

# Keysight

## Low PIM Coaxial Switches

DC to 26.5 GHz

Data Sheet





## Introduction

Keysight low PIM coaxial switches provide ultra-low passive intermodulation (PIM) performance for applications where two or more transmitted signals share a common antenna or whenever the transmitter signal is too high or the receiver is sensitive to high intermodulation. These low PIM switches can help to keep the system PIM level low. A guaranteed 0.03 dB insertion loss repeatability and 3 million cycles of operating life ensures signal integrity, improves testing efficiency, and ultimately maximizes test throughput.

### Key features

- Low PIM performance of  $-165$  dBc to keep your system PIM level low
- Guaranteed 0.03 dB IL repeatability, ensures accuracy and reduces calibration cycles
- Guaranteed 3 million cycles per section of operating life, reduces cost of test and ensures reliability of the test system life expectancy
- Excellent isolation minimizes cross-talk between channels to ensure signal integrity

## Specifications

Specifications refer to the performance standards or limits against which the switch is tested. Specifications are subject to change.

Specifications			Maximum power rating (for all models)	
<b>87104P/87104Q/87104R/87106P/87106Q/87106R</b>			Hot switching	– 1W CW – 50 W peak, 10 $\mu$ s max pulse width, not to exceed 1 W average
Frequency range	DC to 26.5 GHz		Cold switching	– 150 W CW at 3 GHz, 25 °C – 120 W CW at 4.2 GHz, 25 °C
SWR	DC to 4 GHz:	< 1.20		
	4 to 12.4 GHz:	< 1.35		
	12.4 to 20 GHz:	< 1.45		
	20 to 26.5 GHz:	< 1.70		
Insertion loss (dB, maximum)	0.3 + 0.015 f, where f is specified in GHz			
Isolation (dB)	DC to 12 GHz:	> 100		
	12 to 15 GHz:	> 80		
	15 to 20 GHz:	> 70		
	20 to 26.5 GHz:	> 65		
PIM level (typical)	–165 dBc			
Operating life cycle (minimum)	3 million			
Insertion loss repeatability (maximum)	0.03 dB			
Connectors	SMA (f)			
<b>87222R</b>				
Frequency range	DC to 26.5 GHz			
SWR	DC to 4 GHz:	< 1.15		
	4 to 12.4 GHz:	< 1.25		
	12.4 to 20 GHz:	< 1.40		
	20 to 26.5 GHz:	< 1.65		
Insertion loss (dB, maximum)	0.3 + 0.025 f, where f is specified in GHz			
Isolation (dB, minimum)	120 – 2 f, where f is specified in GHz			
PIM level (typical)	–165 dBc			
Operating life cycle (minimum)	3 million			
Insertion loss repeatability (maximum)	0.03 dB			
Connectors	SMA (f)			
<b>87406Q/87606Q</b>				
Frequency range	DC to 20 GHz			
SWR	DC to 4 GHz :	< 1.21		
	4 to 10 GHz :	< 1.35		
	10 to 15 GHz :	< 1.50		
	15 to 18 GHz :	< 1.70		
	18 to 20 GHz :	< 1.90		
Insertion loss (dB, maximum)	0.34 + 0.033 f, where f is specified in GHz			
Isolation (dB)	DC to 12 GHz:	> 100		
	12 to 15 GHz:	> 80		
	15 to 20 GHz:	> 70		
PIM level (typical)	–165 dBc			
Operating life cycle (minimum)	3 million			
Insertion loss repeatability (maximum)	0.03 dB			
Connectors	SMA (f)			
<b>N1810T/N1810U/N1811T/N1812U</b>				
Frequency range	DC to 26.5 GHz			
SWR	DC to 4 GHz:	< 1.15		
	4 to 12.4 GHz:	< 1.25		
	12.4 to 20 GHz:	< 1.30		
	20 to 26.5 GHz:	< 1.60		
Insertion loss (dB, maximum)	0.35 + (0.45/26.5) f, where f is specified in GHz			
Isolation (dB)	90 – (30/26.5) f, where f is specified in GHz			
PIM level (typical)	–165 dBc			
Operating life cycle (minimum)	2 million			
Insertion loss repeatability (maximum)	0.03 dB			
Connectors	SMA (f)			

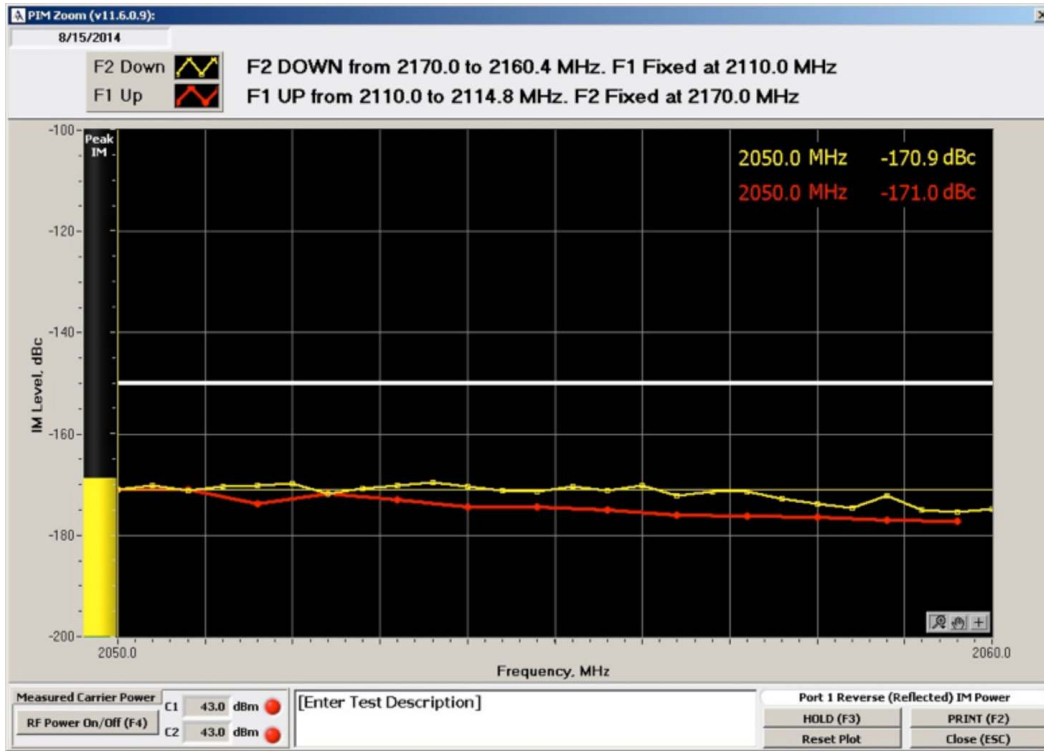
## Passive intermodulation

### 3rd Order intermodulation for two carriers at 43.0 dBm

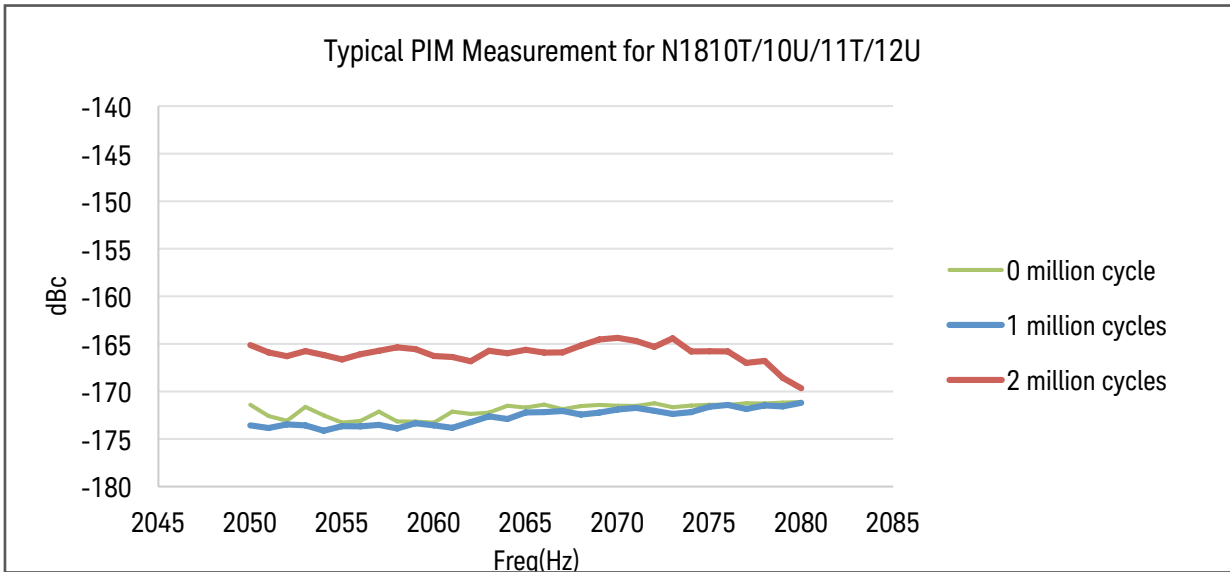
1 Carrier frequency	2nd Carrier frequency	PIM frequency	PIM level
2110 MHz	2170 MHz	2050 MHz	-165 dBc (typical)

NOTE: PIM measurements may vary when different carrier frequencies, power levels and or PIM frequencies are used in the final application.

