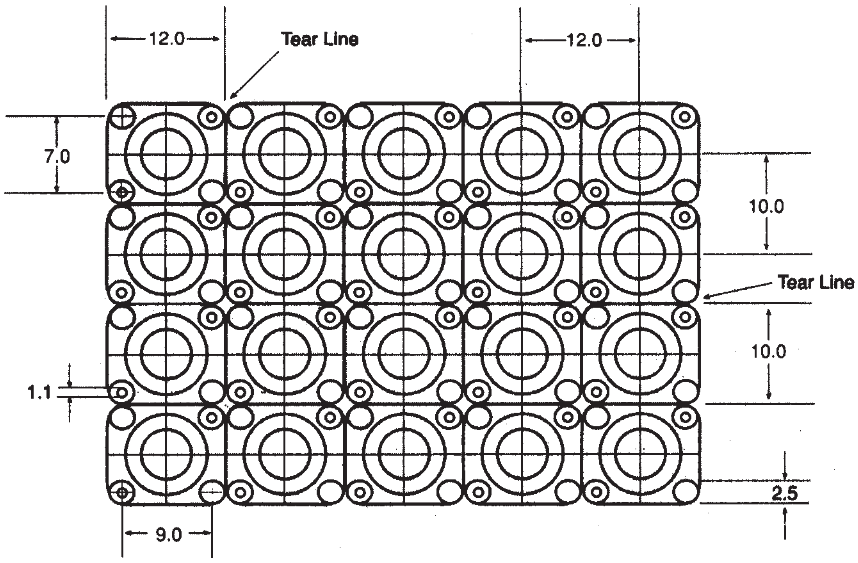


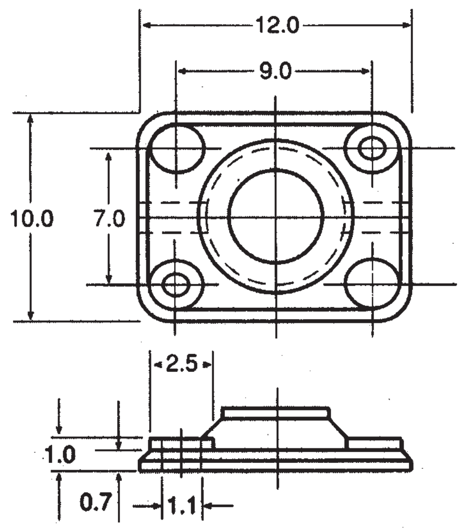
STANDARD PRODUCT GL-003

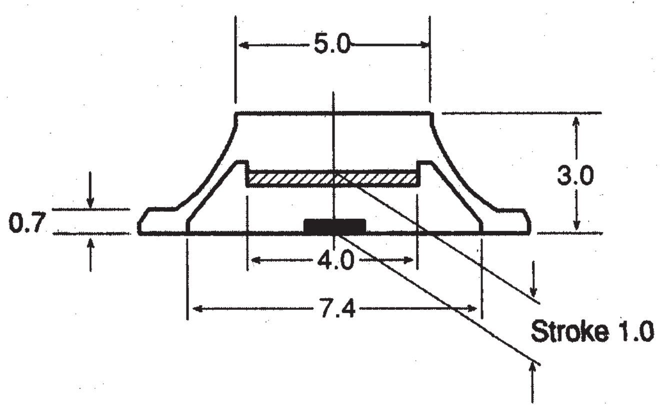
Mechanical Characteristics		
Actuation Force (grams)	Typical Stroke (mm)	Snap Ratio
100 ±25	1.0	50 - 60%

FEATURES / APPLICATION

- This conductive-rubber button has also been designed for use as an individual switch or as a series of switches- Tear lines between switches allow for easy separation of keys and alignment holes on each button promote rapid printed circuit board assembly. This switch has excellent tactile feel and is ideal for use in sound equipment, as well as consumer and industrial electronics applications.





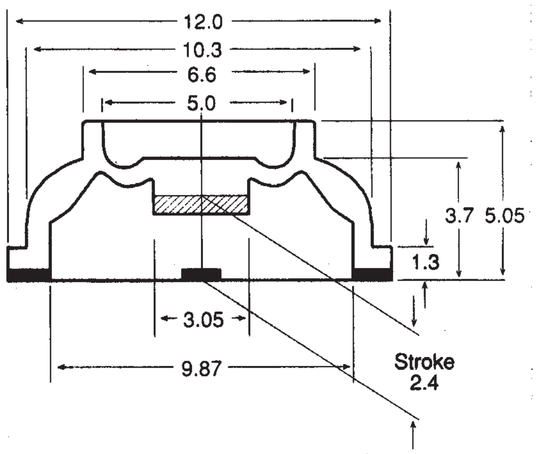


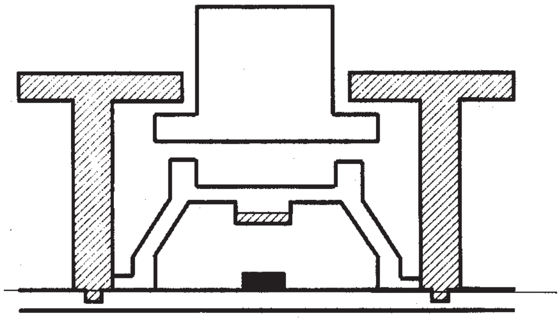
STANDARD PRODUCT GL-004

Mechanical Characteristics		
Actuation Force (grams)	Typical Stroke (mm)	Snap Ratio
50 ±15	2.4	N/A

FEATURES / APPLICATION

- This conductive-rubber button has also been designed with full travel, overstroke and light actuation force for use in computer terminals, printers and electronic typewriters, This single-position switch should be used with some type of plastic keycap and overstroke can be controlled by incorporating stoppers into the final assembly.



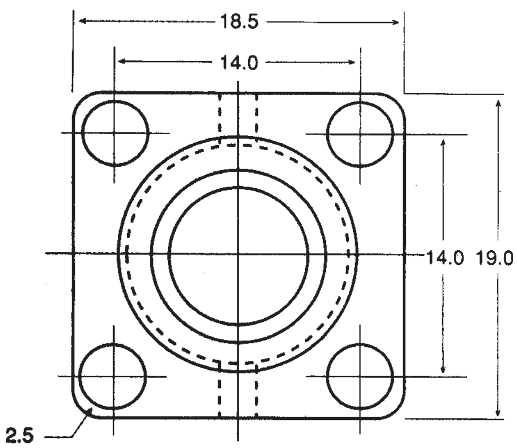


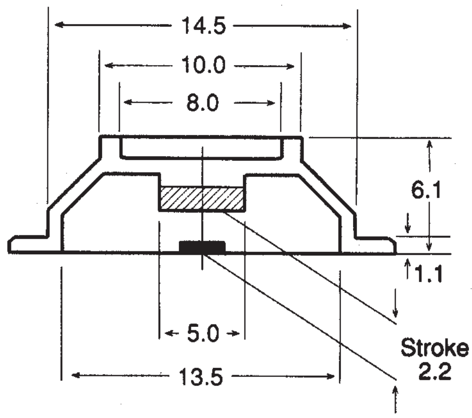
STANDARD PRODUCT GL-005

Mechanical Characteristics		
Actuation Force (grams)	Typical Stroke (mm)	Snap Ratio
150 ±25	2.2	50 - 60%

FEATURES / APPLICATION

- This conductive-rubber button has been designed with full travel, overstroke, light actuation force and positive tactile feel. This switch is ideal for use in computer terminals, printers, electronic typewriters and other office equipment applications.
This switch, like GL-004, should be covered with plastic keycaps in the final assembly.



