SPDT 50W/125W$_{peak}$ RF Switch 1 MHz to 5.0 GHz

Features

- Frequency Range 1 MHz to 5.0 GHz
- Low insertion loss:
  0.25 dB @ 1.0 GHz
  0.35 dB @ 3.0 GHz
  0.50 dB @ 5.0 GHz
- High isolation:
  39 dB @ 1.0 GHz
  27 dB @ 3.0 GHz
  18 dB @ 5.0 GHz
- 50 W CW Power, 125 W$_p$ Peak Power
- Low power consumption, less than 1 mW
- No external DC blocking capacitors on RF lines
- All RF ports OFF state
- Versatile 2.6...5.25 V power supply
- No need to supply negative voltages

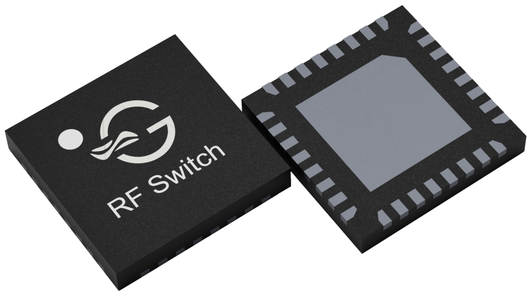


Figure 1: TS8021N in 5.0 x 5.0 mm^2 QFN 32-pin package.

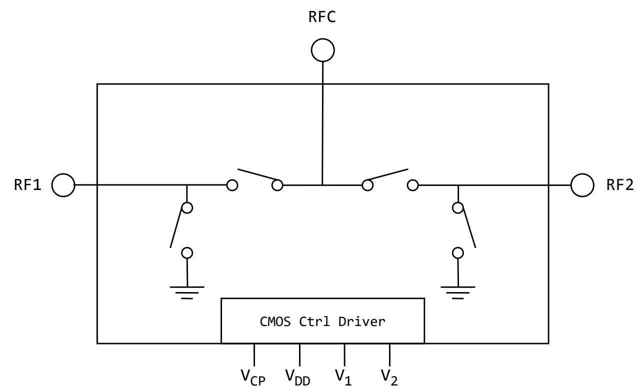


Figure 2: TS8021N functional diagram

Applications

- Private mobile and defense radios
- Public safety handsets
- Cellular infrastructure
- Satellite terminals
- Datalinks

General Description

The TS8021N is a 2nd Generation symmetrical reflective Single Pole Dual Throw (SPDT) switch designed for high power switching applications. The TS8021N covers 1 MHz to 5.0 GHz bandwidth and provides low insertion loss, high isolation, and high linearity within a small package size. The TS8021N is a 50 W CW with peak power capability of 125 W, switch suitable for applications requiring low insertion loss, high isolation, and high linearity.

The TS8021N is packaged into a compact Quad Flat No lead (QFN) 5.0x5.0 mm^2 16 leads plastic package.

RoHS/Reach/Halogen free

Ordering information

Table 1: Ordering Information

Device Part Number	Package Type	Notes
TS8021N	32-Pin 5.0x5.0x0.85 mm^3 QFN	Core part number
TS8021N-EVB	Evaluation Board	
TS8021NMTRPBF[1]	330 mm reel, 3 000pcs	Full reel

[1] MTRPBF - M: Manufacturing, TR: Tape and Reel, and PBF: lead free.

Table 2: Tape and Reel Information

Form	Quantity	Reel Diameter	Reel Width
Tape and Reel	3 000	13” (330mm)	18mm

Pin Assignment

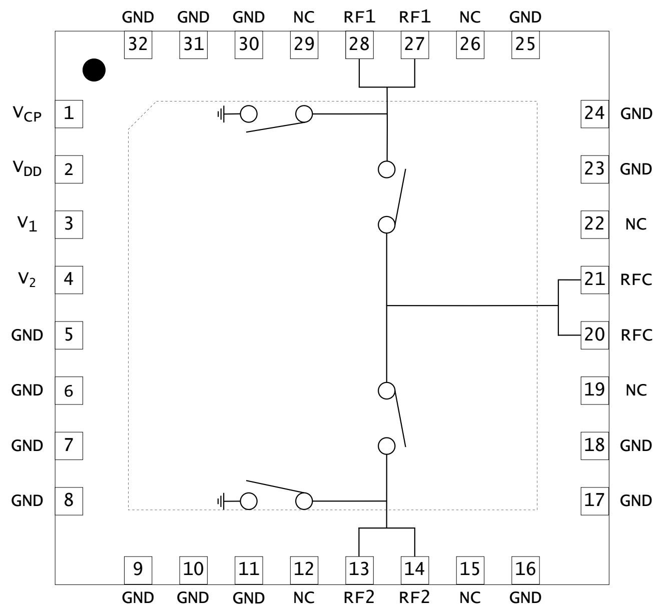


Figure 3: TS8021N pin assignment [top view]

Table 3: Pin Definition

Pin Number	Pin Name	Decription
1	V_{CP}	Internal charge pump voltage output, connect a 1nF capacitor to GND on this node.
2	V_{DD}	DC Power Supply
3	V_1	Switch control input 1
4	V_2	Switch control input 2
13, 14	RF2	RF port 2, please connect together
20, 21	RFC	RF Common port / Antenna port, please connect together
27, 28	RF1	RF port 1, please connect together
12,15,19,22,26,29	NC	NC, Do not connect for adequate clearance and creepage
5,6,7,8,9,10,11	GND	Connect to ground[2]
16,17,18		
23,24,25,30,31,32		
33 [1]	GND	Ground thermal pad, please connect to GND

[1] The backside ground (thermal) pad of the package must be grounded directly to the ground plane of PCB with multiple vias, and adequate heat sinking must be used to ensure proper operation and thermal management.
[2] These pins are NC pins inside the package. To avoid floating pins around RF lines, we request these to be connected to ground.

Absolute Maximum Ratings

Table 4: Absolute Maximum Ratings $T_A = +25$°C unless otherwise specified[1].

Parameter	Symbol	Value	Unit
Electrical Ratings			
Power Supply Voltage	V_{DD}	5.5	V
Storage Temperature Range	T_{st}	-55...+125	°C
Operating Temperature Range	T_{op}	-40...+85	°C
Maximum Junction Temperature	T_j	+140	°C
Max RF CW input power, $\geq$ 400MHz[3]	RFx/RFC	48	dBm
Max RF CW input power, 10-400MHz[3]	RFx/RFC	47	dBm
Max RF CW input power, $\geq$ 400MHz, 20% duty cycle, 2.0 ms pulse [2,3]	RFx/RFC	50	dBm
Max RF peak input power, $\geq$400MHz, 1% duty cycle, 10 μs pulse [2]	RFx/RFC	52	dBm
Max RF peak voltage 30MHz	RFx/RFC	100	V
Max RF peak voltage 800MHz	RFx/RFC	100	V
Thermal Ratings			
Thermal Resistance (junction-to-case) – Bottom side	$R_{\theta jc}$	5.0	°C/W
Soldering Temperature	T_{solder}	+260	°C
ESD Ratings			
Human Body Model (HBM)	Level 1B	500...$<$1000	V
Charged Device Model (CDM)	Level C3	$\geq$1000	V
Moisture Rating			
Moisture Sensitivity Level[4]	MSL	1	

[1] Maximum ratings are absolute ratings. Exposure to absolute maximum rating conditions for extended periods may affect device reliability and can cause permanent damage to the device. Exceeding one or a combination of the absolute maximum ratings may cause permanent and irreversible damage to the device and/or to surrounding circuit. Functional operation of the device is not implied in any conditions above those indicated in the Electrical Specifications section.
[2] Test frequency 800MHz.
[3] See Power De-rating table for low frequencies.
[4] Tagore recommends to store part in moisture barrier bags to preserve solderability.

Electrical Specifications

Table 5: Electrical Specifications $T_A = +25^{\circ}\mathrm{C}; \mathrm{V_{DD}} = +3.3\mathrm{V}; 50\Omega$ Source/Load.

Parameter	Condition	Minimum	Typical	Maximum	Unit
Operating frequency	f	1		5000	MHz
Insertion loss	30 MHz		0.15		dB
unmatched, upto 3.5 GHz	1.0 GHz		0.20	0.30	dB
$\mathrm{RFC - RFx}$	3.0 GHz		0.45		dB
	3.5 GHz		0.70		dB
Insertion loss[1]	30 MHz		0.15		dB
matched upto 5.0 GHz	1.0 GHz		0.25		dB
$\mathrm{RFC - RFx}$	3.0 GHz		0.35		dB
	5.0 GHz		0.50		dB
Isolation	30 MHz		50		dB
unmatched, upto 3.5 GHz	1.0 GHz		43		dB
$\mathrm{RFC - RFx}$	3.0 GHz		27		dB
	3.5 GHz		25		dB
Isolation[1]	30 MHz		50		dB
matched upto 5.0 GHz	1.0 GHz		39		dB
$\mathrm{RFC - RFx}$	3.0 GHz		27		dB
	5.0 GHz		18		dB

[1] Matched values are not guaranteed as they include performance of matching components. These components are beyond control of TagoreTech and therefore given values are indications, not guaranteed values.

Table 6: Electrical Specifications $T_A = +25^{\circ}\mathrm{C}; \mathrm{V_{DD}} = +3.3\mathrm{V}; 50\Omega$ Source/Load.