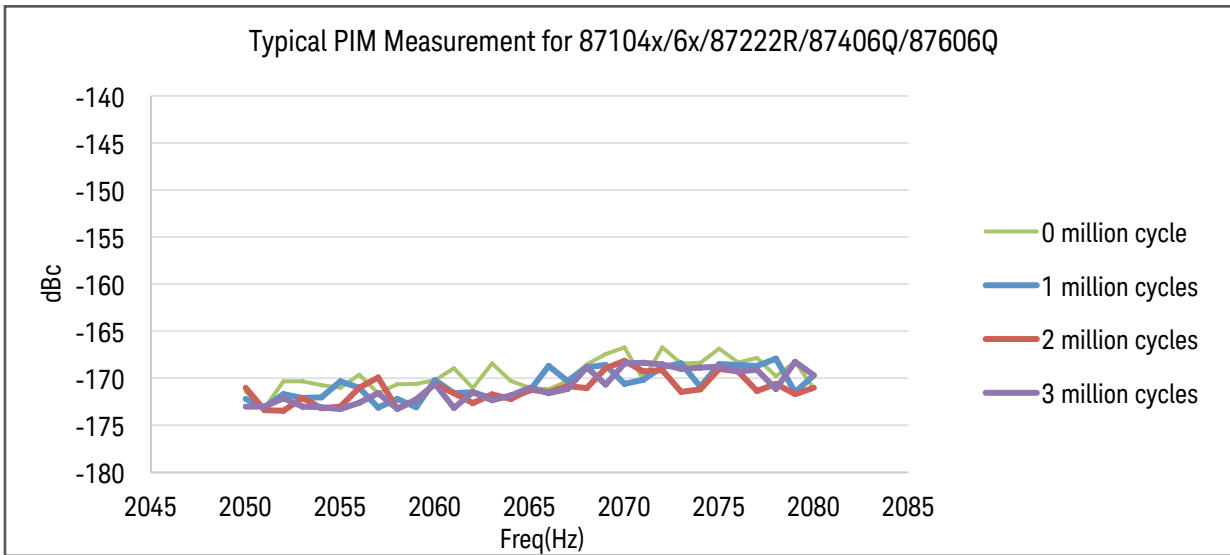
PIM testing is conducted as a part of the standard product acceptance test, with a test specification of -150 dBc.



Screenshot of the PIM measurement.



Typical PIM measurement at 0, 1 & 2 million cycle for N181x.



Typical PIM measurement at 0, 1, 2 & 3 million cycle for Multiport/Transfer/Matrix.

## Driving 87104P/Q/R and 87106P/Q/R

Each RF path can be closed (selected) by applying ground (TTL “High” for option T24) to the corresponding “drive” pin. In general, all other RF paths are simultaneously opened by the internal logic.

RF path			Standard drive						5 V TTL drive (Option T24)4					
	VDC Pin 1	GND Pin 15	Pin 3	Pin 5	Pin 7	Pin 9	Pin 11	Pin 13	Pin 3	Pin 5	Pin 7	Pin 9	Pin 11	Pin 13
Path 1*	20 – 32 V	GND1	GND <sup>2,3</sup>	Open	Open	Open	Open	Open	High <sup>2,3</sup>	Low	Low	Low	Low	Low
Path 2			Open	GND <sup>2,3</sup>	Open	Open	Open	Open	Low	High <sup>2,3</sup>	Low	Low	Low	Low
Path 3			Open	Open	GND <sup>2,3</sup>	Open	Open	Open	Low	Low	High <sup>2,3</sup>	Low	Low	Low
Path 4*			Open	Open	Open	GND <sup>2,3</sup>	Open	Open	Low	Low	Low	High <sup>2,3</sup>	Low	Low
Path 5			Open	Open	Open	Open	GND <sup>2,3</sup>	Open	Low	Low	Low	Low	High <sup>2,3</sup>	Low
Path 6			Open	Open	Open	Open	Open	GND <sup>2,3</sup>	Low	Low	Low	Low	Low	Low

\* Path 1 and 4 not connected for 87104P/Q/R.

### Switch drive specifications

Parameter	Conditions	Min	Nom	Max	Units
Supply voltage, Vcc		20	24	32	V
Supply current, Icc	Switching: Pulse width $\geq$ 15 ms: Vcc = 24 VDC <sup>5</sup>		200 <sup>5</sup>		mA
Quiescent current		25		50	mA
Switching speed				15	ms
5 V TTL drive specification (for Option T24 only)					
High level input		3		7	V
Low level input				0.8	V
Max high input current	Vcc = Max; V <sub>input</sub> = 3.85 VDC		1	1.4	mA

### Indicator specifications

Maximum withstand voltage: 60 V

Maximum current capacity: 150 mA

Maximum “ON” resistance: 2.5  $\Omega$

Maximum “OFF” resistance: 10 G $\Omega$

### Notes:

- Pin 15 must always be connected to ground to enable the electronic position indicating circuitry and drive logic circuitry.  
**CAUTION: IF PIN 15 IS NOT CONNECTED TO POWER SUPPLY GROUND, CATASTROPHIC FAILURE WILL OCCUR.**
- 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.
- The default operation of the switch is break-before-make. Make-before-break switching can be accomplished by simultaneously selecting the old RF path “drive” pin and the new RF path “drive” pin. This will simultaneously close the old RF path and the new RF path. Once the new path is closed (15 ms), de-select the old RF path “drive” pin while leaving the new RF path “drive” pin selected. The switch circuitry will automatically open the old RF path while leaving the new RF path engaged.
- In addition to the quiescent current supplying the electronic position sensing circuitry, the drive current flows out of pin 15 (during switching) on TTL drive switches (Option T24).
- Closing one RF path requires 200 mA. Add 200 mA for each additional RF path closed or opened. Using all RF paths open (selecting pin 16) requires 200 mA per RF path reset with Vcc = 24 VDC.

