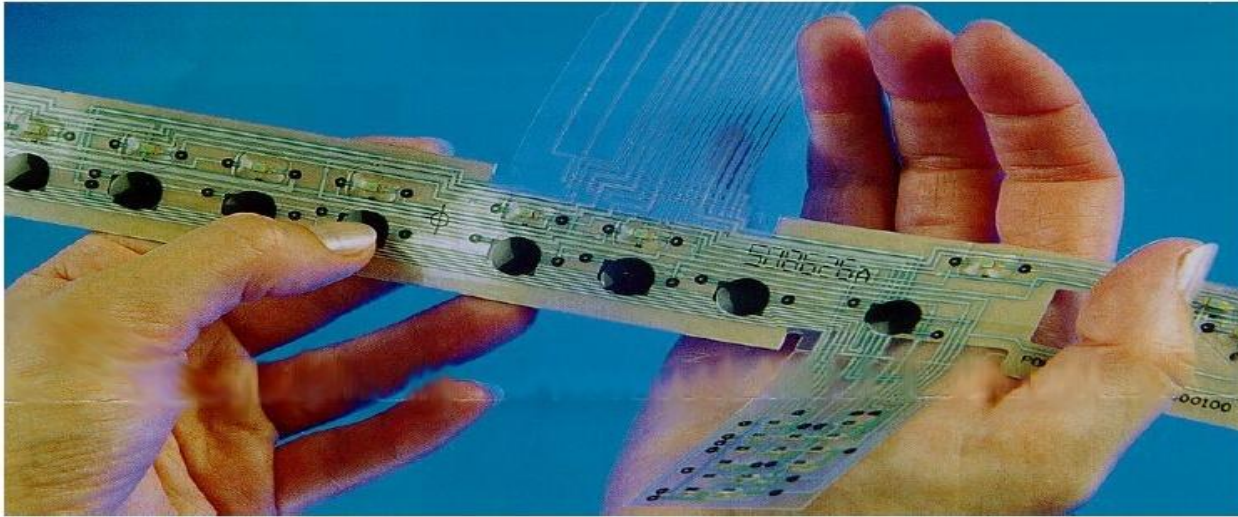


Polymer Thick Film Flex Circuits for Membrane Switch Panels



For more information, contact your local Parlex representative at flexcircuits@parlex.com



A Johnson Electric Company

www.parlex.com



Scope of the presentation

- General introduction
- PTF Fabrication Technology
 - Substrate material
 - Fabrication process & construction
 - Specifications
 - Manufacturing capabilities
- Advantages
- Samples switch types/connectors
- Overview of Parlex manufacturing capability



A Johnson Electric Company



General Introduction Parlex

- Design centres in UK and USA
- Global manufacturing.
- New material research and development centre
- Leading edge product designs.
- Vertical integration/value add assemblies
- > 50 million components annually



A Johnson Electric Company



Parlex Overview

➤ Global Production Capabilities:

- Circuit Design (PTF /FPC / FFC)
- High Volume Printing
- Die-cut
- SMT
- Value Added Operations
- Turnkey solutions

➤ Commercial & Proprietary Materials:

- Ag and Ag/AgCl inks
- Carbon ink
- Dielectric inks
- Hydrogels
- Polysolder[®] Conductive Epoxy
- Z-Axis Conductive Adhesives
- Encapsulants



A Johnson Electric Company

www.parlex.com



General Introduction Polymer Thick Film (PTF)

- Generally polyester substrate
- Additive process
- High speed screen printing process
- Multi-layer circuits
- Dielectric materials as an insulating layer
- Double sided circuits
- Proprietary printed through hole technologies



A Johnson Electric Company



Polymer Thick Film: Overview

➤ What is PTF Circuitry ?

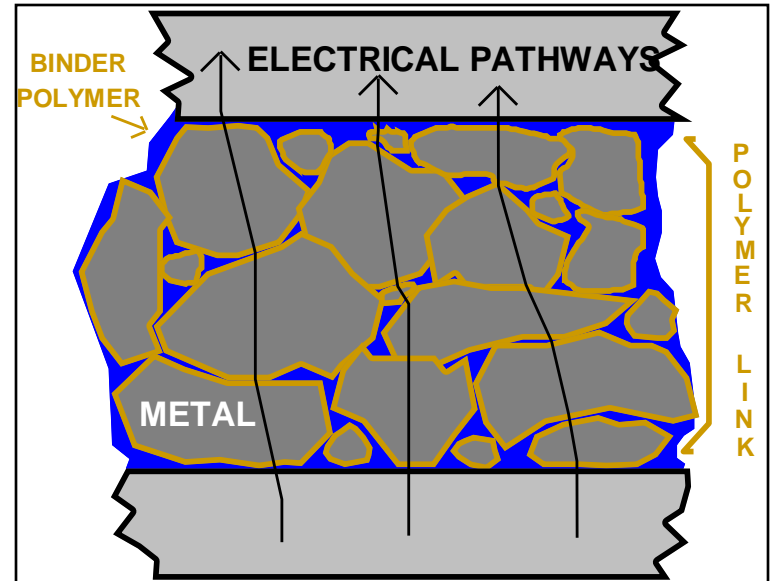
- A circuit made from printed or deposited conductive epoxy inks and adhesives

➤ Why use PTF circuitry ?

