SPDT 20W/60W$_{peak}$ Power Switch 1 MHz to 7.2 GHz

Features

- Frequency Range 1 MHz to 7.2 GHz
- Low insertion loss:
  0.20 dB @ 1.0 GHz
  0.40 dB @ 4.5GHz
  0.60 dB @ 7.0 GHz
- High isolation:
  30 dB @ 3.0 GHz
  20 dB @ 6.0 GHz
- 20 W CW Power, 60 W_p Peak Power
- Low power consumption, less than 1mW
- No external DC blocking capacitors on RF lines
- All RF ports OFF state
- Versatile 2.6...5.25 V power supply
- Charge pump disabled, -18 V supply needed
- Noise level better than -140 dBm/kHz

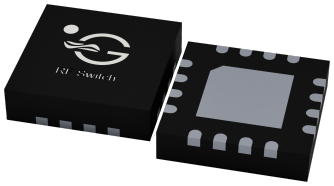


Figure 1: TS84230K in 3.0 x 3.0 mm^2 QFN 16-pin package.

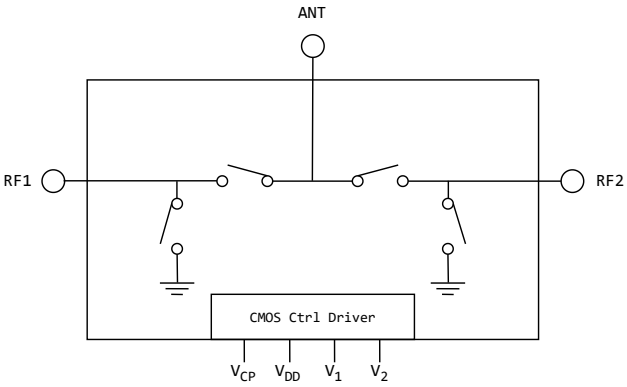


Figure 2: TS84230K functional diagram

Applications

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

RoHS

RoHS/Reach/Halogen free

General Description

The TS84230K is a 2nd Generation symmetrical reflective Single Pole Dual Throw (SPDT) switch designed for medium power switching applications. The TS84230K covers 1 MHz to 7.2 GHz bandwidth and provides low insertion loss, high isolation, and high linearity within a small package size. The TS84230K is a 20 W CW with peak power capability of 60 W, switch suitable for applications requiring low insertion loss, high isolation, and high linearity. TS84230K has charge pump disabled and requires -18 V supply, offering better than -140 dBm/1 kHz noise level.

The TS84230K is packaged into a compact Quad Flat No lead (QFN) 3.0x3.0mm^2 16 leads plastic package.

Ordering information

Table 1: Ordering Information

Device Part Number	Package Type	Notes
TS84230K	16 Pin 3.0x3.0x0.85mm^3 QFN	Core part number
TS84230K-EVB	Evaluation Board	
TS84230KMTRPBF[1]	330mm 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

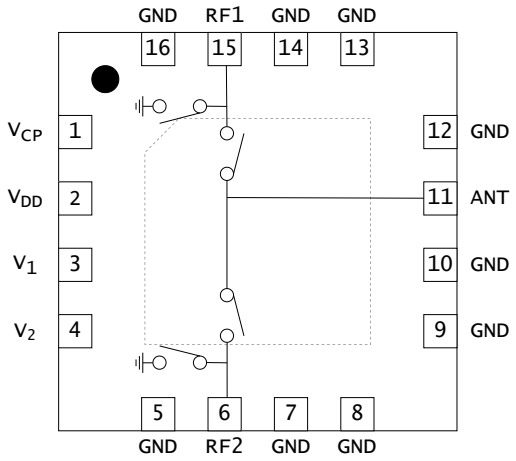


Figure 3: TS84230K pin assignment [top view]

Table 3: Pin Definition

Pin Number	Pin Name	Decription
1	V_{CP}	Internal charge pump voltage disabled, -18V supply needed on this pin.
2	V_{DD}	DC Power Supply
3	V_1	Switch control input 1
4	V_2	Switch control input 2
6	RF2	RF port 2
5,7,8,9,10,12,13,14,16	GND	Connect to ground[2]
11	ANT	Antenna port
15	RF1	RF port 1
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 $T_A \leq +25$°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/ANT	44	dBm
Maximum RF peak input power, 1% duty cycle, 10μs pulse [2]	RFx/ANT	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[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 800 MHz.
[3] See Power De-rating table for low frequencies.
[4] Tagore recommends to store parts in moisture barrier bag to preserve solderability.