# 87104P/Q/R, 87106P/Q/R Dimension and drive connection

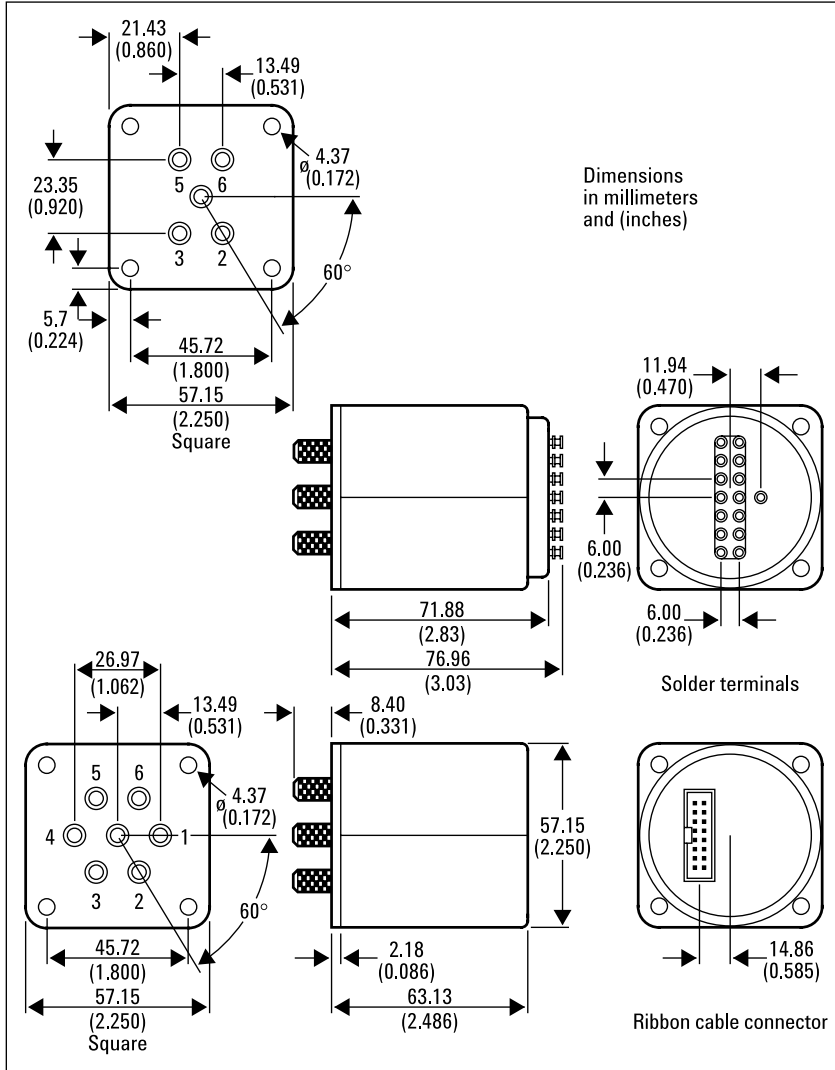
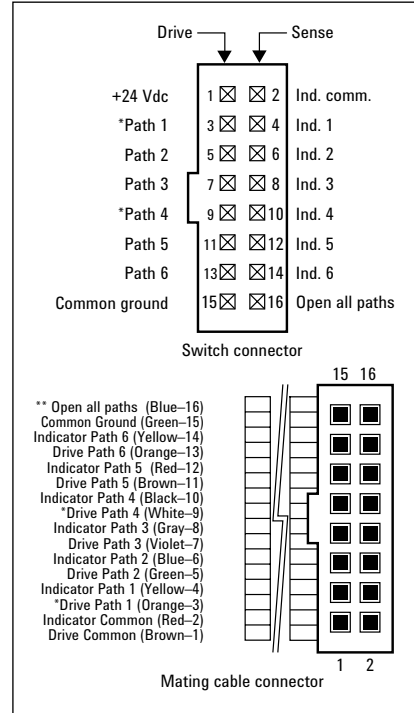


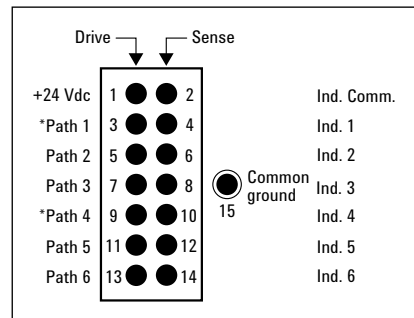
Figure 1. Product outlines



\* Paths 1 and 4 not connected for the 87104P/Q/R.

\*\* "Open all paths" pin is not available for Option 100.

Figure 2. Drive connection diagrams with Option 161



\* Paths 1 and 4 not connected for the 87104P/Q/R.

Figure 3. Drive connection diagrams with Option 100

## Driving 87222R

Each RF path can be closed (selected) by applying ground (or TTL “High”) to the corresponding “drive” pin.

RF path (refer to Figure 4)	VDC		Standard drive		Single line 5 V TTL drive <sup>2,4</sup>		Dual line 5 V TTL drive <sup>2,4</sup>	
	Pin 1	Pin 9	Pin 3	Pin 5	Pin 7	Pin 8	Pin 7	Pin 8
Position A 1 to 2, 3 to 4	20 – 32 V	GND <sup>1,2</sup>	GND <sup>1,3</sup>	Open	High <sup>3</sup>	High <sup>3</sup>	High <sup>3</sup>	Low
Position B 2 to 3, 1 to 4			Open	GND <sup>1,3</sup>	Low	High <sup>3</sup>	Low	High <sup>3</sup>

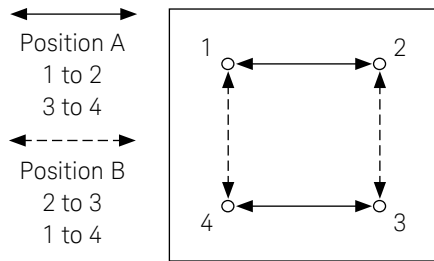


Figure 4. RF port connections

### Switch drive specifications

Parameter	Conditions	Min	Nom	Max	Units
Supply voltage, Vcc		20	24	32	V
Supply current, Icc	Switching: Pulse width $\geq$ 15 ms; Vcc = 24 VDC <sup>5</sup>		200		mA
Quiescent current		25		50	mA
Switching speed				15	ms
5 V TTL drive specification (for Option T24 only)					
High level input		3		7	V
Low level input				0.8	V
Max high input current	Vcc = Max; V <sub>input</sub> = 3.85 VDC		1	1.4	mA

### Indicator specifications

Maximum withstand voltage: 60 V

Maximum current capacity: 100 mA

Maximum “ON” resistance: 50  $\Omega$

Maximum “OFF” resistance: 1 G $\Omega$

**“CAUTION FOR USERS OF THE KEYSIGHT 11713B/C SWITCH DRIVER: Do not drive the 87222R using the S9 or S0 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.”**

### Notes:

- 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.
- For TTL drive, pin 9 must be grounded.
- 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.
- 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.



