SP4T 10W/50W$_{peak}$ Power Switch 1 MHz to 6.0 GHz

Features

- Frequency Range 1 MHz to 6.0 GHz
- Low insertion loss:
  0.30 dB @ 1.0GHz
  0.70 dB @ 3.0GHz
  0.80 dB @ 6.0GHz
- High isolation:
  -25 dB @ 3.0GHz
  -21 dB @ 5.0GHz
- 10 W CW Power, 50 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

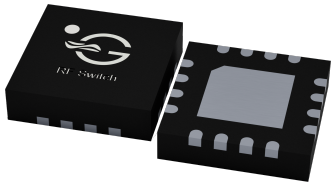


Figure 1: TS8242FK in 3.0 x 3.0 mm^2 QFN 16-pin package.

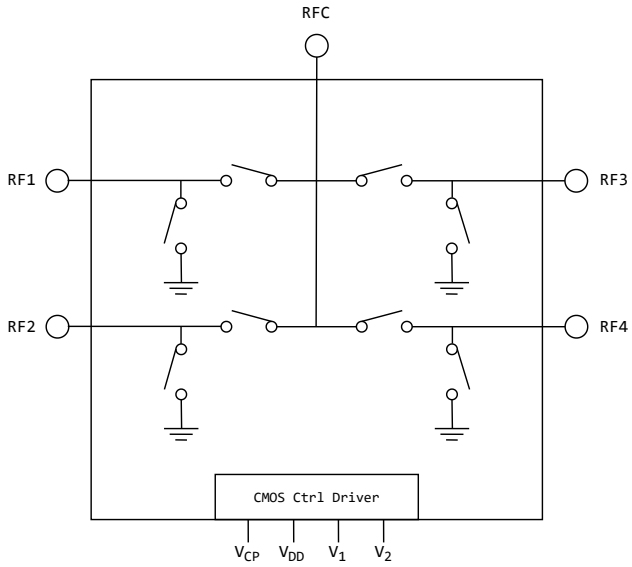


Figure 2: TS8242FK functional diagram

Applications

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

General Description

The TS8242FK is a 2nd Generation symmetrical reflective Single Pole Four Throw (SP4T) switch designed for medium power switching applications. The TS8242FK covers 1 MHz to 6.0 GHz bandwidth and provides low insertion loss, high isolation, and high linearity within a small package size. The TS8242FK is a 10 W CW with peak power capability of 50 W_{peak}, switch suitable for applications requiring low insertion loss, high isolation, and high linearity.

The TS8242FK is packaged into a compact Quad Flat No lead (QFN) 3.0x3.0 mm^2 16 leads plastic package.

RoHS

RoHS10/Reach/Halogen free

Ordering information

Table 1: Ordering Information

Device Part Number	Package Type	Notes
TS8242FK	16 Pin 3.0x3.0x0.85 mm^3 QFN	Core part number
TS8242FK-EVB	Evaluation Board	
TS8242FKMTRPBF[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

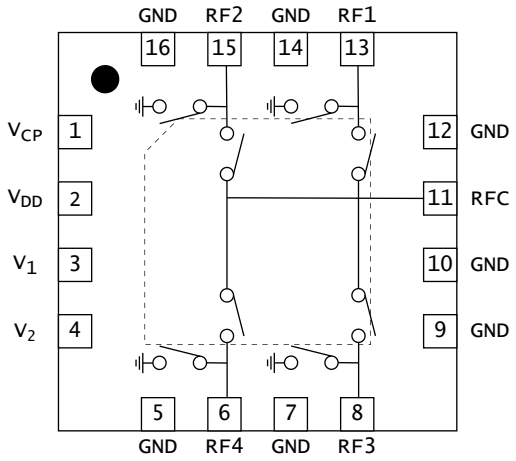


Figure 3: TS8242FK pin assignment [top view]

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
6	RF4	RF port 4
8	RF3	RF port 3
11	RFC	RFC RF Common port (ANT)
13	RF1	RF port 1
15	RF2	RF port 2
5,7,9,10,12,14,16	GND	Connect to ground[2]
17 [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
Maximum RF CW input power[3]	RFx/RFC	44	dBm
Maximum RF peak input power, 1% duty cycle, 10μs pulse [2]	RFx/RFC	49	dBm
Thermal Ratings			
Thermal Resistance (junction-to-case) – Bottom side	$R_{\theta jc}$	9.9	°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	≥1000	V
Moisture Rating			
Moisture Sensitivity Level	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.

Electrical Specifications

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

Parameter	Condition	Minimum	Typical	Maximum	Unit
Operating frequency	f	1		6000	MHz
Insertion loss	30MHz		0.25		dB
unmatched, upto 4.0 GHz	1.0GHz		0.30	0.40	dB
$RFC - RFx$	3.0GHz		0.60		dB
	4.0GHz		0.85		dB
Insertion loss[1]	30MHz		0.20		dB
matched upto 6.0 GHz	1.0GHz		0.30		dB
$RFC - RFx$	3.0GHz		0.70		dB
	5.0GHz		0.70		dB
	6.0GHz		0.80		dB
Isolation	30MHz		60		dB
unmatched, upto 4.0 GHz	1.0GHz		35		dB
$RFC - RFx$	3.0GHz		25		dB
	4.0GHz		23		dB
Isolation[1]	30MHz		60		dB
matched upto 6.0 GHz	1.0GHz		37		dB
$RFC - RFx$	3.0GHz		27		dB
	5.0GHz		21		dB
	6.0GHz		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 $T_A = +25°C; V_{DD} = +3.3V; 50\Omega$ Source/Load.

Parameter	Condition	Minimum	Typical	Maximum	Unit
Operating frequency	f	1		6000	MHz
Return Loss	30MHz		-30		dB
unmatched, upto 4.0 GHz	1.0GHz		-30		dB
$RFC - RFx$	3.0GHz		-15		dB
	4.0GHz		-12		dB
Return Loss[1]	30MHz		-30		dB
matched upto 6.0 GHz	1.0GHz		-30		dB
$RFC - RFx$	3.0GHz		-12		dB
	5.0GHz		-16		dB
	6.0GHz		-15		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 $T_A = +25°C; V_{DD} = +3.3V; 50\Omega$ Source/Load.

Parameter	Condition	Minimum	Typical	Maximum	Unit
Operating frequency	f	1		6000	MHz
Harmonic Distortion					
H_2	800MHz, P_{in} =40dBm		-86		dBc
H_3	800MHz, P_{in} =40dBm		-89		dBc
IIP3	800MHz		74		dBm
Power and Compression point					
P_{maxCW}[2]	Max RF CW Power	40	42		dBm
P_{maxpeak}	Max RF Peak Power		48		dBm
$P_{0.1\text{dB}}$	800MHz, CW	40	43		dBm
$P_{\text{peak}0.1\text{dB}}$	800MHz, 1% duty cycle, 10μs pulse	45	48		dBm
$P_{1\text{dB}}$[1]	800MHz, CW		45		dBm
$P_{\text{maxhot RFx}}$[5]	Max RF CW Power, hot switching		37		dBm
$P_{\text{maxhot RFC}}$[5]	Max RF CW Power, hot switching		37		dBm

[1] $P_{1\,\text{dB}}$ has been given for comparison reasons only. Please do not exceed Absolute Maximum ratings.
[2] See Power De-rating table

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

Parameter	Condition	Minimum	Typical	Maximum	Unit
Operating frequency	f	1		6000	MHz
Noise					
CP switching noise[4]	RBW=1kHz		-140		dBm
Switching Time					
t_{ON}	Switch ON time		0.7	1.3	μs
t_{OFF}	Switch OFF time		0.6	1.2	μs
t_{RISE}	Switch RISE time		0.5	0.7	μs
t_{FALL}	Switch FALL time		0.5	0.9	μs
t_{wON}	Minimum Switch ON time		3.6		μs
t_{wOFF}	Minimum Switch OFF time		3.6		μs
f_{PRR}, $C_{VCP} = 1nF$[3]	Maximum pulse repetition rate		1		kHz
f_{PRR}, $C_{VCP} = 10nF$[3]	Maximum pulse repetition rate		1.4		kHz
f_{PRR}, $C_{VCP} = 100nF$[3]	Maximum pulse repetition rate		1.8		kHz
f_{PRR}, $V_{CPext} = -18\,V$[6]	Maximum pulse repetition rate		>20		kHz
$t_{startup}$, $C_{VCP} = 1nF$[3]	startup time		0.8		ms
$t_{startup}$, $C_{VCP} = 10nF$[3]	startup time		7		ms
$t_{startup}$, $C_{VCP} = 100nF$[3]	startup time		40		ms
Power Supply, DC					
Control voltage[7]	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.
[7] Control voltage V_{ih} cannot be higher than V_{DD} (to avoid forward biasing of ESD diode)

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.