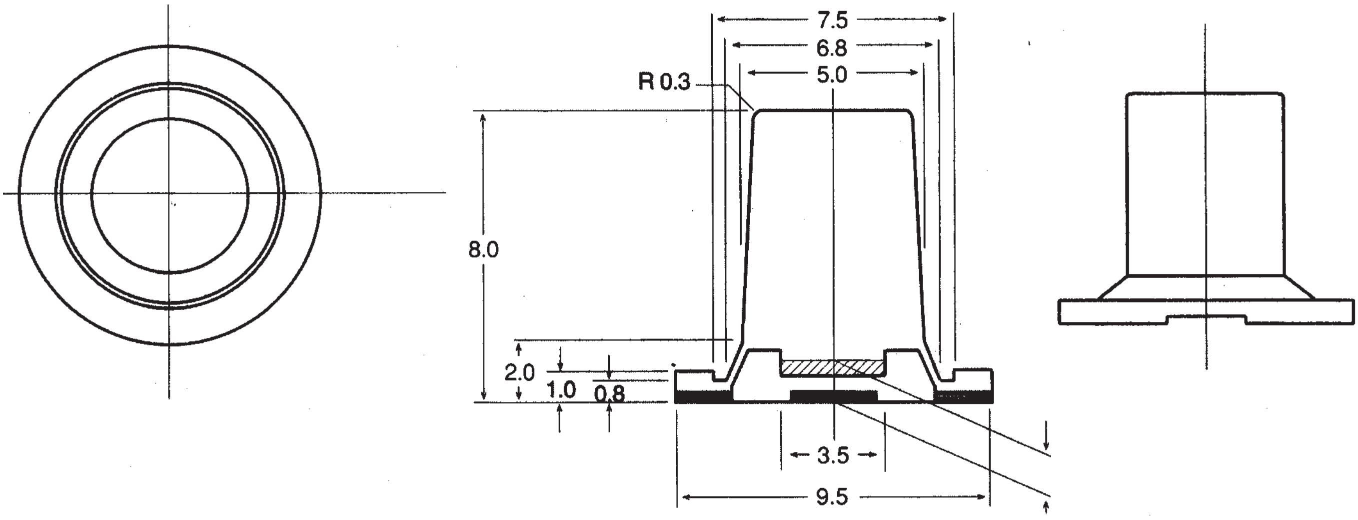


STANDARD PRODUCT GL-006

Mechanical Characteristics		
Actuation Force (grams)	Typical Stroke (mm)	Snap Ratio
135 ±25	1.0	50 - 60%

FEATURES / APPLICATION

- This individual conductive rubber button has been designed with positive tactile feel and is ideal for consumer electronics applications. High actuation force prevents accidental switch closure without sacrificing switch life.

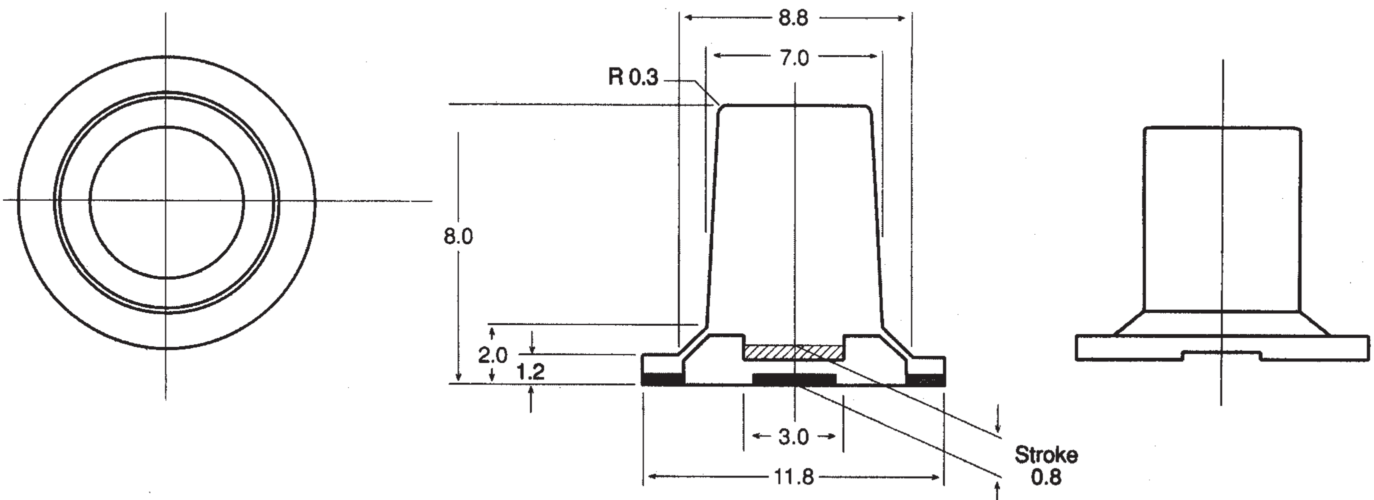


STANDARD PRODUCT GL-007

Mechanical Characteristics		
Actuation Force (grams)	Typical Stroke (mm)	Snap Ratio
100 ±25	0.8	20 - 30%

FEATURES / APPLICATION

- This individual conductive-rubber button has been designed with light tactile feel and is ideal for consumer electronics and office equipment applications. Button size promotes easy switch operation, and button height permits use with high-profile applications.



