

Keysight Technologies

## 87222C/D/E Coaxial Transfer Switches

dc to 26.5, 40, 50 GHz

Technical Overview



# High Performance Transfer Switches for Microwave and RF Instrumentation and Systems

- Exceptional repeatability for more than 5 million cycles
- Excellent isolation, typically > 90 dB at 26.5 GHz; > 60 dB at 40, 50 GHz
- Opto-electronic indicators and interrupts
- Magnetic latching
- TTL/5V CMOS compatible

Flexibility is essential in signal routing applications, and the Keysight Technologies, Inc. 87222C/D/E 4-port coaxial transfer switches offer just that. They provide exceptional repeatability, low insertion loss, and high isolation. These switches provide simplification of design in signal routing and conditioning applications.

The 87222C/D/E can be used in a variety of applications, such as a drop-out switch, switching two inputs and two outputs, or signal reversal switching.

## Description

Innovative design and careful process control mean the 87222C/D/E meet the requirements for highly repeatable switching elements in test instruments and switching interfaces. These switches are designed to operate for more than 10,000,000 cycles. They offer exceptional insertion loss repeatability, reducing sources of random errors in the measurement path and improving measurement uncertainty.

Switch life is a critical consideration in production test systems, satellite and antenna monitoring systems, and test instrumentation. The longevity of these switches increases system uptime and lowers the cost of ownership by reducing calibration cycles and switch maintenance.



Microwave test accessories

Operating from dc to 50 GHz, these switches exhibit exceptional isolation performance required to maintain measurement integrity. Isolation between ports is typically > 100 dB to 12 GHz, > 90 dB to 26.5 GHz, and > 60 dB to 50 GHz, reducing the influence of signals from other channels and system measurement uncertainties. Hence, the 87222C/D/E are ideal elements in large, multitiered switching systems.

The Keysight 87222C/D/E are designed to fall within most popular industry footprints. The 1¼ inch square flange provides tapped mounting holes, while the rest of the 2¾ inch long by 1¼ inch square body will easily fit into most

systems. The standard 10-pin ribbon drive cable or optional solder terminal connections accommodate the need for secure and efficient control cable attachment.

Opto-electronic interrupts and indicators improve reliability and extend the life of the switch by eliminating DC circuit contact failures characteristic of conventional electromechanical switches. The 87222C/D/E have circuits that interrupt the current to all the solenoids once switching is complete and offer independent indicators that are controlled by optical interrupts. These indicators provide a closed path between the indicator common pin and the corresponding sense pin of the selected path.