- Low cost substrate and materials
- Fewer components in assembly
- Integrate circuit and interconnect
- Easy integration into sub-assemblies
- Able to provide curved assembly
- Reliable for long life applications

➤ Polymer Inks

- Silver and carbon Inks
- Dielectrics
- Conductive adhesives



Fabrication Technology - Substrate

➤ Substrates material and comparison

- Standard PET for circuits, Translucent, clear and white: 0.003” (0.075mm) 0.004” (0.100mm) 0.005” (0.125mm)
- Available PET: 0.002” (0.050mm) through > 0.010”, other substrates include Polycarbonate (for graphics). PEN. Polyimide.

Substrate	Common Names	Advantages	Disadvantages
PET	Polyester	Low cost Availability	Low temp processing
PEN		Cost in between PET & PI Higher temp than PET	Higher cost PET Not widely used
PI	Polyimide Kapton (DuPont TM)	High temp processing Standard Cu/Flex substrate	High cost
Rigid PCB	FR4, G10	Lower cost than PI Industry standard Versatility	Higher cost than PET Not flexible

Fabrication Technology : Conductive Inks

- Silver inks (either commercially available or formulated in-house)
- Carbon inks (commercially available)
- Screen printed, thermally cured
- Optimized for a variety of applications
 - High hardness: (approx 2H Typical for standard Ag ink)
 - High conductivity:
 - Standard Ag ink: 10-15mOhms/sq
 - High conductivity antenna Ag ink: 5-10mOhms/sq
 - Ag/AgCl medical electrode ink: 15-30mOhms/sq
 - Carbon ink: High resistance: <150
 - High speed printing and curing



A Johnson Electric Company

www.parlex.com



Fabrication Technology : Dielectric Inks

- Dielectric inks (either commercially available or formulated in-house)
- Screen printed, UV & thermally cured
- Optimized for a variety of applications
 - Hydrophobic: moisture barrier
 - Mechanical protection
 - Dielectric strength: 1000VDC/0.0254 millimetres



A Johnson Electric Company

www.parlex.com



Fabrication Technology: Printing/Component Attach Media

Conductors comparison

Ink Type		Description/Applications
Conductive Ink	Standard silver ink	Hard ink for standard apps
	High conductivity silver ink	High conductivity ink for antenna
	Silver/silver Chloride ink	Medical Electrode ink
	Carbon ink	High resistance, no migration, cover
Dielectric Ink	Standard dielectric	Flexible, moisture resistant, UV cure dielectric suitable for use as a printed spacer, cover-coat, and as insulation between conductive layers
	Flame retardant dielectric	White dielectric for reflectivity and flame retardancy, used for automotive
Component and circuit attach inks	Poly-solder [®]	Isotropic adhesive, attaching leaded components, junction encapsulated. Junction resistance < 30mohm, typical shear strength on chip components > 5 lbs
	Z-axis attach	Anisotropic adhesive, attaching Flip Chip and bonding circuit to circuit. Ability to bond tails after circuit processing to save costs.



A Johnson Electric Company

www.parlex.com



Fabrication Technology: Trace Materials

Ink materials comparison

Conductor	Process	Advantages	Disadvantages
Copper	Etched (subtractive)	Conductivity Trace routing density Accepted technology	Expensive processing Oxidation
PTF-Silver	Additive	Low cost / green process Oxides are conductive Most conductive PTF	Trace resistance vs. Cu Silver migration Higher cost than C inks
PTF-Carbon	Additive	Low cost / green process Good for interconnect points (lubricity, Ag migration protection) Lower cost than Ag inks	Very high trace resistance
Copper	Laminated	Conductivity Lower cost than etching	Limited routing flexibility PET tem limitations
Copper	Additive	Conductivity Lower cost than etching	Higher cost than PTF Developmental



A Johnson Electric Company

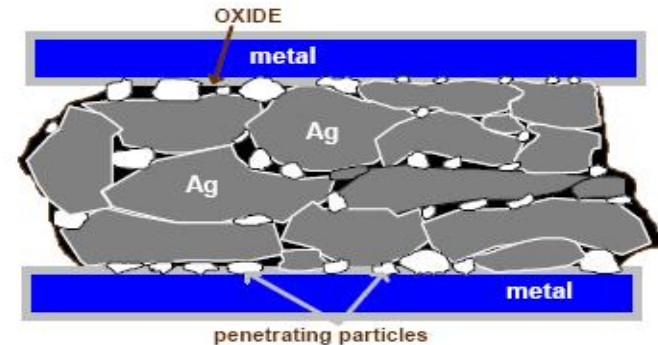
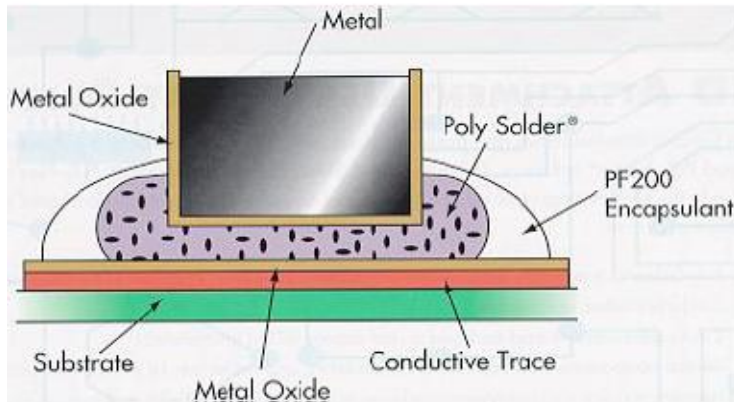
www.parlex.com