Parameter	Condition	Minimum	Typical	Maximum	Unit
Operating frequency	f	1		5000	MHz
Return Loss	30 MHz		-30		dB
unmatched, upto 3.5 GHz	1.0 GHz		-22		dB
$\mathrm{RFC - RFx}$	3.0 GHz		-14		dB
	3.5 GHz		-13		dB
Return Loss[1]	30 MHz		-30		dB
matched upto 5.0 GHz	1.0 GHz		-17		dB
$\mathrm{RFC - RFx}$	2.0 GHz		-13		dB
	3.0 GHz		-17		dB
	4.0 GHz		-17		dB
	5.0 GHz		-17		dB

[1] Matched values are not guaranteed as they include performance of matching components. These components are beyond control of TagoreTech and therefore given values are indications, not guaranteed values.

Table 7: Electrical Specifications $T_A = +25^{\circ}\mathrm{C}; \mathrm{V_{DD}} = +3.3\mathrm{V}; 50\Omega$ Source/Load.

Parameter	**Condition**	**Minimum**	**Typical**	**Maximum**	**Unit**
Operating frequency	f	1		5000	MHz
Harmonic Distortion					
H_2	800MHz, P_{in} =45dBm		-86		dBc
H_3	800MHz, P_{in} =45dBm		-89		dBc
IIP3	800MHz		71		dBm
Power and Compression point					
P_{maxCW}[2]	Max RF CW Power 400-f_{max}		47		dBm
P_{maxCW}[2]	Max RF CW Power 10-400		46		dBm
P_{maxpeak}	Max RF Peak Power 400-f_{max}		51		dBm
$P_{\mathrm{maxhot\ RFx}}$[5]	Max RF CW Power, hot switching		40		dBm
$P_{\mathrm{maxhot\ RFC}}$[5]	Max RF CW Power, hot switching		40		dBm
$P_{\mathrm{0.1dB}}$	800MHz, CW		47		dBm
P_{1dB}[1]	800MHz, CW		49		dBm
$P_{\mathrm{peak0.1dB}}$	800MHz, 1% duty cycle, 10μs pulse		48		dBm

[1] $P_{1\,\mathrm{dB}}$ has been given for comparison reasons only. Please do not exceed Absolute Maximum ratings.
[2] See Power De-rating table
[5] Dependent on thermal design and surrounding circuits.

Table 8: Electrical Specifications $T_A = +25^{\circ}\mathrm{C}; \mathrm{V}_{\mathrm{DD}} = +3.3\mathrm{V}; 50\Omega$ Source/Load.

Parameter	Condition	Minimum	Typical	Maximum	Unit
Operating frequency	f	1		5000	MHz
Noise					
CP switching noise[4]	RBW=1kHz		-140		dBm
Switching Time					
t_{ON}	Switch ON time		5.2	9.0	μs
t_{OFF}	Switch OFF time		5.2	9.0	μs
t_{RISE}	Switch RISE time		4.5	5.0	μs
t_{FALL}	Switch FALL time		4.5	7.0	μs
t_{wON}	Minimum Switch ON time		3.6		μs
t_{wOFF}	Minimum Switch OFF time		3.6		μs
f_{PRR}, $C_{\mathrm{VCP}} = 1\mathrm{nF}$[3]	Maximum pulse repetition rate		1		kHz
f_{PRR}, $C_{\mathrm{VCP}} = 10\mathrm{nF}$[3]	Maximum pulse repetition rate		1.4		kHz
f_{PRR}, $C_{\mathrm{VCP}} = 100\mathrm{nF}$[3]	Maximum pulse repetition rate		1.8		kHz
f_{PRR}, $V_{\mathrm{CPext}} = -18\,\mathrm{V}$[6]	Maximum pulse repetition rate		>20		kHz
t_{startup}, $C_{\mathrm{VCP}} = 1\mathrm{nF}$[3]	startup time		0.8		ms
t_{startup}, $C_{\mathrm{VCP}} = 10\mathrm{nF}$[3]	startup time		7		ms
t_{startup}, $C_{\mathrm{VCP}} = 100\mathrm{nF}$[3]	startup time		40		ms
Power Supply, DC					
Control voltage	Power Supply V_{DD}	2.6	3.3	5.25	V
	All control pins high, V_{ih}	1.0	3.3	5.25	V
	All control pins low, V_{il}	-0.3	0	0.5	V
Control current	All control pins high, I_{ih}			7.5	μA
	All control pins low, I_{il}		0		μA
Current consumption	I_{DD}, active mode (V_{DD} on)		160	260	μA

[3] With internal charge pump and with C_{VCP}.
[4] Above 250 MHz. For operation at VHF frequencies, below 250 MHz, consider charge pump bypass switch version, if charge pump noise is critical for your application. Please contact TagoreTech for more information.
[5] Dependent on thermal design and surrounding circuits.
[6] External -18 V applied to V_{CP} pin.

Switching time definition

Example of the definition by using 10 W/40 dBm signal. We apply 10W signal to RF port, stabilized with isolator. Isolator is needed as our switch shows to RF port approximately 4Ω impdance. Lets assume that that switch insertion loss is 0.3 dB. Therefore 90% of the RF signal is 39.55 dBm and 10% of the RF signal is 1W/30dBm. We need to take into account 0.3dB insertion loss, therefore numbers are 39.25 dBm and 29.7 dBm respectively. We change the control from low to high and our time reference point is when our control signal exceeds lower threshold value V_{ihlow}. In certain measurements when control signal rise time is significantly shorter than RF output signal, we approximate start of the clock with 50% point of of control signal.

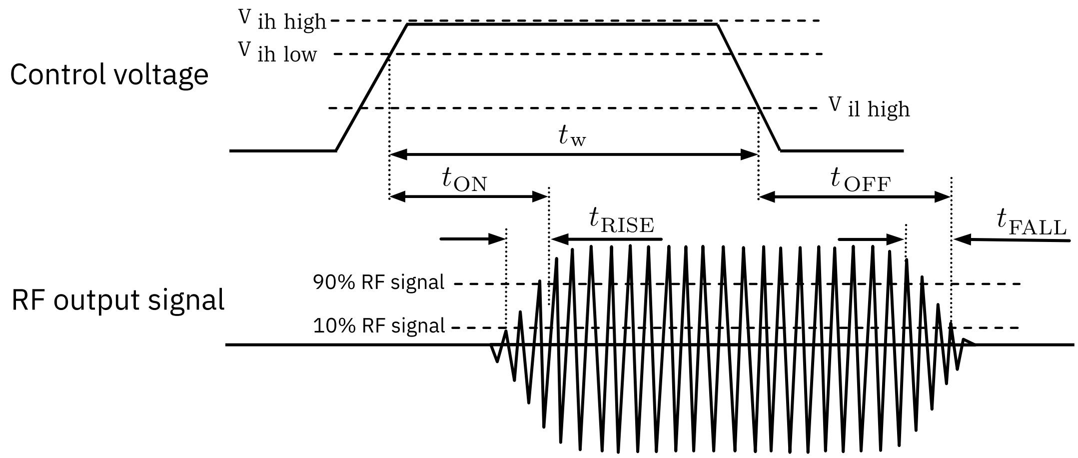


Figure 4: Switching time definition, t_{ON}, t_{OFF}, t_{RISE}, t_{FALL}. Minimum pulse width t_w.

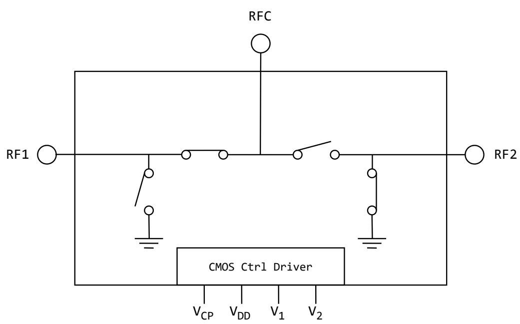
Our component uses integrated charge pump. Maximum pulse repetition rate defines what is maximum frequency for switching events. Please do not exceed given maximum frequency. By feeding external -18 V to V_{CP}, one can improve maximum pulse repetition rate f_{PRR}. Feeding external -18V to V_{CP}, one can drive switch at least to 20kHz f_{PRR}. Expect current consumption of 10mA of -18V.