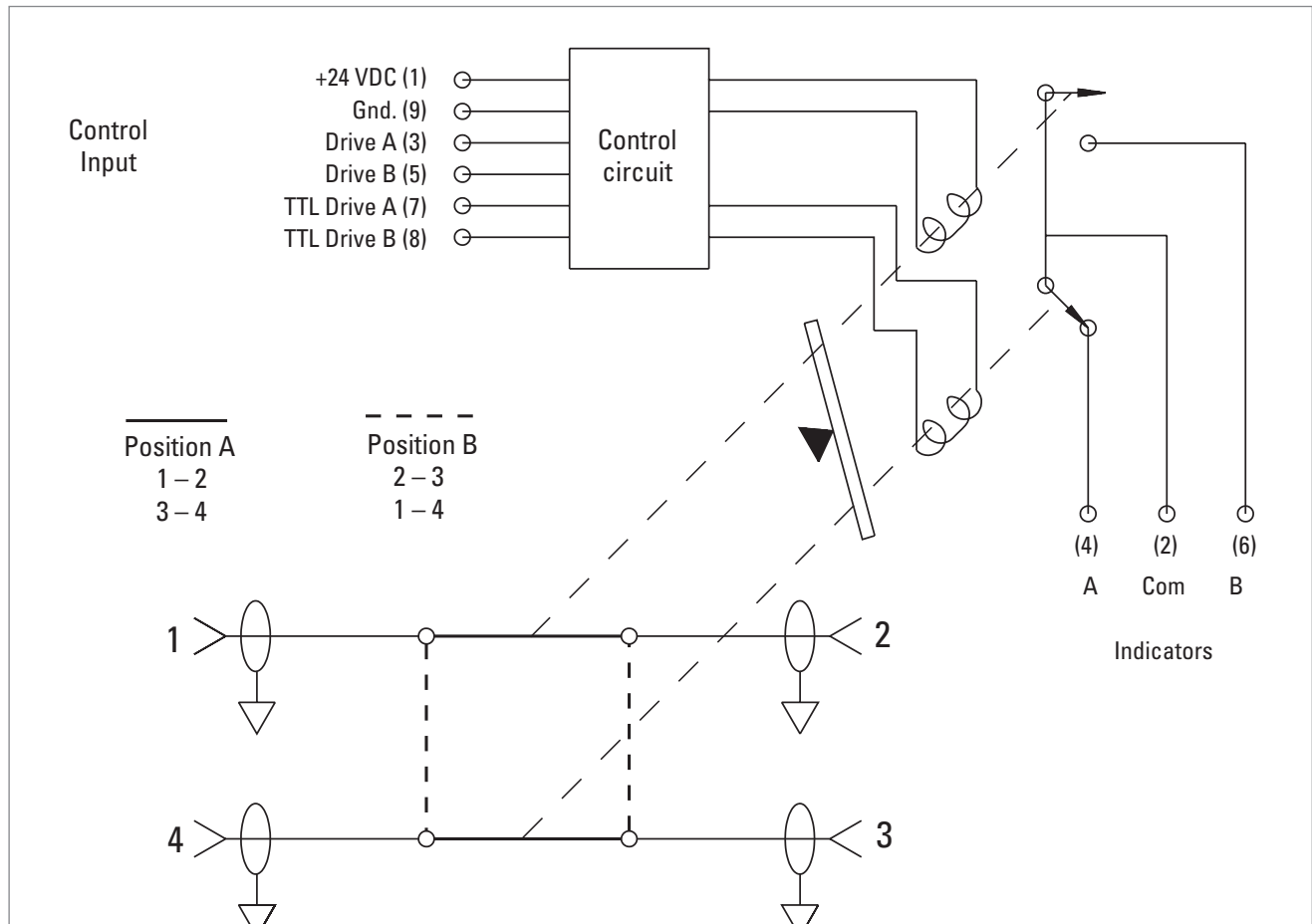


Figure 1. Keysight 87222C/D/E schematic

## Applications

The Keysight 87222C/D/E transfer switches can be used in many different applications to increase system flexibility and simplify system design. The following are five examples: switch between two inputs and two outputs, use as a drop-out switch, use for signal reversal, configure as a SPDT switch, and bypass an active device.

The 87222C/D/E transfer switches have the ability to exchange two signals between two inputs and two outputs. Either transfer switch can connect two different instruments with two devices under test (DUT). Once switched, the signals are exchanged between the two instruments and the two DUTs. The exchanged signals allow complete network and spectrum analysis on two devices with a single switch and one test setup. See Figure 2 for an example of this application.

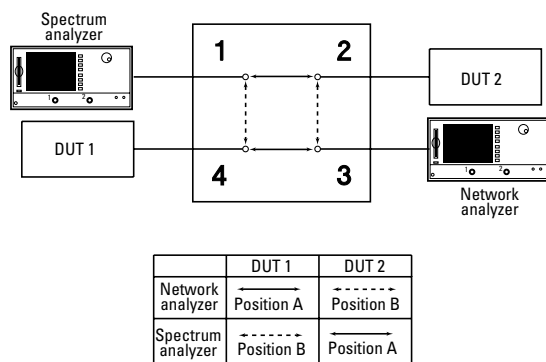


Figure 2. Switching two instruments and two DUTs

The 87222C/D/E can be used as a simple drop-out switch where a signal is either run through the device under test or straight through the switch, bypassing the device. See Figure 3.

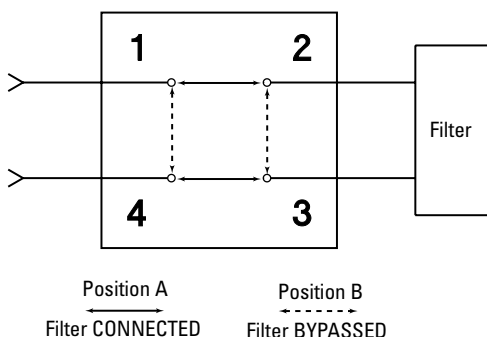


Figure 3. Drop-out switch

In the signal reverse configuration, a device can be connected across two diagonal ports of the 87222C/D/E transfer switch. This will allow the signal direction through the device to be reversed. See Figure 4.