Fabrication Technology : Component Attach

➤ Isotropic Conductive Adhesive - Polysolder®

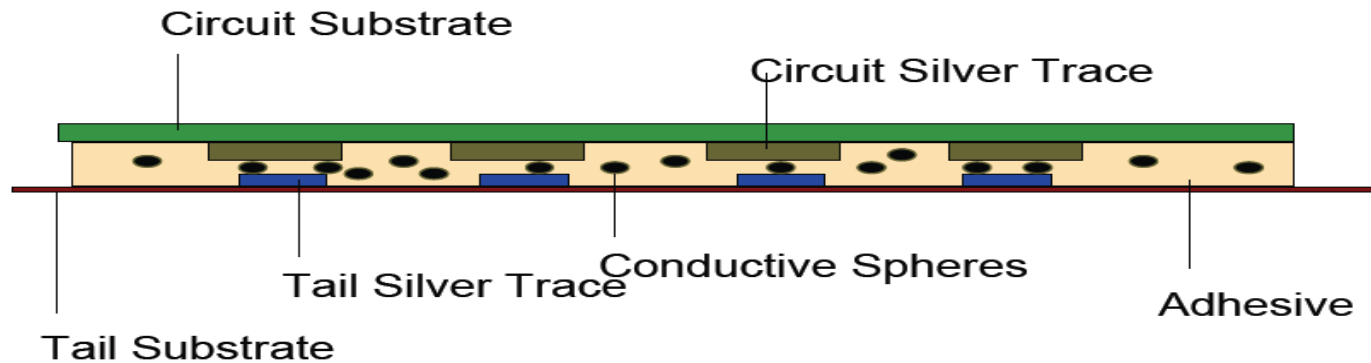
- Conducts in all axes
- Silver filled epoxy, Lead-free
- Thermally Cured
- Non-Reworkable
- Components to 0603 size or 0.25" (6.35mm) pitch



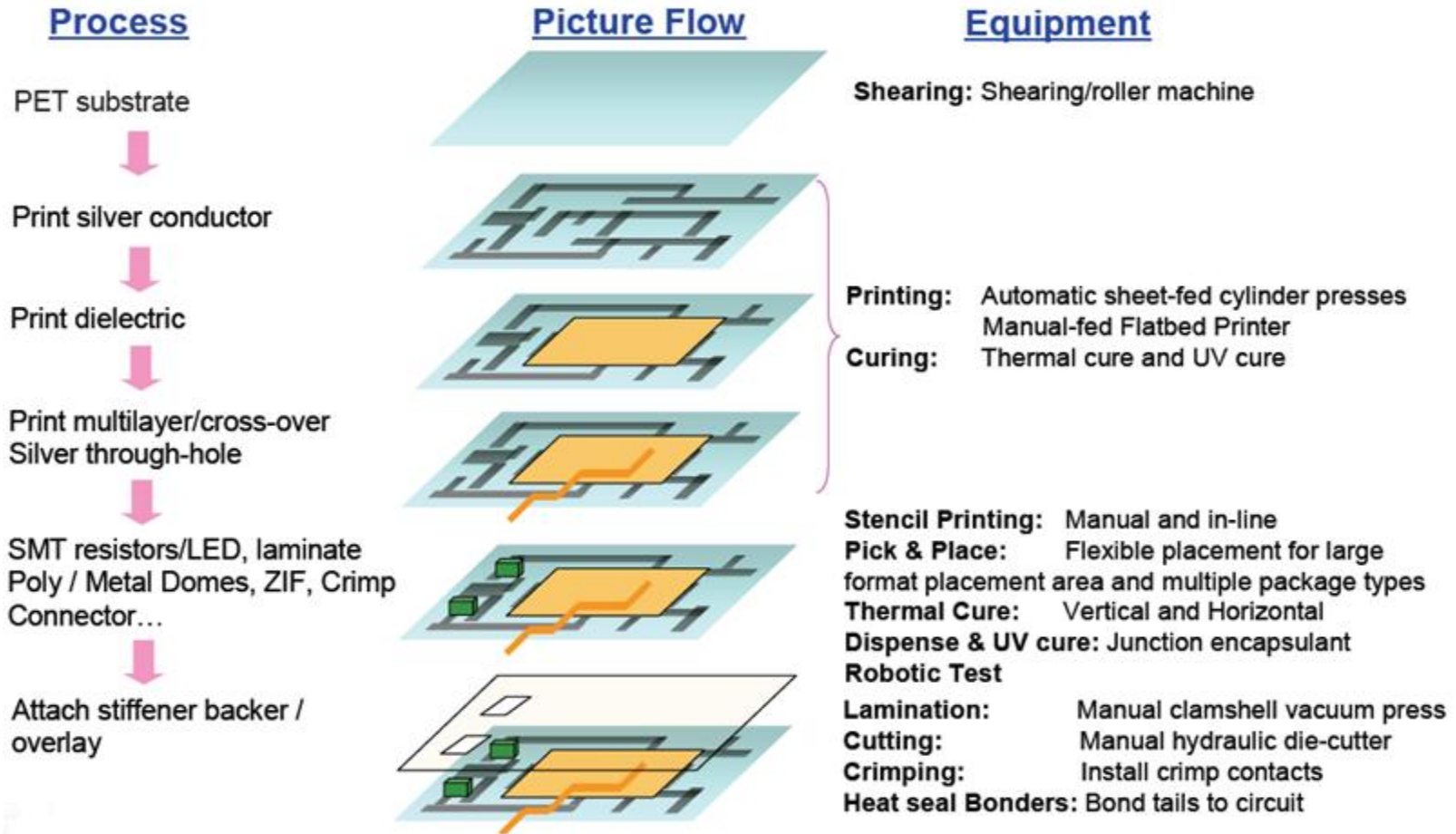
Fabrication technology : Circuit Attach

➤ Z-axis adhesive: anisotropic Conductive Adhesive (ACA)

