Characterization of SPDT RF Switch (Mini-circuits MSP2TA-18-12+)

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Description

The RF switch Mini-circuits MSP2TA-18-12+ was characterized in terms of repeatability and isolation in order to assess its usefulness for EDGES, i.e., for using it to route the antenna either through the LNA/back-end or toward the VNA. The specifications of the switch are provided in its datasheet attached at the end of this document. An important feature of the switch is that it is absorptive, meaning that the inactive output is terminated at 50 Ω.

Two experiments were done:

1. In the first one, the two outputs of the switch were connected to the two VNA ports. A two-port VNA calibration was performed at these ports. Port 1 is located at the panel connector of the VNA. Port 2 is located at the end of a semi-rigid cable. This cable is needed to match the physical dimensions of the switch, and to allow for the connection of the Thru standard between the ports during calibration.

   A 7-dB attenuator is connected to the input of the switch to simulate the reflection coefficient of the antenna, of ~ -14 dB. The experiment consists of switching back and forth between the two outputs (connected to the VNA ports), with the attenuator at the input. The relevant quantities for study are the repeatability of S_{11} (output 1), S_{22} (output 2), and the corresponding transmissions S_{21} (when output 1 is active) and S_{12} (when output 2 is active). A total of 10 intermittent measurements through outputs 1 and 2 were done.
2. The second experiment requires only one VNA port, connected to output 1 of the switch. With output 1 active, a VNA calibration is performed at the input of the switch. During calibration, output 2 of the switch remains open (although it is terminated internally).

   After calibration, the 7-dB attenuator is connected to the input of the switch. Then, output 1 (connected to the VNA) is deactivated and activated 5 times in a row. This serves to set a reference for the repeatability. Five measurements are done with output 2 open, then connected to a Short, a Match, and a 5-dB attenuator. The goal is to see if there is any dependence of the measurements through output 1, on the impedance of the passive load connected at output 2.

The measurements were conducted using an Agilent E5072A VNA in the range 50-200 MHz, with a power of 0 dBm, a bandwidth of 100 Hz, and 10-trace averaging for noise suppression (which takes 10 seconds to compute with the settings described).

The following slides present the results.

Experiment 1

The results of experiment 1 are presented in figure 1. The left side corresponds to measurements with output 1 of the switch active, and the right side with output 2 active. The 10 repetitions are separated into three groups identified by colors, to differentiate between possible scatter due to VNA drift (values increasing or decreasing with time) from scatter due to the switch (random). Since the scatter seems to be primarily random, VNA effects are assumed to be minor (however, more comments on this are presented for experiment 2).

Since the VNA calibration was performed at the *outputs* of the switch, the S_{11} and S_{22} shown in the figure represent the input attenuator *plus* the corresponding paths within the switch. Their average peak-to-peak scatter in magnitude at 200 MHz is 0.005 dB. The scatter in phase for S_{11} (after subtracting the mean) is $\pm$ 0.05°, while for S_{22} it is 6 times larger. The only external difference between the two paths is that there was a 4" semi-rigid cable between output 2 and the VNA panel connector. Thus, the larger scatter could be attributed to an extra effect due to changes in this cable, or alternatively, to differences in the internal paths of the switch. However, this wasn't explored further.

The isolation, expressed as $|S_{21}|$ and $|S_{12}|$, is better than 110 dB. Specifically, S_{21} corresponds to the transmission from output 2 to output 1 when output 1 is the active output of the switch. Equivalently for S_{12}.

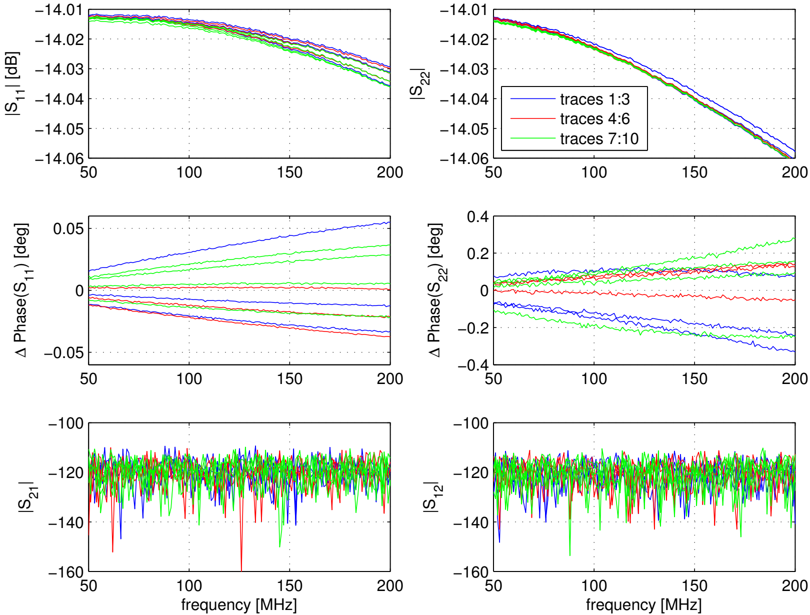


Figure : (1): Results of experiment 1. See previous slide for comments.