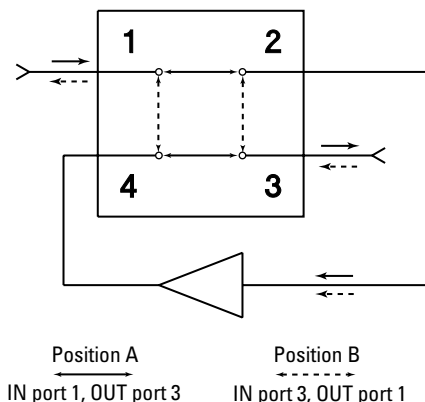


Figure 4. Signal reversal

By attaching an external termination, the designer can use the 87222C/D/E in a SPDT terminated switch configuration. See Figure 5.

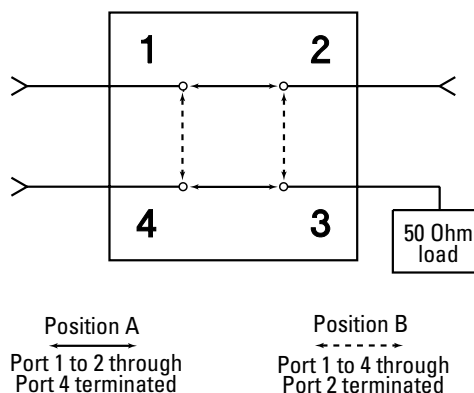


Figure 5. SPDT terminated

In Figure 6, an active device, such as an amplifier, is inserted into a signal path presenting a unique problem. A single transfer switch has the undesirable characteristic of shunting the output of the amplifier to its input when the signal is bypassing the amplifier. The advantage of using two transfer switches is that an additional signal path is available, however two SPDT switches can also be used. This additional path can utilize the same amplifier when the original path is bypassed.

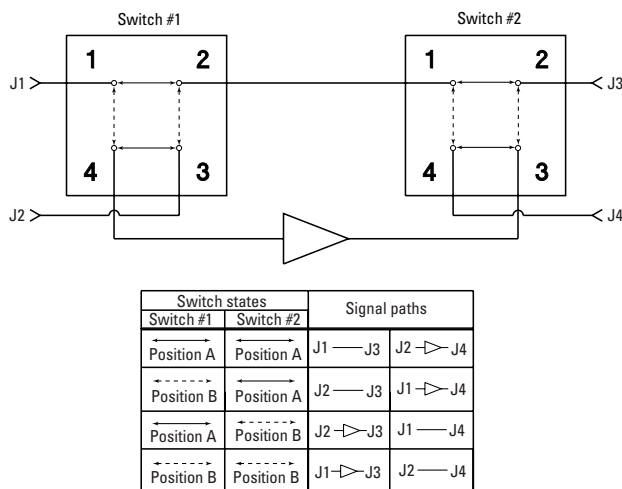


Figure 6. Bypassing an active device

## Driving the switch

There are two positions for the 87222C/D/E transfer switches. See Table A. Position A has RF Port 1 connected to RF Port 2 and RF Port 3 connected to RF Port 4. Position B has RF Port 2 connected to RF Port 3 and RF Port 1 connected to RF Port 4. Either switch can be driven with a standard grounding drive control with or without a separate ground. Single line or Dual line TTL control are also available. The switch operates in a break-before-make mode. See Figure 7.

### (I) Standard drive:

See Figure 8 for drive connection diagrams.

- Connect pin 1 to supply (+20 VDC to +32 VDC).
- Connect pin 9 to ground (see Note 1).
- Select position A by applying ground to pin 3 (see Note 3).
- Select position B by applying ground to pin 5 (see Note 3).

### (II) Single line TTL drive:

See Figure 8 for drive connection diagrams.

See Figure 9 for TTL voltage states.

- Connect pin 1 to supply (+20 VDC to +32 VDC).
- Connect pin 9 to ground (see Notes 2, 4).
- Connect pin 8 to TTL “High.”
- Select position A by applying TTL “High” to pin 7 (see Note 3).
- Select position B by applying TTL “Low” to pin 7 (see Note 3).

### (III) Dual line TTL drive:

See Figure 8 for drive connection diagrams.

See Figure 9 for TTL voltage states.

- Connect pin 1 to supply (+20 VDC to +32 VDC).
- Connect pin 9 to ground (see Notes 2, 4).
- Select position A by applying TTL “High” to pin 7 and TTL “Low” to pin 8 (see Note 3).
- Select position B by applying TTL “Low” to pin 7 and TTL “High” to pin 8 (see Note 3).