# 87222R Dimension and drive connection

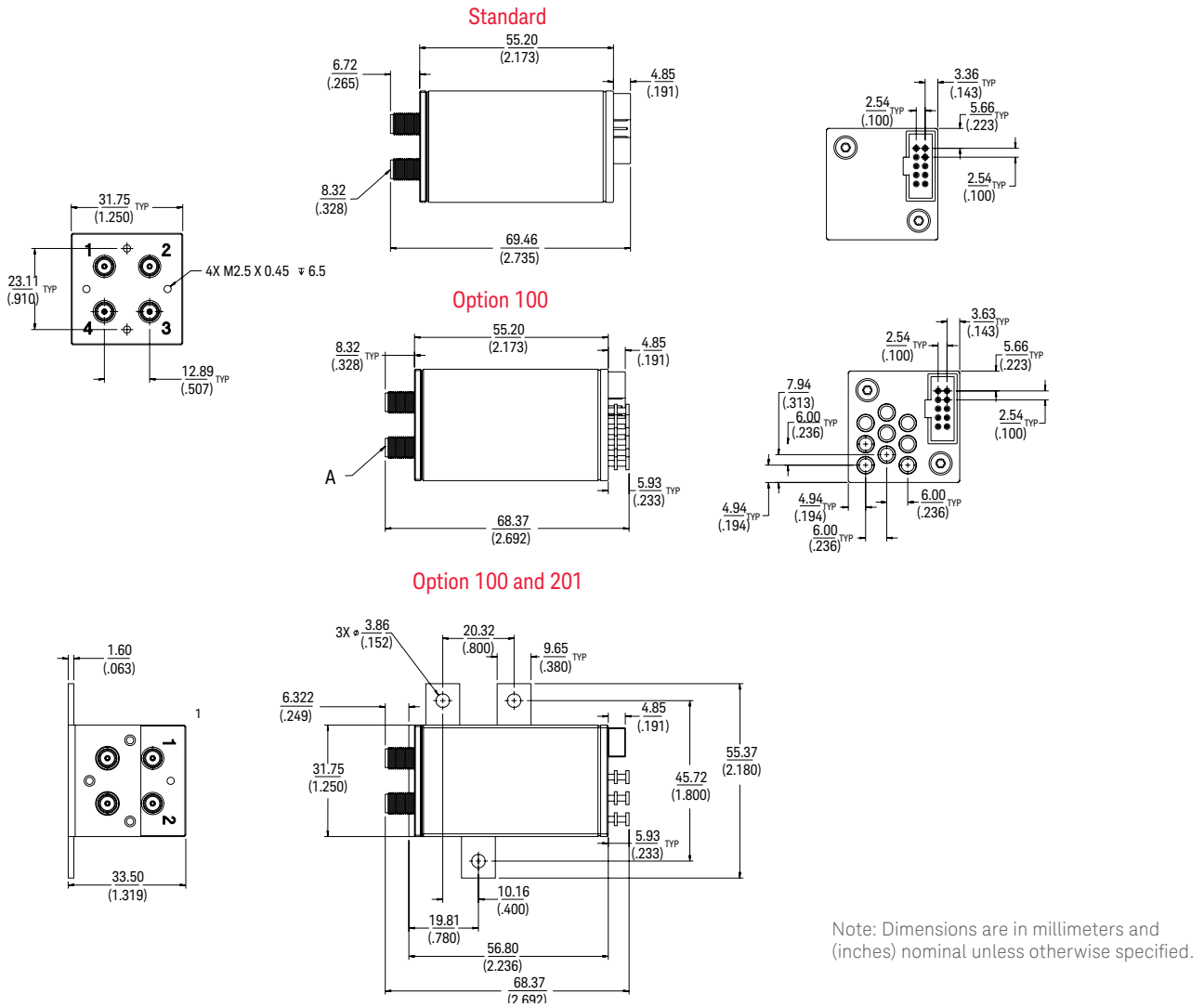


Figure 5.

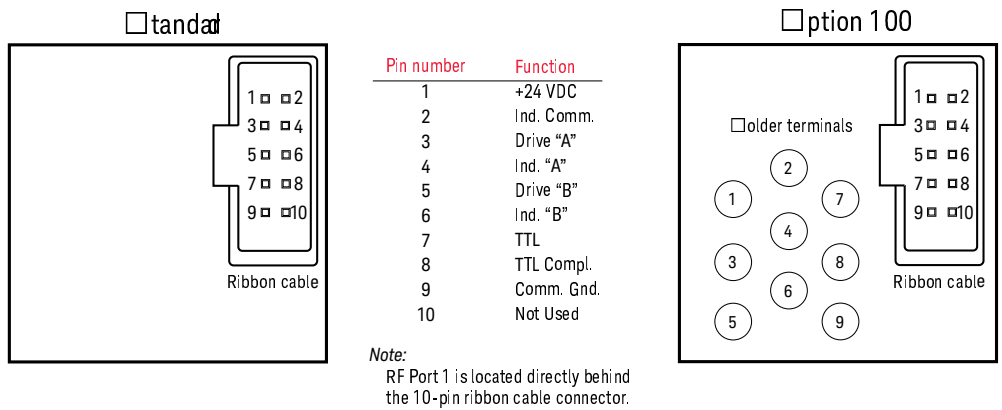


Figure 6. Drive connections

## Driving 87406Q

Each RF path can be closed (selected) by applying ground (TTL “High” for option T24) to the corresponding “drive” pin. To connect to any two ports, apply control signal to the corresponding “drive” pins as shown below. See *Dimension and Drive Connection* for drive connection diagrams.

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

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

RF port			1	2	3	4	5	6
	VDC	GND						
Drive pin	Pin 1	Pin 15	Pin 3	Pin 5	Pin 7	Pin 9	Pin 11	Pin 13
Standard drive			Open	GND <sup>2,3</sup>	Open	Open	GND <sup>2,3</sup>	Open
5 V TTL drive	20 – 32 V	GND <sup>1</sup>	Low	High <sup>2,3</sup>	Low	Low	High <sup>2,3</sup>	Low

Switch drive specifications

Parameter	Conditions	Min	Nom	Max	Units
Supply voltage, Vcc		20	24	32	V
Supply current, Icc	Switching: Pulse width $\geq$ 15 ms: Vcc = 24 VDC <sup>4</sup>		200 <sup>4</sup>		mA
Quiescent current		25		50	mA
Switching speed				15	ms
5 V TTL drive specification (for Option T24 only)					
High level input		3		7	V
Low level input				0.8	V
Max high input current	Vcc = Max; V <sub>input</sub> = 3.85 VDC		1	1.4	mA

Indicator specifications

Maximum withstand voltage: 60 V  
 Maximum current capacity: 150 mA  
 Maximum “ON” resistance: 2.5  $\Omega$   
 Maximum “OFF” resistance: 10 G $\Omega$

### Notes:

- Pin 15 must always be connected to ground to enable the electronic position indicating circuitry and drive logic circuitry.  
**CAUTION: IF PIN 15 IS NOT CONNECTED TO POWER SUPPLY GROUND, CATASTROPHIC FAILURE WILL OCCUR.**
- 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.
- The default operation of the switch is break-before-make. Make-before-break switching can be accomplished by simultaneously selecting the old RF path “drive” pin and the new RF path “drive” pin. This will simultaneously close the old RF path and the new RF path. Once the new path is closed (15 ms), de-select the old RF path “drive” pin while leaving the new RF path “drive” pin selected. The switch circuitry will automatically open the old RF path while leaving the new RF path engaged.
- Closing one RF path requires 200 mA, add 200 mA for each additional RF path closed or opened. Using all RF paths open (selecting pin 16) requires 200 mA per RF path reset with Vcc = 24 VDC.

## 87406Q Dimension and drive connection

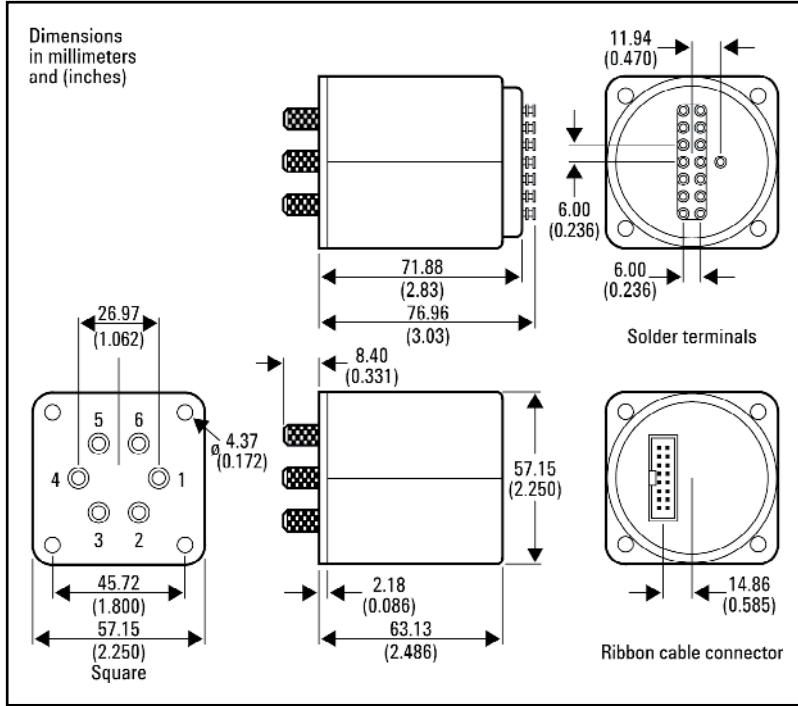


Figure 7. Product outline

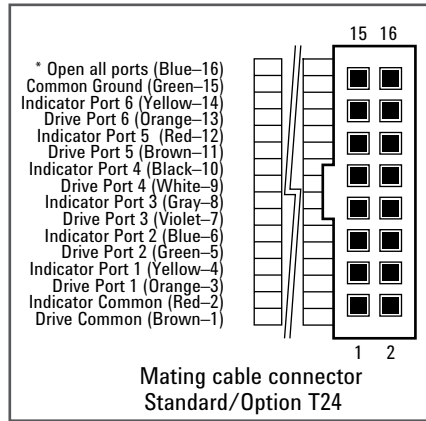
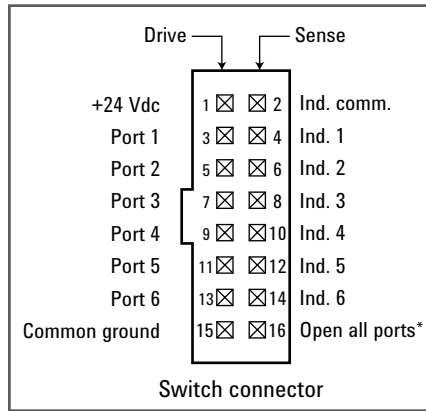


Figure 8. Drive connection diagrams

\* Open all ports pin is not available with Options 100/T24.