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		7200	MHz
Insertion loss	30MHz		0.15		dB
unmatched, upto 5GHz	1.0GHz		0.18	0.30	dB
RFC – RFx	3.0GHz		0.30		dB
	5.0GHz		0.50		dB
Insertion loss[1]	30MHz		0.15		dB
matched upto 7.2GHz	1.0GHz		0.20		dB
RFC – RFx	3.0GHz		0.40		dB
	5.0GHz		0.50		dB
	6.0GHz		0.55		dB
	7.2GHz		0.65		dB
Isolation	30MHz		60		dB
unmatched, upto 5GHz	1.0GHz	40	43		dB
RFC – RFx	3.0GHz		30		dB
	5.0GHz		21		dB
Isolation[1]	30MHz		60		dB
matched upto 7.2GHz	1.0GHz		43		dB
RFC – RFx	3.0GHz		30		dB
	5.0GHz		22		dB
	6.0GHz		18		dB
	7.2GHz		15		dB
Isolation[1]	30MHz		60		dB
Isolation state	1.0GHz		37		dB
RFC – RFx	3.0GHz		25		dB
	5.0GHz		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		7200	MHz
Return Loss	30MHz		-30		dB
unmatched, upto 5GHz	1.0GHz		-30	-25	dB
$RFC - RFx$	3.0GHz		-20		dB
	5.0GHz		-15		dB
Return Loss[1]	30MHz		-30		dB
matched upto 7.2GHz	1.0GHz		-30	-25	dB
$RFC - RFx$	3.0GHz		-18		dB
	5.0GHz		-18		dB
	6.0GHz		-15		dB
	7.2GHz		-13		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	30		7200	MHz
Harmonic Distortion					
H_2	800MHz, P_{in} =40dBm		-92		dBc
H_3	800MHz, P_{in} =40dBm		-95		dBc
IIP3	800MHz		77		dBm
Power and Compression point					
P_{maxCW}	Max RF CW Power		43		dBm
P_{maxpeak}	Max RF Peak Power		48		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
$P_{0.1\text{dB}}$	800MHz, CW	43	45		dBm
$P_{1\text{dB}}$[1]	800MHz, CW		48		dBm
$P_{\text{peak0.1dB}}$	800MHz, 1% duty cycle, 10μs pulse		48		dBm
Noise					
CP switching noise[4]	RBW=1kHz		-140		dBm
Switching Time					
t_{ON}	Switch ON time		900	1170	ns
t_{OFF}	Switch OFF time		900	1170	ns
t_{RISE}	Switch RISE time		500	600	ns
t_{FALL}	Switch FALL time		500	600	ns
t_{wON}	Minimum Switch ON time		3.6		μs
t_{wOFF}	Minimum Switch OFF time		3.6		μs
$f_{\text{PRR}}, V_{\text{CP}} = -18V$	Maximum pulse repetition rate		>20		kHz
$t_{\text{startup}}, V_{\text{CP}} = -18V$	startup time		0.8		ms
Power Supply, DC					
Power supply[7]	V_{CP}	-19	-18	-17	V
Power supply[6]	I_{CP}	100			μA
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

[1] $P_{1\,\text{dB}}$ has been given for comparison reasons only. Please do not exceed Absolute Maximum ratings.
[4] TS84230K has disabled internal chargepump and therefore requires external -18 V. Therefore whole frequency range is clean and noise level is less than -140 dBm/kHz.
[5] Dependent on thermal design and surrounding circuits.
[6] Depends on the pulse repetition rate, even upto 10mA with 20kHz pulse repetition rate.
[7] V_{DD} should be applied first before V_{CP}. Minimum time between V_{DD} and V_{CP} should be 50 μs.

Switching time definition

Example of the definition by using 10 W/40dBm signal. We apply 10 W 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 0.3dB. 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.

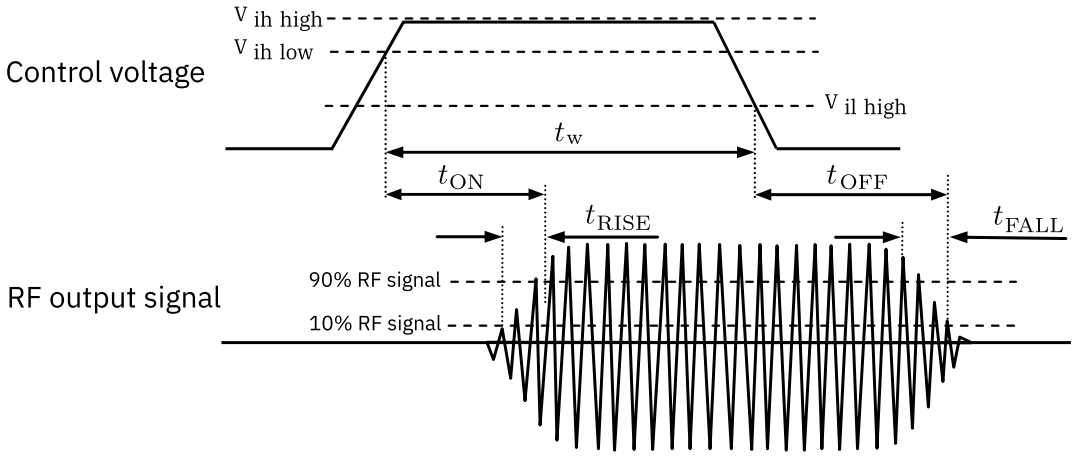


Figure 4: Switching time definition, t_{ON}, t_{OFF}, t_{RISE}, t_{FALL}. Minimum pulse width t_w.