### Notes:

1. Pin 9 does not need to be grounded for the switch to operate in standard drive mode. If pin 9 is not grounded, the position indicators will only function while the appropriate drive has ground applied. Therefore, if a pulse drive is used and continuous indicator operation is required, pin 9 must be grounded.
2. For TTL drive, pin 9 must be grounded.
3. After the RF path is switched and latched, the drive current is interrupted by the electronic position-sensing circuitry. Pulsed control is not necessary, but if implemented, the pulse width must be 15 ms minimum to ensure that the switch is fully latched.
4. In addition to the quiescent current supplying the electronic position-sensing circuitry, the drive current flows out of pin 9 (during switching) when using TTL drive.

“CAUTION FOR USERS OF THE Keysight 11713B/C SWITCH DRIVER: Do not drive the 87222C/D/E using the S9 or SO outputs from either the banana plugs or from pins 3 or 4 within the Atten X and Atten Y Viking sockets located on the rear panel of the 11713B/C.”

Table A. Drive control alternatives

| RF path                      | (I)<br>Standard drive<br>voltage |         | (II)<br>Single line TTL/5V CMOS<br>drive voltage |             | (III)<br>Dual line TTL/5V CMOS<br>drive voltage |             |
|------------------------------|----------------------------------|---------|--------------------------------------------------|-------------|-------------------------------------------------|-------------|
|                              | Drive A                          | Drive B | TTL Drive A                                      | TTL Drive B | TTL Drive A                                     | TTL Drive B |
|                              | Pin 3                            | Pin 5   | Pin 7                                            | Pin 8       | Pin 7                                           | Pin 8       |
| Position A<br>1 to 2, 3 to 4 | Ground                           | Open    | High                                             | High        | High                                            | Low         |
| Position B<br>2 to 3, 1 to 4 | Open                             | Ground  | Low                                              | High        | Low                                             | High        |

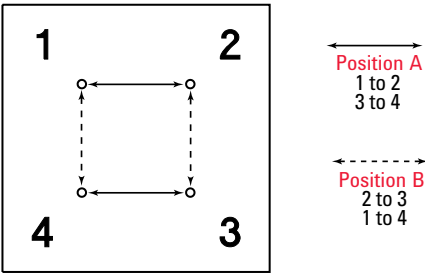


Figure 7. RF port connections

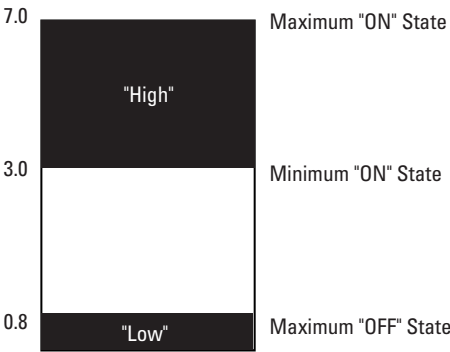


Figure 9. TTL control voltage states

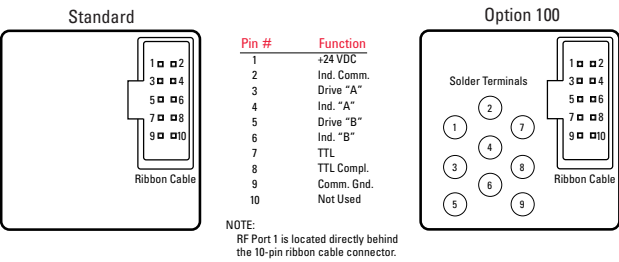


Figure 8. Drive connections

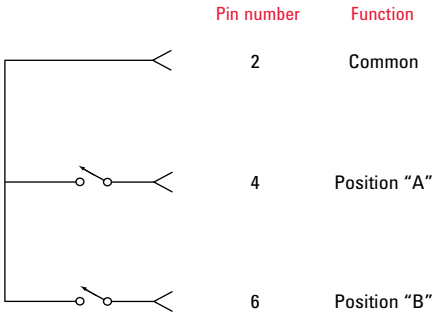


Figure 10. Indicator function diagram

## Electronic position indicators

The independent electronic position indicators consist of optically isolated, solid-state relays, which are driven by photo-electric sensors coupled to the mechanical position of the RF path's moving elements. See Figure 10. The circuitry consists of a common which can be connected to an output corresponding to either position A or position B. The solid state relays are configured for AC and/or DC operation. (See indicator specifications.) The electronic position indicators require that the supply (+20 VDC to +32 VDC) be connected to pin 1 but requires that pin 9 be grounded if pulse drive is used and continuous indicators operation is desired. If pin 9 is not grounded, the position indicators will function while the appropriate drive has ground applied.