- a.k.a. ACA, ACP, Z-Axis: conducts in one axis only
- Filler loaded into adhesive matrix
- Stencil printed or dispensed
- Cured with Thermal compression
- Thermoplastic and thermosetting options
- Used for attaching circuit tails

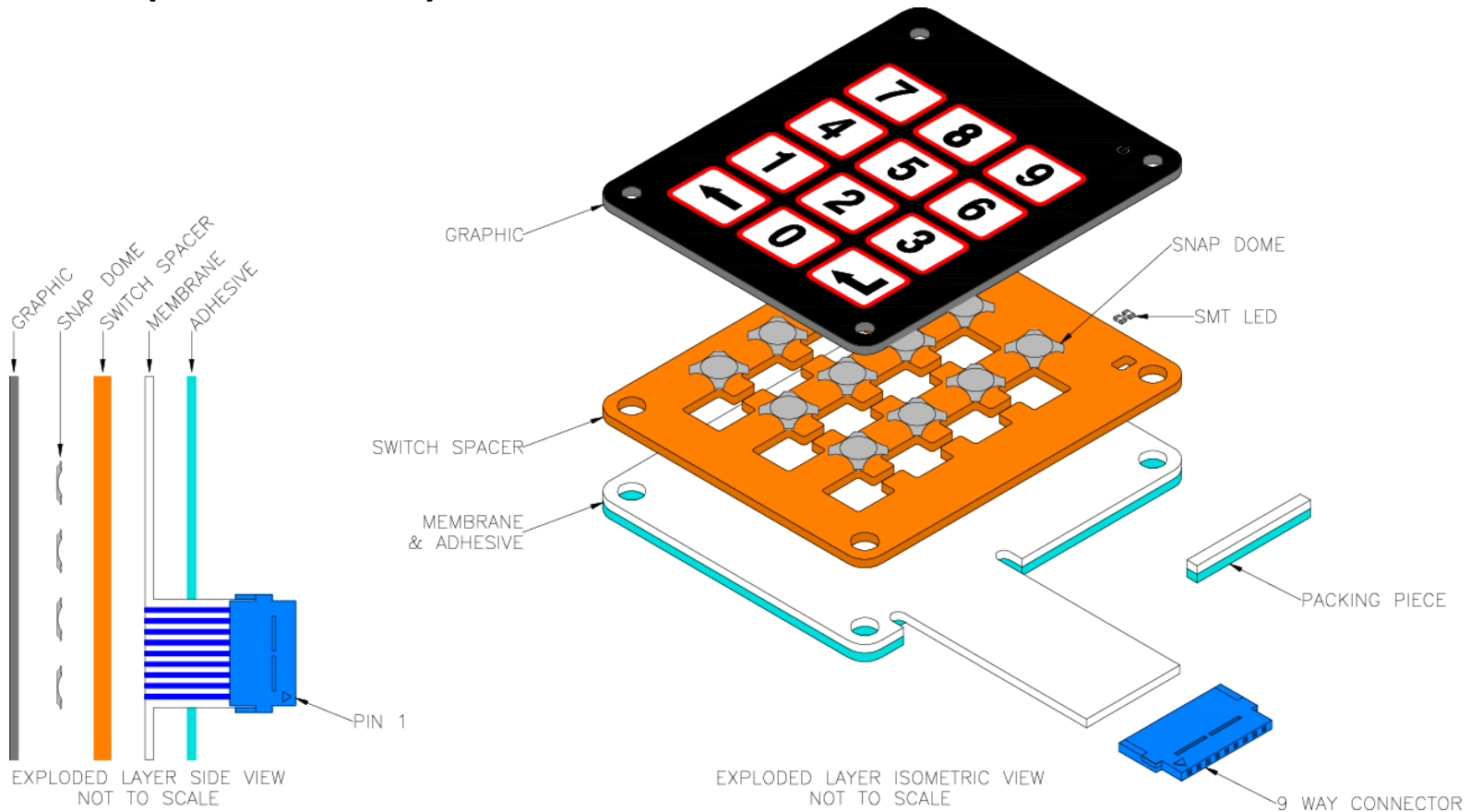


Fabrication Technology : Manufacturing Process



Fabrication Technology - Membrane Switch Construction

➤ Tactile (metal domes)