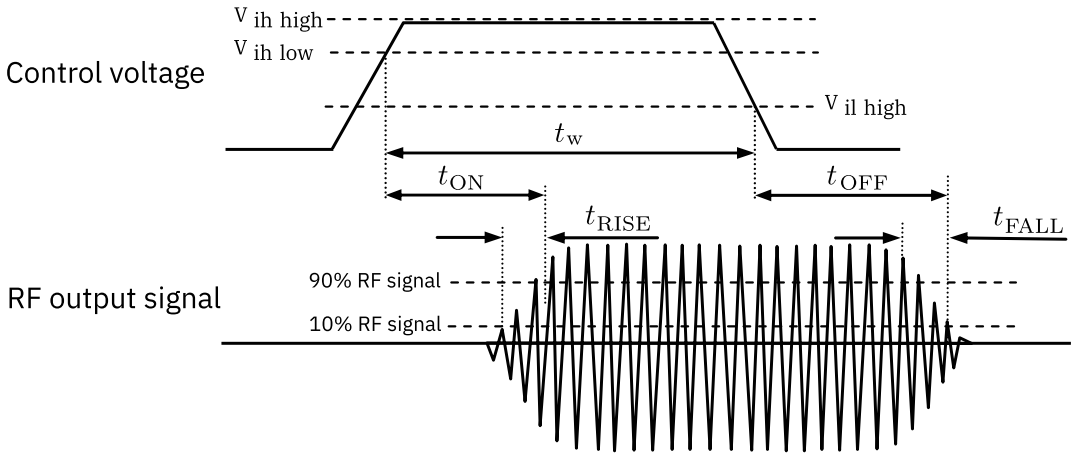


Figure 4: Switching time definition, t_{ON}, t_{OFF}, t_{RISE}, t_{FALL}. Minimum pulse width t_w.

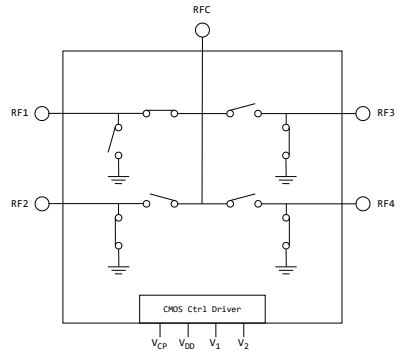
Our component uses integrated charge pump. Maximum pulse repetition rate defines what is maximum frequency for switching events. Please do not exceed given maximum frequency. By feeding external -18 V to V_{CP}, one can improve maximum pulse repetition rate f_{PRR}. Feeding external -18V to V_{CP}, one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

Switch Control table

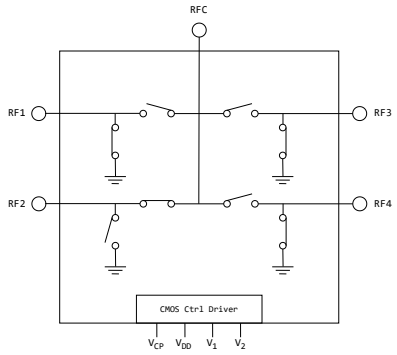
Table 9: Switch Control Table

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	RFC – RF3 ON
1	1	1	RFC – RF4 ON
0	0	0	V_{DD} off (Isolation), all FETs are on, short shown to ANT and RF ports

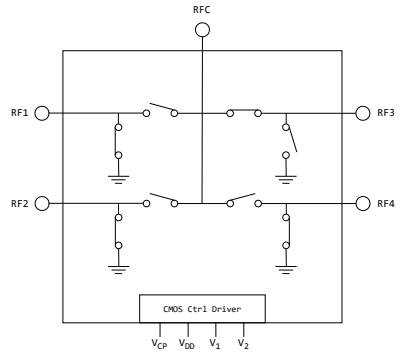
[1] V_{DD} should be applied first before V_1 and V_2, otherwise may cause damage to the device.
[2] There are internal pull-downs to ground on both V_1 and V_2 control pins, the state at start-up without any control voltage applied will be RFC – RF1 ON.



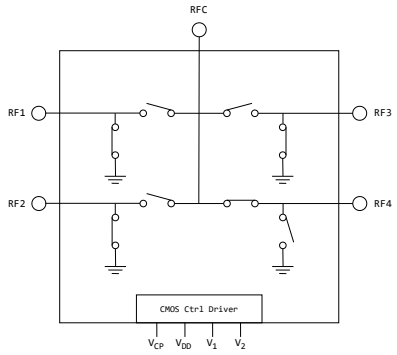
RFC-RF1 ON



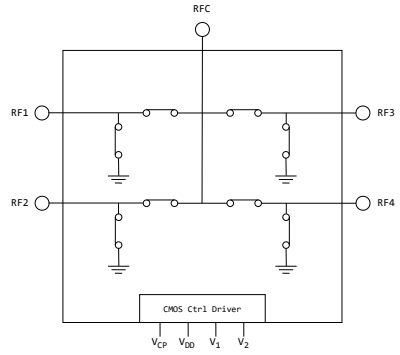
RFC-RF2 ON



RFC-RF3 ON



RFC-RF4 ON



V_{DD} off state

Theory of Operation

Isolation modes

TS8242FK has one isolation mode, VDD off mode.

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 ANT port. This is practical when device is directly connected to ANT, there is certain protection against induced electrical fields. This can partially protect radio equipment against electrical fields, when device is not in usage.

Applications

TS8242FK is offering 10 W/50 W_{peak} capability from 1 MHz to 6.0 GHz 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, TS8242K significantly reduces design complexity for such RF switching needs. TS8242K works well up to 4.0 GHz frequency without external matching components, for frequency above 4.0 GHz, matching is recommended. Datasheet provides an example matching and its performance.

Schematics and Evaluation Board

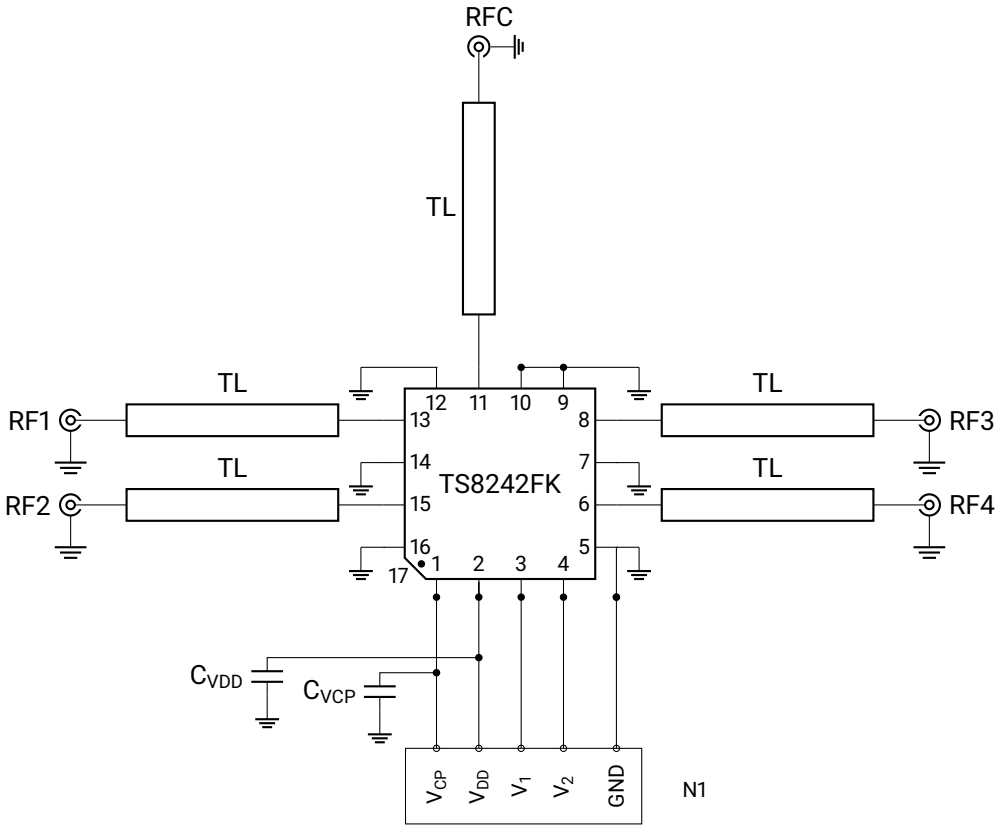
S-parameters of the both presented EVBs can be downloaded from link: Download TS8242FK S-parameters