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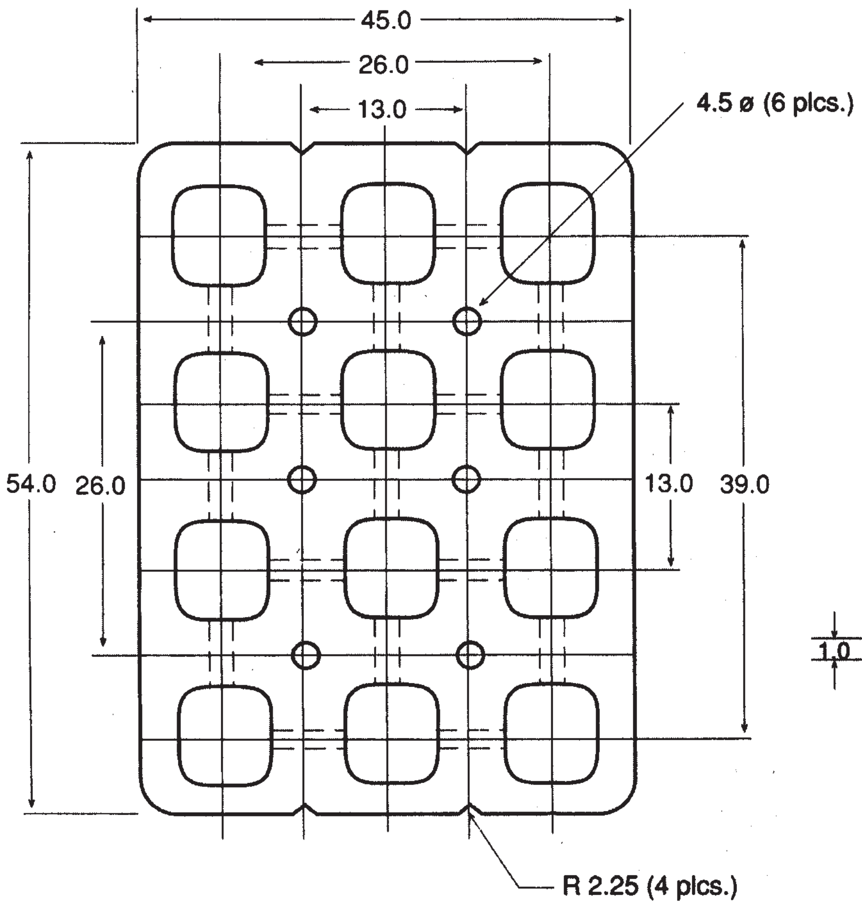
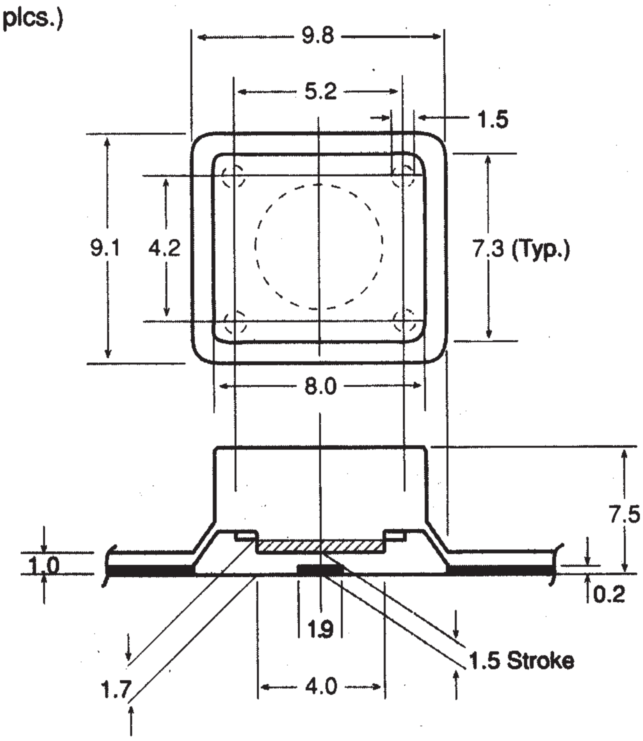
STANDARD PRODUCT GL-101

Mechanical Characteristics		
Actuation Force (grams)	Typical Stroke (mm)	Snap Ratio
150 ±25	1.5	40 - 50%

FEATURES / APPLICATION

- This conductive-rubber keypad is available with or without printed legends and eliminates the need for plastic keycaps and costly inventory. Custom legends and colors are available if artwork and Pantone numbers are supplied at the time of order entry. This 12-position keypad is ideal for use in communication and electronic equipment applications.



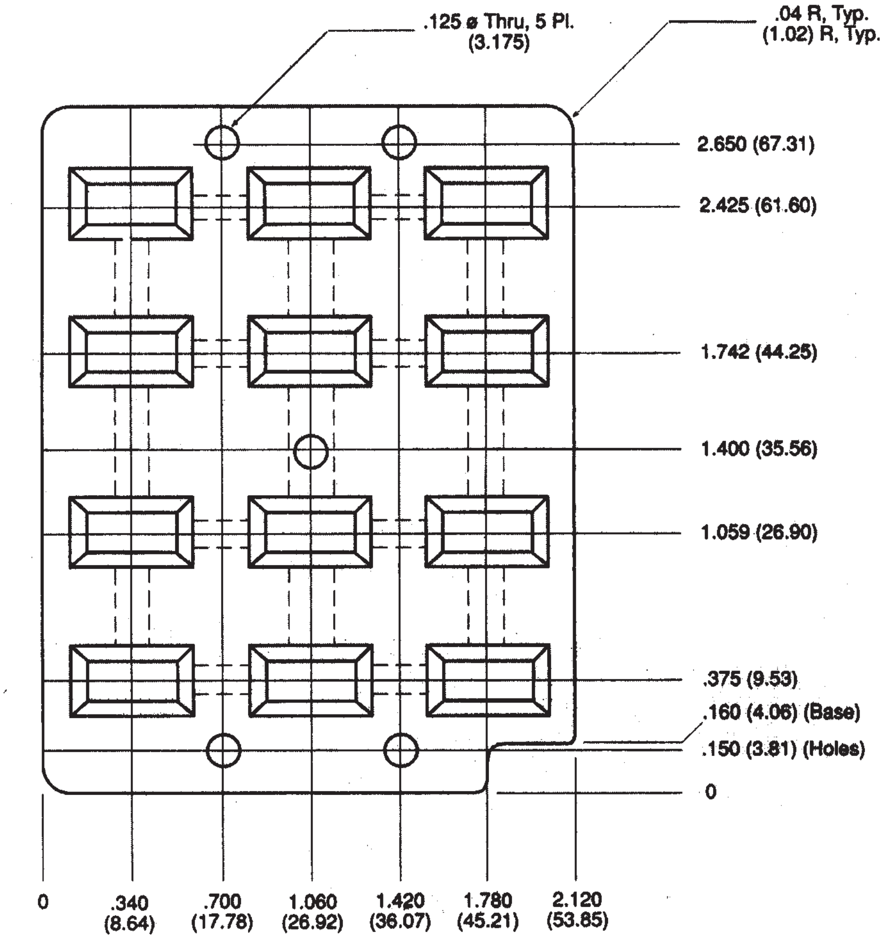


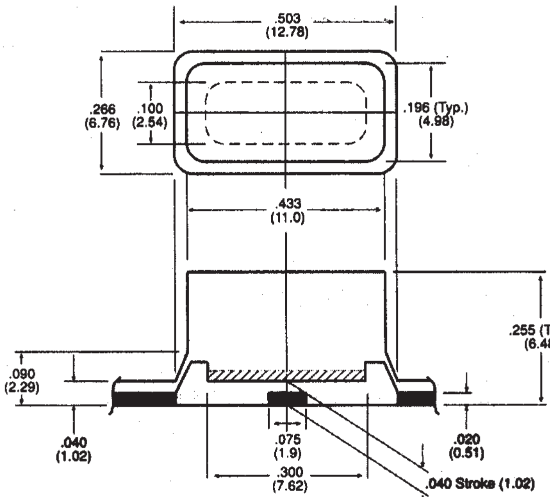
STANDARD PRODUCT GL-102

Mechanical Characteristics		
Actuation Force (grams)	Typical Stroke (mm)	Snap Ratio
130 ±25	1.02	30 - 40%

FEATURES / APPLICATION

- This conductive-rubber keypad, like GL-101, is available with or without printed legends and can be supplied with custom graphics in a variety of colors. Rectangular keys facilitate switch operation and provide excellent tactile feel. This 12-position keypad is ideal for use in communication, measurement and electronics applications.