Experiment 2

Figure 2 presents the results of experiment 2. The attenuator is measured five times through output 1 of the switch (port 1 of the VNA) after activating and deactivating this path, while the load at output 2 remains constant. The loads at output 2 used are: an open connector, a Short standard, a Match standard, and a 5-dB attenuator.

In general, it is seen that the scatter produced by the different loads is consistent with the scatter due to the repetitions using a constant load, which indicates that the device connected to the inactive output of the switch does not impact the measurement through the active path. It can be argued that there are two exceptions in the plots: i) the magnitude is higher below $\sim$ 130 MHz when the 5-dB attenuator is connected to output 2, and ii) the phase is higher when the Match is connected to output 2. Since the differences are at the 0.001-dB and 0.01° levels, they are assumed as the repeatability limits of the whole measurement setup, representing a combination of several error sources and not necessarily an effect of the actual load at output 2.

It is interesting to note that the scatter found in experiment 2 is lower than that from experiment 1, even though in experiment 2 the load at output 2 of the switch was being changed after the five repetitions of each case, i.e., there was a potential extra source of error. This argues for a degradation in performance in experiment 1 due to the use of two VNA ports, at least with these particular settings. It is a confusing effect nonetheless, since the scatter is random, not following a typical *drift* pattern. Therefore, other aspects of the measurement setup could be responsible.

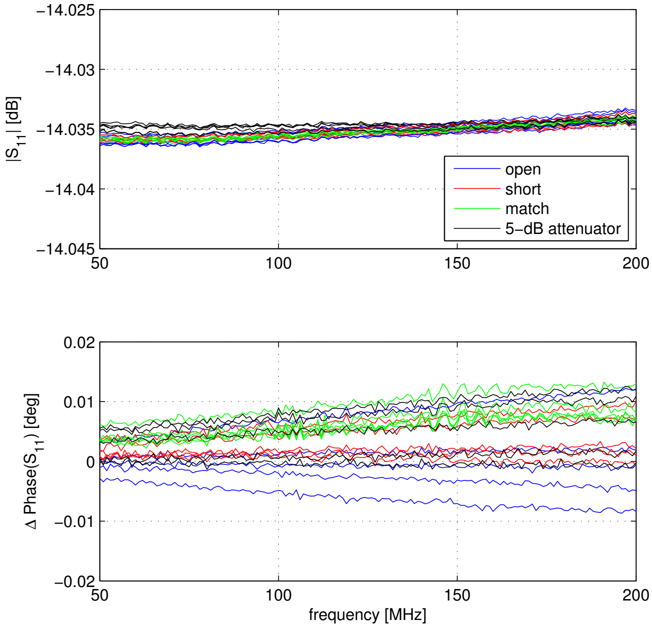


Figure : (2): Results of experiment 2. See previous slide for comments.

Conclusion

- When measuring an attenuator with a reflection coefficient of -14 dB through the switch, the results of experiments 1 and 2 suggest that the switch introduces an S_{11} (S_{22}) scatter of 0.005 dB and 0.6° peak to peak, as upper limits. In fact, when measurements are conducted using only one VNA port, these numbers go down to 0.002 dB and 0.02°, suggesting that some of the scatter observed in experiment 1 is not due to switching but to the VNA or measurement setup.
- The isolation between the outputs of the switch is better than 110 dB. Measurements of a -14-dB load performed through output 1 are affected by the reflection coefficient of the load connected to output 2 at a level of at most 0.002 dB and 0.02° peak to peak.