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	
RF3	4	S44	
RF4	5	S55	
RF1ON	12	S21	RFC-RF1 ON
RF2ON	13	S31	RFC-RF2 ON
RF3ON	14	S41	RFC-RF3 ON
RF4ON	15	S51	RFC-RF4 ON

Performance upto 4.0 GHz, unmatched

TS8242FK shows usable performance upto 4.0 GHz frequency without any matching components. Only two external components are recommended, 10 nF for V_{CP} and 100nF forV_{DD} lines.



Schematics of TS8242FK EVB without matching components

Table 11: Components used for TS8242FK EVB

Reference	Part number / Value	Description	Notes
C_{VDD}	10nF	Capacitor	
C_{VCP}	1nF	Capacitor	

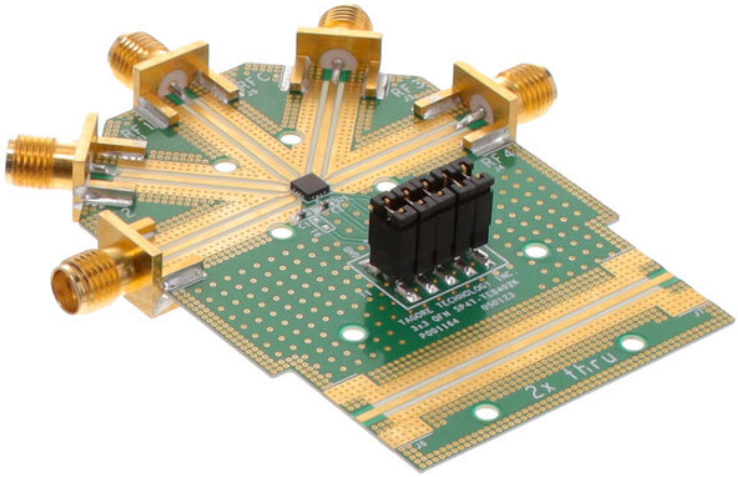
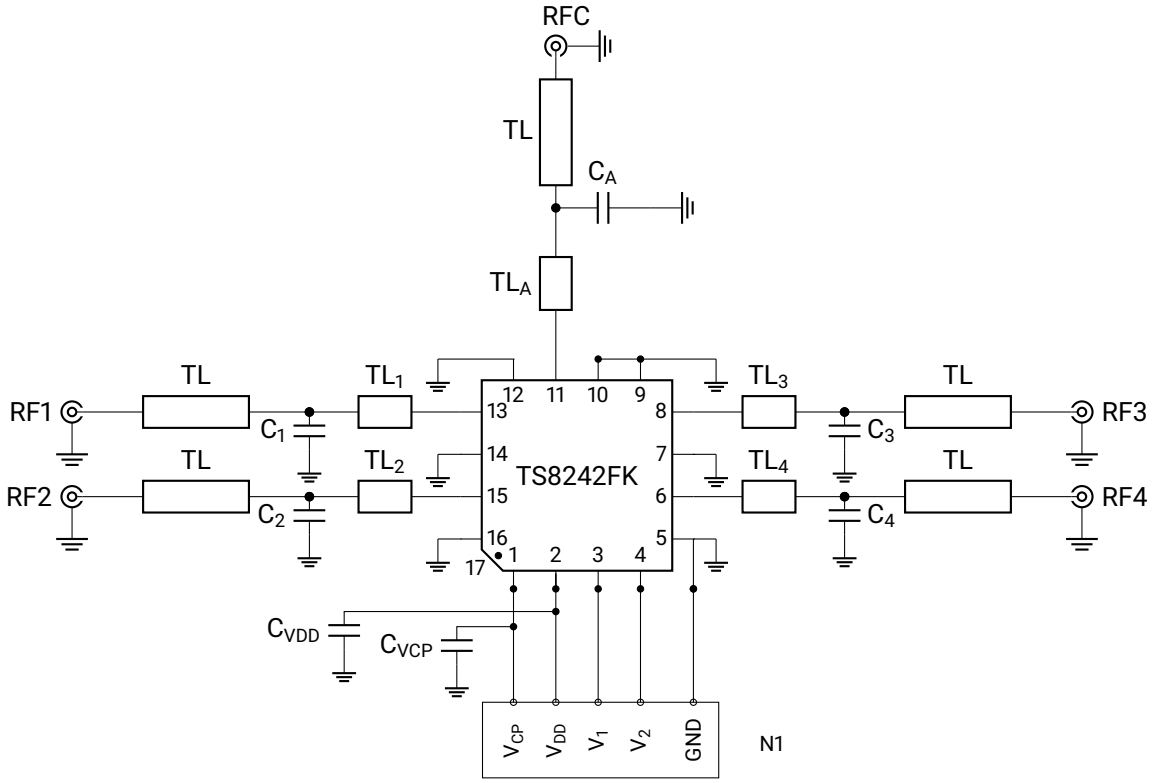


Photo of TS8242FK EVB

Performance upto 6.0 GHz, matched



Schematics of TS8242FK EVB with matching components

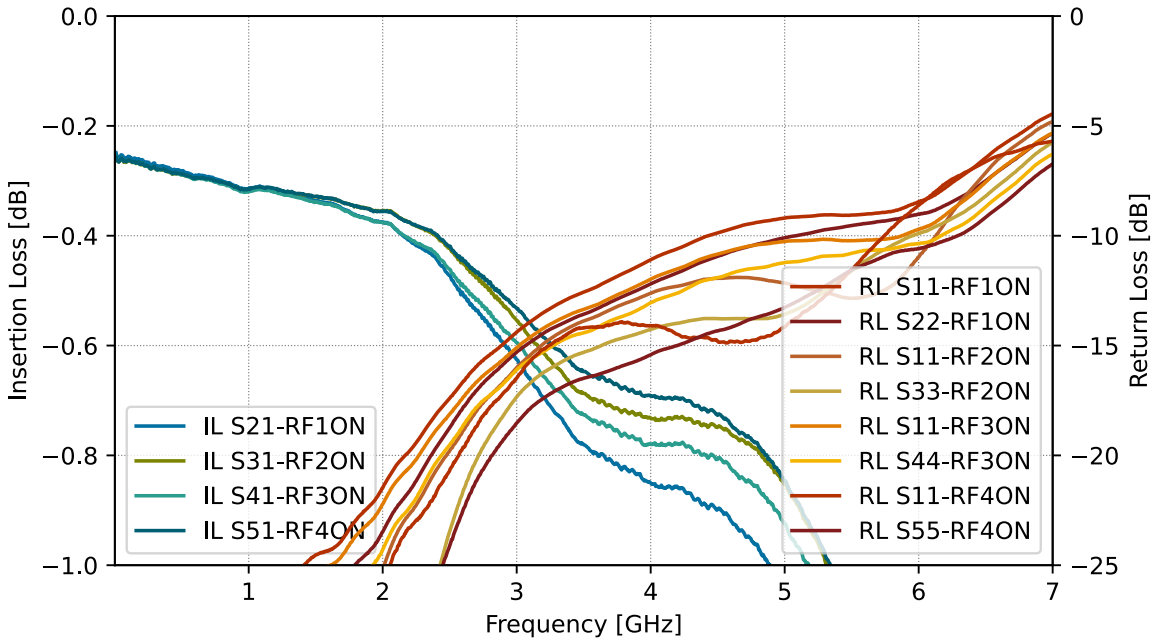
Table 12: Matching components used for 6.0 GHz performance