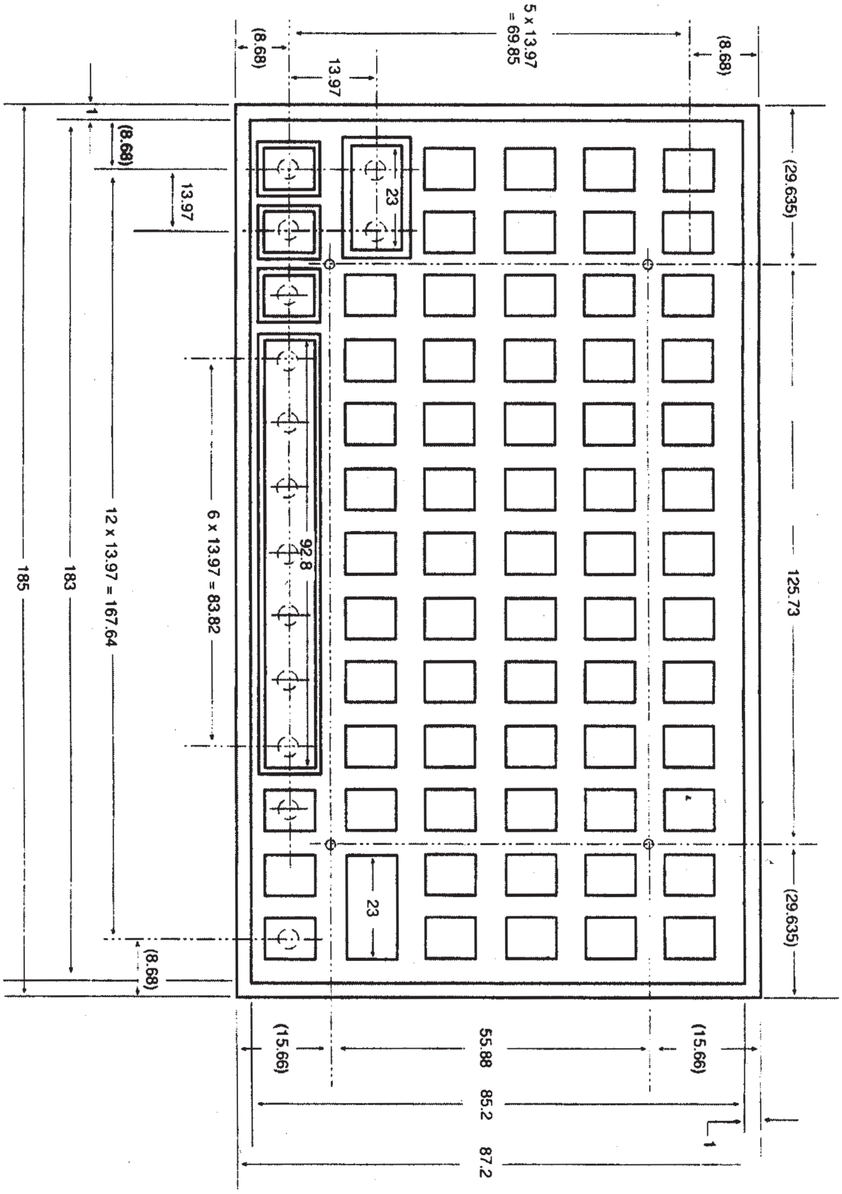


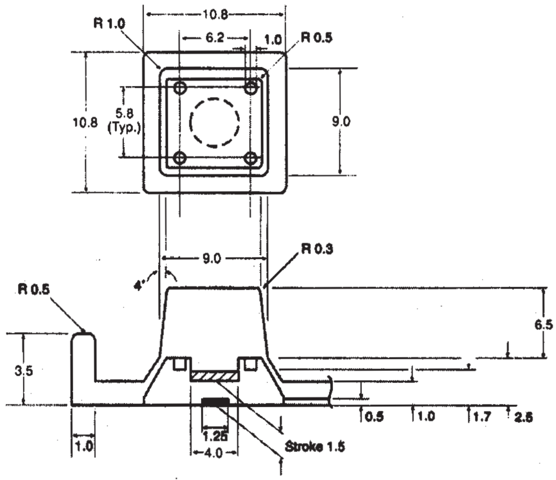
STANDARD PRODUCT GL-103

Mechanical Characteristics		
Actuation Force (grams)	Typical Stroke (mm)	Snap Ratio
70 ±20	1.5	30 - 40%

FEATURES / APPLICATION

- This qwerty style keypad provides a complete keyboard panel with comparatively light actuation force, long travel and excellent tactile feel. GL-103 can be supplied with or without graphics and is available in a variety of colors. This keypad is ideally suited for use in instrumentation and data-entry applications.





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TERMINOLOGY

Actuation Force
The force required to collapse the membrane of a rubber switch (identified as F1 on force / stroke curve).

Air Channel
Air path(s) on the bottom of rubber keypads and switches that allows for air passage (venting) when switch is actuated. Switches must be vented on at least two sides.

Alignment Hole
Through hole in rubber keypad that is used to position keypad in enclosure when overall keypad size exceeds three inches in either length or width.

Base
Silicone sheet material that joins all keys/switches on a rubber keypad. Also known as **apron**.

Bezel
The faceplate or cover, typically either plastic or metal, used to secure a key pad to a printed circuit board. The bezel also alings the keypad during the final assembly and protects keypad-base material from contact with human hands.

Breakdown Voltage
Voltage at which an insulator or dielectric ruptures. Also known as dielectric strength.

Compression Set
The measurement of a material s ability to recover its original size and shape after compression under prescribed conditions. It is usually expressed as a recovery percentage (fraction) of the compression condition.

Conductive Rubber Switch
Mechanical switch made of silicone rubber, either direct or indirect contact.

Contact
The current-carrying area/surface under each rubber switch (conductive pill or carbon-inked surface) that makes electrical connection with the electrode on a printed circuit board when the switch is actuated.