Xtra Long Life
SPDT Switch

50Ω DC to 18 GHz 12 Volt

MSP2TA-18-12+
MSP2TA-18-12PM+
MSP2TA-18-12BM+

MSP2TA-18-12+

MSP2TA-18-12PM+
Panel Mount

MSP2TA-18-12BM+
Base Mount

Model No.	Connectors	Bracket Option	Price	Qty.
MSP2TA-18-12+	SMA	—	$189.95	(1-9)
MSP2TA-18-12PM+	SMA	Panel Mount	$192.95	(1-9)
MSP2TA-18-12BM+	SMA	Base Mount	$192.95	(1-9)

See Page 2 for Mounting Options Available
Option must be specified when ordering

+RoHS Compliant
The +Suffix identifies RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications

Features

- low voltage operation, 12V
- low insertion loss, 0.25 dB typ.
- high isolation, 80 dB typ.
- high power handling, 10W
- ultra reliable
- break-before-make configuration
- absorptive failsafe switch
- protected by US Patents 5,272,458; 6,414,577;

Applications

- Automatic Test Equipment (ATE)
- reliable "sleeptime" switching
- redundancy switching for microwave radio

Electrical Specifications

Parameter	Condition	Min.	Typ.	Max.	Unit
Frequency Range		DC	—	18	GHz
Insertion Loss	DC - 1 GHz	—	0.10	0.15	dB
	1 - 8	—	0.15	0.30	
	8 - 12	—	0.25	0.40	
	12 - 18	—	0.30	0.50	
Isolation	DC - 1 GHz	85	100	—	dB
	1 - 8	75	90	—	
	8 - 12	70	80	—	
	12 - 18	60	66	—	
VSWR	DC - 1 GHz	—	1.05	1.10	:1
	1 - 8	—	1.20	1.30	
	8 - 12	—	1.20	1.35	
	12 - 18	—	1.15	1.40	
DC Current	at 12V	—	350	430	mA
RF Power Cold Switching[4]	DC - 18 GHz	—	—	10	W
RF Power Hot Switching	Note 1	—	—	0.1	W
	Note 2	—	—	1.0	

Additional Specifications

Operating Voltage Range	12V (nom) ±0.5V
Switching Time (Typ.)	20ms
Life[3] (Min.)	1year/10 million cycles

Notes
1. To achieve specified life, hot switching RF power must not exceed this level.
2. Degradation in life (min.) to typically 3 million switch cycles for hot switch at this RF power level.
3. Tested at 0 dBm RF power.
4. Power handling is specified with RF applied to the IN port and output load connected to either J1 or J2.

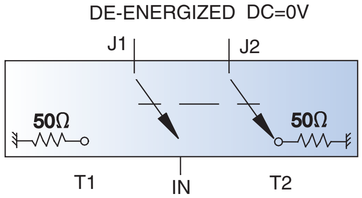
Maximum Ratings

Operating Temperature	-15°C to +45°C
Storage Temperature	-15°C to +45°C
RF Power (at IN port)	10W
RF Power (at J1 and J2)	1W
Control Voltage	13VDC

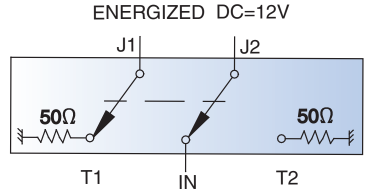
Permanent damage may occur if any of these limits are exceeded.

Switching States

DE-ENERGIZED DC=0V



ENERGIZED DC=12V



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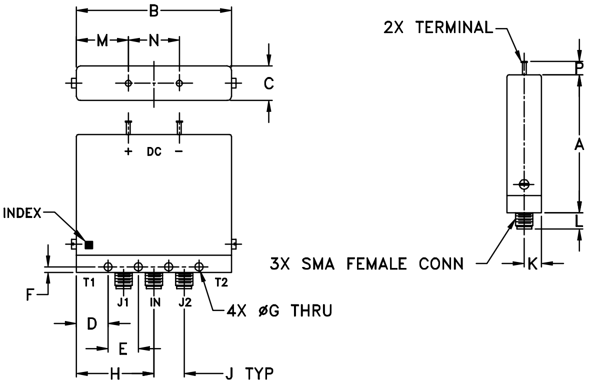
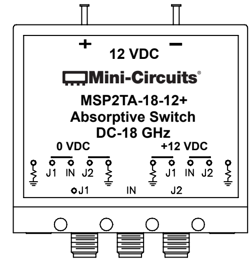
REV. B
M146907
MSP2TA-18-12+
WZ/CP/AM
140616

Outline Drawing (FP914)



MSP2TA-18-12+

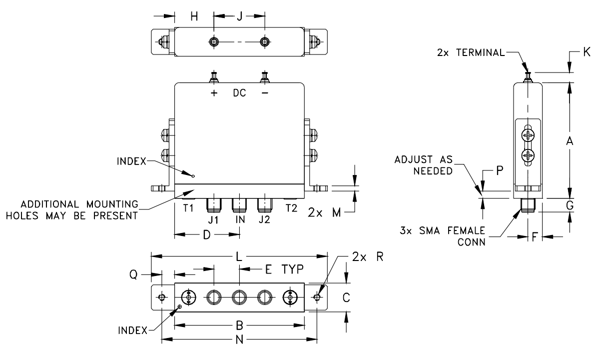
Marking Drawing



Outline Dimensions (inch / mm)

