

# Keysight Technologies

## 87606B Coaxial Matrix Switch

DC to 20 GHz

Technical Overview



## High Performance Matrix Switch for RF and Microwave Test Systems

- 3 x 3, 2 x 4, and 1 x 5 blocking matrix configurations
- Magnetic latching
- Make-before-break or break-before-make operation
- Operating life of 10 million cycles typical
- Repeatability of 0.03 dB up to 5 million cycles
- Excellent isolation, typically > 100 dB at 20 GHz
- Terminated ports
- Self-interrupting drive circuit
- Fully compatible with Keysight 87130A/70611A switch drivers

Modern automated test systems demand higher accuracy and performance than ever before. The Keysight Technologies Inc. 87606B matrix switch offers improvements in insertion loss repeatability and isolation necessary to achieve higher test system performance. Long life, excellent repeatability, and high reliability lowers the cost of ownership by reducing calibration cycles and increasing test system uptime and are vital to ATS measurement system integrity.

### Description

The 87606B matrix switch provides the life and reliability required for automated test and measurement, signal monitoring, and routing applications. Innovative design and careful process control creates a switch that meets the requirements for highly repeatable switching elements in test instruments and switching interfaces. The switch is designed to operate for more than 10 million cycles and will meet all electrical specifications for at least 5 million cycles.

The switch exhibits exceptional insertion loss repeatability. This reduces sources of random errors in the measurement path and improves measurement uncertainty. Switch life is a critical consideration in production test systems, satellite and antenna monitoring systems, and test instrumentation. The longevity of the switch increases system uptime, and lowers the cost of ownership by reducing calibration cycles and switch maintenance.

Operating to 20 GHz, this switch exhibits the exceptional isolation performance required to maintain measurement integrity. Isolation between ports is typically > 100 dB to 20 GHz. This reduces the influence of signals from other channels, sustains the integrity of the measured signal, and reduces system measurement uncertainties. This switch also minimizes measurement uncertainty with low insertion loss and reflection, which makes it an ideal element in large, multi-tiered switching systems.

The 87606B is designed to fall within most popular industry footprints. The 2¼ inch square flange provides mounting holes, while the rest of the 2½ inch long by 2¼ inch diameter body will easily fit into most systems. Ribbon cable or optional solder terminal connections accommodate the need for secure and efficient control cable attachment.

Option 100 provides solder terminal connections in place of the 16-pin ribbon drive cable. Option 100 does not incorporate the “open all ports” feature.

Each port is individually controlled by its corresponding “close” and “open” control lines. A port is closed or open when its corresponding “close” or “open” pin is connected to ground.

At this point, the current to the solenoids is shut off by the opto-electronic interrupts. This improves reliability and extends the life of the switch by eliminating dc circuit contact failures characteristic of conventional electromechanical switches. Full position sensing capability is assured when used with the Keysight 87130A/70611A switch drivers.

All unselected RF ports are terminated with 50 Ω loads.

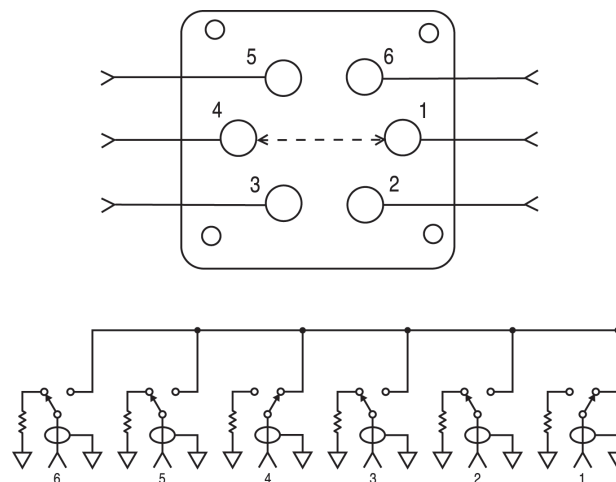


Figure 1. Keysight 87606B connection diagram and simplified schematic (RF path 4 to 1 shown)

## Applications

### Matrix signal routing

Figures 2 and 3 show the 87606B configured for blocking 2 x 4 and 3 x 3 applications. With outstanding repeatability and life greater than 5 million cycles, these switches enhance measurement confidence and reduce cost of ownership. In addition, the matrix switch has the versatility to provide single pole multiple throw signal routing up to 1 x 5 (SP5T). For applications requiring only single pole multithrow signal routing, the 87204 and 87206 series high performance switches are recommended.