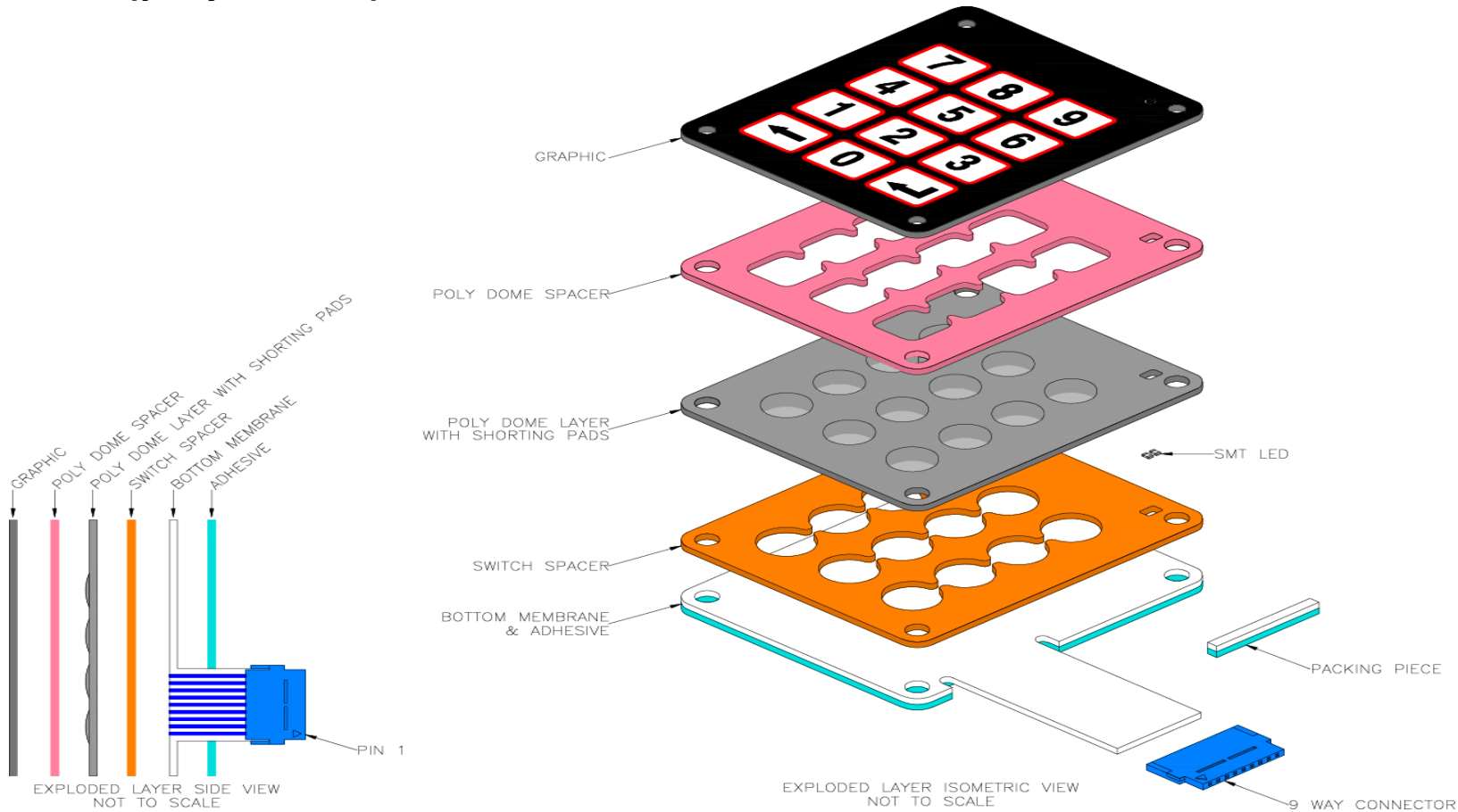
A Johnson Electric Company

www.parlex.com



Fabrication Technology - Membrane Switch Construction

➤ Tactile (poly domes)