## 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.

*Table B. Standard switch drive specifications*

| Parameter                  | Conditions                                       | Min | Nom | Max | Units |
|----------------------------|--------------------------------------------------|-----|-----|-----|-------|
| Supply voltage             |                                                  | 20  | 24  | 32  | V     |
| Supply current, $I_{cc}$   | Switching: Pulse width >15 ms: $V_{cc} = 24$ VDC |     | 200 |     | mA    |
| Supply current (quiescent) |                                                  | 25  |     | 50  | mA    |

*Table C. TTL Specific drive specifications*

| Parameter              | Conditions                                             | Min | Nom | Max | Units |
|------------------------|--------------------------------------------------------|-----|-----|-----|-------|
| High level input       |                                                        | 3   |     | 7   | V     |
| Low level input        |                                                        |     |     | 0.8 | V     |
| Max high input current | $V_{cc} = \text{Max}$<br>$V_{\text{input}} = 3.85$ VDC |     | 1   | 1.4 | mA    |

## General operating data

|                      |                                                                         |
|----------------------|-------------------------------------------------------------------------|
| Nominal/Impedance    | 50 $\Omega$                                                             |
| Maximum power rating |                                                                         |
| Hot switching        | 1W CW<br>50 W peak, 10 us max pulse width,<br>not to exceed 1 W average |
| Cold switching       | 150 W CW at 3 GHz, 25 °C<br>120 W CW at 4.2 GHz, 25 °C                  |
| Life                 | 5,000,000 cycles minimum                                                |
| Switching speed      | 15 ms maximum                                                           |

## Indicator specifications

|                           |              |
|---------------------------|--------------|
| Maximum withstand voltage | 60 V         |
| Maximum current capacity  | 100 mA       |
| Maximum "ON" resistance   | 50 $\Omega$  |
| Minimum "OFF" resistance  | 1 G $\Omega$ |

## Environmental specifications

|                       |                                                                                    |
|-----------------------|------------------------------------------------------------------------------------|
| Operating temperature | –25 to 75 °C                                                                       |
| Storage temperature   | –55 to 85 °C                                                                       |
| Temperature cycling   | 55 to 85 °C, 10 cycles per<br>MIL-STD-202F, Method 107D,<br>Condition A (modified) |
| Vibration             |                                                                                    |
| Operating             | 7 g, 5 to 2000 Hz at 0.25 inches pk-pk                                             |
| Survival              | 20 g, 20 to 2000 Hz at 0.06 inches<br>pk-pk, 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,<br>18 total                                    |
| Operating             | 50 g at 6 ms, 6 directions                                                         |
| Moisture resistance   | 65 °C, 95% RH, 10 days per<br>MIL-STD-202F, Method 106E                            |
| Altitude storage      | 50,000 feet (15,240 meters per<br>MIL-STD-202F, Method 105C,<br>Condition B)       |
| RFI                   | Per MIL-STD-461C, RE02, Part 4                                                     |

## Keysight 87222C

|                              |                                                                                                                                               |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| Frequency range              | dc to 26.5 GHz                                                                                                                                |
| Insertion loss               | 0.2 dB + 0.025 x frequency (GHz)                                                                                                              |
| Isolation                    | 120 dB–2.0 x frequency (GHz)                                                                                                                  |
| SWR                          | 1.1 maximum dc to 2 GHz<br>1.15 maximum 2 to 4 GHz<br>1.25 maximum 4 to 12.4 GHz<br>1.4 maximum 12.4 to 20 GHz<br>1.65 maximum 20 to 26.5 GHz |
| Insertion loss repeatability | < 0.03 dB typical                                                                                                                             |
| Connectors                   | SMA (f)                                                                                                                                       |

## Keysight 87222D

|                              |                                                                                                  |
|------------------------------|--------------------------------------------------------------------------------------------------|
| Frequency range              | dc to 40 GHz                                                                                     |
| Insertion loss               | 0.2 dB + 0.025 x frequency (GHz)                                                                 |
| Isolation                    | DC–26.5 120 dB–2.0 x frequency (GHz)<br>26.5–40 60 dB                                            |
| SWR                          | 1.3 maximum dc to 12.4 GHz<br>1.4 maximum dc to 12.4 to 25 GHz<br>1.7 maximum dc to 25 to 40 GHz |
| Insertion loss repeatability | < 0.03 dB typical                                                                                |
| Connectors                   | 2.92 mm (f)                                                                                      |