Switch Control table

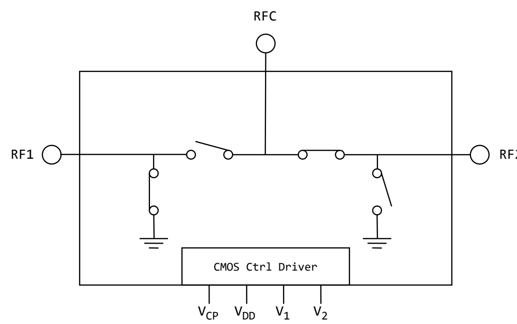
Table 9: Switch Control Table

V_{DD}[1]	V_2	V_1	**Switch state**
1	0	0	$RFC - RF1$ ON[2]
1	0	1	$RFC - RF2$ ON
1	1	0	ISO (Isolation), RFC port open, RF ports shorted[3].
0	0	0	V_{DD} off (Isolation), all FETs are on, short shown to RFC and RF ports

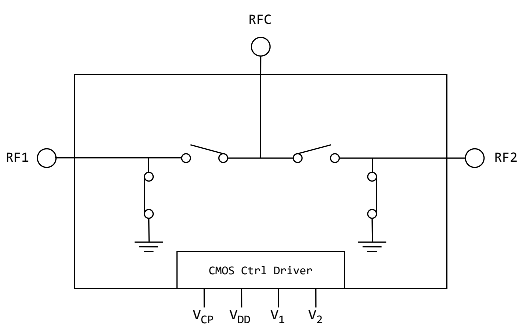
[1] V_{DD} should be applied first before V_1 and V_2, otherwise may cause damage to the device.
[2] There are internal pull-downs to ground on both V_1 and V_2 control pins, the state at start-up without any control voltage applied will be $RFC - RF1$ ON.
[3] If ISO state is not used, the switch can be operated with single control pin V_1



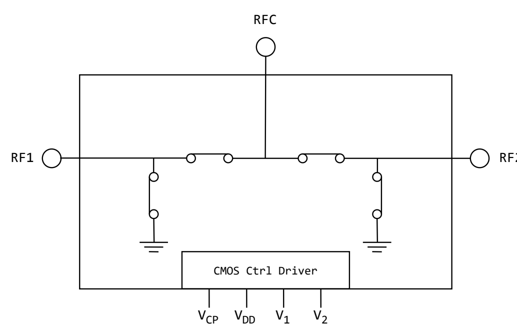
RFC-RF1 ON



RFC-RF2 ON



ISO (Isolation state)



V_{DD} off state

Theory of Operation

Isolation modes

TS8021N has two isolation modes. Both Isolation mode measurements are shown at electrical performance section. Both modes described below.

Device powered off

When V_{DD} is 0V, all switch RF transistors are on, ie. every MOSFET is on. This means that series MOSFETS and shunt MOSETs are conducting. Every RF port is essentially connected to ground, including RFC port. This is practical when device is directly connected to RFC, there is certain protection against induced electrical fields. This can partially protect radio equipment against electrical fields, when device is not in usage.

Device powered, ISO state

In this state, series MOSFETs are OFF, ie. OPEN and shunt MOSFETs are on, ie. closed. RF1 to RF2 isolation is maximum and antenna is completely isolated. RFC port is open, whereas RFx ports are showing effectively short. Low frequency isolation in this case is approximately 60dB as basically there is DC block due to open FETs.

Feeding external V_{CP} voltage of -18 V

TS8021N supports external voltage supply to V_{CP} to increase pulse repetition rate f_{PRR}. With external voltage supply, f_{PRR} can be increased at least to support pulse repetition rate more than 20 kHz, in some cases even up to 100 kHz. In order to use external voltage, it is mandatory to supply first V_{DD}, have a delay of 1 ms and then apply -18 V to V_{CP}. Shutdown should be in opposite order.

Applications

TS8021N is offering 50 W/125 W_{peak} capability from 1 MHz to 5,000 MHz frequency band. Applications include narrowband and multi-octave wideband radios, jammers, EMC testing, public mobile radios, industrial and scientific applications. In the past, such applications were covered with power hungry and complex PIN diodes, TS8021N significantly reduces design complexity for such RF switching needs. TS8021N works well upto 2.5 GHz frequency without external matching components, for frequency above 2.5 GHz, matching is recommended. Datasheet provides an example matching and its performance.

Schematics and Evaluation Board

S-parameters of the both presented EVBs can be downloaded from link: Download TS8021N S-parameters

Table 10: Port definitions in s-parameter files and plots.

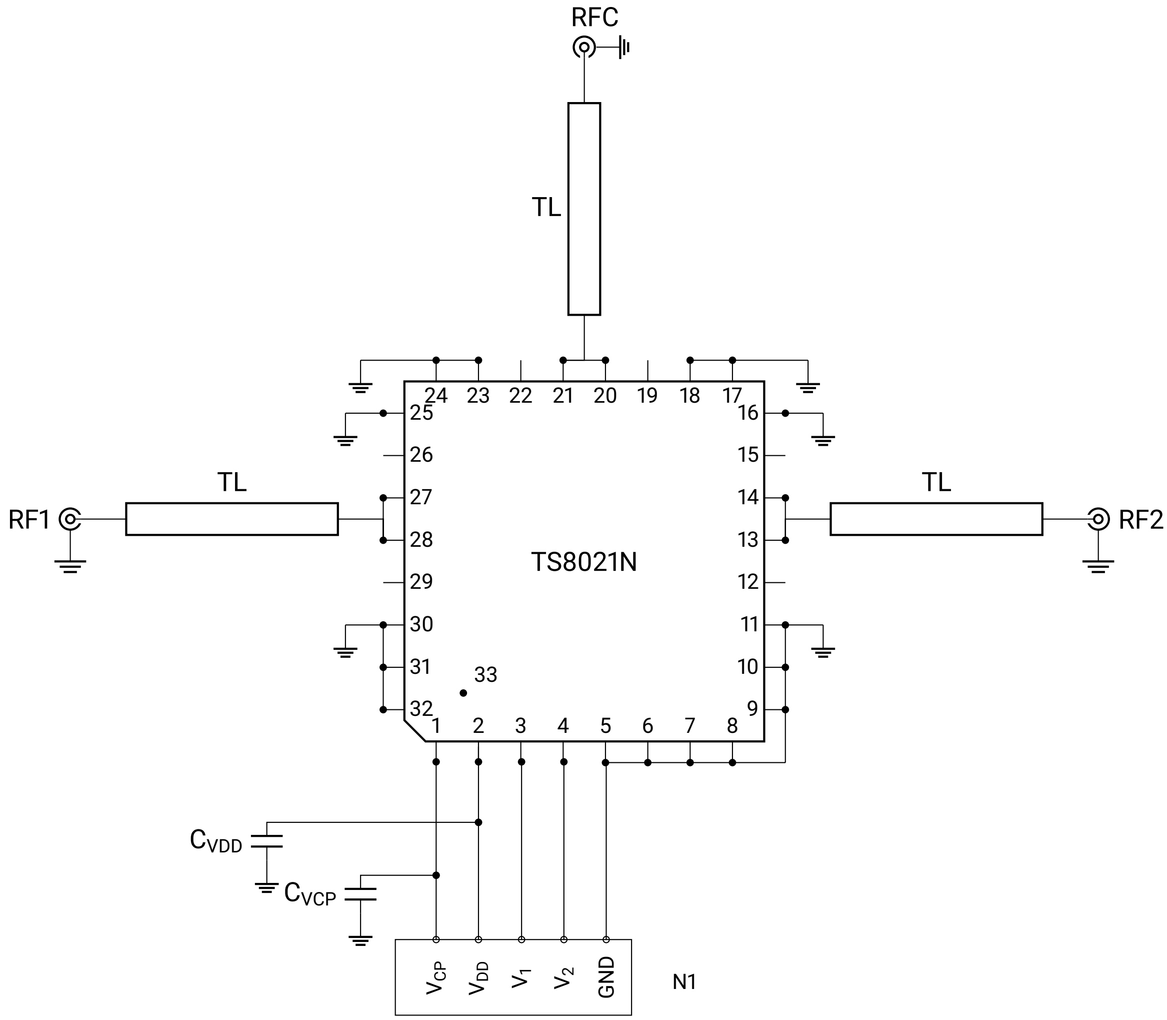
PIN name	Port numbers	S-parameters	Function
RFC	1	S11	
RF1	2	S22	
RF2	3	S33	
RF1ON	12	S21	RFC-RF1 ON
RF2ON	13	S31	RFC-RF2 ON

Content of s-parameter repository:

```
TS8021N.zip
├── IDX_00_no_match .................. Directory for s-parameters without matching components
│   ├── Readme.txt
│   ├── TS8021N_RF1ON_3PORT.s3p ....................................S3P file for RFC-RF1ON mode
│   ├── TS8021N_RF2ON_3PORT.s3p ....................................S3P file for RFC-RF2ON mode
│   ├── TS8021N_IDX00_IL_RL.png ................................ insertion loss and return loss plot
│   └── TS8021N_IDX00_ISO.png ..........................................................isolation plot
└── IDX_01_wideband ............Directory for s-parameters with matching components, 5.0 GHz
    ├── Readme.txt
    ├── TS8021N_RFOFF_3PORT.s3p ..............................................S3P file for ISO mode
    ├── TS8021N_VDDOFF_3PORT.s3p.......................................S3P file for VDD off mode
    ├── TS8021N_RF1ON_3PORT.s3p ....................................S3P file for RFC-RF1ON mode
    ├── TS8021N_RF2ON_3PORT.s3p ....................................S3P file for RFC-RF2ON mode
    ├── TS8021N_IDX01_IL_RL.png ................................ insertion loss and return loss plot
    └── TS8021N_IDX01_ISO.png..........................................................isolation plot
```

Performance upto 2.5 GHz, unmatched

TS8021N shows best performance upto 2.5 GHz frequency without any matching components. Only two external components are recommended, 1 nF for V_{CP} and 10nF for V_{DD} lines for supporting charge pump and power supply.