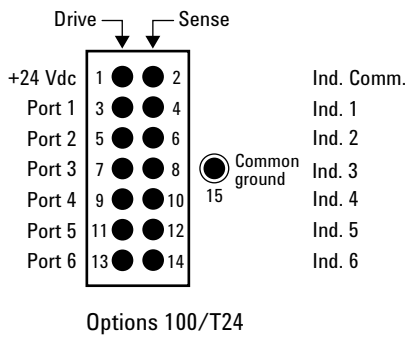


Figure 9. Drive connection diagrams

## Driving 87606Q

Each RF path can be closed (selected) by applying ground to the corresponding “drive” pin. To connect to any two ports, apply ground to the corresponding “drive” pins as shown below. See *Dimension and Drive Connection* for drive connection diagrams.

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

To open RF ports, apply ground to the corresponding drive pins as shown below. See *Dimension and Drive Connection* for drive connection diagrams.

RF port	1	2	3	4	5	6
Drive pin	Pin 4	Pin 6	Pin 8	Pin 10	Pin 12	Pin 14

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

RF port			1		2		3		4		5		6	
	VDC	GND	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Pin 10	Pin 11	Pin 12	Pin 13	Pin 14
Drive pin	Pin 1	Pin 15	Open	GND <sup>2</sup>	GND <sup>2</sup>	Open	Open	Open	Open	Open	GND <sup>2</sup>	GND <sup>2</sup>	Open	Open
Standard drive	20 – 32 V	GND <sup>1</sup>	Open	GND <sup>2</sup>	GND <sup>2</sup>	Open	Open	Open	Open	Open	GND <sup>2</sup>	GND <sup>2</sup>	Open	Open

### Switch drive specifications

Parameter	Conditions	Min	Nom	Max	Units
Supply voltage, Vcc		20	24	32	V
Supply current, Icc	Switching: Pulse width $\geq$ 15 ms: Vcc = 24 VDC <sup>3</sup>		200 <sup>3</sup>		mA
Quiescent current		25		50	mA
Switching speed				15	ms

### Notes:

- Pin 15 must always be connected to ground to enable the electronic position indicating circuitry and drive logic circuitry.  
**CAUTION: IF PIN 15 IS NOT CONNECTED TO POWER SUPPLY GROUND, CATASTROPHIC FAILURE WILL OCCUR.**
- 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.
- Closing one RF path requires 200 mA, add 200 mA for each additional RF path closed or opened. Using all RF paths open (selecting pin 16) requires 200 mA per RF path reset with Vcc = 24 VDC.

## 87606Q Dimension and drive connection

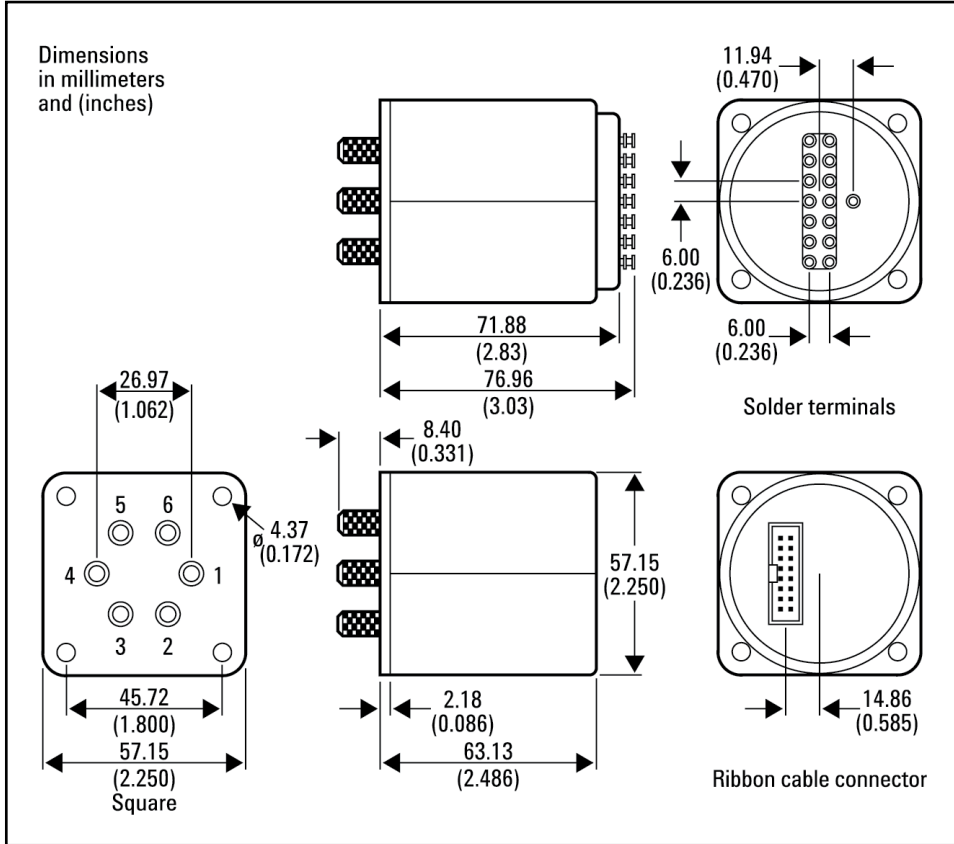


Figure 10. Product outline

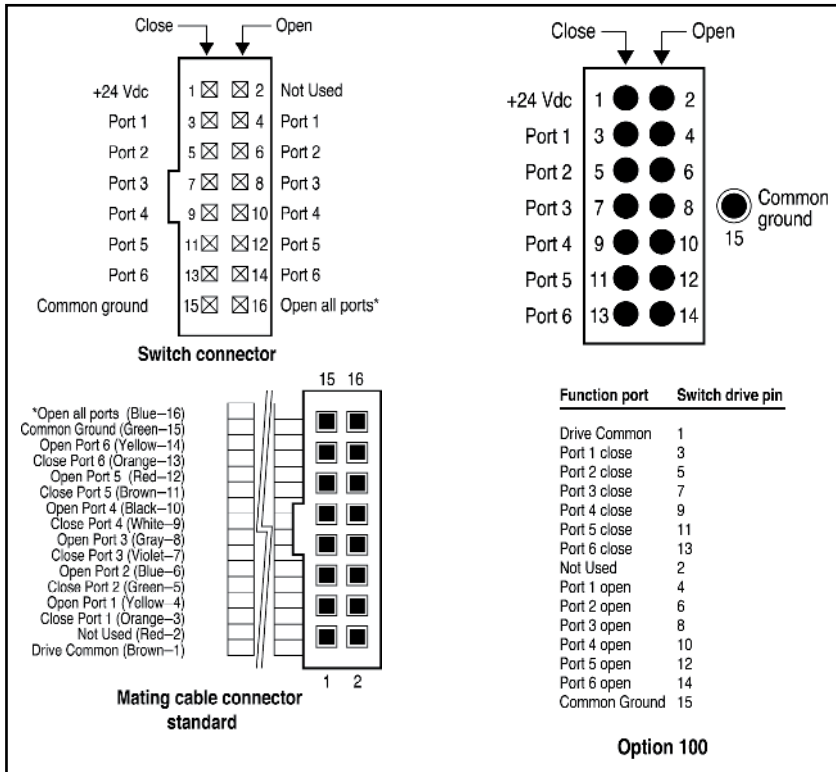


Figure 11. Drive connection diagrams

\* Open all ports pin is not available with Option 100.

## Driving N1810U/10T/11T/12U

There are two positions for the N181x family of switches. Standard switching is accomplished by applying the supply voltage to pin 5 (+V) and grounding either pin 4 (A) or pin 3 (B) to actuate the mechanism to the desired state. See *Dimension and Drive Connection* for pin out diagrams.