Contact Force
The force required to maintain rubber-switch contact closure (F2 on force/stroke curve) with a printed circuit board.

Contact Rating
The electric power handling capability for rubber contacts under strictly controlled laboratory conditions.

Contact Resistance
Electrical resistance of a contact measured in ohms through an electrode on a printed circuit board. Contact resistance is greatly affected by actuation force, electrode type, and contact type and size.

Dual Durometer
Silicone-rubber keypads manufactured using a two-shot molding process and two-material hardnesses.

Electrode
Contact surface/design on a printed circuit board that conducts current when rubber switch is actuated and switch closure occurs.

Key Height
The measured distance from the bottom of a keypad (base) to the top surface of a key.

Legend
Some type of printed graphic (symbol, letter or number) on the top of the key surface.

Life
The number of switch actuations realized before the switch membrane ruptures or over-stresses.

Membrane
The non-conductive hinge that permits a rubber key to flex, and is responsible for the tactile feel realized.

Negative-Image Graphics
Graphics that allow switch color or switch masking color to be seen through top-surface printing on keypad.

Overstroke
Additional travel experienced with a rubber switch after initial switch closure has been realized. Rubber switches with overstroke require a double-cone or double-bell shaped membrane.

Positive-Image Graphics
Single or multi-color printing on top of key surface.

Return Force
Force created by switch membrane as it returns the key to a non-actuated position.

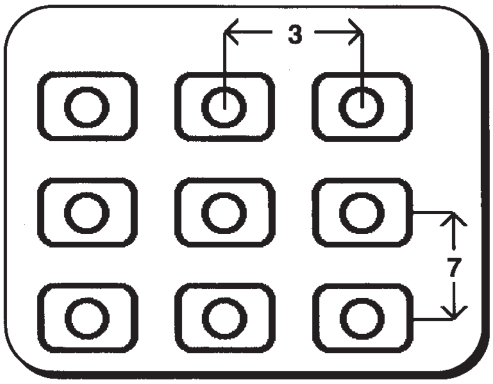
Snap Ratio $\left(\frac{F1-F2}{F1}\right)$
The difference between the actuation force (F1) and the contact force (F2) of a switch divided by the actuation force.

Stroke
Distance from the contact surface on a rubber switch to an electrode pattern on a printed circuit board.

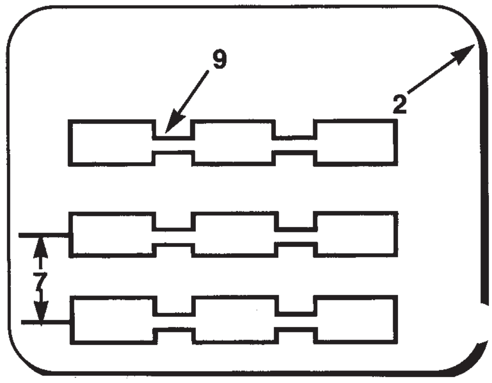
POLYDOMES

POLYDOME DESIGN REQUIREMENTS

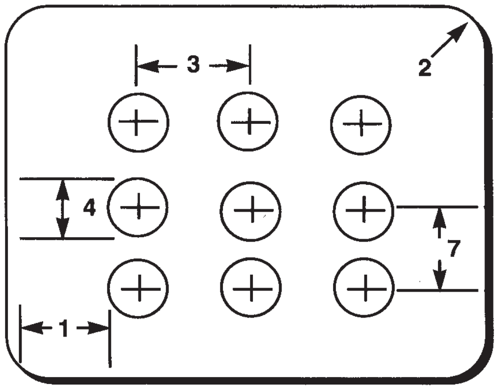
LAYER1
Ribber Detail Drawing



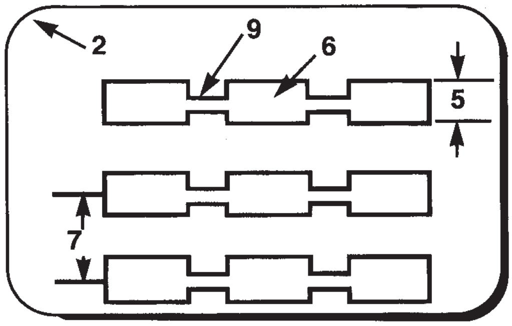
LAYER2
Adhesive Spacer Detail Drawing
.05mm, .08mm, .125mm thick



LAYER3
Popydome Detail Drawing
.075mm, .1mm, .125mm thick



LAYER4
Adhesive Spacer Detail Drawing
.05mm, .08mm, .125mm thick



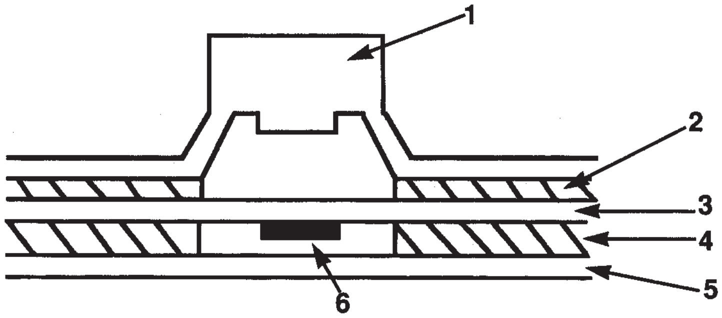
NOTES TO DESIGN REQUIREMENTS-POLYDOMES

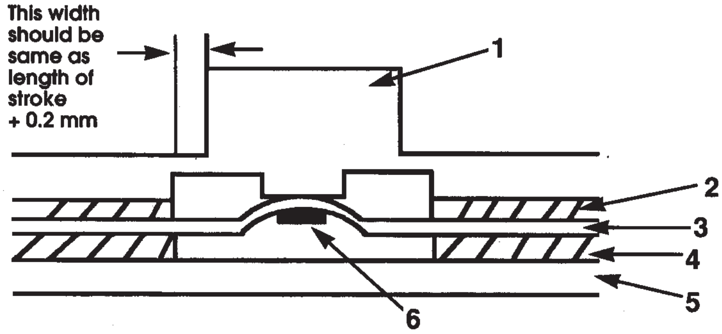
1. Minimum distance from edge of polydome: 1 mm (2.0 mm is recommended).
2. Corner radius dimension: 1 mm or more typical.
3. Pitch or polydome spacing: Minimum of 7mm.
4. Diameter of polydome: Minimum of 5mm.
5. Adhesive hole size must be larger than polydome size by 1 mm.
6. Adhesive hole must not interfere with key plunger or polydome.
7. Pitch of rubber keypad, adhesive spacer, and polydome all must be the same.
8. Layer 2 and layer 4 can be the same to keep design simple.
9. Should have air channel cuts between keys to help keep polydomes from sticking.