Schematics of TS8021N EVB with matching components

Table 11: Components used for TS8021N EVB

Reference	Part number / Value	Description	Notes
C_{VDD}	10nF	Capacitor	GRM155R71H103KA88
C_{VCP}	0.1μF	Capacitor	GRM155R61E104KA87D

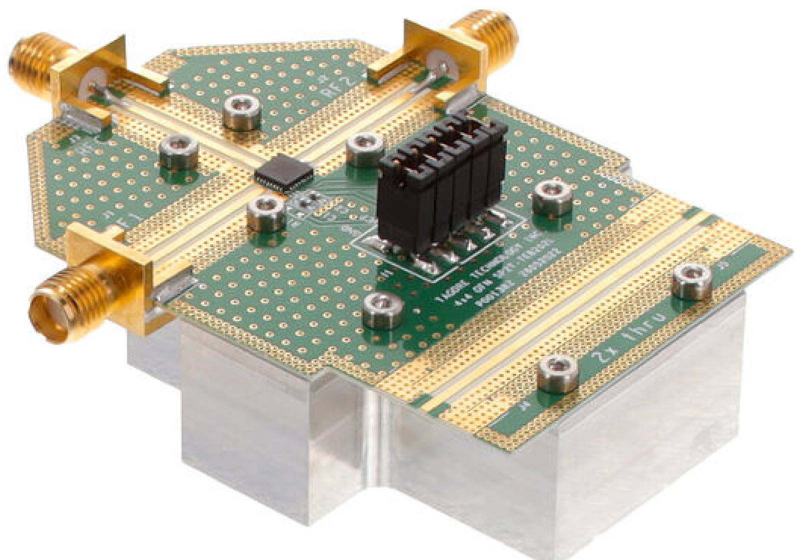


Photo of TS8021N EVB

Performance upto 5.0,GHz, matched

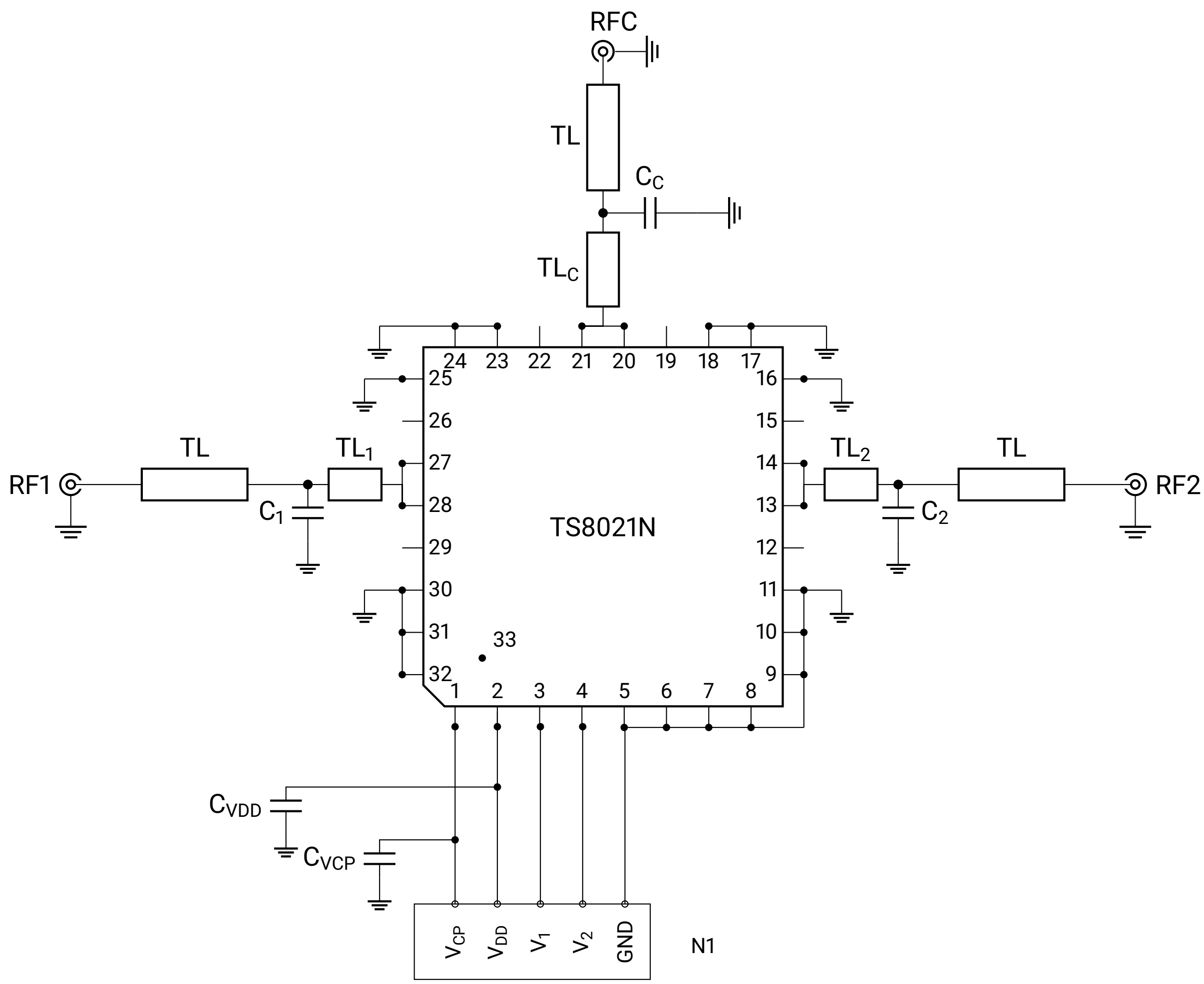


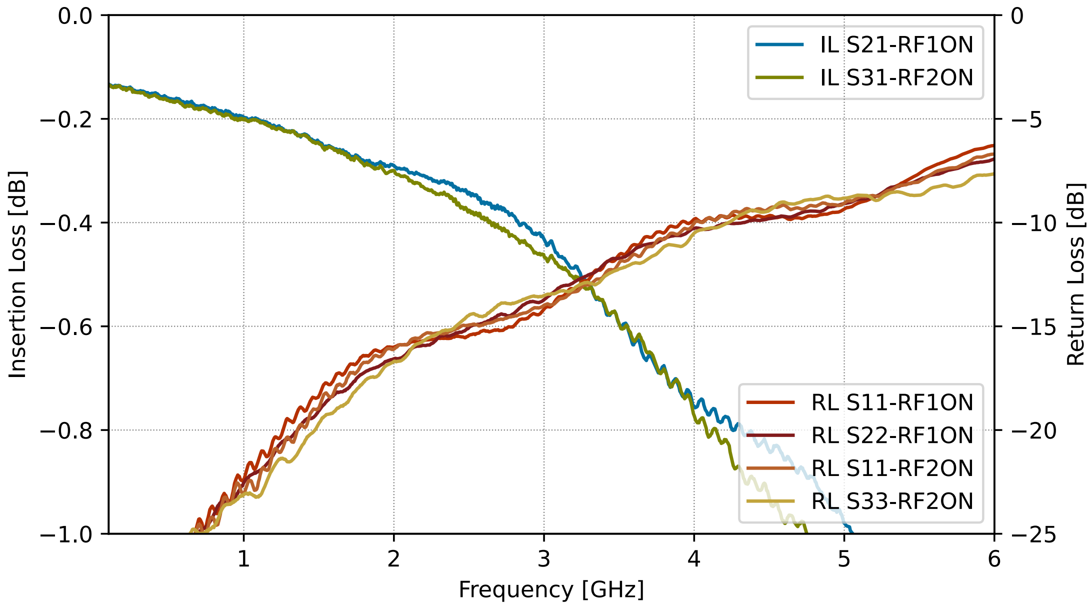
Table 12: Matching components used for 5.0 GHz performance

Reference	Part number / Value	Description	Notes
TL_C	5.1mm	CPW length	Edge of SW to edge of capacitor
C_C	0603N0R3BW251	Ceramic capacitor	0.3pF, 250V, ± 0.1pF
TL_1	7.9mm	CPW length	Edge of SW to edge of capacitor
C_1	0603N0R1BW251	Ceramic capacitor	0.1pF, 250V, ± 0.1pF
TL_2	7.9mm	CPW length	Edge of SW to edge of capacitor
C_2	0603N0R1BW251	Ceramic capacitor	0.1pF, 250V, ± 0.1pF
C_{VDD}	GRM155R71H103KA88	Capacitor	10nF
C_{VCP}	GRM155R61E104KA87D	Capacitor	0.1μF