RF path (refer to Figure 12)	Standard drive		Single line 5 V TTL drive			
	V+ Pin 5	GND Pin 1	Pin 3	Pin 5	Pin 7	Pin 8
Position A	$V_{supply}$	GND <sup>1,2</sup>	GND <sup>1,2</sup>	Open	High <sup>1,2</sup>	Low
Position B			Open	GND <sup>1,2</sup>	Low	High <sup>1,2</sup>

### RF circuits

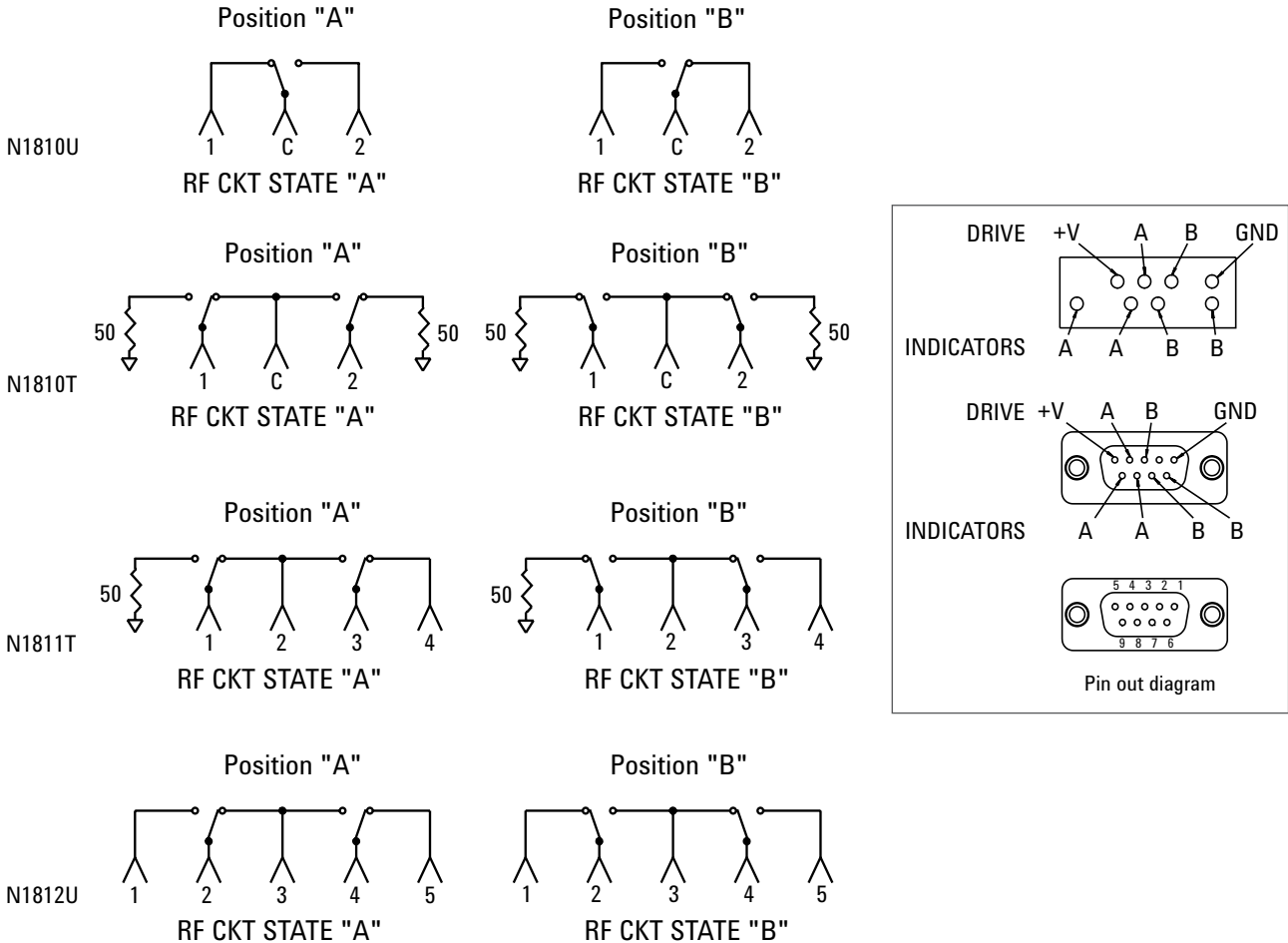


Figure 12.

### Notes:

- Pin 1 (GND) must always be connected to ground.  
**CAUTION: IF PIN 1 IS NOT CONNECTED TO THE POWER SUPPLY GROUND, CATASTROPHIC FAILURE WILL OCCUR.**
- 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.
- The default operation of the switch is break-before-make. Make-before-break switching can be accomplished by simultaneously selecting the old RF path "drive" pin and the new RF path "drive" pin. This will simultaneously close the old RF path and the new RF path. Once the new path is closed (15 ms), de-select the old RF path "drive" pin while leaving the new RF path "drive" pin selected. The switch circuitry will automatically open the old RF path while leaving the new RF path engaged.

## Switch drive specifications

<b>N1810U</b>							
Option	Parameter	Conditions	Min	Nom	Max	Units	
All options	Switching speed				15	ms	
105	Supply voltage, Vcc		4.5	5.0	7.0	V	
	Supply current, Icc	Supply voltage = 5 V		300		mA	
115 <sup>4</sup>	Supply voltage, Vcc		12.5	15.0	20.0	V	
	Supply current, Icc	Supply voltage = 15 V		125		mA	
105 <sup>5</sup>	Supply voltage, Vcc		20.0	24.0	32.0	V	
	Supply current, Icc	Supply voltage = 24 V		75		mA	
5 V TTL drive specification							
401	High level input		3.0		12.0	V	
	Low level input				1.0	V	
	Max high input current	Input voltage = 12.0 V				1.0	mA
		Input voltage = 3.85 V			0.25	0.5	mA
<b>N1810T/N1811T/N1812U</b>							
Option	Parameter	Conditions	Min	Nom	Max	Units	
All options	Switching speed				15	ms	
105	Supply voltage, Vcc		4.5	5.0	7.0	V	
	Supply current, Icc	Supply voltage = 5 V		600		mA	
115 <sup>4</sup>	Supply voltage, Vcc		12.5	15.0	20.0	V	
	Supply current, Icc	Supply voltage = 15 V		250		mA	
105 <sup>5</sup>	Supply voltage, Vcc		20.0	24.0	32.0	V	
	Supply current, Icc	Supply voltage = 24 V		150		mA	
5 V TTL drive specification							
401	High level input		3.0		12.0	V	
	Low level input				1.0	V	
	Max high input current	Input voltage = 12.0 V				1.0	mA
		Input voltage = 3.85 V			0.25	0.5	mA

### Notes:

4. Option 115: Operating life will be less than normal (3 million cycles) when driven at voltage 18 – 20 VDC.
5. Option 124: Operating life will be less than normal (3 million cycles) when driven at voltage 28 – 32 VDC.