ADDITIONAL DESIGN REQUIREMENTS

Minimum force at 5mm diameter 200g +- 50g.
Maximum force at 5mm diameter 280g +- 50g.
Thickness of spacer for above diameter/forces = 0.15mm.
Stroke at 5mm diameter and 200g = 0.5mm.
Stroke at 5mm diameter and 280g == 0.6mm.

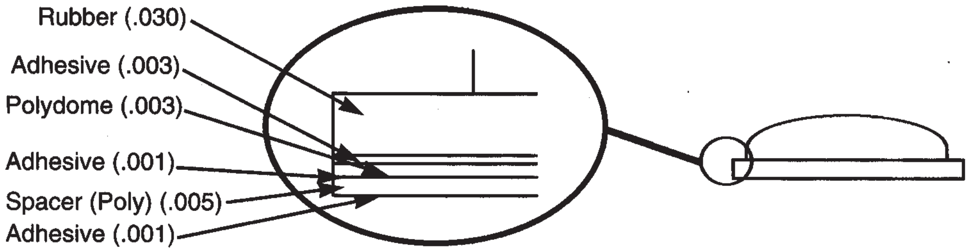
TYPE OF POLYDOME CONSTRUCTION



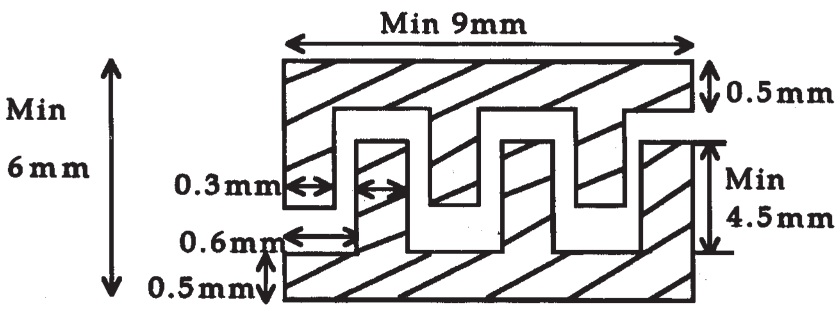


NOTES:

1. Rubber Keypad (non-conductive)
2. Spacer/adhesive
3. Polydome layer with conductive ink
4. Spacer/adhesive
5. PCB
6. Conductive ink

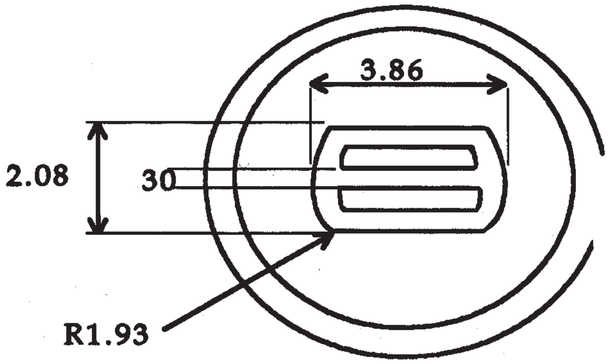


PRINTED CIRCUIT BOARD DESIGN FOR USE WITH POLYDOMES



Width of conductive area = 0.3mm
Pitch of conductive area = 0.6mm

Electrical traces on printed circuit boards recommended for polydomes.



Sample measurements

Detailed drawing of polydome shorting pad.

POLYDOME OPERATING PROPERTIES

- **Temperature Range:**

Operating Temperature	-35°C to 75°C (-31 T to 167°F)
Storage Temperature	-40°C to 90°C (-40°F to 194'F)

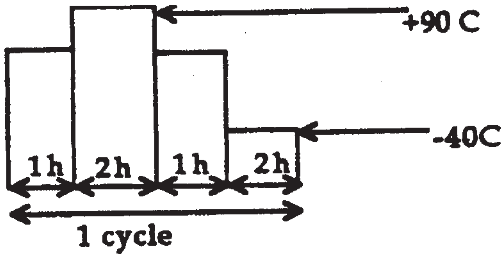
- **High Humidity Range:**

Storage	65°C (149°F) and 95% humidity

- **Thermal Shock Test:**

Storage	-40°C to 90°C (-4u'F to 194°F) (alternately for 20 cycles)

Thermal Shock Test



- **Operational Life:**

Specification of Force	200 +/- 60g
Results	Exceeded 200,000 times by 300g load Compared the actuation forces before & after

- **Polydome Ink:**

Ink Type	Silver
Life	> 1 Million Cycles
Thickness	.005mm to .01mm

- **Mylar Material:**

Force Provided	100-200g (@ 0.1mm thickness)
General Thickness	0.1mm
Other Thickness Available	.075mm and .125mm

- **NOTES:**

Average actuation force is 150 grams. Higher actuation force gives better tactile feel. We suggest if this area is important, protot type tooling be made to check force/feel before ordering a production tool. Minimum stroke is 0.4mm. Lower stroke will produce less tactile feel.

POLYDOME TOLERANCES

Actuation Force Tolerances	
Design Force (grams)	**General (±g)**
40 - 60	20
75 - 100	25
100 - 150	30
150 - 200	35
200 - 300	40

Dimensional Tolerances	
Dimensions (mm)	**Tolerance (±mm)**
0 - 25.37	0.2
25.4 - 50.77	0.25
50.8 - 101.57	0.3

TERMINOLOGY

Actuation Force

The force required to collapse the membrane of the dome (identified as F' on force/stroke curve).

Conductive Rubber Switch

Mechanical switch made of silicone rubber, either direct or indirect contact (rubber domes covered with plastic caps).

Contact

The current-carrying area/surface under each dome (silver-inked surface) that completes electrical connections with the electrode on a printed circuit board when the keytop (switch) is actuated.

Contact Force

The force required to maintain switch-contact closure (F2 on a force/stroke curve) with a printed circuit board.

Polydome

Polyester material that has been embossed to provide the tactile feel/snap -for some other form of overlay.

Printed Circuit Board

An electrical circuit formed by applying conductive material (gold, nickel, tin, ead or carbon) to fine lines, or other shapes, to an insulating sheet.

Snap Ratio (F1-F2)
F1

The difference between the actuation force (F') and the contact force (F2) of a switch divided by the actuation force.

Stroke/Travel

The distance from the contact surface on a rubber switch to an electrode pattern on a printed circuit board.

Tactile Feel

Term often used to describe the response of rubber and dome switch after actuation. Tactile feel is created by shape and thickness of a switch's membrane, and is the most critical process in manufacturing rubber keypads.

ELASTOMERIC CONNECTORS

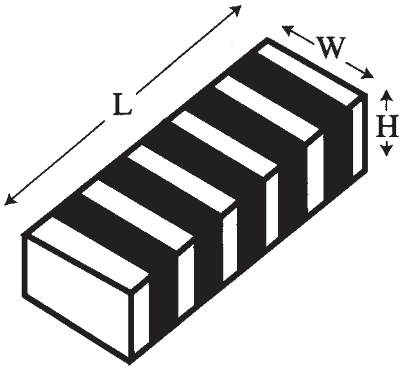
ELASTOMERIC CONNECTORS TYPES

CONNECTOR TYPE - (G)

FEATURES / APPLICATION

- These connectors are used in designs where side insulation is not required or w here a wider conductive path is needed than the 0.4mm (0.016") common with the (GL) styles.