Reference	Part number / Value	Description	Notes
TL_A	2.1 mm	CPW length	Edge of SW to center of capacitor
C_A	0603N0R3BW251	Ceramic capacitor	0.3pF, 250V, ± 0.1pF
TL_1	1.5 mm	CPW length	Edge of SW to center of capacitor
C_1	0603N0R2BW251	Ceramic capacitor	0.2pF, 250V, ± 0.1pF
TL_2	0.3 mm	CPW length	Edge of SW to center of capacitor
C_2	0603N0R2BW251	Ceramic capacitor	0.2pF, 250V, ± 0.1pF
TL_3	1.5 mm	CPW length	Edge of SW to center of capacitor
C_3	0603N0R2BW251	Ceramic capacitor	0.2pF, 250V, ± 0.1pF
TL_4	0.3 mm	CPW length	Edge of SW to center of capacitor
C_4	0603N0R2BW251	Ceramic capacitor	0.2pF, 250V, ± 0.1pF
C_{VDD}	10 nF	Capacitor	
C_{VCP}	1 nF	Capacitor	

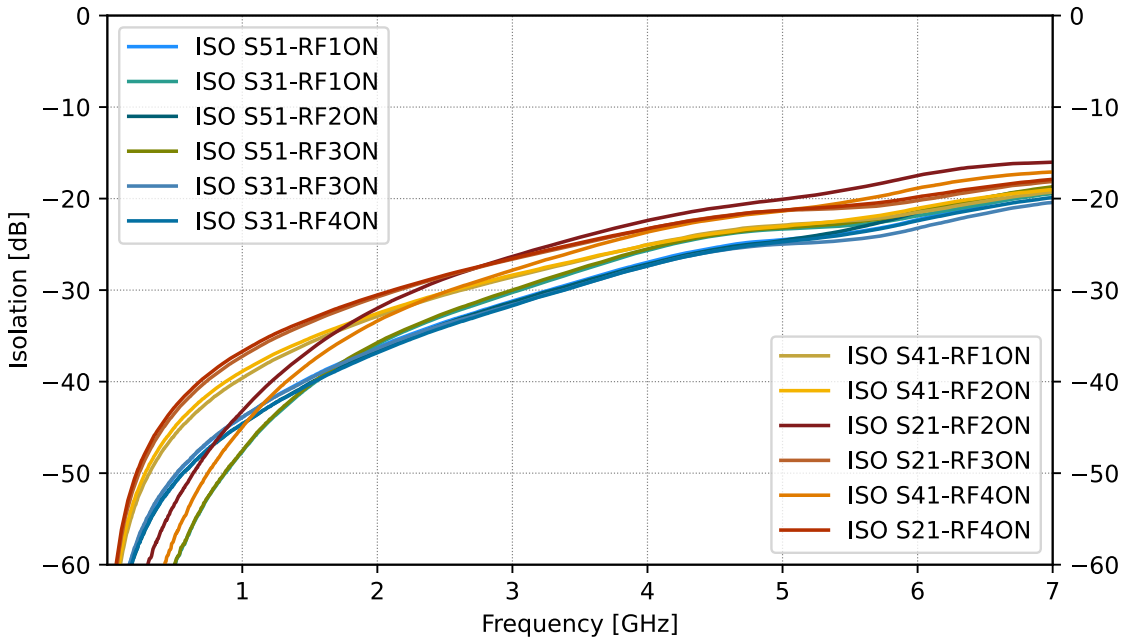
Typical characteristics

Performance upto 4.0 GHz, unmatched

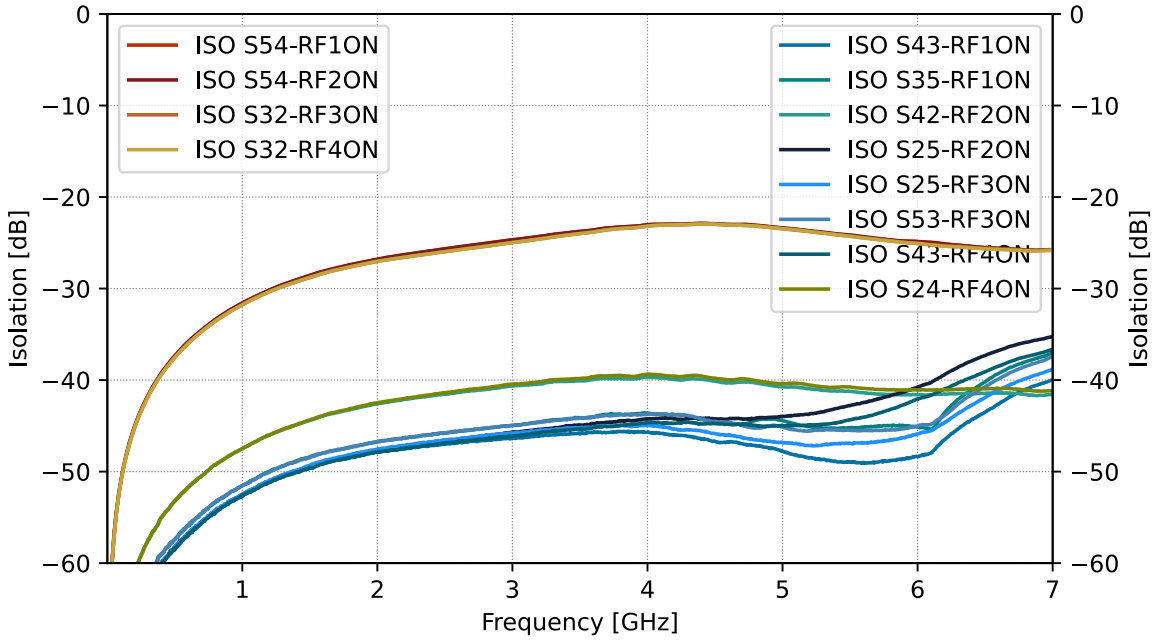
These measurements have been taken from TS8242FK EVK, CPW losses have been de-embedded from the measurements. Device does not require any matching components for operation upto 4.0 GHz. Going above 4.0 GHz, performance can be improved by adding matching to ports. Our matching example shows excellent performance upto 6.0 GHz.



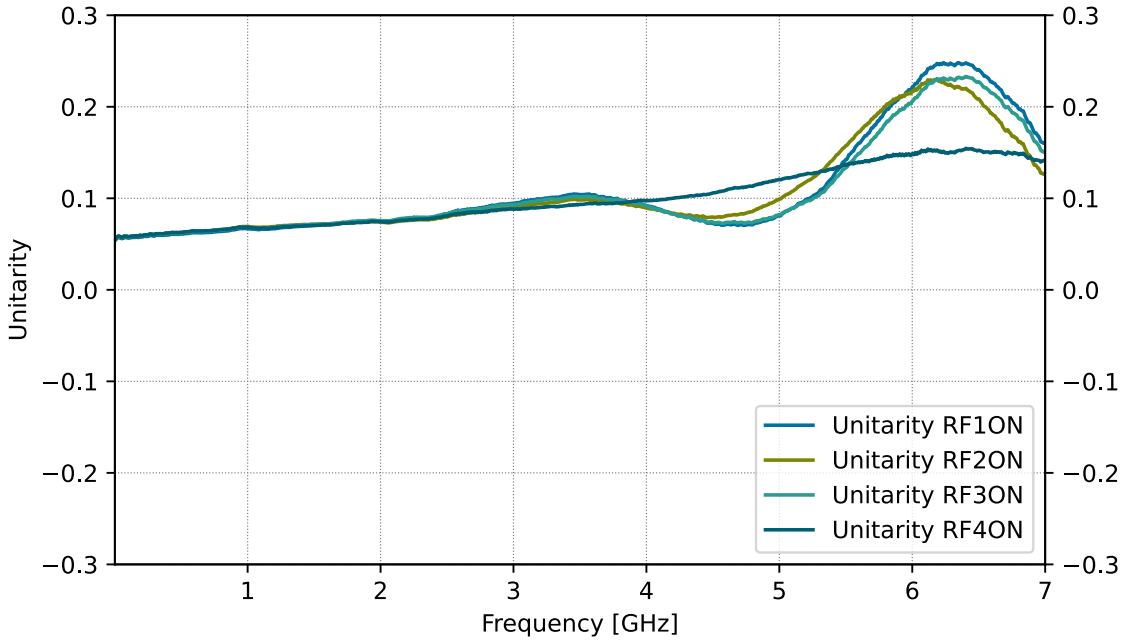
Insertion loss and Return loss, $\mathrm{RFC} - \mathrm{RFx}$.