# N1810U/10T/11T/12U Dimension and drive connection

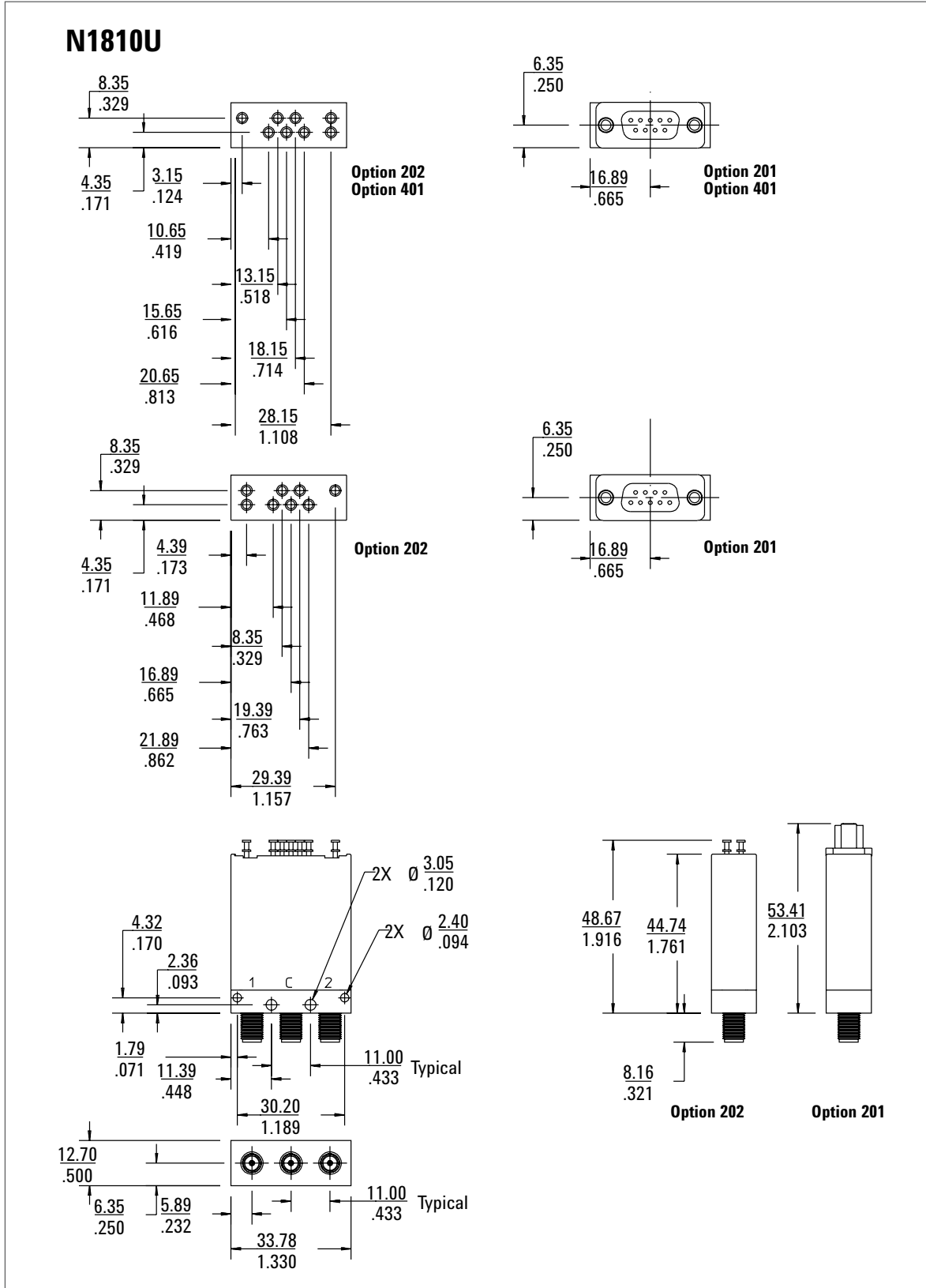


Figure 13.



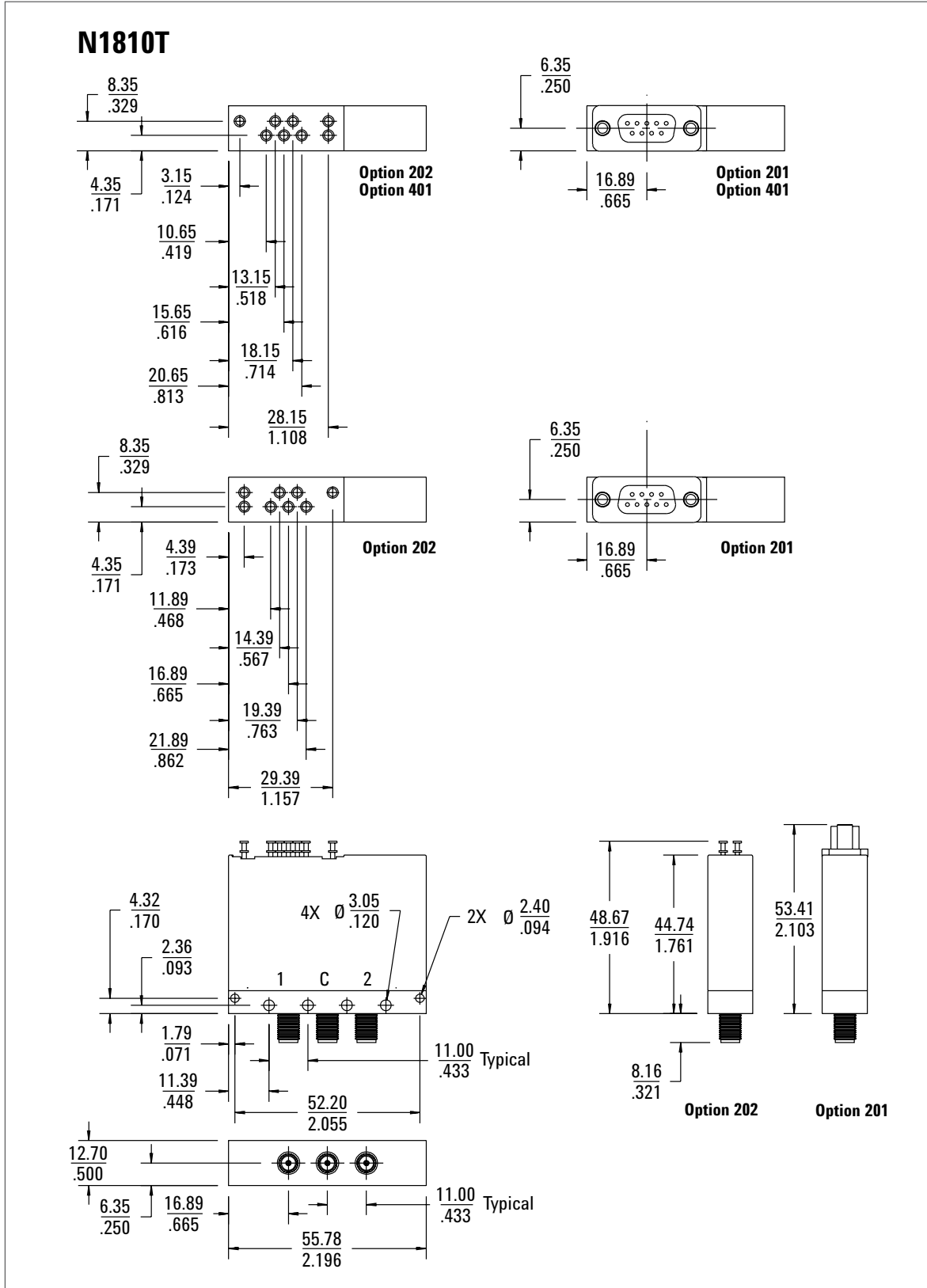


Figure 14.