Connector Type (G)



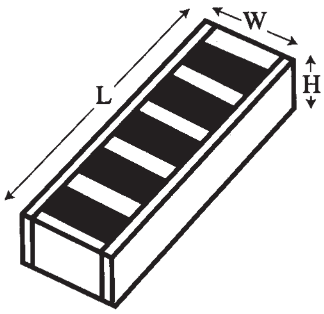
- These connectors range in width from a minimum of 0.4mm (0.016") to a maximum of 1,4mm (0.055"). If the desired width exceeds 1.4mm (0.055"), (GL) style connectors should always be recommended.

CONNECTOR TYPE - (G2)

FEATURES / APPLICATION

- The (G2) is a thin version of the (G) connector and is used when the space available to work with is extremely narrow, but side insulation is required.

Connector Type (G2)



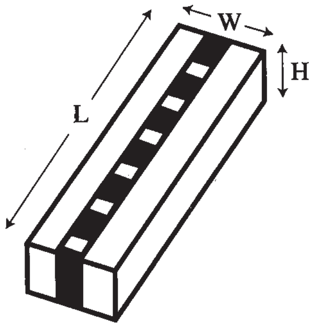
- This connector has a special, thin side insulation applied that shields it from metallic casing if this casing is used in customer's application.
- The thickness of the side insulation is limited to < 0.05mm, and cannot be applied more thinly or thickly, so great care must be taken when recommending this connector to avoid alignment problems.
- These connectors range in width from 0.45mm (0.016") to 1.4mm (0.055").

CONNECTOR TYPE - (GL)

FEATURES / APPLICATION

- This connector consists of alternating layers of conductive and non-conductive material sandwiched between outside layers of soft, non-conductive insulating material.

Connector Type (GL)



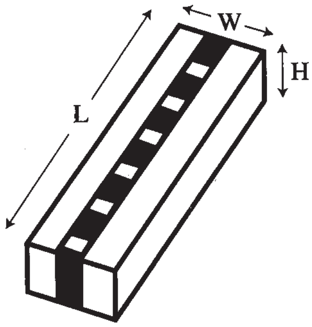
- The minimum width of (GL) connectors is 1.4mm (0.055"). If a narrower connector is required the customer must select from the (G) and (G2) types.
- (GL) connectors can be "color coded" (insulative material on one side colored red, green, etc.) if the insulating layers are not the same width. This color coding is done so that the customer can use the connector in his product without worrying whether or not it has been assembled (inserted) properly. Color coding is also often used to solve alignment problems.

CONNECTOR TYPE - (GL)

FEATURES / APPLICATION

- This connector consists of alternating layers of conductive and non-conductive material sandwiched between outside layers of soft, non-conductive insulating material.

Connector Type (GL)



- The minimum width of (GL) connectors is 1.4mm (0.055"). If a narrower connector is required the customer must select from the (G) and (G2) types.
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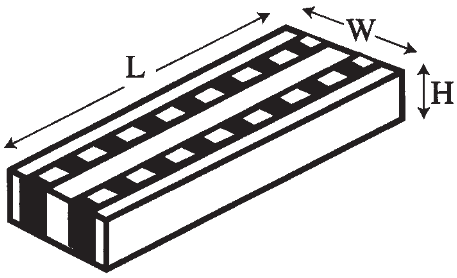
CONNECTOR TYPE - (GL-A)

FEATURES / APPLICATION

- This connector is simply a double-row (GL) connector with insulating material between the two (2) rows of conductive material and on the outside walls of the connector.

Connector Type (GL-A)



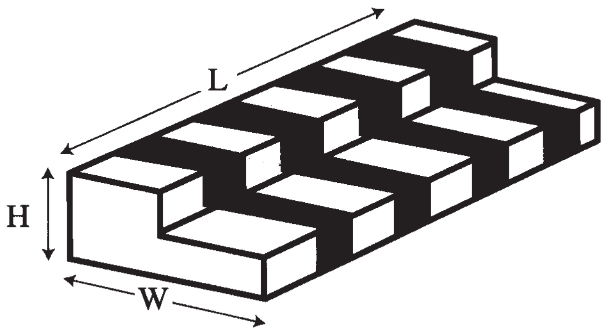
- (GL-A) connectors provide two (2) rows of contacts for applications when electrodes on the surfaces to be joined are not in a single straight line.

CONNECTOR TYPE - (FCL)

FEATURES / APPLICATION

- This connector is used for right-angle connections between LCD's and printed circuit boards.
- A// FCL connectors require tooling charges as there are no standard sizes available.
  Since samples of FCL connectors are "hand made" and very costly, lot charges are usually required.
  Contact us for tooling and other charges, and lead times.

Connector Type (FCL)

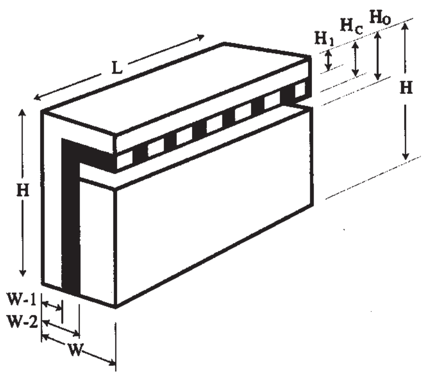


CONNECTOR TYPE - (FK)

FEATURES / APPLICATION

- This connector is used to make connections on the common side of LCD's — connecting electrodes on the top surface of the LCD to the printed circuit board.
- This connector fully insulates the LCD from mounting grounds because it is completely covered with insulating material and can only make contact with the PCB through its narrow (channel) conductive area.

Connector Type (FK)

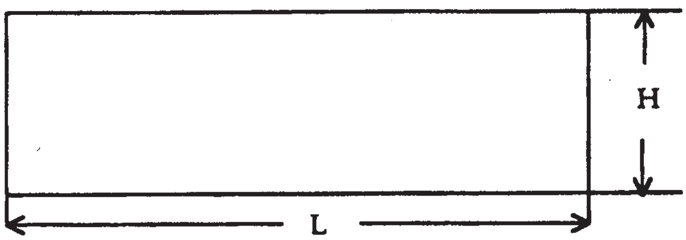


- Almost all FK connectors require tooling charges. There are a few standard sizes available, but the selection is very, very small. Connect us for tooling charges for FK connectors.