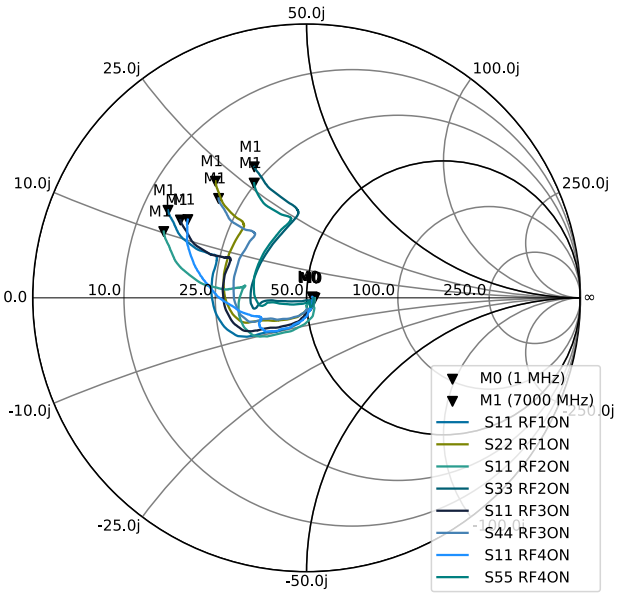
RFC – RFx isolation of non-active ports.



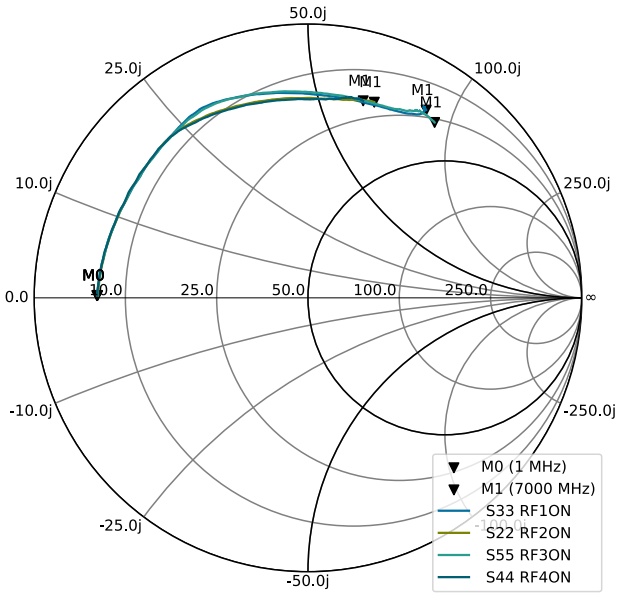
RFx – RFx isolation of non-active ports. Red/orange color curves are adjacent paths.



Unitarity, power absorption of the component, $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2 - |S_{41}|^2 - |S_{51}|^2$



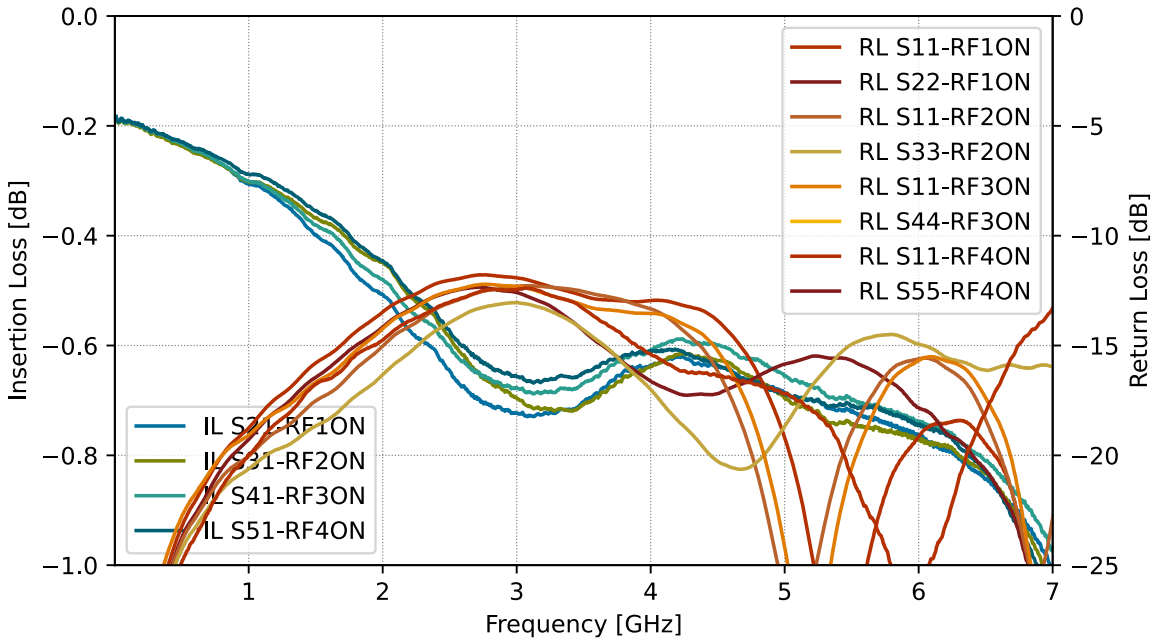
Matching of active port



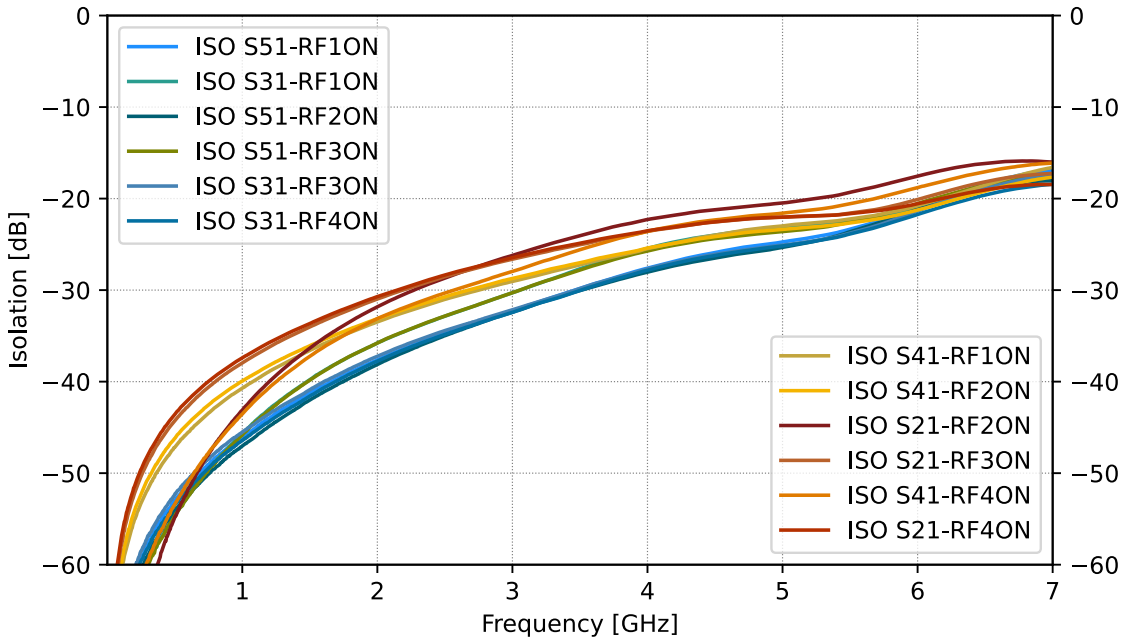
Termination impedance of non-active RFx.