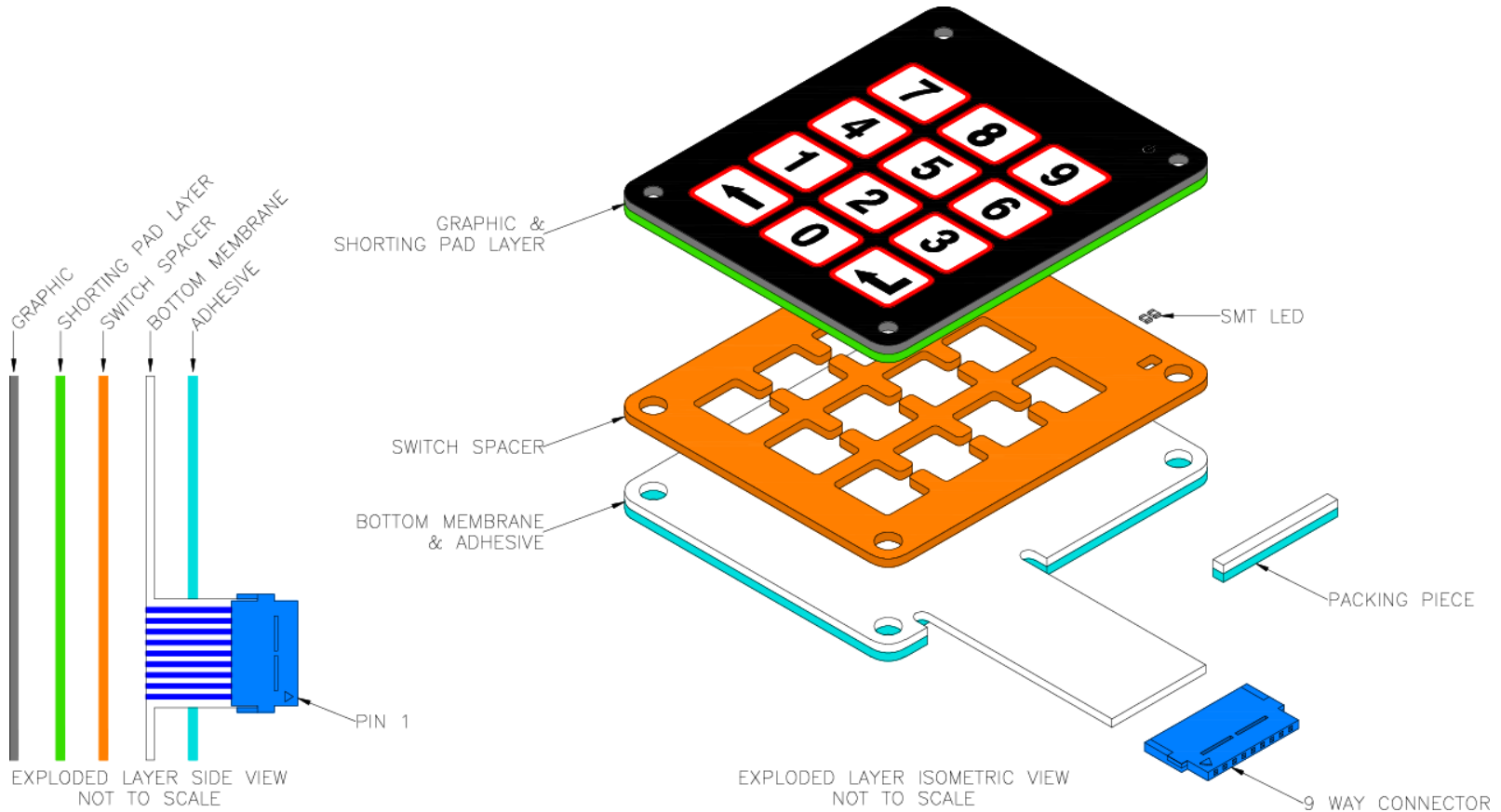
A Johnson Electric Company

www.parlex.com



Fabrication Technology - Membrane Switch Construction

➤ Non Tactile

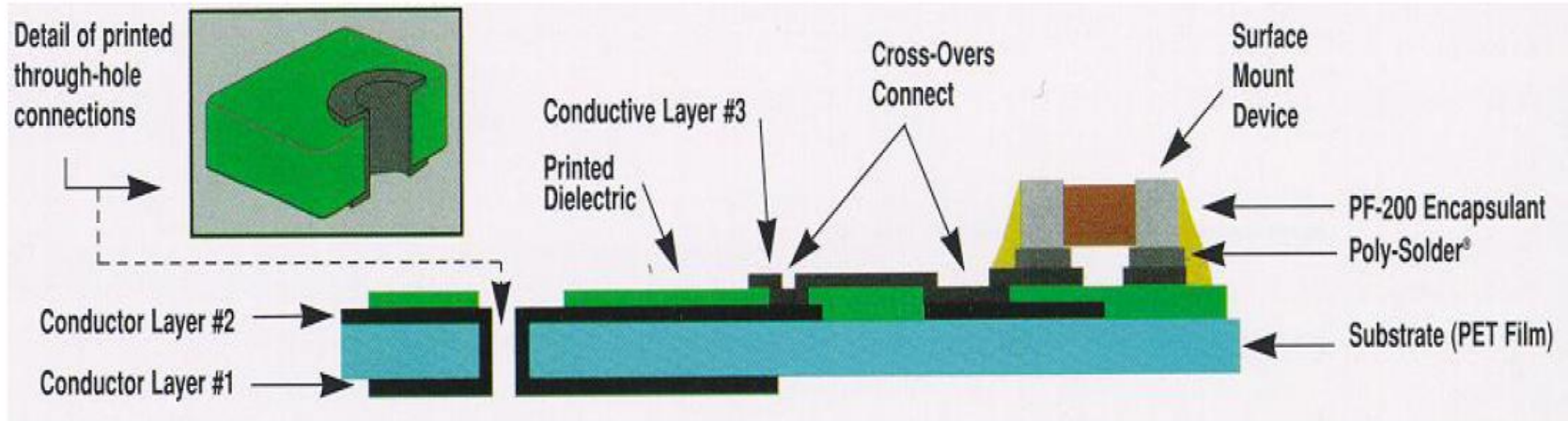


A Johnson Electric Company

www.parlex.com



Fabrication Technology : Membrane Switch Construction (Component attach)



- Line pitch and density down to 10/10 (0.25mm x 0.25mm)
- Double sided circuits require printed vias
- Crossovers up to 3 or more conductive layers
- Capable of printed shielding layers for ESD

Fabrication technology: Design Specifications

➤ Flexibility

- Trace/conductor maybe flexed around a 0.125" (3.125mm) minimum radii under both compression & tension.
- Circuits maybe flexed in the component area around a 4" (100mm) radii under both compression & tension

➤ Trace resistance of silver ink at 10mOhm/sq

- A 1.7ohm/inch resistance is typical for a 0.020" (0.5mm) wide trace at nominal thickness of 0.0003" (7 microns).
- Resistance change as a function of line width is inversely proportional when ink thickness is constant (i.e. resistance of a 0.040" (1mm) width trace at 0.0003" (7 microns) thickness=0.83 Ohms/inch)
- The formula to calculate resistance is $\text{Ohms} = \text{ink resistivity} \times (\text{length}/\text{width}) \times (1/\text{thickness})$



Fabrication technology: Design Specifications

➤ Venting Switches

- In order to reduce the effects of altitude, and temperature variation upon the switching pressure due to the expansion and contraction of gases trapped within the construction a system of venting should be used. Preferably the venting is entirely internal (switch to switch) resulting in fully sealed switches however switches may be vented internally to the enclosure if the enclosure is sealed. They may be vented to atmosphere providing an IP rating is not required. If the group is vented to atmosphere or internally then there are no minimum number of switches/area to vent into.