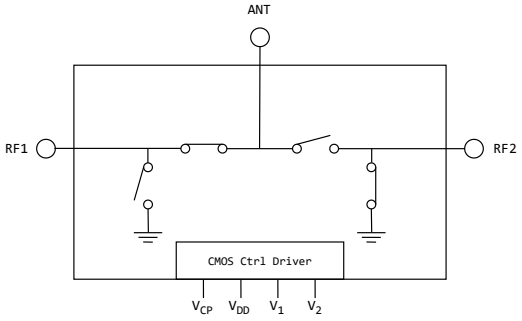
Our component uses integrated charge pump. Maximum pulse repetition rate defines what is maximum frequency for switching events. Please do not exceed given maximum frequency. By feeding external -18V to V_{CP}, one can improve maximum pulse repetition rate f_{PRR}. Feeding external -18 V to V_{CP}, one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

Switch Control table

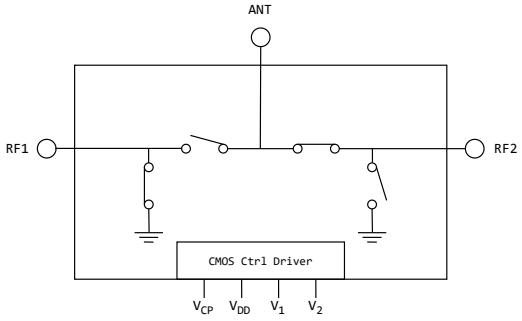
Table 8: Switch Control Table

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

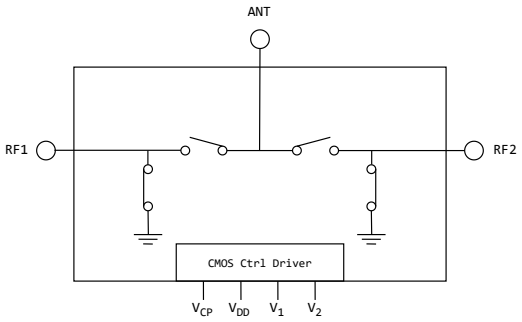
[1] V_{DD} should be applied first before V_1 and V_2, otherwise may cause damage to the device.
[2] There are internal pull-downs to ground on both V_1 and V_2 control pins, the state at start-up without any control voltage applied will be $ANT - RF1$ ON.
[3] If ISO state is not used, the switch can be operated with single control pin V_1
[4] V_{DD} should be applied first before V_{CP}. Minimum time between V_{DD} and V_{CP} should be 50 μs.



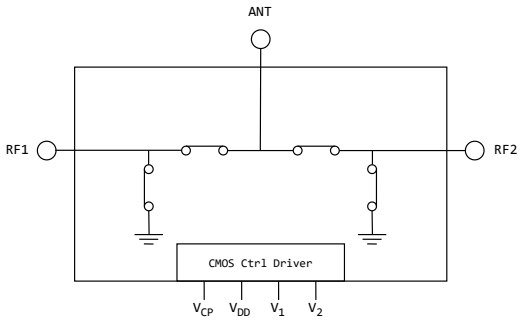
ANT-RF1 ON



ANT-RF2 ON



ISO (Isolation state)



V_{DD} off state

Theory of Operation

Isolation modes

TS84230K 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 ANT/RFC 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.

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. ANT 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.

Applications

TS84230K is offering 20W/60W_{peak} capability from 1 MHz to 7200 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, TS84230K significantly reduces design complexity for such RF switching needs. TS84230K works well upto 5 GHz frequency without external matching components, for frequency above 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 TS84230K S-parameters

Table 9: Port definitions in s-parameter files and plots.

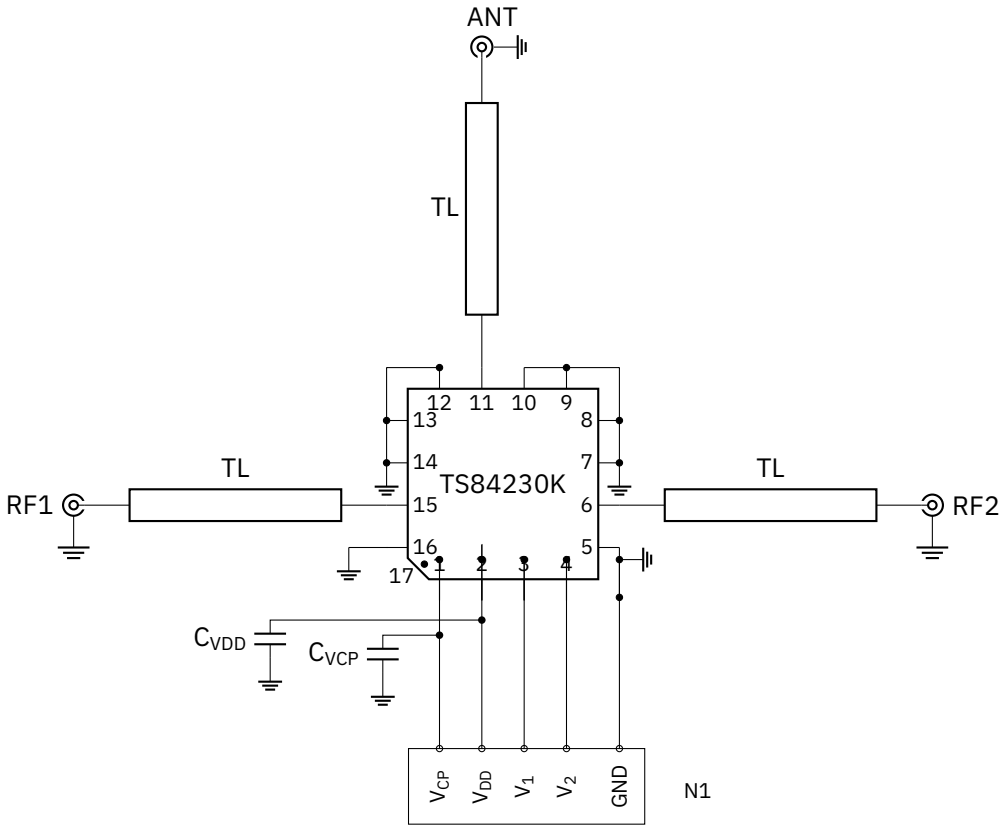
PIN name	Port numbers	S-parameters	Function
ANT	1	S11	
RF1	2	S22	
RF2	3	S33	
RF1ON	12	S21	ANT-RF1 ON
RF2ON	13	S31	ANT-RF2 ON