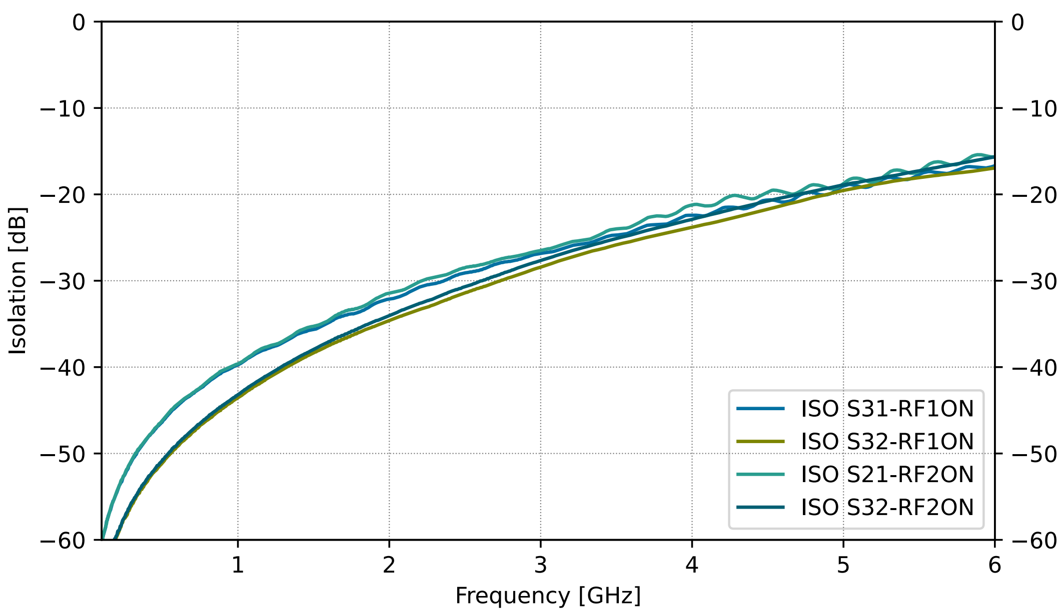
Typical characteristics

Performance upto 2.5 GHz, unmatched

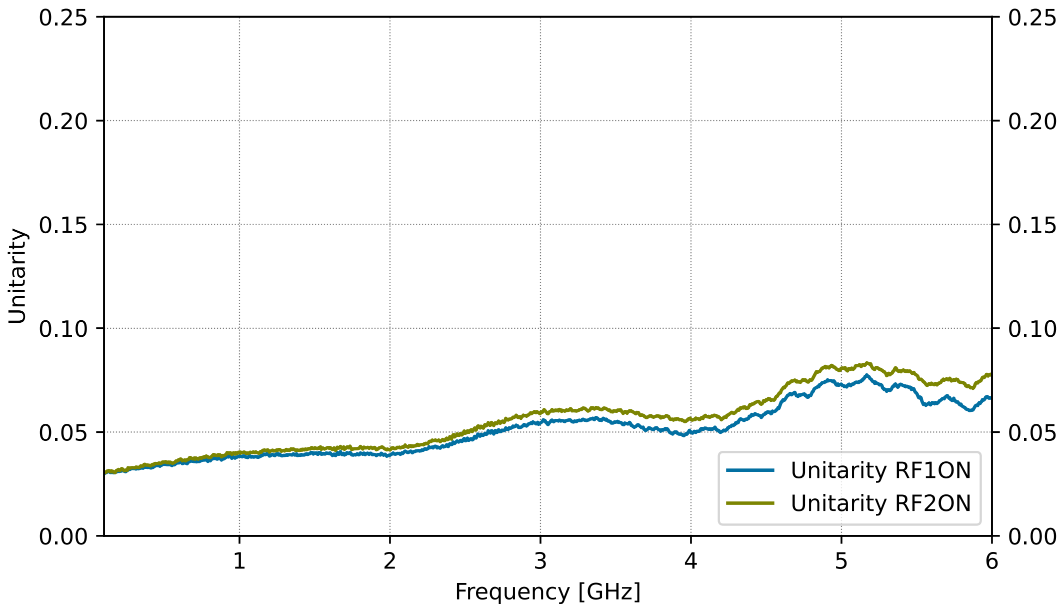
These measurements have been taken from TS8021N EVK, CPW losses have been de-embedded from the measurements. Device does not require any matching components for operation upto 2.5 GHz. Going above 2.5 GHz, performance can be improved by adding matching to ports. Our matching example shows excellent performance upto 5.0 GHz.



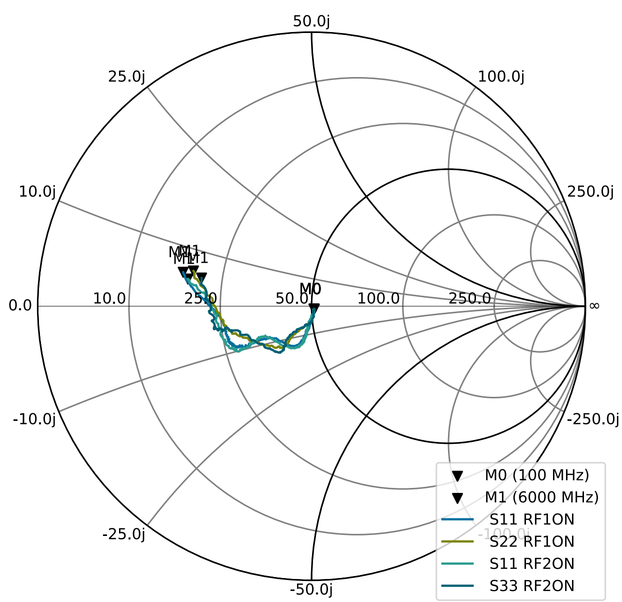
Insertion loss and Return loss, RFC − RFx.



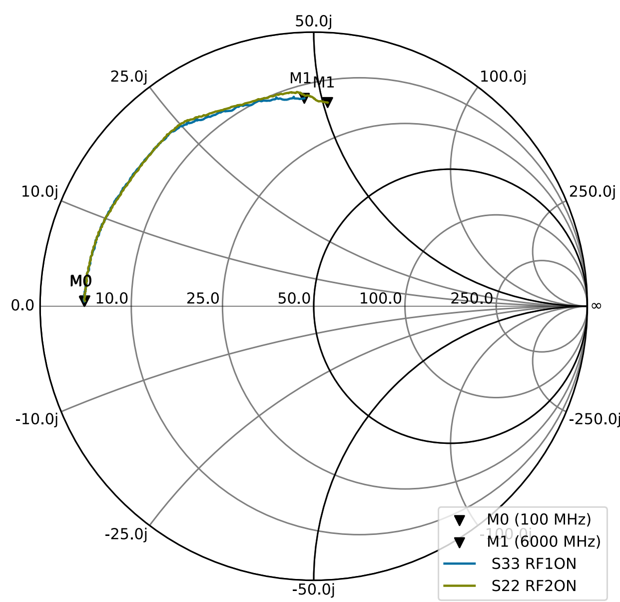
Isolation between RFC to non-active RFx and active RFx to non-active RFx.



Power absorption of the switch $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2$, $\mathrm{RFC} - \mathrm{RFx}$.



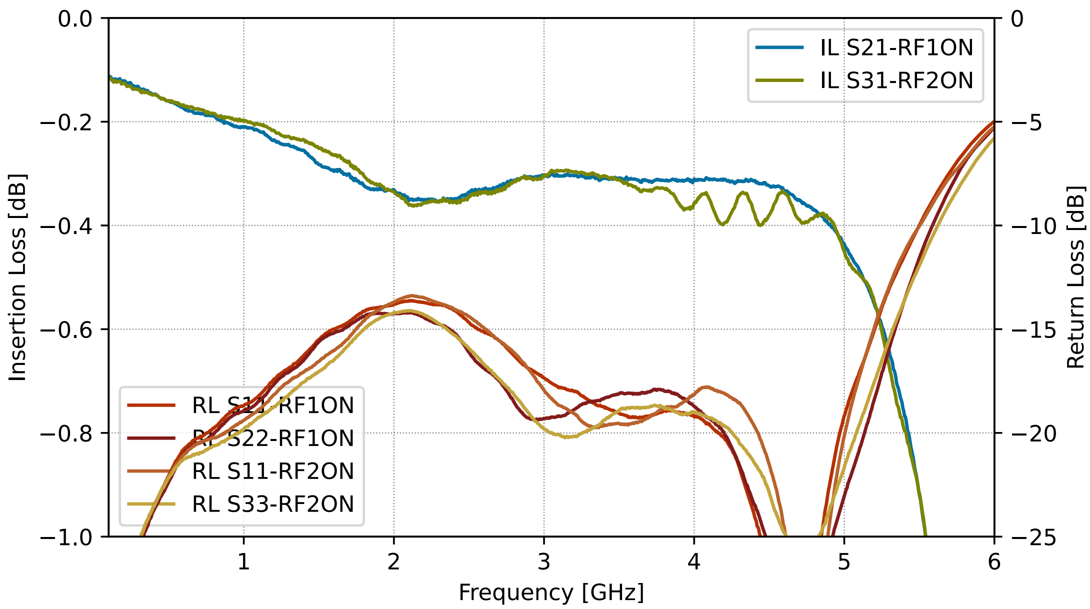
RFC and RFx matching at ON state.