A Johnson Electric Company

www.parlex.com



Fabrication technology: Design Specifications

➤ Environmental Specification

- Operating temperature: -40°C to +85°C
- Humidity: 5% to 95% RH non condensing
- Storage and Shipping: -40°C to +85°C. 5% to 90% RH non condensing
- Accelerated ageing 1000 hours 85/85%RH
- Thermal Shock:-40°C to +85°C 25 cycles
- Mechanical shock : 30G,11msec, half sine wave
- Vibration: 5.35 grms,50-2000Hz

➤ Mechanical Specification

- Switch life > 1 million cycles
- Dynamic Flex life > 600K flexes

Fabrication technology: Design Specifications

➤ Interfaces

• Connectors

FFC Connector, ZIF or other type	0.039" to 0.100" pitch typical (0.1 to 2,54mm)
Crimp connectors	>/= 0.100 pitch typical (2.54mm)
Z-axis or pressure fit	>/= 0.02 pitch (0.50mm)

• Operator interfaces

Interface	Force (typical)	Tactile ratio (typical)
Tactile Poly-Dome	200-300g	30-60
Tactile Metal Dome	200-400g	30-60
Non tactile membrane	100-300g	



Fabrication technology: Manufacturing Capabilities

➤ Print

- **Trace pitch capabilities**

Standard	0.10" (0.25mm) track & gap
Available	0.008" (0.2mm) within limited areas

- **Circuit construction**

Double sided	Double sided circuits using printed via. Vias maybe punched or drilled up to 0.030" (0.76mm) or laser cut to 0.005" (0.127mm)
Multi layer	Up to 4 conductive layers including shield can be printed on one side using cross over technology

Fabrication technology: Manufacturing Capabilities

➤ Print

- Registration

Standard	+/-0.10" (0.25mm) print to print on same side and front to back
Available	+/- 0.006" (0.152mm) same side print to print in limited areas of the sheet



A Johnson Electric Company



Fabrication technology: Manufacturing Capabilities

➤ Die cut

Type	Cut to Print Tolerance	Max cut size	Description
Hard Tool	+/-0.008" (0.20mm)	18"x24" (610x457mm)	High volume , long life high accuracy , highest cost
Laser Cut	+/-0.008" (0.20mm)	18"x24" (610x457mm)	High accuracy, complex cuts, micro via, lowest tooling cost
Steel Rule Die	+/-0.10" (0.25mm)	18"x24" (610x457mm)	Low accuracy, lower cost , lower volume
Optical Punch	+/-0.002 (0.05mm)	One feature	High tolerance, typically used for punching registration holes

Fabrication technology: Manufacturing Capabilities

➤ SMT Assembly Capability

Component Type	Examples	Package size/pitch
Chip components	Resistors, capacitors, LEDs	0603 minimum package size
Lead components	SOIC & PLCC packages	≥ 0.020 " (0.5mm) pitch
Bare die	Low IC count	≥ 0.016 " (0.4mm) pitch
Odd form components	Buzzers, 7 segment displays, connectors, switches	

PTF Advantages

➤ Less Cost

- Additive process.
- Like for like are less costly than copper circuits
- Less waste than Copper process of subtracting materials.
- Polyester substrate is less expensive than Polyimide.

➤ Environmentally friendly manufacturing

- Additive process for fabrication.
- Less waste than Copper process of subtracting materials.
- Less chemicals used.
- Less hazardous waste (significant cost).
- Smaller waste streams.



A Johnson Electric Company



PTF Advantages

➤ Lead-Free construction

- Poly-Solder[®] is a lead-free, silver loaded isotropic conductive adhesive that provides an electrical and mechanical connection of the component leads to the circuit traces.
- Offers much lower temperatures than traditional SnPb reflow to aid component reliability.
- Possibility of lighter weight and lower profile circuits.