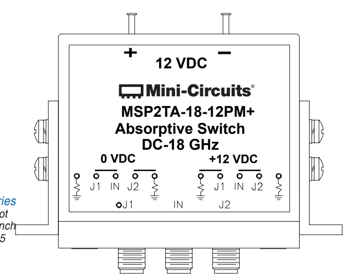
A	B	C	D	E	F	G	H	J	K	L	M	N	P	wt
2.00	2.25	.50	.460	.440	.080	.120	1.125	.440	.25	.24	.755	.740	.19	grams
50.80	57.15	12.70	11.68	11.18	2.03	3.05	28.58	11.18	6.35	6.10	19.18	18.80	4.83	93.1

Outline Drawing (FP914-PM) *Panel Mount Bracket*



MSP2TA-18-12PM+
Panel Mount Option

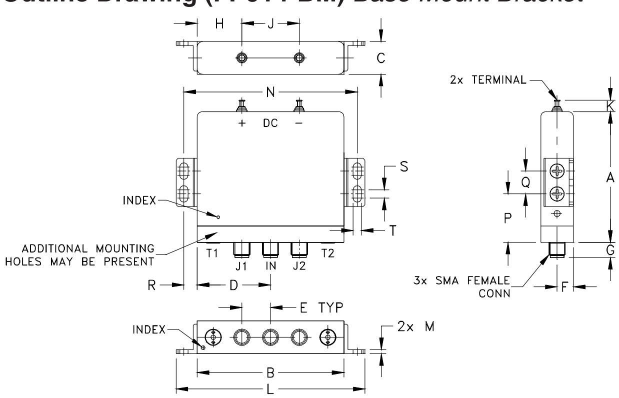
Marking Drawing



Outline Dimensions (inch / mm)

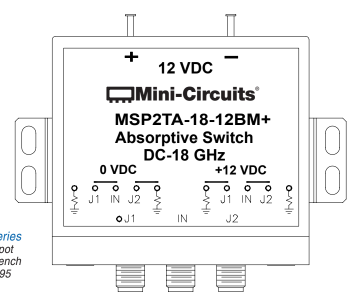
A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	wt
2.00	2.25	.50	1.125	.440	.25	.24	.755	.740	.19	3.05	.094	2.69	0 MIN/.25 MAX	.22	#4-40	grams
50.80	57.15	12.70	28.58	11.18	6.35	6.10	19.18	18.80	4.83	77.47	2.39	68.33	0 MIN/6.35 MAX	5.59	--	102

Outline Drawing (FP914-BM) *Base Mount Bracket*



MSP2TA-18-12BM+
Base Mount Option

Marking Drawing

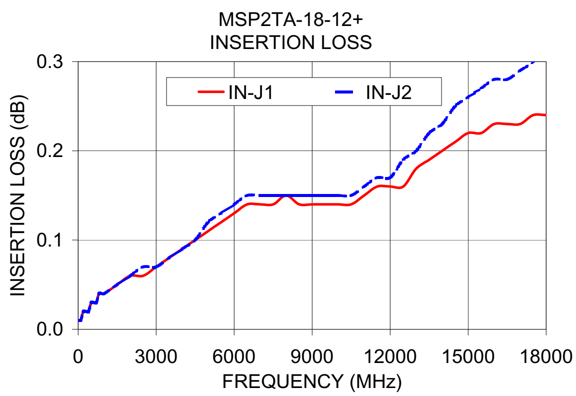


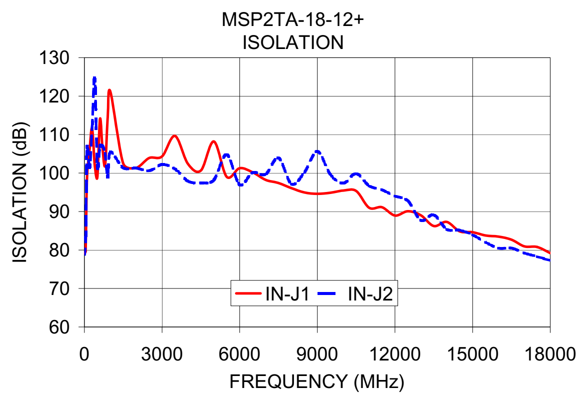
Outline Dimensions (inch / mm)