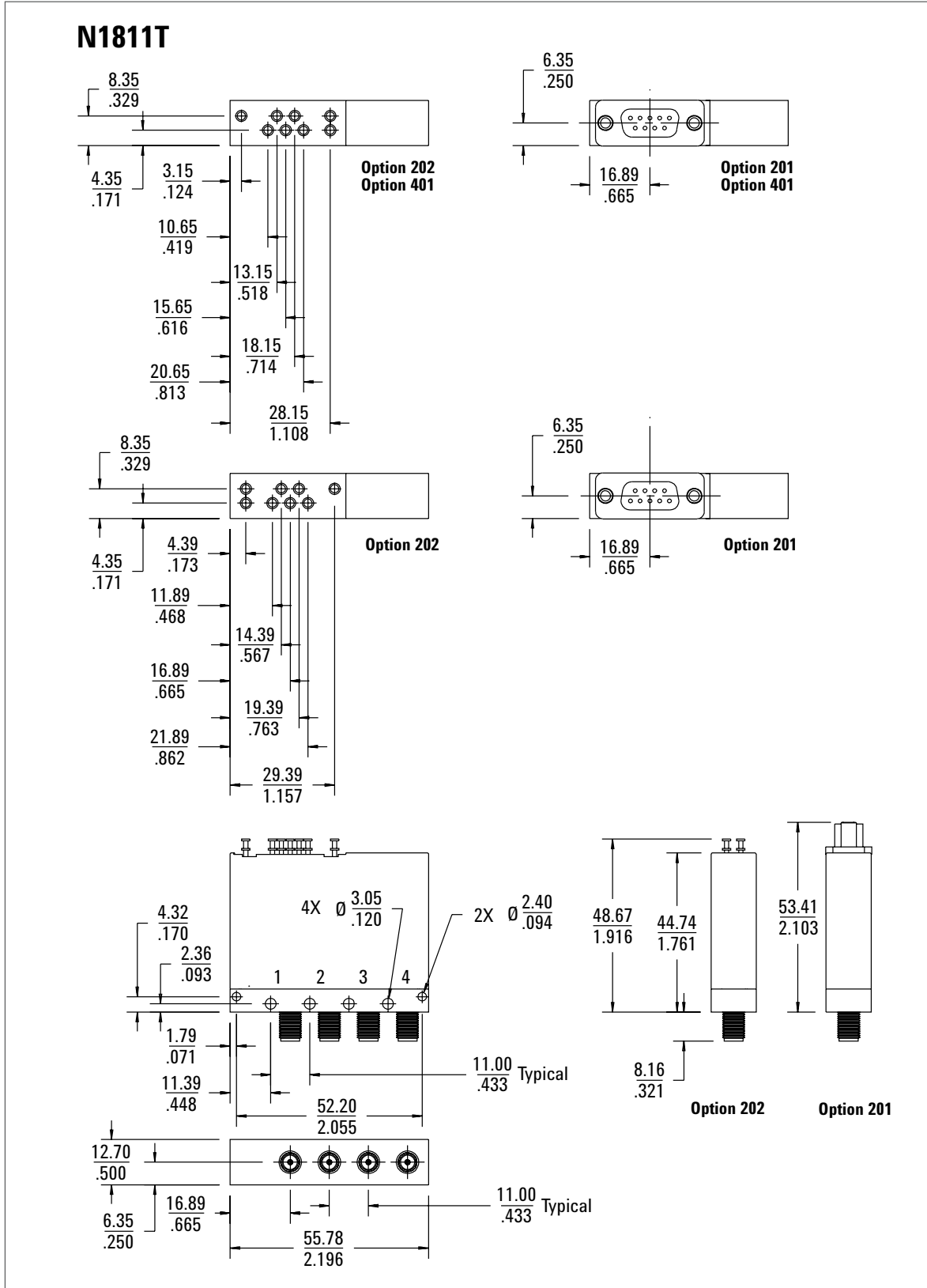


Figure 15.

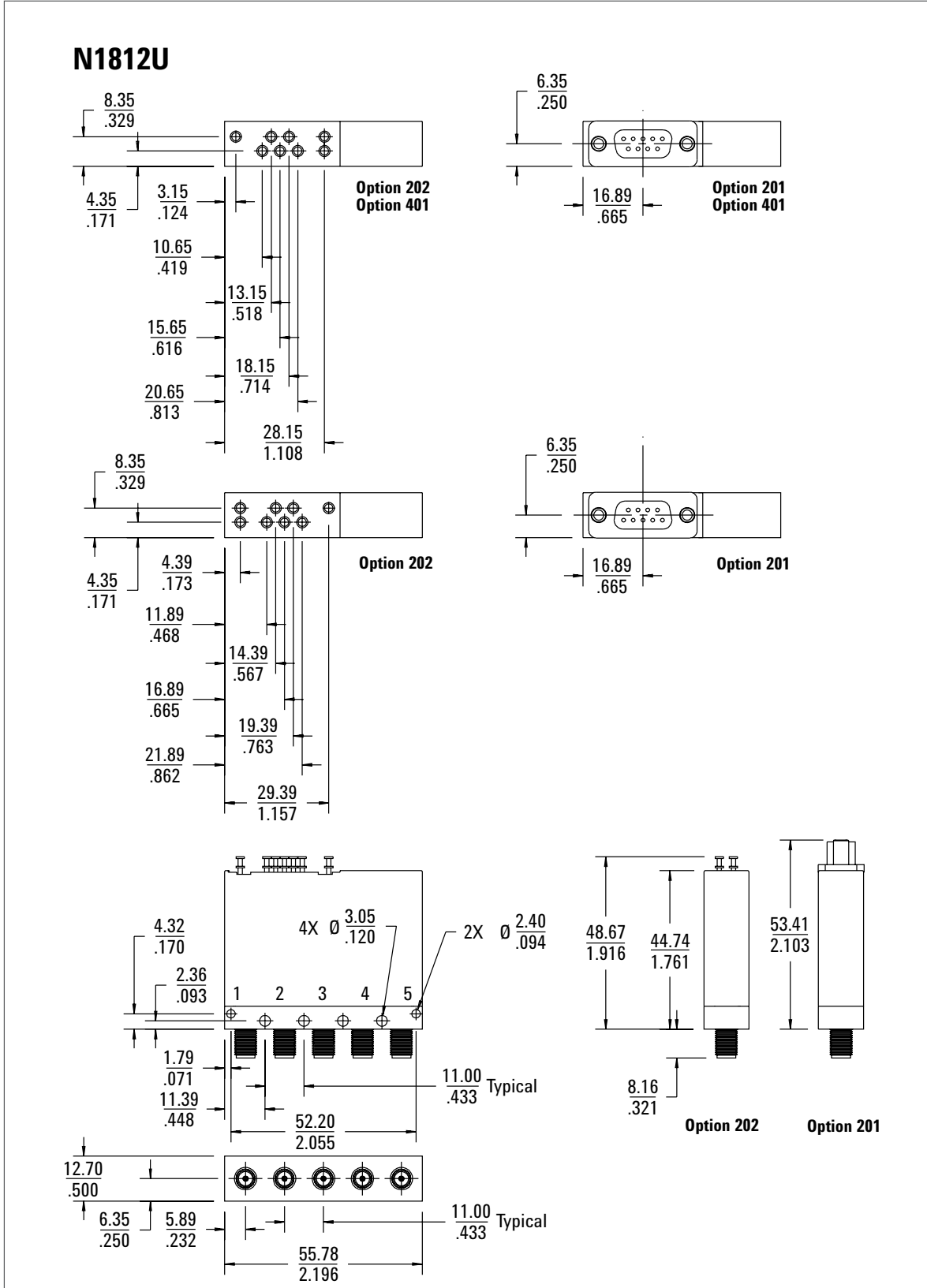


Figure 16.

## Ordering information

Model	Description	16 pin DIP socket and connector with 24 inch ribbon cable	Solder terminals to replace ribbon cable	24 V DC without TTL Logic	TTL/5 V CMOS compatible	Mounting bracket (assembly required)
87104P	DC to 4 GHz, SP4T Terminated	Option 161	Option 100	Option 024	Option T24	N/A
87104Q	DC to 20 GHz, SP4T Terminated	Option 161	Option 100	Option 024	Option T24	N/A
87104R	DC to 26.5 GHz, SP4T Terminated	Option 161	Option 100	Option 024	Option T24	N/A
87106P	DC to 4 GHz, SP6T Terminated	Option 161	Option 100	Option 024	Option T24	N/A
87106Q	DC to 20 GHz, SP6T Terminated	Option 161	Option 100	Option 024	Option T24	N/A
87106R	DC to 26.5 GHz, SP6T Terminated	Option 161	Option 100	Option 024	Option T24	N/A
87222R <sup>1</sup>	DC to 26.5 GHz, Transfer	Option 161	Option 100	N/A	N/A	Option 201
87406Q	DC to 20 GHz, Matrix	Option 161	Option 100	Option 024	Option T24	N/A
87606Q	DC to 20 GHz, Matrix	Option 161	Option 100	N/A	N/A	

Model	Frequency range	Coil voltage	DC connector	Drive (optional)
N1810U: SPDT Un-terminated				
N1810T: SPDT Terminated	004: DC to 4 GHz	105: 5 VDC <sup>2</sup>	201: D-sub 9 pin (f)	401: TTL/5 V CMOS compatible
N1811T: 4-ports Bypass	020: DC to 20 GHz	115: 15 VDC	202: Solder lug	402: Position indicators
N1812U: 5-ports Bypass	026: DC to 26.5 GHz	124: 24 VDC		

1. For 87222R, the connector type is 10 pin DIP socket.
2. Option 105 includes Option 402.



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