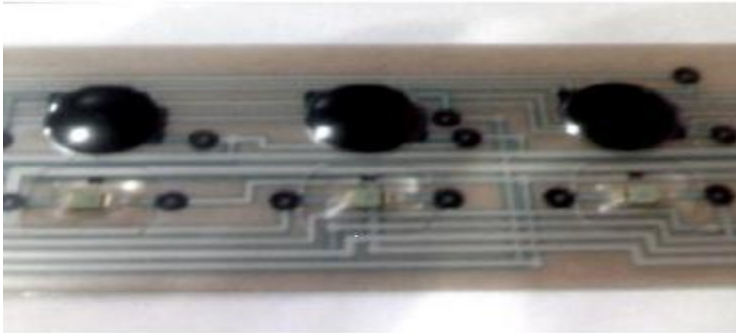


A Johnson Electric Company



Sample Switch Types

Membrane Switch Human Interface Methods



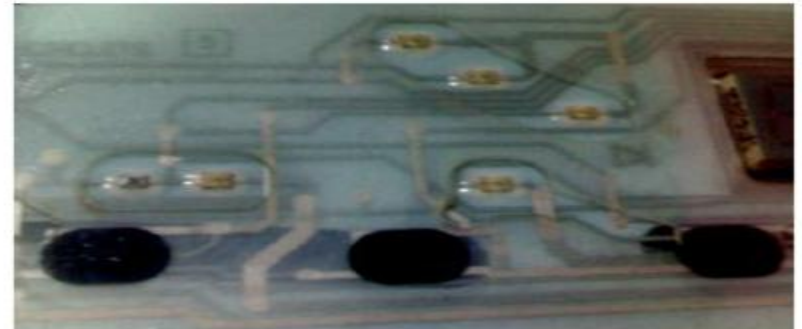
Tactile Poly-Domes



Tactile Metal Domes



SMT switches



Non Tactile Switches

Connection Methods

Multiple Interconnection Methods



Zero Insertion Force ZIF

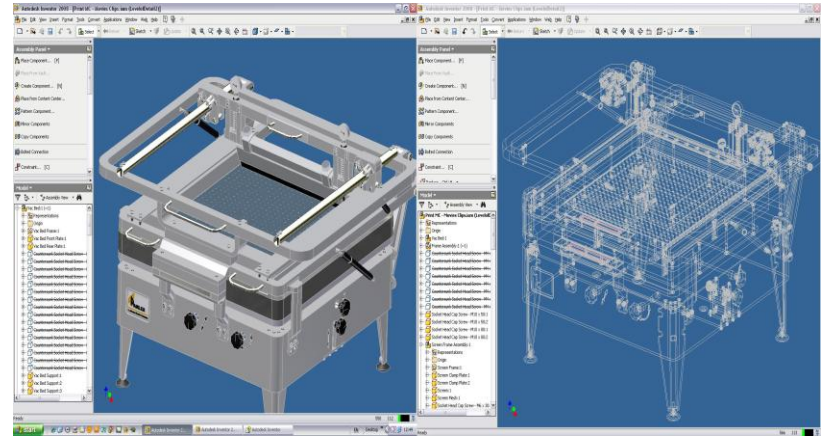


Crimp Connector

Design Overview

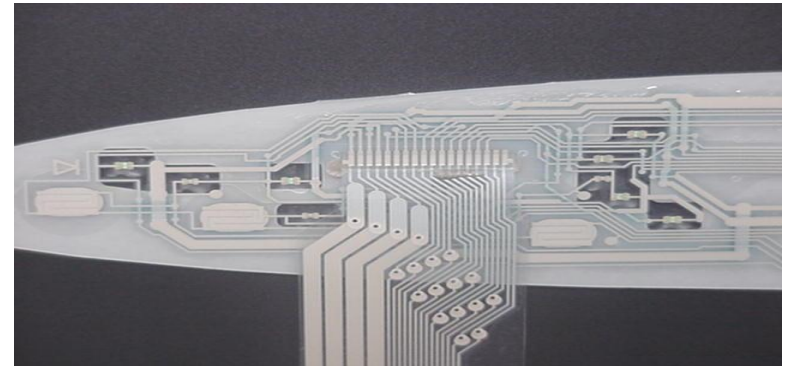
➤ 2D/3D designs

- Data and file conversion
 - AutoCad 2009
 - Inventor 2009
 - CAMmaster Pro 10.0.18
 - Illustrator CS3 13.0.2



➤ Mechanical and electrical design

- Circuit layout
- Device construction
- Custom materials
- Development and prototypes
- Testing and reliability



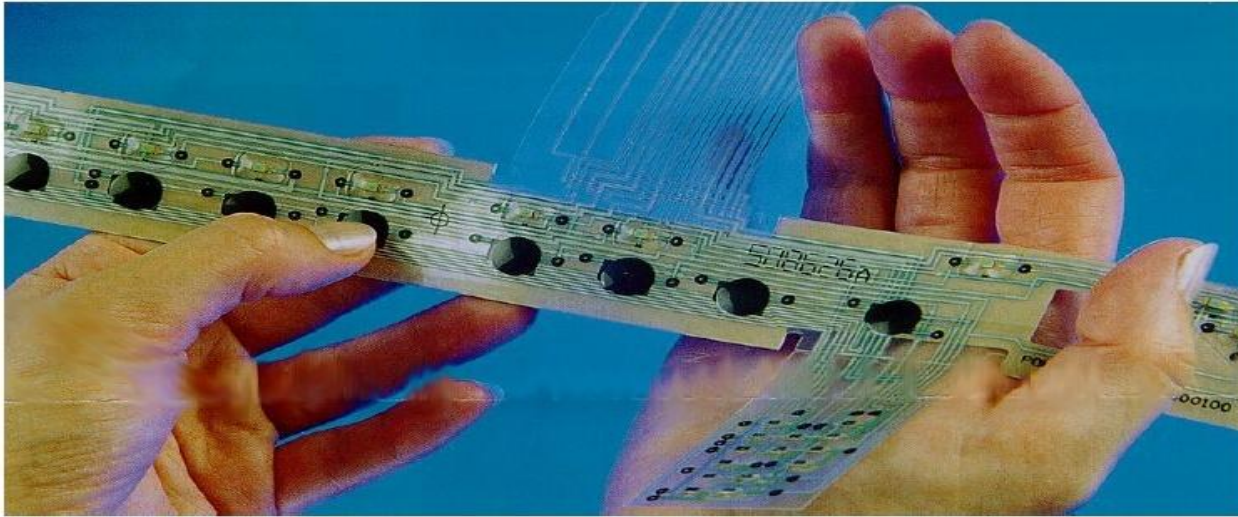
A Johnson Electric Company

www.parlex.com

**JOHNSON
ELECTRIC**
... innovating motion ...

Polymer Thick Film Flex Circuit Introduction

Membrane Switch Panels



For more information, contact your local Parlex representative at flexcircuits@parlex.com



A Johnson Electric Company

www.parlex.com