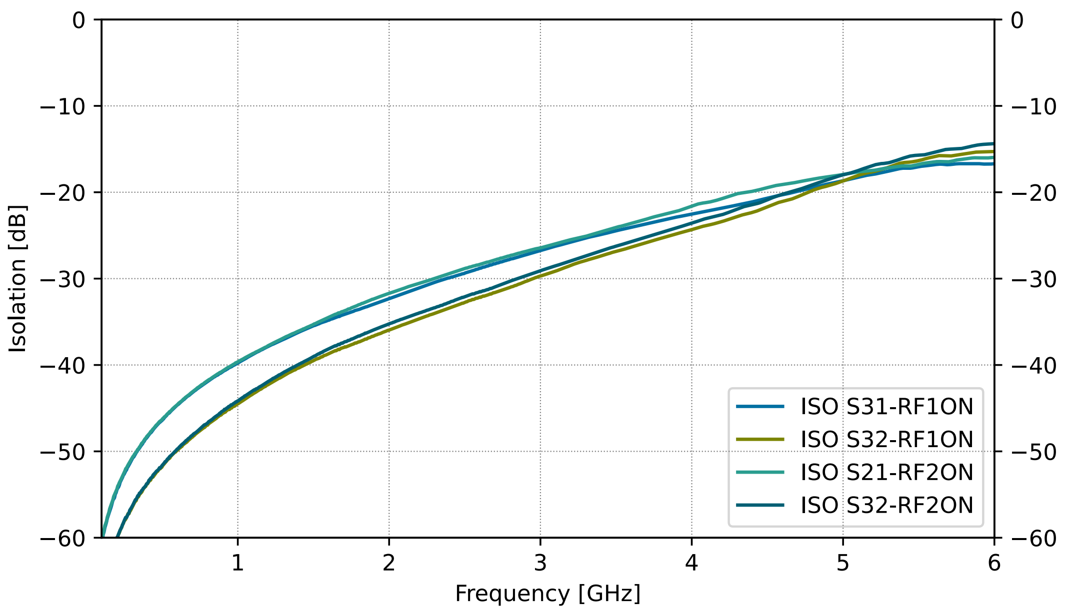
Non-active RFx port impedance. Low frequency starts from closed and circulates towards open at higher frequencies.

Performance upto 5.0 GHz, matching applied to EVK

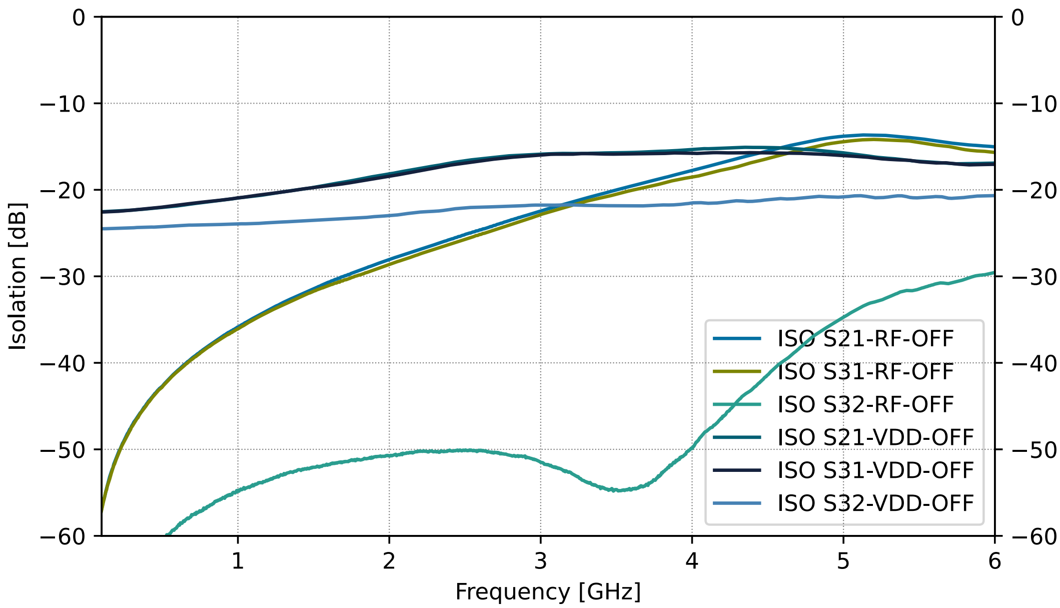
These measurements have been taken from TS8021N EVK, matching components applied. CPW losses have been de-embedded from the measurements, but matching component losses are present. This example matching pushes corner frequency to 5.0 GHz. In case of for example 2.5-5.0 GHz operation, matching should be optimized to have corner frequency closer to 5.0 GHz. This will also improve low frequency Return Loss.



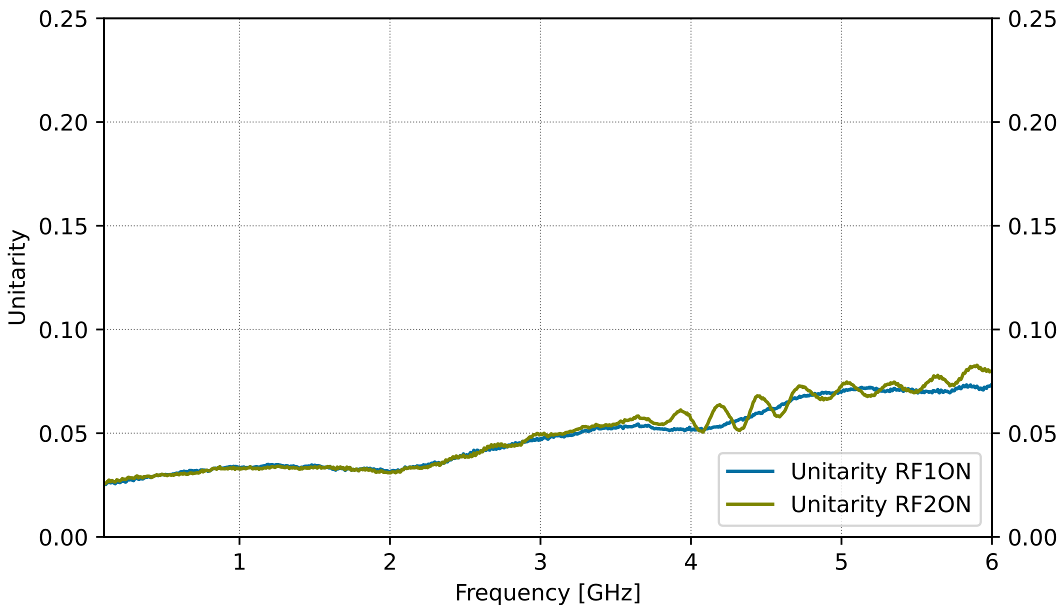
Insertion loss and Return loss, $\mathrm{RFC} - \mathrm{RFx}$.



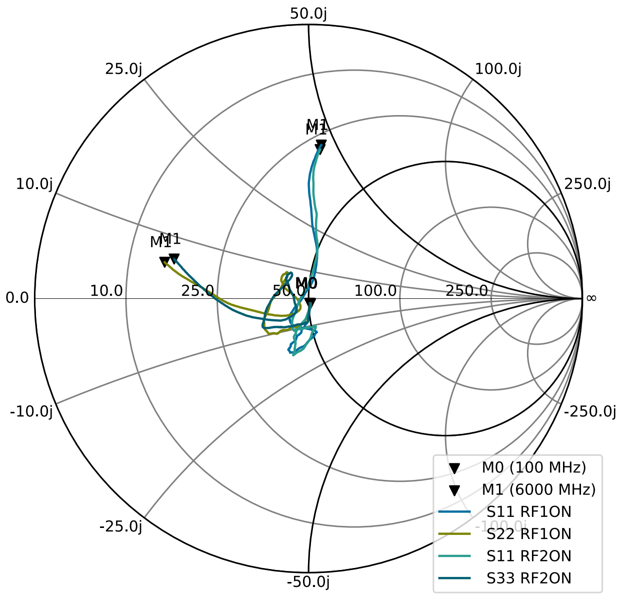
Isolation between RFC to non-active RFx and active RFx to non-active RFx.



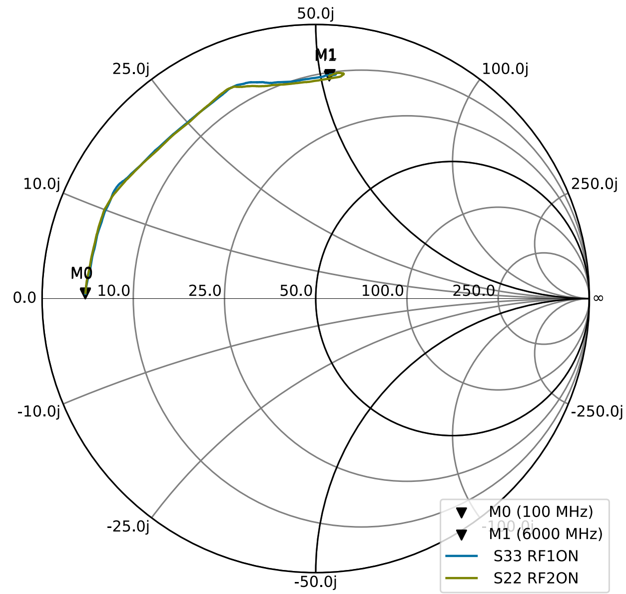
Isolation at V_{DD} off and ISO state between RFC to RFx and $\mathrm{RF1}$ to $\mathrm{RF2}$.



Power absorption of the switch $1-|S_{11}|^2-|S_{21}|^2-|S_{31}|^2$, $\mathrm{RFC}-\mathrm{RFx}$.