Information on switch drivers can be found on page 8 of this document. For additional information, request one of the configuration guides listed in the Related Literature section on page 11 of this document.

### General operation

The 87606B matrix switch consists of 6 ports which can be individually connected via internal microwave switches to form an RF path. When control inputs are sent to the switch, the internal logic and position sensing circuitry routes current to the appropriate solenoids to open or close the microwave switches based on the input state. The position sensing circuitry utilizes opto-electronic components to determine the position of the individual internal microwave switches. Each internal microwave switch has two solenoids: one

to **select** the RF port, and one to **unselect** the RF port. The position sensing circuits serve two purposes: to enable solenoids that need to be switched, and to interrupt the solenoid current once the individual internal microwave switch is closed or opened. Each solenoid requires 200 mA @ 24 VDC nominal for 15 ms. The solenoid current is interrupted once the switching solenoids are magnetically latched. The supply current then returns to the standby level that is required by the opto-electronic components.

To configure a desired RF path, two ports must be closed. The ports are closed by grounding the “RF port close” pin that corresponds to the RF port (see Table 1). RF ports that are already closed must be opened if they are not part of the desired RF path. RF ports may be opened by grounding the “RF port open” pin that corresponds to the desired port (see Table 2).

**Simultaneously selecting the “RF port close” pin and the “RF port open” pin for the same port will cause rapid cycling and premature failure of the switch.**

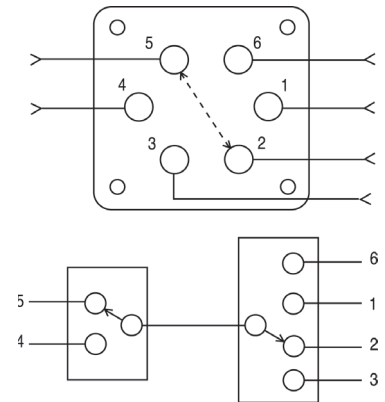


Figure 2. Matrix switch configured for a 2 x 4 blocking application (RF Path 5 to 2 shown)

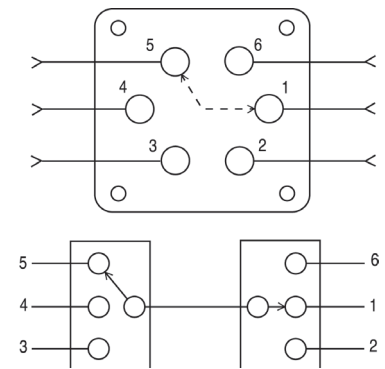


Figure 3. Matrix switch configured for a 3 x 3 blocking application (RF Path 5 to 1 shown)

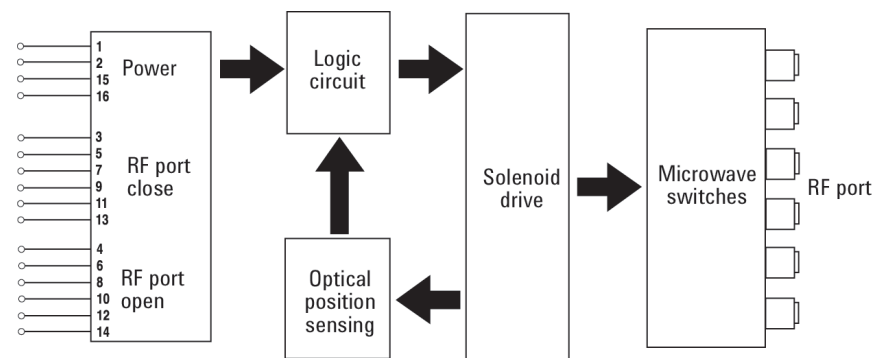


Figure 4. Keysight 87606B block diagram

## General operation (continued)

All of the “RF port open” solenoids are connected to pin 16 via logic circuitry. Grounding of pin 16 will open all RF ports (this feature is not available with Option 100, solder terminals).

Simultaneously grounding any “RF port close” pin and pin 16 will cause rapid cycling and premature failure of the switch.

## Driving the switch

### DC power connection

- Connect pin 1 to supply (+20 VDC to +32 VDC)
- Connect pin 15 to chassis ground to enable the electronic position-indicating circuitry and drive logic circuitry.