## Keysight 87222E

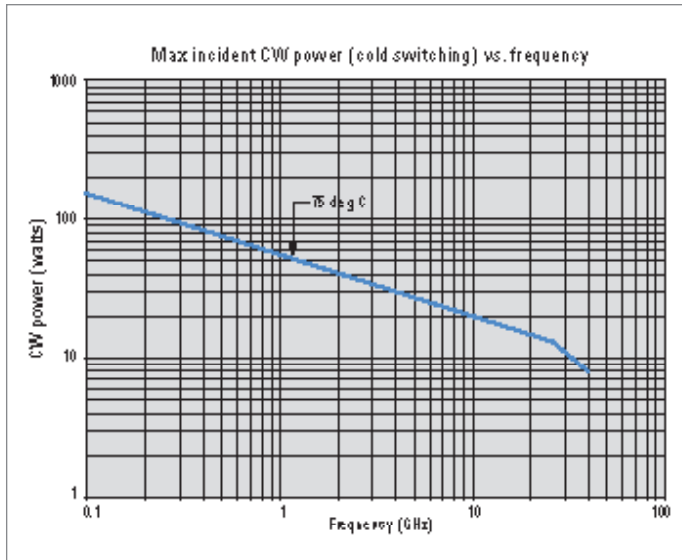
|                              |                                                                                                                                              |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Frequency range              | dc to 50 GHz                                                                                                                                 |
| Insertion loss               | 0.15 dB + 0.020 x frequency (GHz)                                                                                                            |
| Isolation                    | DC–26.5 120 dB–2.0 x frequency (GHz)<br>26.5–50 60 dB                                                                                        |
| SWR                          | 1.3 maximum dc to 12.4 GHz<br>1.4 maximum 12.4 to 20 GHz<br>1.5 maximum 20 to 30 GHz<br>1.6 maximum 30 to 40 GHz<br>1.7 maximum 40 to 50 GHz |
| Insertion loss repeatability | DC–40 GHz < 0.03 dB typical<br>40–50 GHz < 0.05 dB typical                                                                                   |
| Connectors                   | 2.4 mm (f)                                                                                                                                   |

## Keysight 87222C/D/E physical specifications

|            |                  |
|------------|------------------|
| Dimensions | Per Figure 13    |
| Weight     | 100 gm (0.23 lb) |



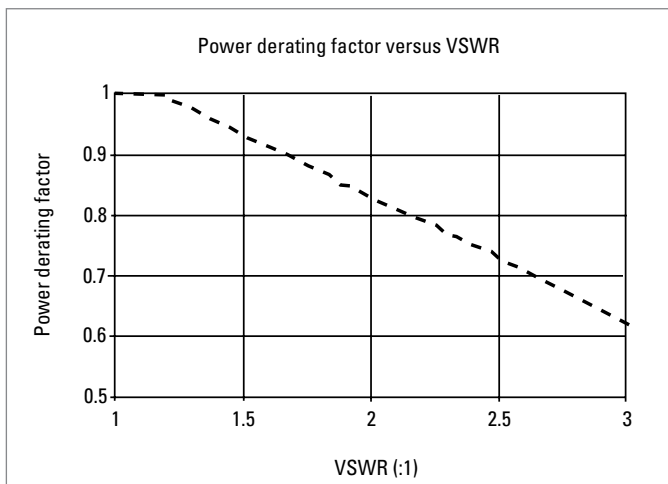
## Supplemental Characteristic



Power Handling at 25 °C is 100 W at 4 GHz

### Reference conditions:

- Cold switching only (NO Hot switching)
- Ambient temperature of 75 °C or less
- Sea level (0.88 derating @ 15,000 ft.)
- Load VSWR < 1.2 (see graph for derating above 1.2 VSWR)