Performance upto 6.0 GHz, matching applied to EVK

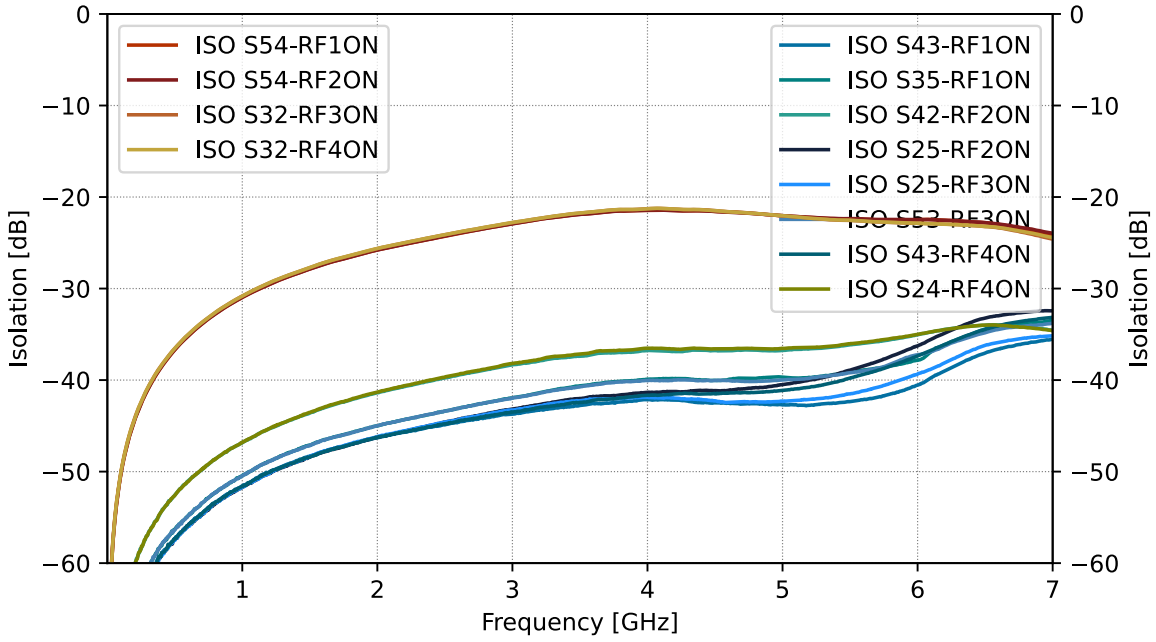
These measurements have been taken from TS8242FK EVK, matching components applied. CPW losses have been de-embedded from the measurements, but matching component losses are present.



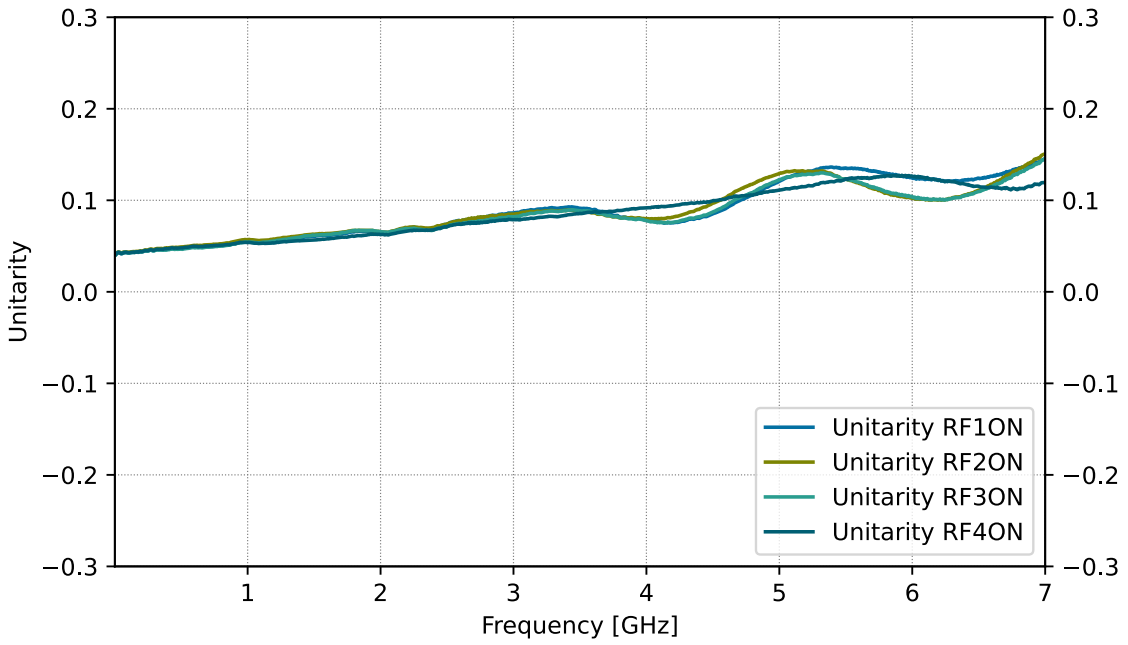
Insertion loss and Return loss, $\mathrm{RFC} - \mathrm{RFx}$.



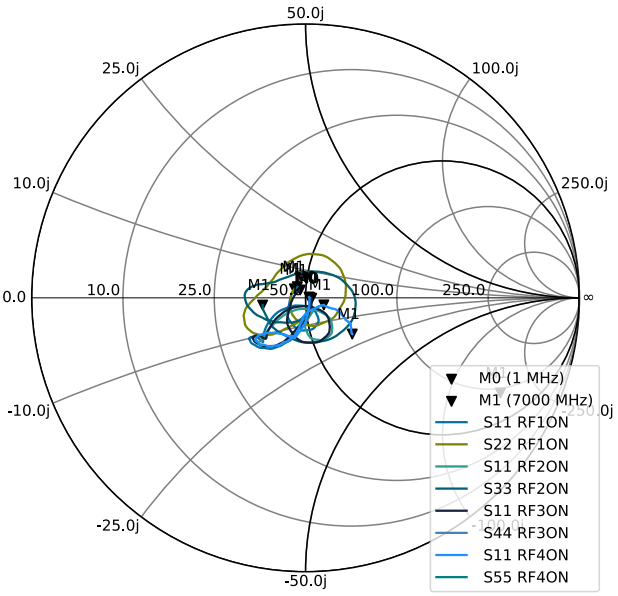
RFC – RFx isolation of non-active ports.



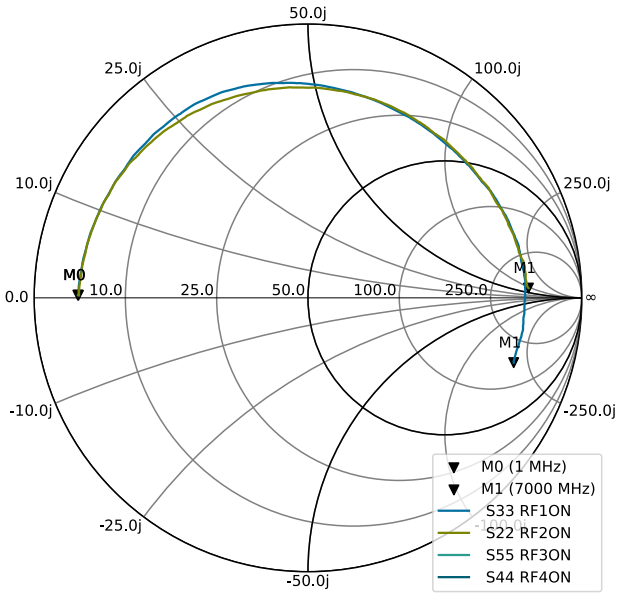
RFx – RFx isolation of non-active ports. Red/orange color curves are adjacent paths.