Content of s-parameter repository:

```
TS84230K.zip
├── IDX_00 ..... Directory for s-parameters without matching components
│   ├── Readme.txt
│   ├── TS84230K_ISO_3PORT.s3p ..... S3P file for ISO mode
│   ├── TS84230K_OFF_3PORT.s3p ..... S3P file for VDD off mode
│   ├── TS84230K_RF1ON_3PORT.s3p ..... S3P file for ANT-RF1ON off mode
│   └── TS84230K_RF2ON_3PORT.s3p ..... S3P file for ANT-RF2ON off mode
└── IDX_01 ..... Directory for s-parameters with matching components, 7.2GHz
    ├── Readme.txt
    ├── TS84230K_ISO_3PORT.s3p ..... S3P file for ISO mode
    ├── TS84230K_OFF_3PORT.s3p ..... S3P file for VDD off mode
    ├── TS84230K_RF1ON_3PORT.s3p ..... S3P file for ANT-RF1ON off mode
    └── TS84230K_RF2ON_3PORT.s3p ..... S3P file for ANT-RF2ON off mode
```

Performance upto 5GHz, unmatched

TS84230K shows best performance upto 5 GHz frequency without any matching components. Only two external components are recommended, 1 nF for V_{CP} and 10 nF forV_{DD} lines.



Schematics of TS84230K EVB

Table 10: Components used for TS84230K EVB

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

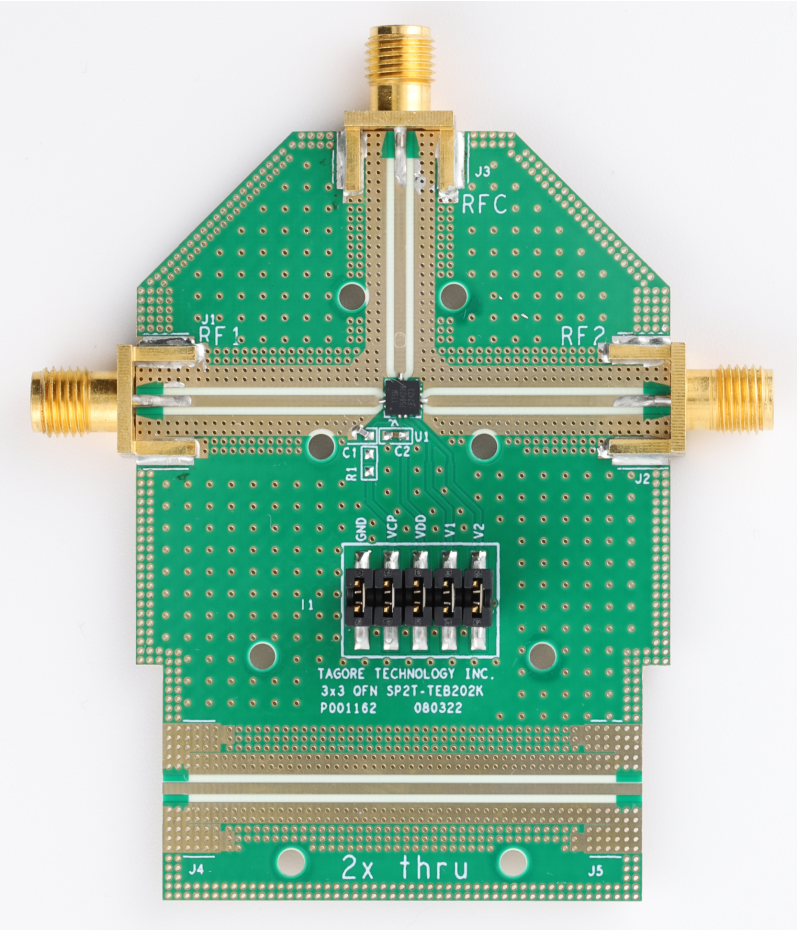
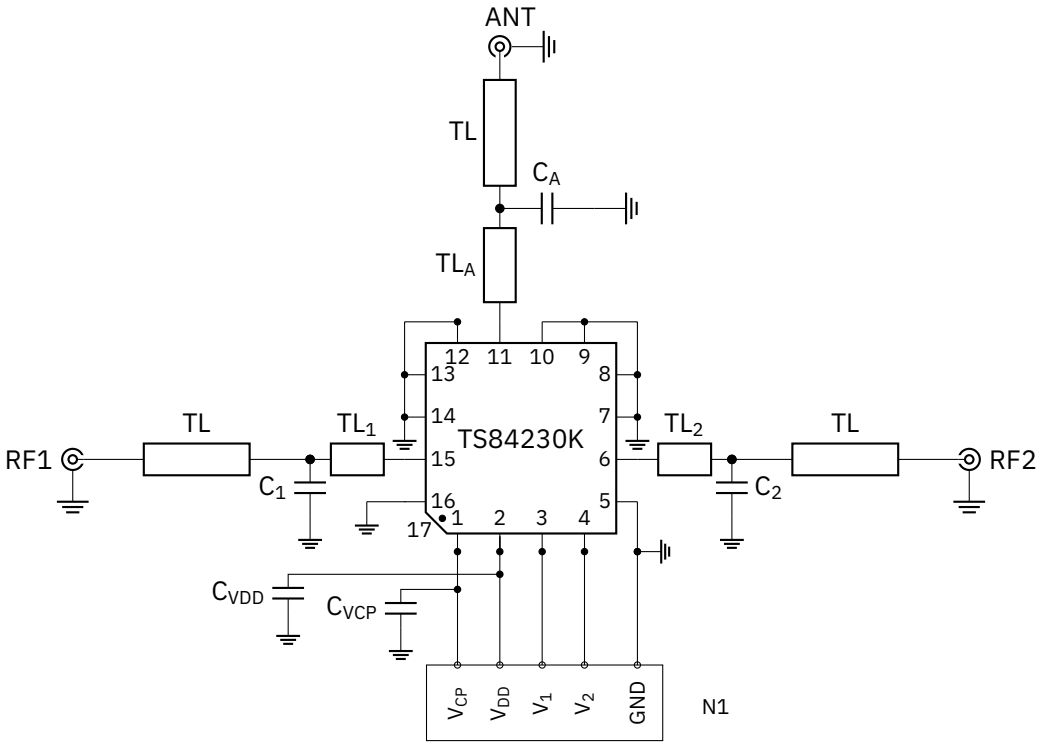