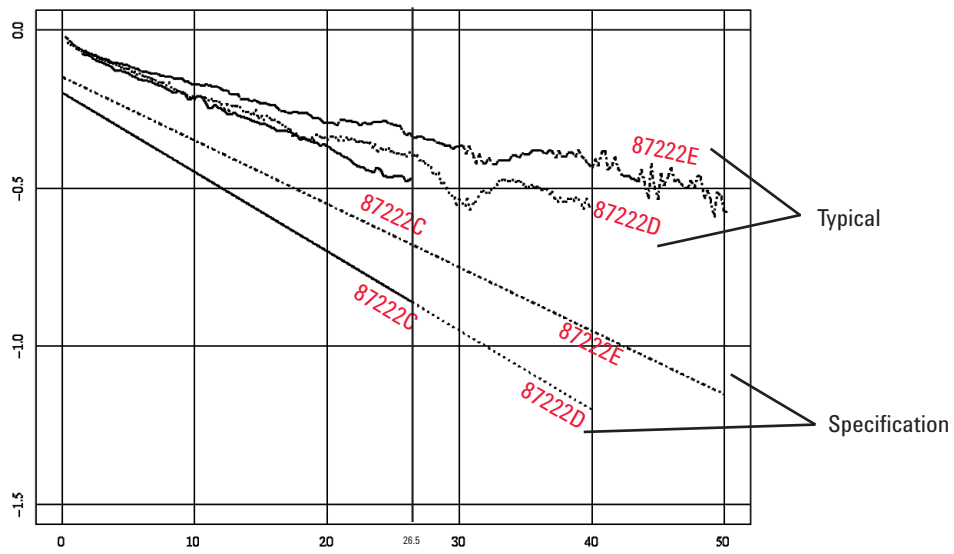


Figure 11. Keysight 87222C/D/E insertion loss versus frequency

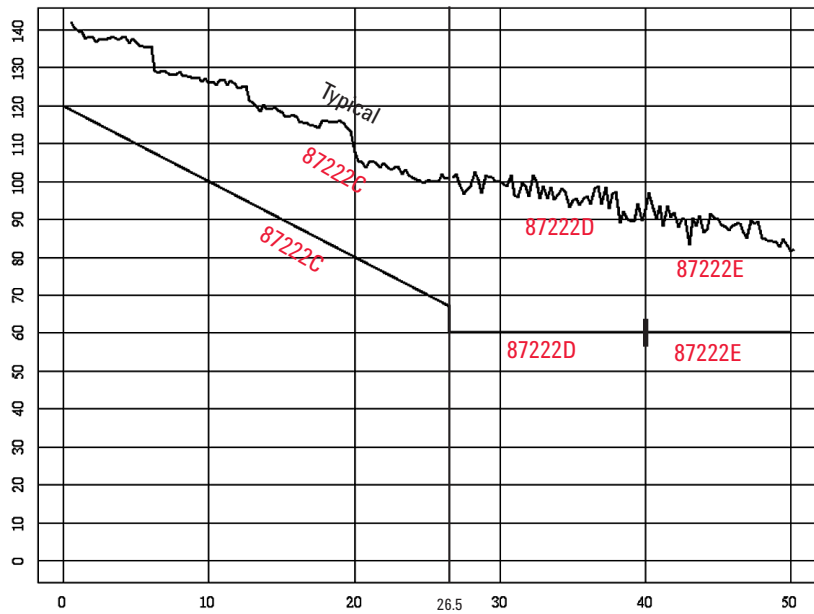


Figure 12. Keysight 87222C/D/E isolation versus frequency

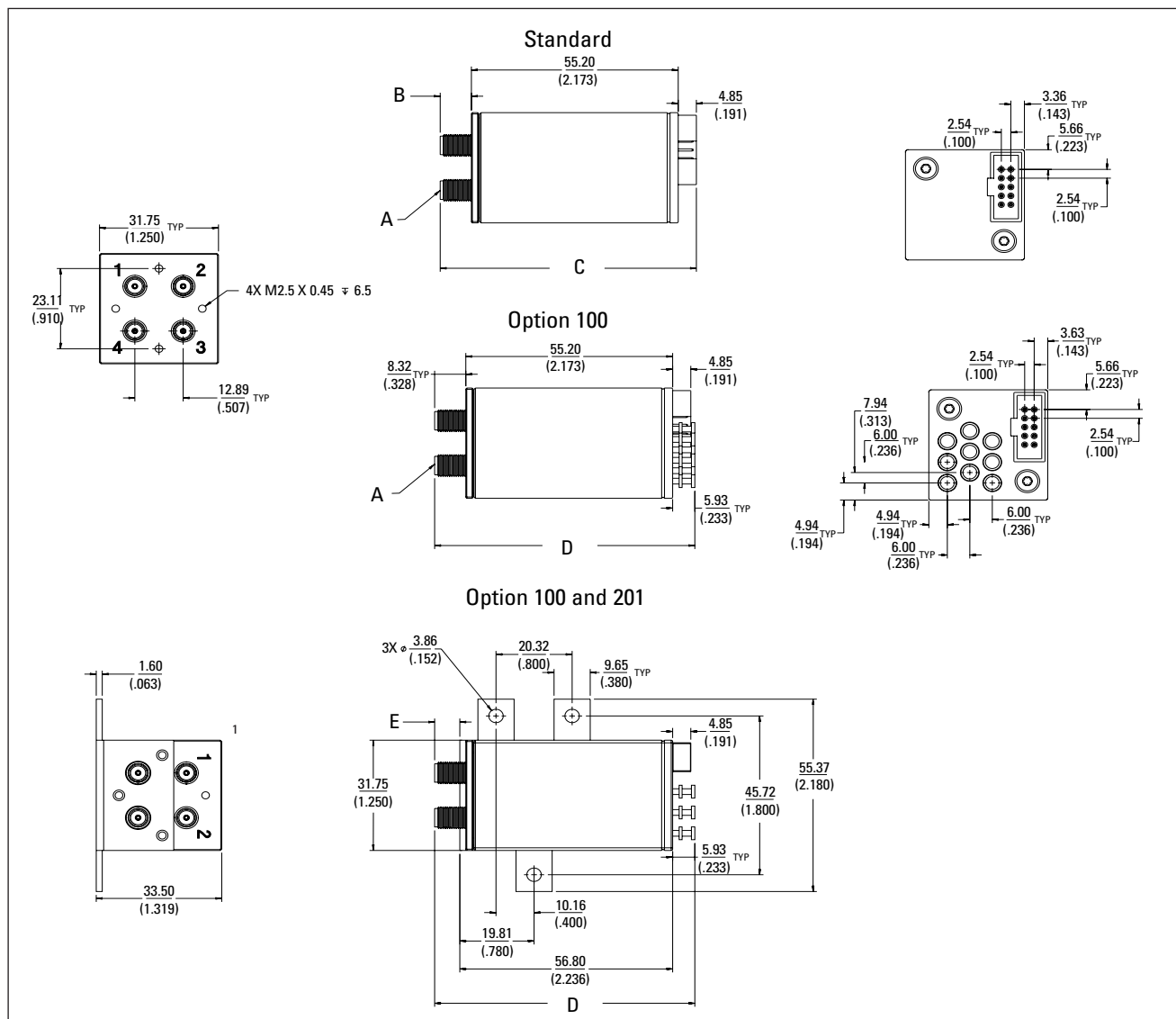


Figure 13. Product outlines

**Note:** Dimensions are in millimeters and (inches) nominal unless otherwise specified.

| Keysight model number |                        |             | A                  | B                  | C                    | D                    | E                   |
|-----------------------|------------------------|-------------|--------------------|--------------------|----------------------|----------------------|---------------------|
| 87222C                | millimeter<br>(inches) | SMA (f)     | 8.32<br>(.328) TYP | REF 6.72<br>(.265) | REF 69.46<br>(2.735) | REF 68.37<br>(2.692) | REF 6.322<br>(.249) |
| 87222D                | millimeter<br>(inches) | 2.92 mm (f) | 8.32<br>(.328) TYP | REF 6.72<br>(.265) | REF 69.46<br>(2.735) | REF 68.37<br>(2.692) | REF 6.722<br>(.265) |
| 87222E                | millimeter<br>(inches) | 2.4 mm (f)  | 9.00<br>(.354) TYP | REF 7.40<br>(.291) | REF 70.14<br>(2.761) | REF 69.05<br>(2.719) | REF 7.002<br>(.276) |

1. One of four bracket configurations shown.

## Ordering Guide

### Keysight Coaxial transfer switch

87222C dc to 26.5 GHz

87222D dc to 40 GHz

87222E dc to 50 GHz

Option 100 Solder terminals in addition to ribbon cable

Option 201 Mounting bracket-assembly required