Unitarity, power absorption of the component, $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2 - |S_{41}|^2 - |S_{51}|^2$



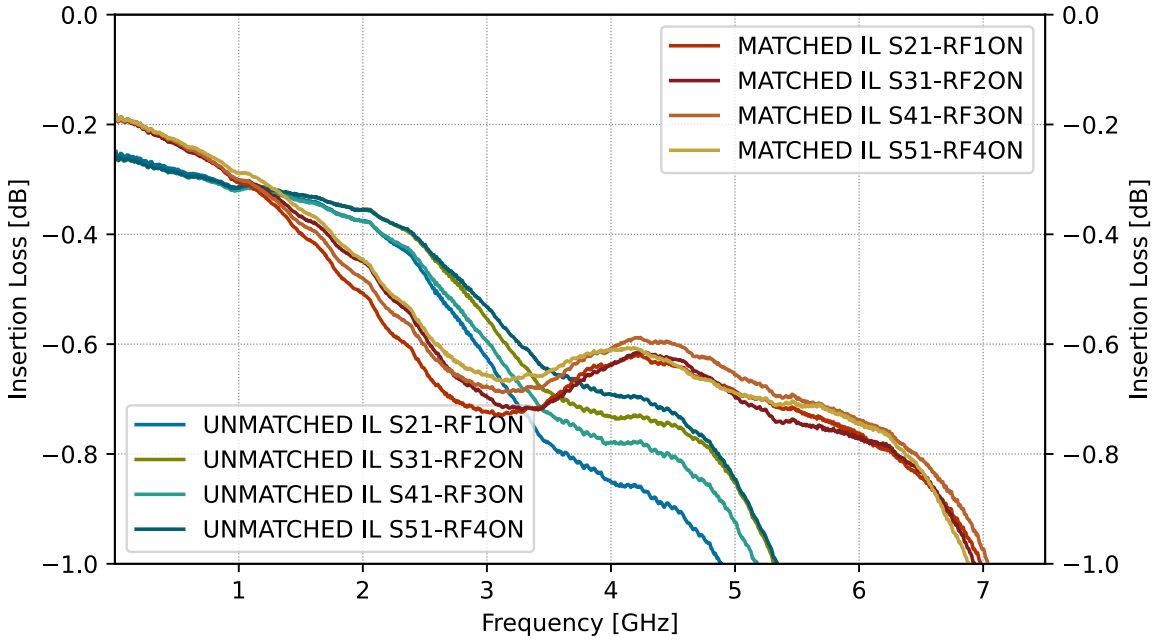
Matching of active port



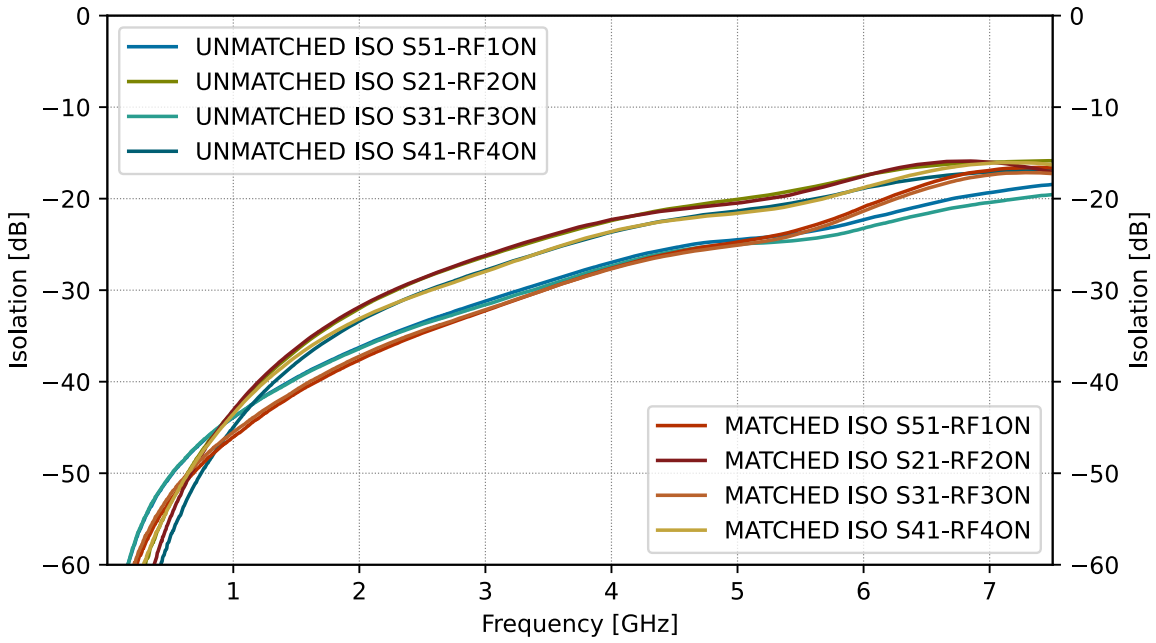
Termination impedance of non-active RFx.

Comparison plots of matched and unmatched switch.

Below Insertion Loss and Isolation comparison plots of matched and unmatched switch. Matching extends frequency response to 6.0 GHz without affecting isolation.



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

TS8242FK has power handling de-rating below 30MHz. Power de-rating table has been defined for 50ohm environment.

Table 13: Power De-Rating table

Start f	**Stop** f	**Max Power**	**Unit**
1 MHz	2 MHz	33	dBm
2 MHz	5 MHz	35	dBm
5 MHz	10 MHz	39	dBm
10 MHz	$f_{\max}$	40	dBm

Device Package information

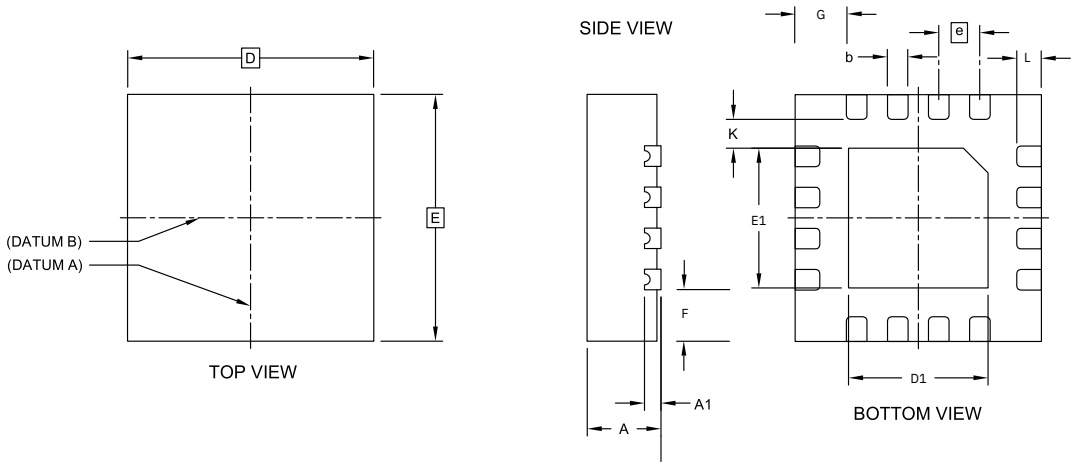
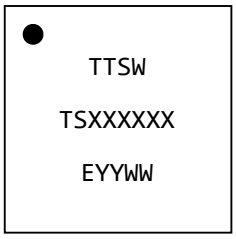


Figure 8: 16-pin QFN 3.0 x 3.0 x 0.85 mm^3 package drawing.

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	3.00 BSC	±0.05
A1	0.203	±0.02	E1	1.70	±0.05
b	0.25	+0.05/-0.07	F	0.625	±0.05
D	3.00 BSC	±0.05	G	0.625	±0.05
D1	1.70	±0.05	L	0.25	±0.05
e	0.50 BSC	±0.05	K	0.40	±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.

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.