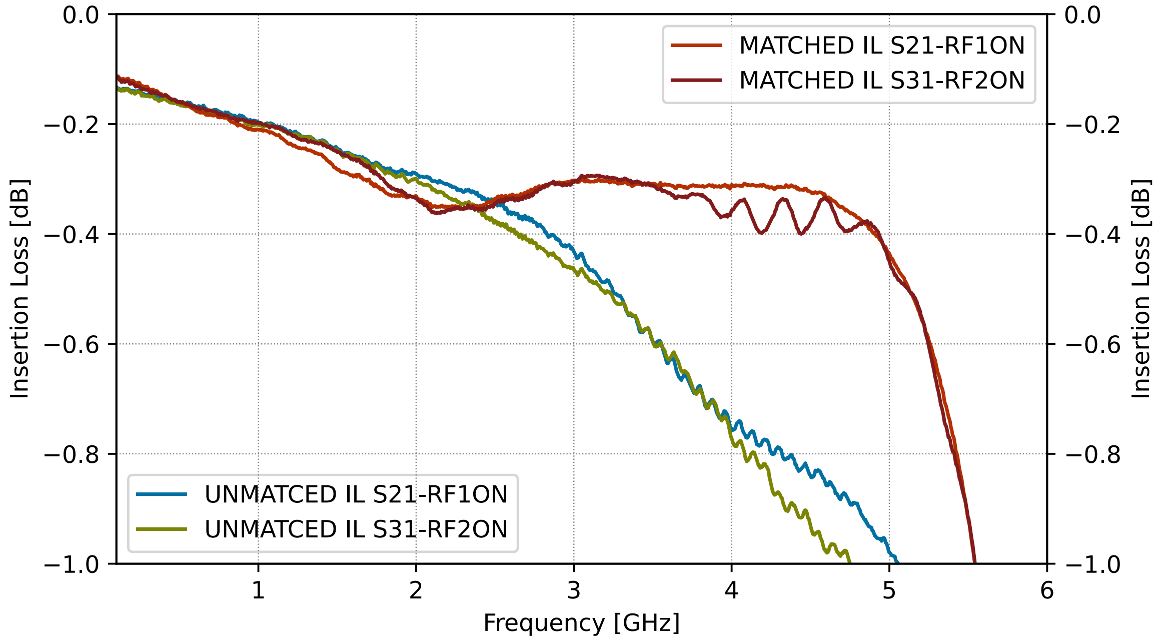
RFC and RFx matching at ON state.



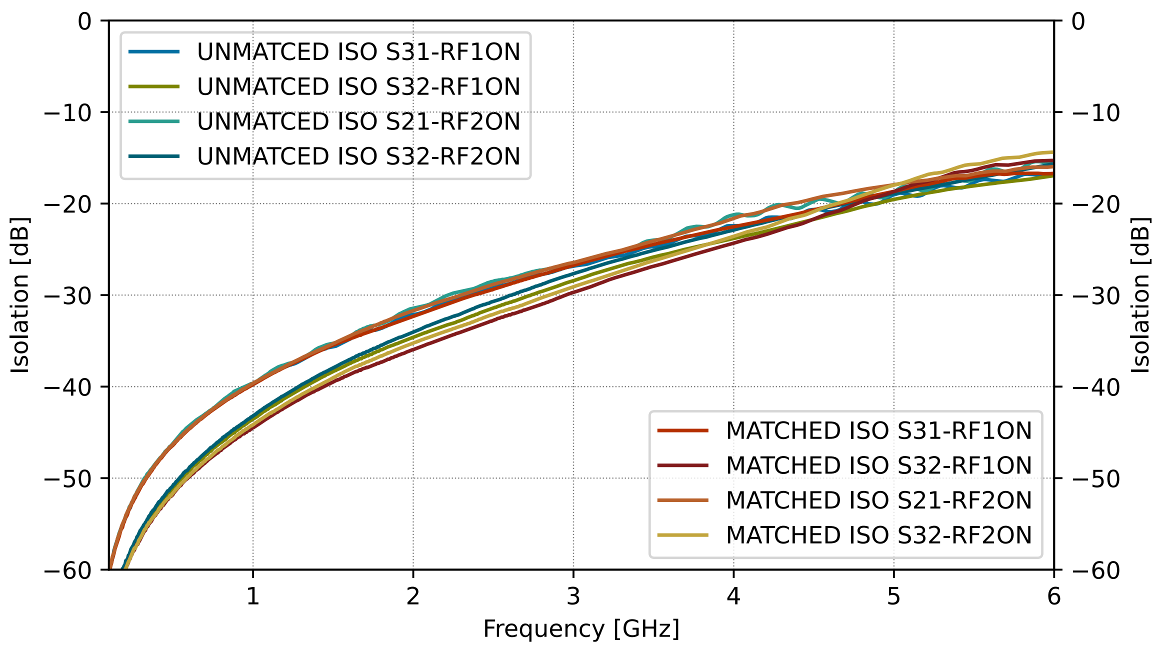
Non-active RFx port impedance. Low frequency starts from closed and circulates towards open at higher frequencies.

Comparison plots of matched and unmatched switch.

Below are Insertion Loss and Isolation comparison plots of matched and unmatched switch. Matching extends frequency response upto 5.0 GHz without affecting isolation. Any application above 2.5 GHz, one should apply matching to improve performance above 2.5 GHz.



Insertion loss comparison of matched to 6.0 GHz and unmatched switch.



Isolation comparison of matched to 6.0 GHz and unmatched switch.

Power De-rating

TS8021N has power handling de-rating below 10MHz. Power de-rating table has been defined for 50 ohm environment. Tagore is currently working with additional measurements and will update power de-rating table in future. This table is conservative, our preliminary indication is that part can handle higher power at lower frequencies. Customers are advised to carrier own measurements when operating below 30MHz.

Table 13: Power De-Rating table

Start f	**Stop f**	**Max Power**	**Unit**
1 MHz	2 MHz	40	dBm
2 MHz	5 MHz	43	dBm
5 MHz	10 MHz	45	dBm
10 MHz	400 MHz	47	dBm
400 MHz	f_{max}	47	dBm

Device Package information

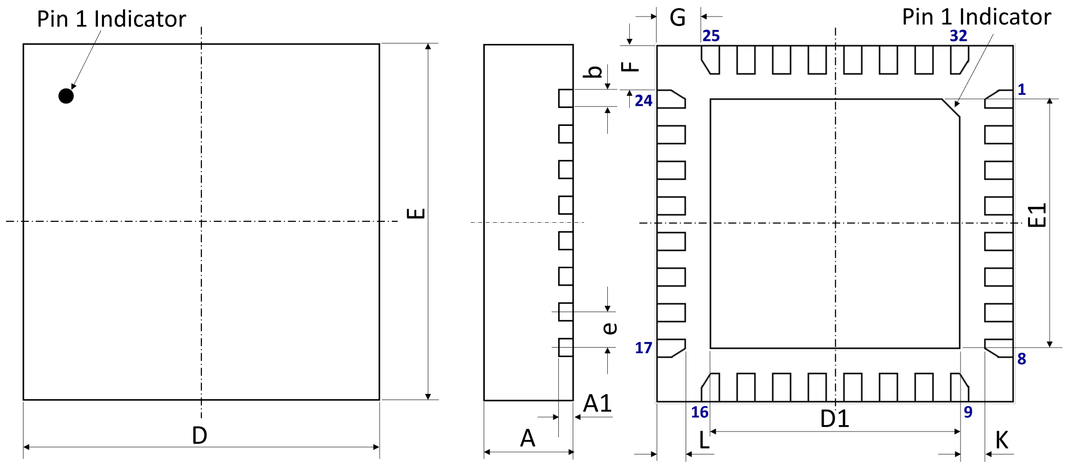
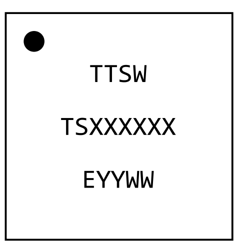


Figure 8: 32-pin QFN 5.0 x 5.0 x 0.85 mm^3 package drawing.

Please refer to application notes TN-001 and TN-002 at TagoreTech web page for PCB and soldering guidelines.

Table 14: Device Package Dimensions

Dimension	Value [mm]	Tolerance [mm]	Dimension	Value [mm]	Tolerance [mm]
A	0.85	±0.05	E	5.00 BSC	±0.05
A1	0.203	±0.02	E1	2.70	±0.05
b	0.20	+0.05/-0.07	F	0.50	±0.05
D	5.00 BSC	±0.05	G	0.50	±0.05
D1	2.70	±0.05	L	0.40	±0.05
e	0.40 BSC	±0.05	K	0.25	±0.05



●	Pin 1 indicator
TTSW	TagoreTech SWitch
TSXXXXXX	Part number (8 digits max)
E	Fixed letter before date code
YY	Last two digits of assembly year
WW	Assembly work week

Figure 9: Part marking specification.

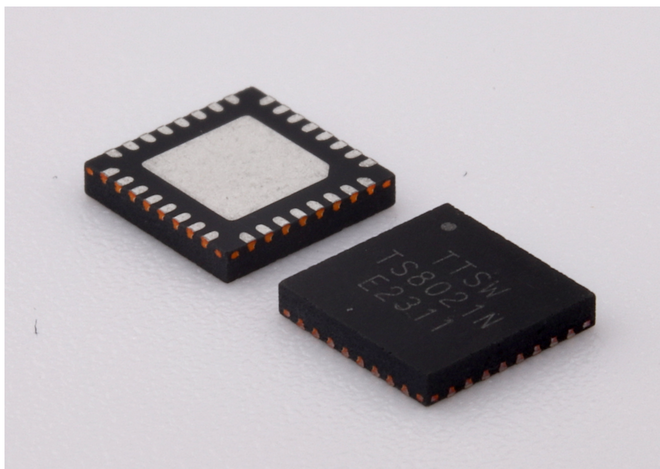


Figure 10: TS8021N photo, top and bottom side.