Photo of TS84230K EVB

Performance upto 7.2GHz, matched



Schematics of TS84230K EVB with matching components.

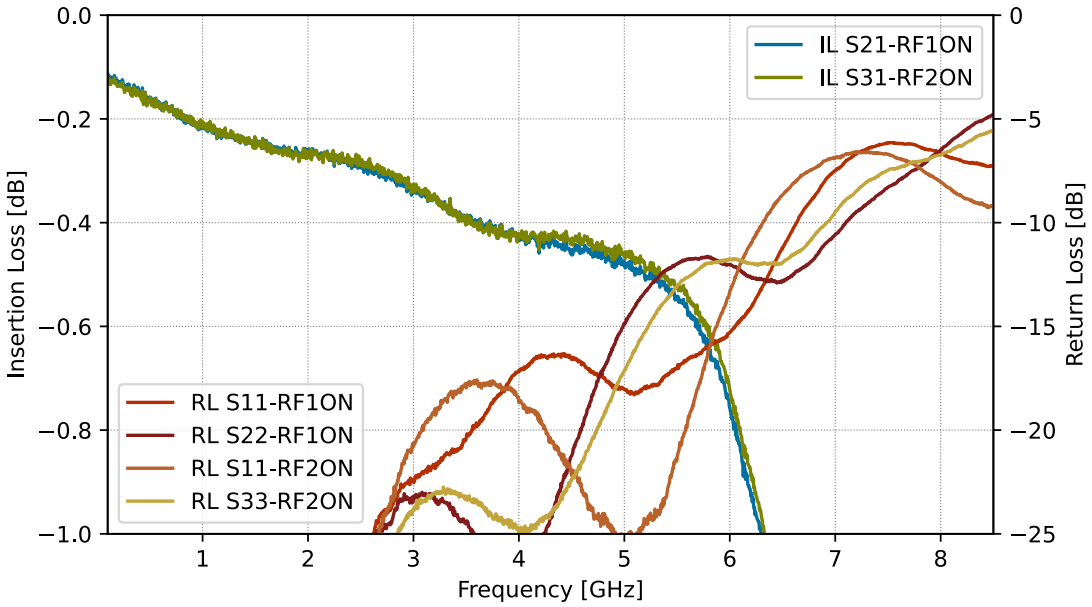
Table 11: Matching components used for 7.2GHz performance

Reference	Part number / Value	Description	Notes
TL_A	3.0mm	CPW length	Edge of SW to center of capacitor
C_A	0603N0R1BW251	Ceramic capacitor	0.1pF, 250V, ± 0.1pF
TL_1	0.9mm	CPW length	Edge of SW to center of capacitor
C_1	0603N0R2BW251	Ceramic capacitor	0.2pF, 250V, ± 0.1pF
TL_2	0.9mm	CPW length	Edge of SW to center of capacitor
C_2	0603N0R2BW251	Ceramic capacitor	0.2pF, 250V, ± 0.1pF
C_{VDD}	10nF	Capacitor	
C_{VCP}	1nF	Capacitor	