Warning: Damage to switch will occur if pin 15 is not grounded.

## RF path selection

### Close an RF port

To connect any two RF ports, apply control signals to the corresponding drive pins as shown below.

Table 1. Keysight 87606B “Close” RF Port Control Data (See Figure 7 for drive connection diagrams.)

RF port	6	5	4	3	2
1	3, 13	3, 11	3, 9	3, 7	3, 5
2	5, 13	5, 11	5, 9	5, 7	
3	7, 13	7, 11	7, 9		
4	9, 13	9, 11			
5	11, 13				

Using Table 1, select (close) the desired RF path by connecting ground to the corresponding “drive” pins.

### Open an RF port

To open RF ports, apply control signal to the corresponding drive pins as shown below.

Table 2. Keysight 87606B “Open” RF Port Control Data (See Figure 7 for drive connection diagrams.)

RF port	1	2	3	4	5	6
Drive pin	3	5	7	9	11	13

Using Table 2, unselect (open) the desired RF path by connecting ground to the corresponding “drive” pins.

### Example: Configure the RF path from port 2 to port 5

Using the data in Tables 1 and 2, close ports 2 and 5 while opening all other ports (1, 3, 4, 6); ground pins 4, 5, 8, 10, 11, 14; all other drive pins must be removed from ground. Another method is to first apply ground to pin 16; with all other drive pins (3–14) ungrounded, for 15 milliseconds to open all paths, then apply ground to pins 5 and 11, to close ports 2 and 5.

RF port	1		2		3		4		5		6	
Drive pin	3	4	5	6	7	8	9	10	11	12	13	14
Standard, Option 100	U	G	G	U	U	G	U	G	G	U	U	G

U = Ungrounded, G = Grounded

Removing all drive pins (3–14) from ground and grounding pin 16 will open all RF paths. **Simultaneously grounding any “RF port close” pin and pin 16 will cause rapid cycling and premature failure of the switch.**

### Break-before-make

Open the undesired RF path. After 15 ms (minimum), close the new RF port(s).

### Make-before-break

Close the new RF port(s). After 15 ms (minimum), open the undesired RF port(s).

## Specifications

**Specifications** describe the instrument’s warranted performance. **Supplemental and typical characteristics** are intended to provide information useful in applying the instrument by giving typical, but not warranted, performance parameters.

Maximum power rating	1 W average into 50 $\Omega$ internal loads
Switching	1 W average
Non-switching	50 W peak (10 $\mu$ s max, not to exceed 1 watt average)
Life	5,000,000 cycles minimum
Switching speed	15 ms maximum

## Switch drive specifications

Parameter	Conditions	Min	Nom	Max	Units
Supply voltage, Vcc		20	24	32	V
Switching current	Vcc = 24 VDC		200 <sup>1</sup>		mA
Standby current (quiescent)		25		50	mA

1. 200 mA is required for each RF port closed or open. Using “open all ports” (pin 16) will require up to 1200 mA (6 ports times 200 mA each). See General Operation, page 3.

## Specifications (continued)

Frequency range	DC to 20 GHz
Insertion loss	0.34 dB + 0.033 x frequency (GHz) maximum
Isolation	100 dB minimum to 12 GHz 80 dB minimum from 12 to 15 GHz 70 dB minimum from 15 to 20 GHz
SWR	1.21 maximum from DC to 4 GHz 1.35 maximum from 4 to 10 GHz 1.5 maximum from 10 to 15 GHz 1.7 maximum from 15 to 18 GHz 1.9 maximum from 18 to 20 GHz

## Supplemental characteristics<sup>1</sup>

Insertion loss repeatability (measured at 25 °C)	0.03 dB
Characteristic impedance	50 $\Omega$
RF connectors	SMA (f)

1. **Supplemental** and **typical characteristics** are intended to provide information useful in applying the instrument by giving typical, but not warranted, performance parameters.