Option UK6<sup>1</sup> Commercial calibration test data with certificate

Accessories available

87222-00003 Mounting bracket

### Keysight drivers

11713B/C attenuator switch driver

Drives up to 10 switches.

### Accessory cables

5061-0969 Viking connector to bare tinned wires (60 inches long). Use to connect 11713B/C to 87222C/D/E with Option 100. Will operate four 87222C/D/E switches.

11713-60047 Viking connector to (4) 10-pin DIP connectors. Will operate four 87222C/D/E switches using the 11713B/C driver.

## Related Literature

1. *Keysight Technologies Bench and System Switching Products*, Literature Number 5989-9872EN
2. *Keysight RF and Microwave Switch*, Selection Guide, Literature Number 5989-6031EN
3. *Keysight 11713B/C Attenuator/Switch Drivers*, Configuration Guide, Literature Number 5989-7277EN

### Application Notes:

*Power Handling Capability of Electromechanical Switches*, Literature Number 5989-6032EN

*How Operating Life and Repeatability of Keysight's Electromechanical Switches Minimize System Uncertainty*, Literature Number 5989-6085EN

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1. Option UK6 not available with 87222D.

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### Three-Year Warranty

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Keysight's commitment to superior product quality and lower total cost of ownership. The only test and measurement company with three-year warranty standard on all instruments, worldwide.



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