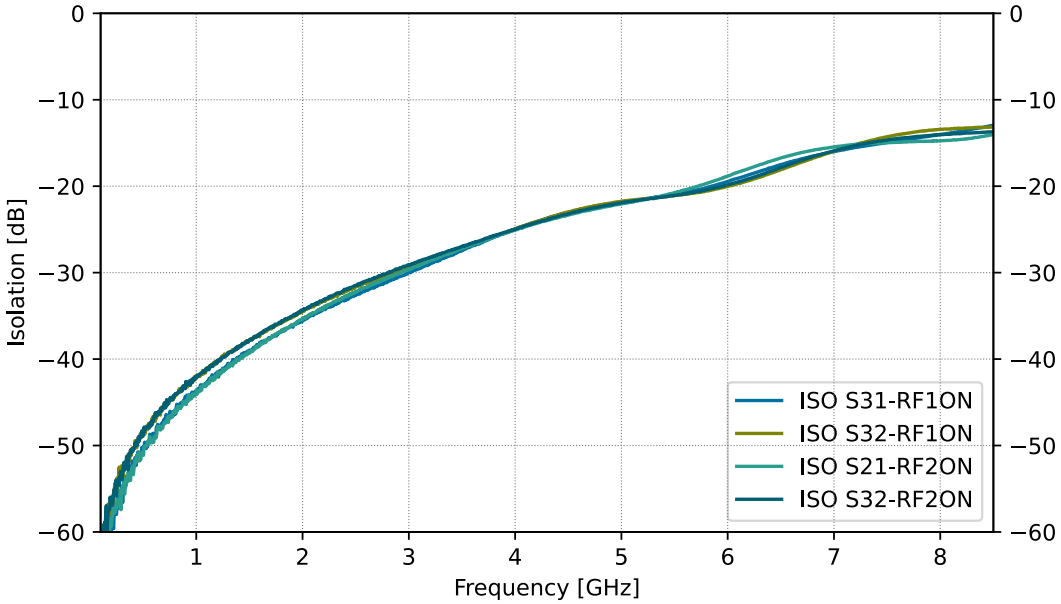
Typical characteristics

Performance upto 5 GHz, unmatched

These measurements have been taken from TS84230K EVK, CPW losses have been de-embedded from the measurements. Device does not require any matching components for operation upto 5 GHz. Going above 5 GHz, performance can be improved by adding matching to ports. Our matching example shows excellent performance upto 7.2 GHz.

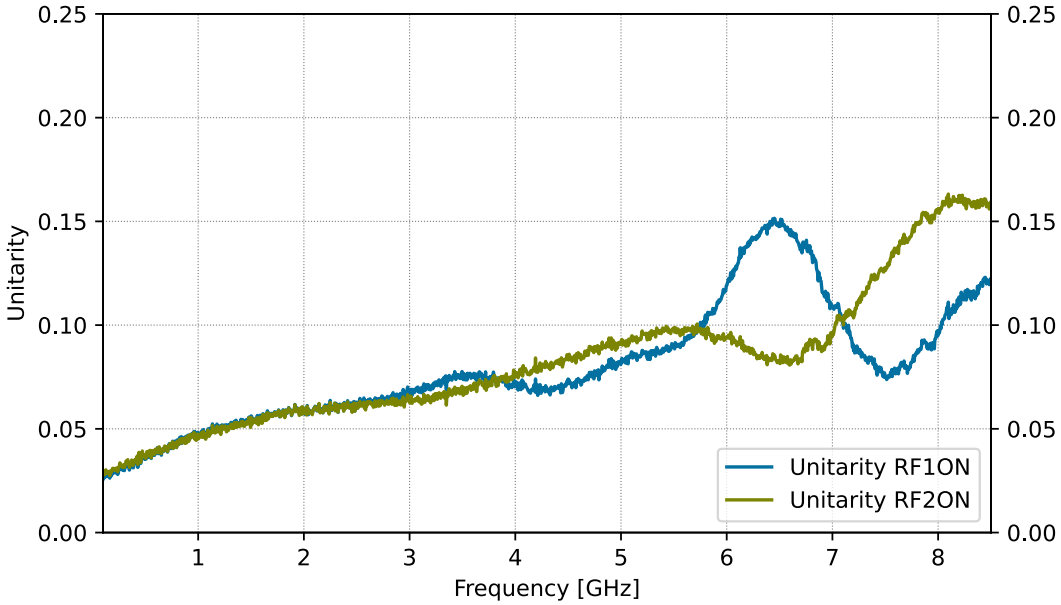


Insertion loss and Return loss, RFC − RFx.