**Environmental specifications**

Operating temperature	-25 to 75 °C
Storage temperature	-55 to 85 °C
Temperature cycling	-55 to 85 °C, 10 cycles per MIL-STD-202F, Method 107D, Condition A (modified)
Vibration	
Operating	7 g: 5 to 2000 Hz at 0.25 in p-p
Survival	20 g: 20 to 2000 Hz at 0.06 in p-p, 4 min/cycle, 4 cycles/axis
Random	2.41 g (rms) 10 min/axis
Shock	
Half-sine	500 g at 0.5 ms, 3 drops/direction, 18 total
Operating	50 g at 6 ms, 6 directions
Moisture resistance	65 °C, 95% RH, 10 days per MIL-STD-202F, Method 106E
Altitude storage	50,000 feet (15,240 meters) per MIL-STD-202F, Method 105C, Condition B
RFI	Per MIL-STD-461C, RE02, Part 4
Magnetic field	< 5 gauss 1/4 inch from surface

**Physical specifications**

Dimensions	Per Figure 6
Weight	229 gm (0.50 lb)

Dimensions  
in millimeters  
and (inches)  
Typical Tolerance  $\pm 0.5\text{mm}$

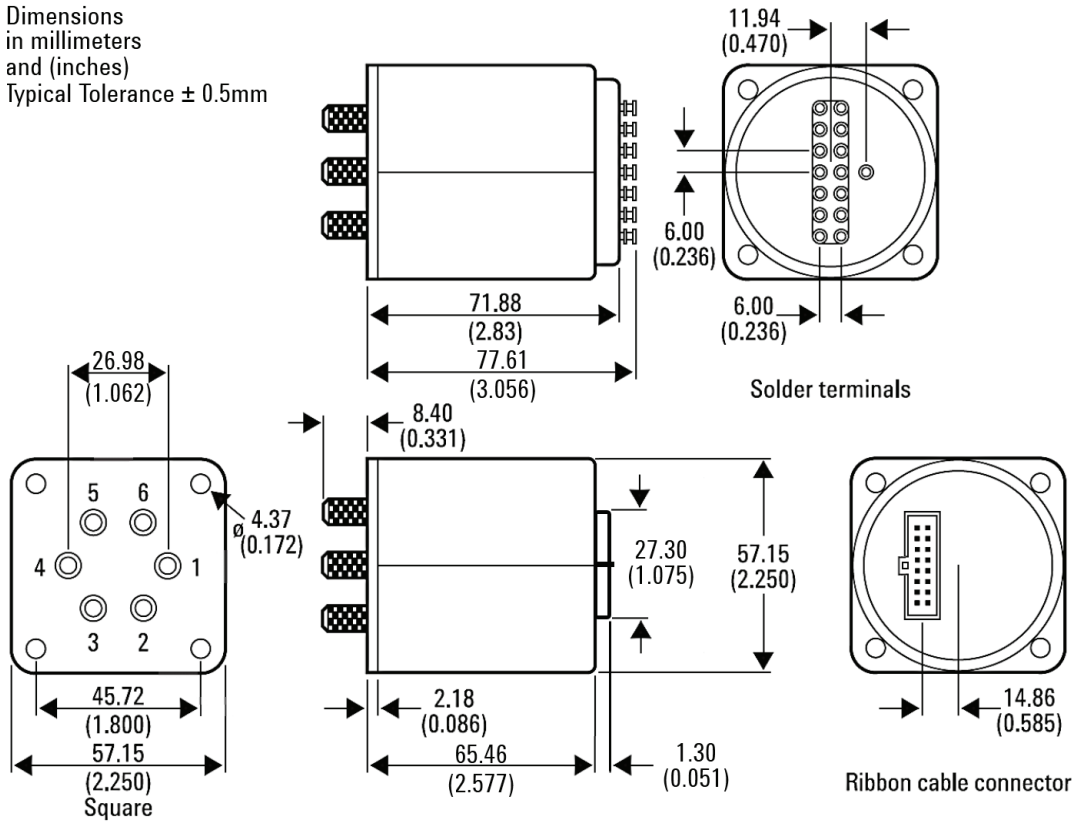


Figure 6. Product outline



## Troubleshooting

Symptom	Probable cause
1. Will not switch	<ul style="list-style-type: none"> <li>- Not connected to supply</li> <li>- Supply &lt; 20 V</li> <li>- Insufficient supply current</li> <li>- Pin 15 not connected to ground</li> <li>- Select line not at ground</li> </ul>
2. Switch buzzes	<ul style="list-style-type: none"> <li>- "Open" and "close" pins on same RF path are selected simultaneously</li> <li>- Pin 16 and any "close" pins selected simultaneously</li> </ul>