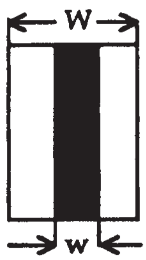
ELASTOMERIC CONNECTOR DESIGN REQUIREMENTS

- All elastomeric connectors are "custom made," and we require the following information in order to successfully quote and supply against all inquiries received:

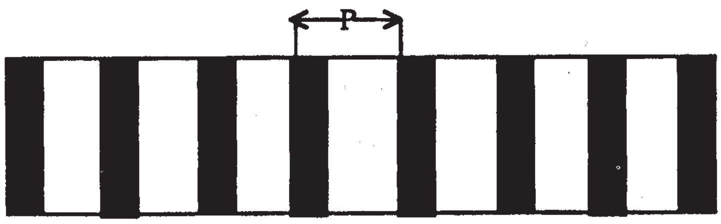
LENGTH (L):	End-to-end dimension of each connector.
HEIGHT (H):	Vertical size of connector (dimension from top to bottom).
WIDTH (W):	Thickness of the connector (dimension from side to side).
Width (w):	Thickness of conductive material (strip) in each connector.
PITCH (P):	Distance from center-to-center of each conductor in a connector.



(Side View)



(End View)



(Top View--Magnified)

■ Shaded Protion is Conductive Material

□ Unshaded Portion is Nonconductive Material

HEIGHT (H)

A connector's Height (H) is important because it is used to calculate the correct compression (deflection rate) to be applied to the connector for reliable connections.

- The typical compression (deflection rate) to be applied to connectors varies with the type (G.Ga.GL). The rates below are recommended by us for most applications:

Connectors G, G2, GL types

1. If H is less than 6mm: 15% of connector's height.
2. If H is more than 6mm but less than 10mm: 13% of connector's height.
3. If H is more than 10mm: 10% of connector's height.

WIDTH (W)

Width (W) is important because its design is critical in eliminating buckling when clamping force is applied to the connector. If a connector buckles, its resistance rises. If the buckling is too severe, contact can be lost completely.

- We strongly recommend that the ratio between the H and W of a connector be as close to one-to-one as possible. In other words, the connector should be as close to "square" as possible. Although the H of the connector can be as small as 1/4W, it is recommended that the H not be less than 3/4W.

- Most our connectors (particularly G and G-2 types which are very thin and have a thin insulating coating or lack a side insulating coating) require plastic holders ("pockets") of some type to facilitate assembly, prevent accidental side contact and eliminate alignment problems.

width (W)

Conductive width (w) is important because it is instrumental in determining the cost, resistance and rigidity of the connector.

- The more conductive material a connector contains, the more expensive it is.
  Therefore, it is very important to keep the conductive layer as narrow (small) as possible when cost is the overriding concern in a product's design. In addition to keeping the conductive layer as narrow as possible, it should also be kept within standard sizes whenever possible. Our standard dimension for the conductive layer width is 0.4mm.

- The conductive layer (w) should not only be as narrow as possible, but the Pitch (P) should be as wide (far apart) as possible to keep cost to a minimum.

- We also offer many non-conductive materials for insulating its connectors. These non-conductive materials are rated according to hardness so the correct load compression (deflection rate) is calculated for reliable interconnections.

LENGTH (L)

Length (L) is important only in that it must fit the customer's particular application. This is very important when the connector is being fitted into some type of plastic holder.

- Tolerances for elastomeric connectors can be found in connector/keypad catalog with the maximum length being 300mm +/- 0.8mm (11.82-+/-.03").

PITCH (P)

Pitch (P) is important because it guarantees a reliable connection is made between the two (2) surfaces being joined.

- We recommend three (3) conductors per electrode, although two (2) are often adequate to ensure all connections are reliable and to eliminate "intermittent contact."
- In order to minimize cost, it is strongly recommended that customers utilize our standard pitches in their connector designs whenever possible. The following tables illustrate the number of conductors per inch in each of our standard connectors. The second table lists pitch recommendations.

Table 1

Pitch (P) (mm)	Conductors per Inch	Pitch (P) (in)
0.40	63	.016
0.25	100	.010
0.18	143	.007
0.15	170	.006
0.10	254	.004

Table 2

Electrode/Pad Spacing/3 = (inches/mm)	Recommended Connector Pitch (mm)
.040 / 1.0	0.25
.030 / 0.76	0.25
.020 / 0.508	0.18
.015 / 0.380	0.15
.010 / 0.254	0.10

CUSTOMER CONNECTOR CHECKLIST

The following provides the customer with a checklist that should be reviewed when connectors are going to be used.

- The cost of a connector is directly linked to the amount of conductive material it contains.
- Elastomeric connectors usually require bezels of some type to promote easy assembly and eliminate alignment problems.
- Bezels, or holders, are also used with elastomeric connectors to prevent over compression of the connector and buckling problems.
- The more "square" (H X W : 1 to 1) a connector is, the more likely it wilt not require a bezel, or holder, when assembled.
- Connectors can be color-coded for easy identification when side insulation is not identical on both sides of the connector.
- Elastomeric connectors utilizing carbon conductors are much cheaper than those using silver. In addition, carbon connectors remain oxidation-free over the life of the connector.
- The conductive areas of elastomeric connectors should never be handled by human hands because the oils and contaminants inherent in the human body can cause contact problems after the product is assembled.
- High-quality connectors can only be supplied if the manufacturing process is completely sanitary and the raw materials utilized are of exceptional quality.
- Connectors go through two (2) curings — the second being six (6) hours at 200°C. The second curing is critical because it eliminates siloxanes which cause contact problems as connectors are left out in the field.
- The most popular connector currently being used in the United States is the (GL) style.
- (GL) style connectors, with a pitch of 0.25, are suitable for most LCD applications.
- FK and FCL-type elastomeric connectors require tooling charges.
  Although samples can be made by hand, production orders cannot.
- It s possible to manufacture almost any type of connector if complete design information is supplied.
- If the dimensions of a connector are not known, the pitch for the same can be determined by obtaining the dimensions for the pads on the printed circuit board. The height of the connector can be determined by finding the distance between the LCD and the printed circuit board, then adjusting for connector deflection (approximately 15%).

PHYSICAL & ELECTRICAL PROPERTIES OF ELASTOMERIC CONNECTORS

Volume Resistivity:	
Standard	5.0 ohms/cm^2
Temperature Range:	
Operating Temperature	-20˚C to +180˚C
Storage temperature	-20˚C to +180˚C
Dielectric Strength:	25 kv/mm
Insulative Resistance @ 500 VDC:	10^{14} ohms
Current Carrying Capacity:	
Standard	1 mA/mm^2
Conductive Layers Per Inch:	
Standard (0.25mm to 0.10mm)	More than 100, but less than 500
Deflection:	
All connectors using carbon conductors	10% to 15%
Skew:	0° ~ 0.3°

COMPRESSION HEIGHT

- The following formula can be used to determine the uncompressed height of the connector to be ordered. When the compres sed height (space between LCD and PCB in assembly) and the percentage of compression are known but the height prior to assembly is not certain.

$$X = \frac{n}{1 - \%}$$

Where:
x = uncompressed height
n = compressed height
% = percent of desired compression

Notes:

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