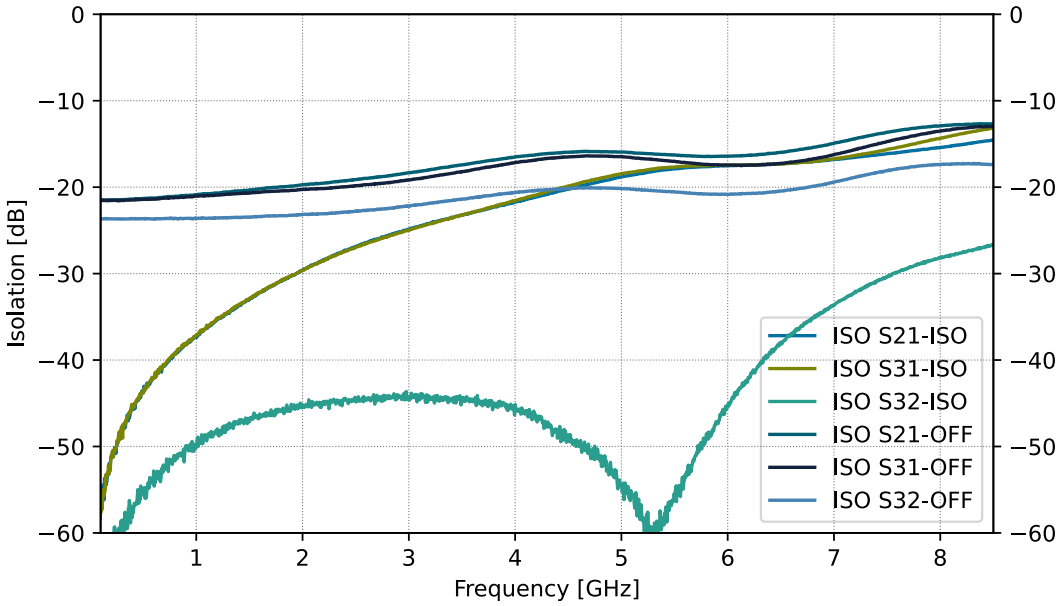


Isolation between RFC to non-active RFx and active RFx to non-active RFx.

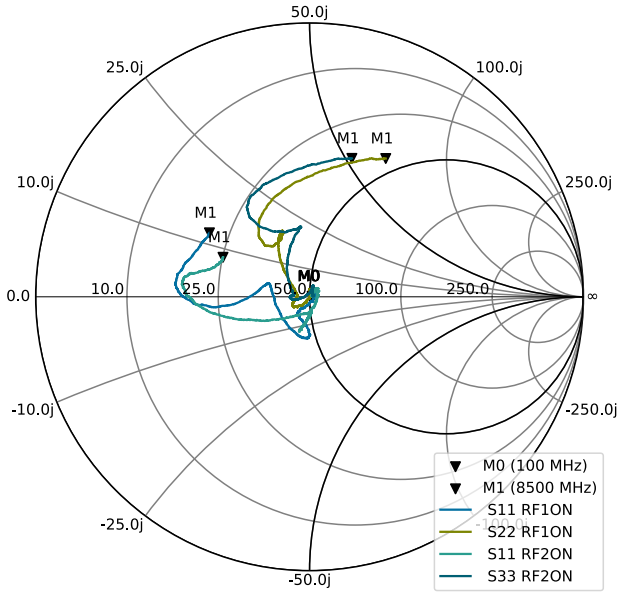
Unitarity, ie. power absorption of the switch describes power absorption of the switch and required cooling. In case of 20W input power, and power absorption of 0.07 means that 1.4 W is converted to heat.



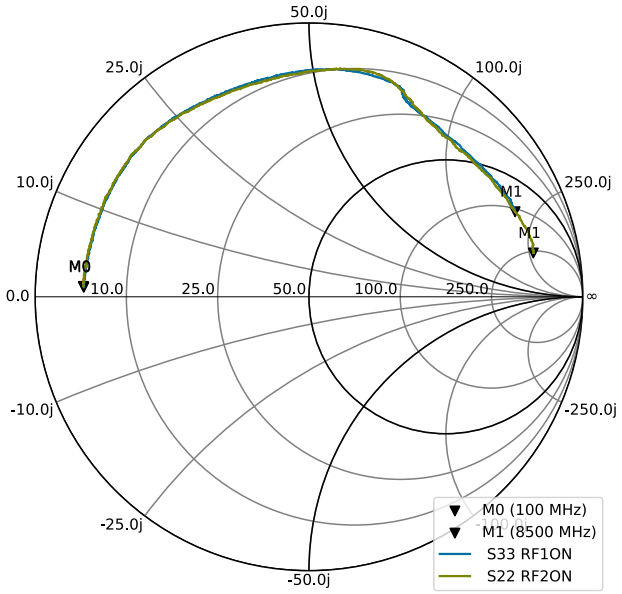
Power absorption of the switch $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2$, RFC − RFx.



RFC − RFx isolation at ISO mode and V_{DD} off (Isolation).



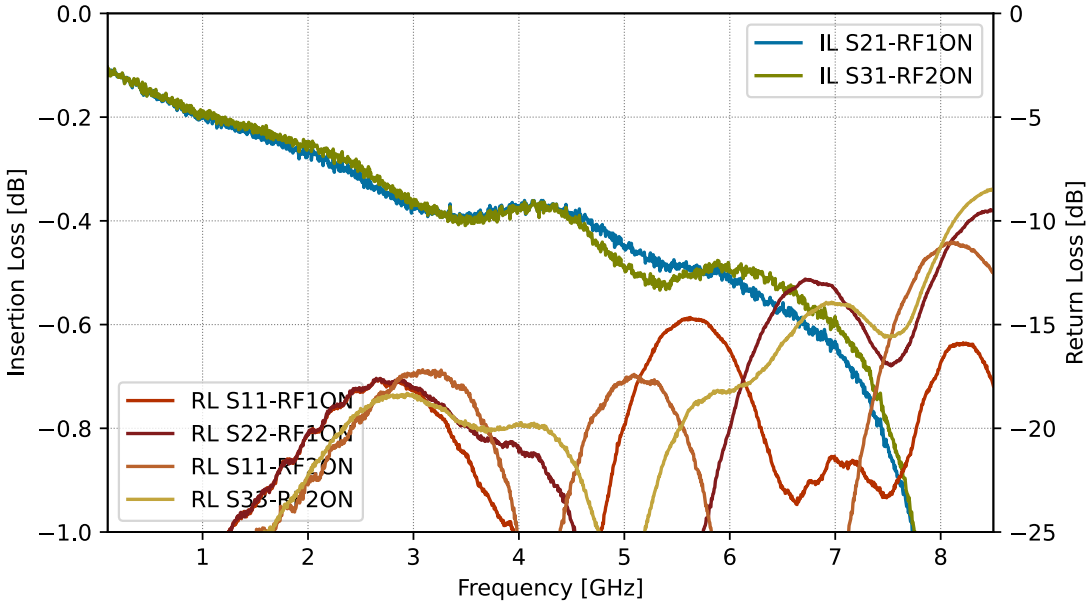
Active RF port impedance plotted to Smith chart