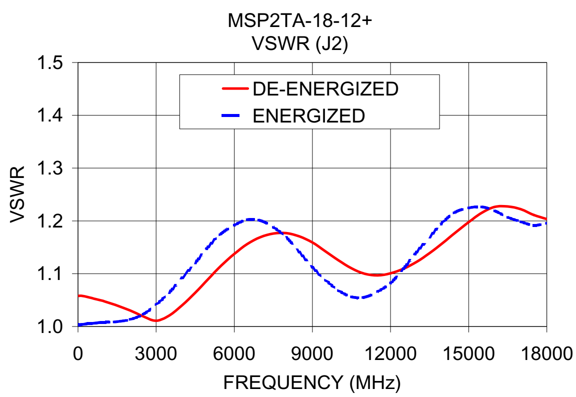
A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	wt
2.00	2.25	.50	1.125	.440	.25	.24	.755	.740	.19	2.90	.062	2.660	.19	.350	.205	.125	.125	grams
50.80	57.15	12.70	28.58	11.18	6.35	6.10	19.18	18.80	4.83	73.66	1.57	67.56	4.83	8.89	5.21	3.18	3.18	96.6

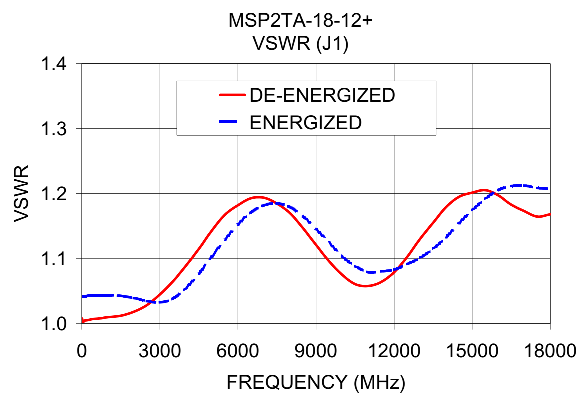
Typical Performance Data

FREQ. (MHz)	ON INSERTION LOSS (dB)		OFF ISOLATION (dB)		VSWR, IN (:1)		VSWR (J2) (:1)		VSWR (J1) (:1)	
	IN-J2	IN-J2	IN-J1	IN-J2	De-Energized	Energized	De-Energized	Energized	De-Energized	Energized
10.0	0.01	0.01	79.15	78.83	1.00	1.01	1.06	1.00	1.01	1.04
100.0	0.01	0.01	98.51	106.49	1.00	1.00	1.06	1.00	1.00	1.04
1000.0	0.04	0.04	121.18	105.44	1.01	1.01	1.05	1.01	1.01	1.04
2000.0	0.06	0.06	101.35	101.29	1.01	1.02	1.03	1.01	1.02	1.04
3000.0	0.07	0.07	104.33	102.22	1.04	1.05	1.01	1.04	1.04	1.03
4000.0	0.09	0.09	102.39	97.90	1.09	1.09	1.04	1.09	1.09	1.05
5000.0	0.11	0.12	108.21	98.20	1.15	1.14	1.09	1.15	1.14	1.10
6000.0	0.13	0.14	101.25	96.96	1.20	1.18	1.14	1.19	1.18	1.15
7000.0	0.14	0.15	98.22	99.67	1.20	1.19	1.17	1.20	1.19	1.18
8000.0	0.15	0.15	96.08	97.15	1.17	1.16	1.18	1.17	1.17	1.18
9000.0	0.14	0.15	94.61	105.59	1.11	1.12	1.16	1.11	1.12	1.15
10000.0	0.14	0.15	95.45	97.35	1.07	1.07	1.13	1.07	1.08	1.10
11000.0	0.15	0.16	90.97	96.67	1.05	1.06	1.10	1.06	1.06	1.08
12000.0	0.16	0.17	88.97	94.03	1.08	1.08	1.10	1.08	1.08	1.08
13000.0	0.18	0.20	89.02	87.71	1.15	1.13	1.12	1.14	1.13	1.10
14000.0	0.20	0.23	87.29	85.40	1.21	1.18	1.16	1.20	1.18	1.13
15000.0	0.22	0.26	84.63	83.93	1.23	1.20	1.20	1.22	1.20	1.17
16000.0	0.23	0.28	83.48	80.49	1.21	1.20	1.23	1.22	1.20	1.21
17000.0	0.23	0.29	80.95	79.21	1.16	1.17	1.22	1.20	1.17	1.21
18000.0	0.24	0.32	79.20	77.24	1.16	1.17	1.20	1.20	1.17	1.21









Additional Notes

A. Performance and quality attributes and conditions not expressly stated in this specification document are intended to be excluded and do not form a part of this specification document.

B. Electrical specifications and performance data contained in this specification document are based on Mini-Circuit's applicable established test performance criteria and measurement instructions.

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