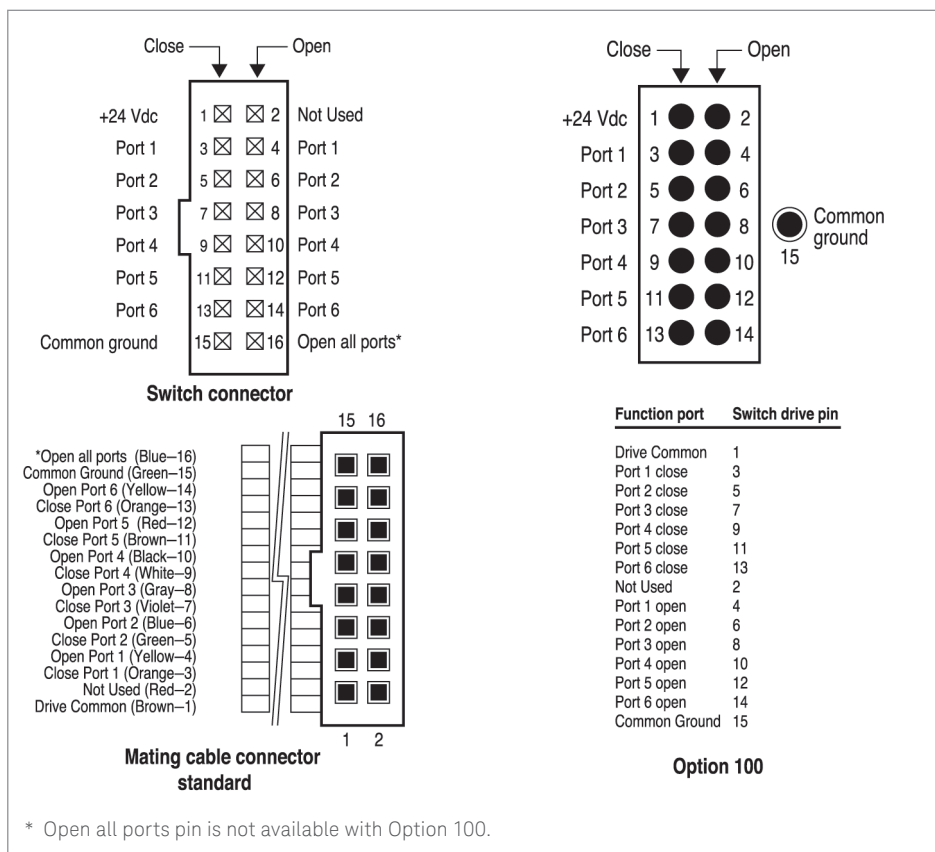


Figure 7. Drive connection diagrams

## Ordering information

Switch	
87606B	Coaxial matrix switch, dc to 20 GHz
Option 100	Solder terminals to replace ribbon cable
Option 161	16-pin DIP socket and connector with 24-inch ribbon cable
Option UK6	Commercial calibration test data with certificate

Note: 24 Vdc and Option 161 are default options for dc drive and connector option.

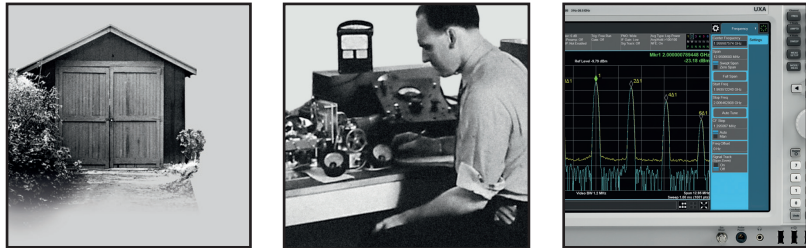
Drivers	
11713B/C Attenuator switch driver	Drives up to 10 or 20 sections of switches or attenuators.
5061-0969 Accessory cable	Viking connector to bare tinned wires (60 inches long). Use two (2) to connect the 11713B/C to one 87606B, Option 100 switch.

## Related literature

Publication title	Pub number
<i>Keysight RF and Microwave Switch Selection Guide</i>	5989-6031EN
<i>Power Handling Capability of Electromechanical Switches</i> Application Note	5989-6032EN
<i>Coaxial Electromechanical Switches: How Operating Life and Repeatability of Keysight's Electromechanical Switches Minimize System Uncertainty</i> Application Note	5989-6085EN
<i>Keysight 11713B/C Attenuator/Switch Drivers</i> Configuration Guide	5989-7277EN

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