PCB Land Design

Notes:

- 4-layer PCB is recommended.
- Via diameter is recommended to be 0.3mm to prevent solder wicking inside the vias.
- Thermal vias shall only be placed on the center pad.
- The maximum via number for the center pad is 11(X)×11(Y)=121.

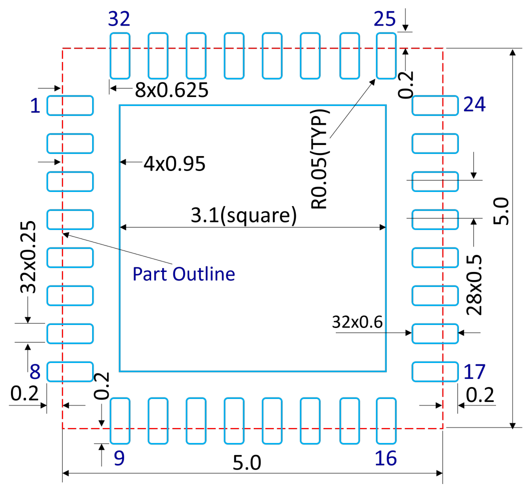


Figure 11: PCB land pattern, dimensions in [mm].

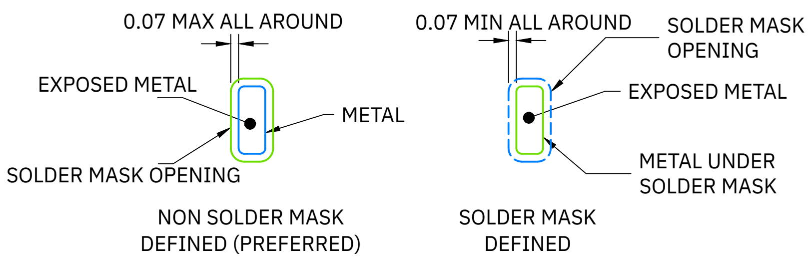


Figure 12: Solder mask opening, dimensions in [mm].

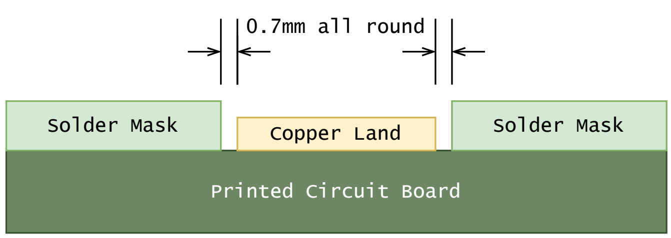


Figure 13: Preferred solder mask opening, side view, dimensions in [mm].

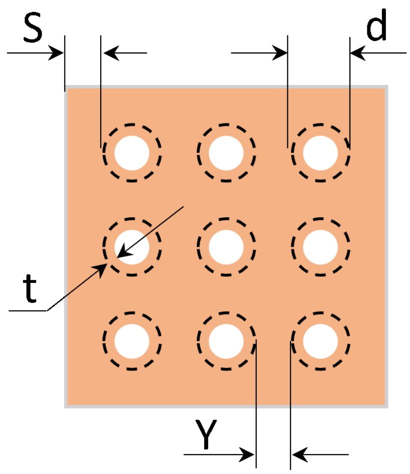


Figure 14: Thermal Via Pattern, Recommended Values: S≥0.15mm; Y≥0.20mm; d=0.2mm; Plating Thickness t=25μm or 50μm.

PCB Stencil Design

Notes:

- Laser-cut, stainless steel stencil is recommended with electro-polished trapezoidal walls to improve the paste release.
- Stencil thickness is recommended to be 125μm.

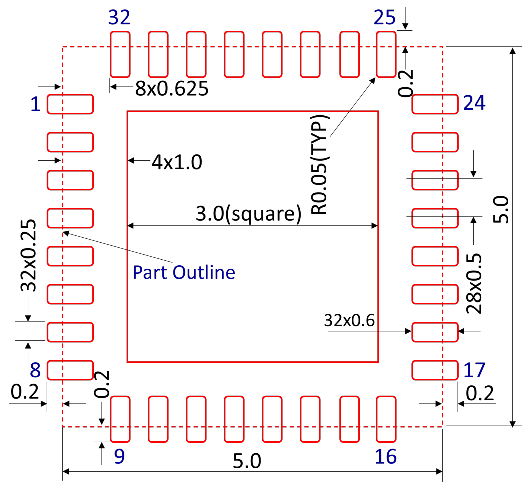


Figure 15: Stencil Openings, dimensions in [mm].

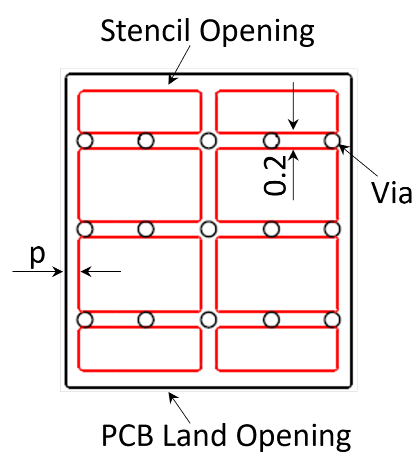
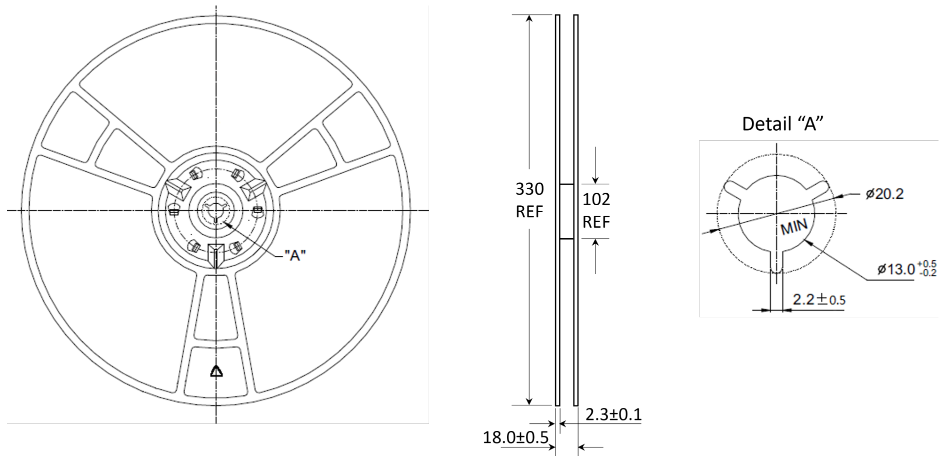
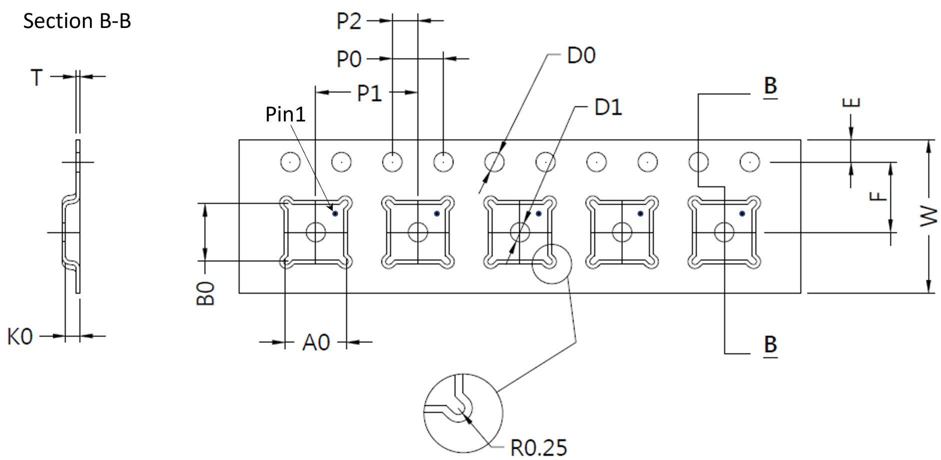


Figure 16: Stencil Openings Shall not Cover Via Areas If Possible, dimensions in [mm].

Tape and Reel Information





A0[mm]	B0[mm]	D0[mm]	D1[mm]	E[mm]	F[mm]	K0[mm]	P0[mm]	P1[mm]	P2[mm]	T[mm]	W[mm]
5.25	5.25	1.50	1.50	1.75	5.50	1.10	4.00	8.00	2.00	0.30	12.00

Glossary

IL	Insertion loss
ISO	Isolation
RL	Return loss
VSWR	Voltage Stading Wave Ratio
RFC	RF Common port, sometimes referred as ANT
RFx	RF Port number x
Unitarity	Describes power absorption of the component, $1 - \|S_{11}\|^2 - \|S_{21}\|^2 - \|S_{31}\|^2$

Changelog

Table 15: Changelog

Date	Revision	Notes
02/01/2026	3.0	New release with updated information, frequency range extended from 1 MHz to 5.0 GHz

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