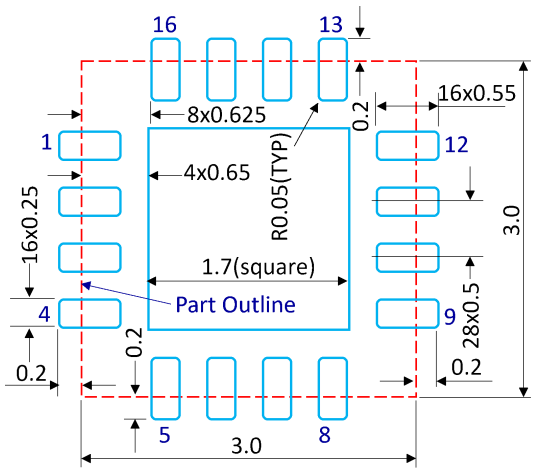


Figure 10: PCB land pattern, dimensions in [mm].

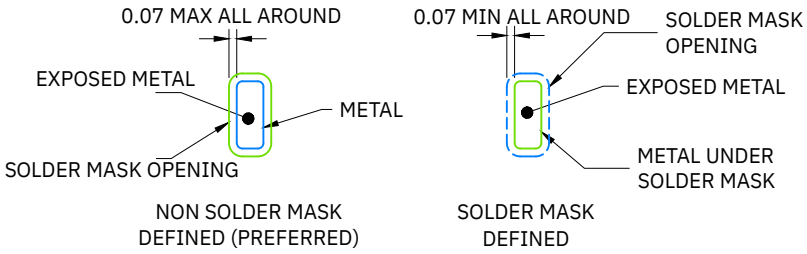


Figure 11: Solder mask opening, dimensions in [mm].

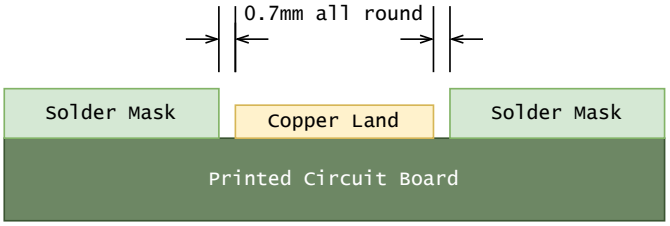


Figure 12: Preferred solder mask opening, side view, dimensions in [mm].

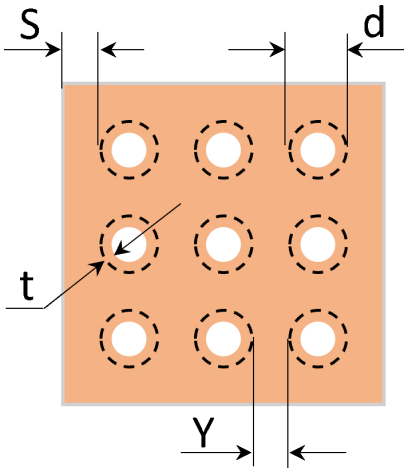


Figure 13: Thermal Via Pattern, Recommended Values: S≥0.15mm; Y≥0.20mm; d=0.2mm; Plating Thickness t=25μm or 50μm.

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.

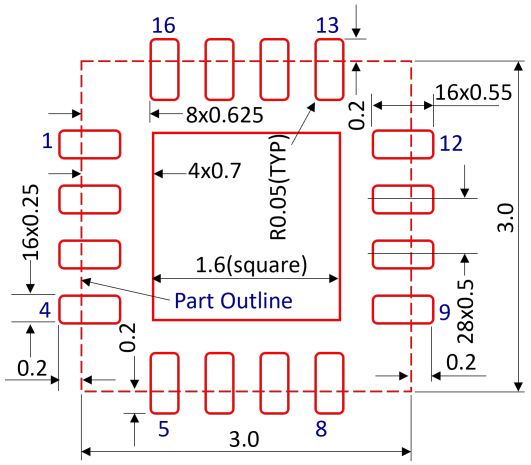


Figure 14: Stencil Openings, dimensions in [mm].

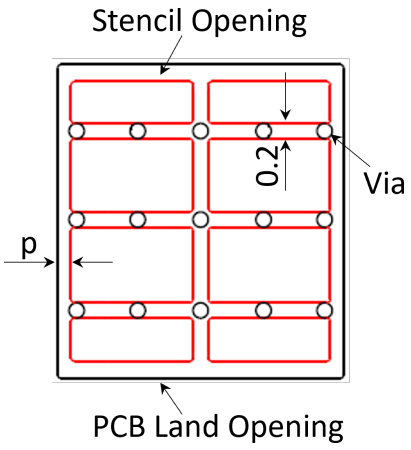
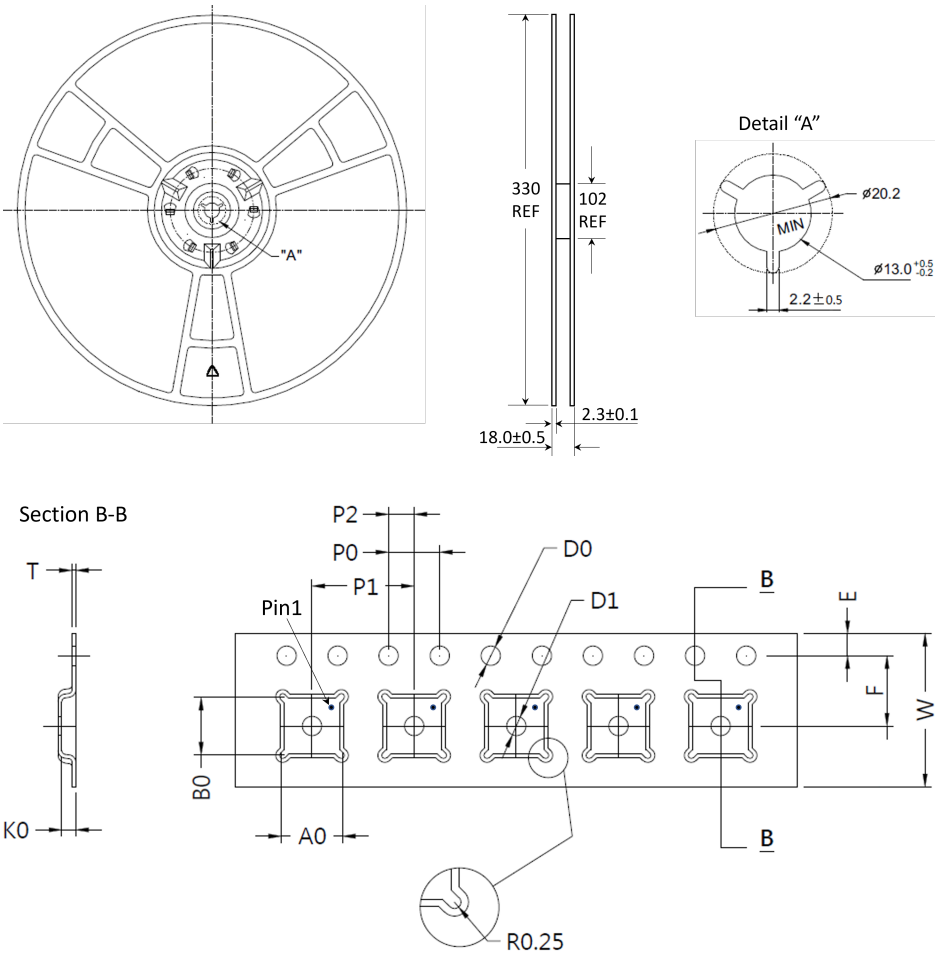


Figure 15: Stencil Openings Shall not Cover Via Areas If Possible, dimensions in [mm].

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]
3.30	3.30	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	RFC RF Common port, sometimes referred as ANT
RFx	RF Port number x
Unitarity	Describes power absorption of the component, $1-\|S_{11}\|^2-\|S_{21}\|^2-\|S_{31}\|^2-\|S_{41}\|^2-\|S_{51}\|^2$ here with SP4T

Changelog

Table 15: Changelog

Date	Revision	Notes
03/31/2026	3.0	New release with updated information, frequency range extended to 6.0GHz

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