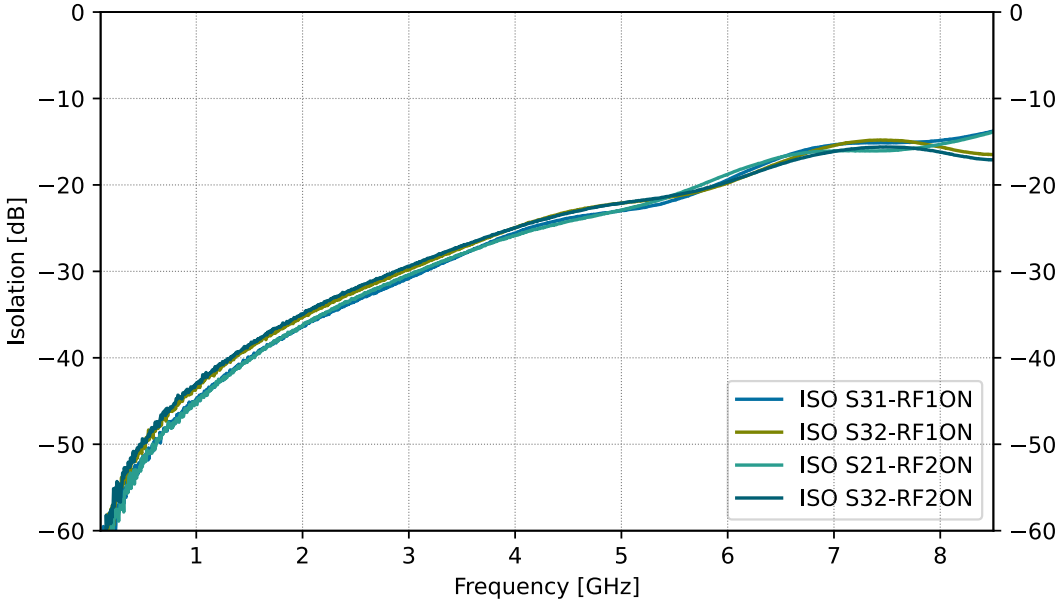
Non-active RF1 and RF2 termination impedance on Smith chart.

Performance upto 7200 MHz, matching applied to EVK

These measurements have been taken from TS84230K EVK, matching components applied. CPW losses have been de-embedded from the measurements, but matching component losses are present.

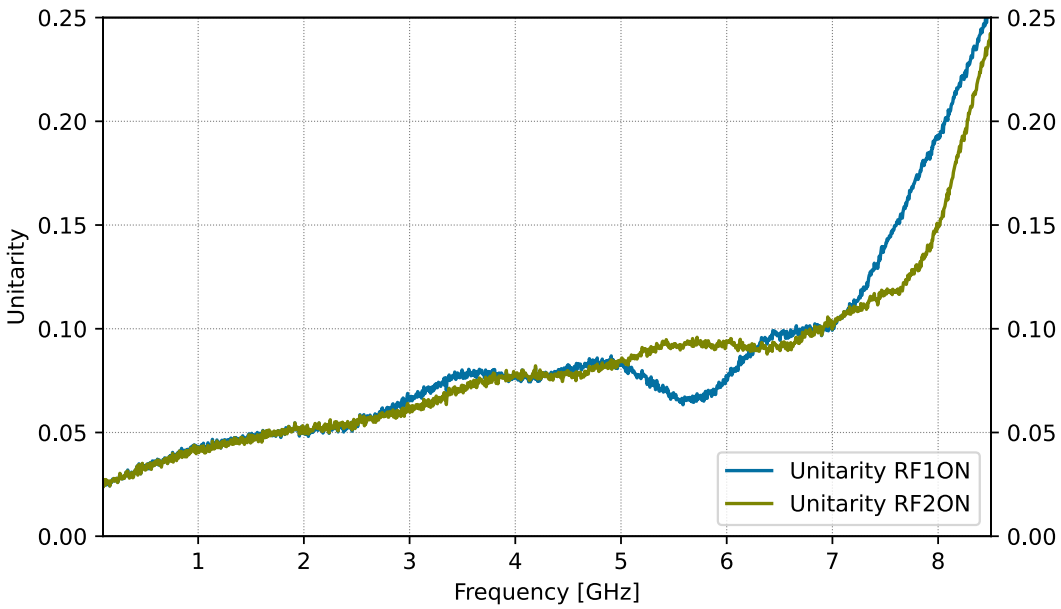


Insertion loss and Return loss, RFC − RFx.

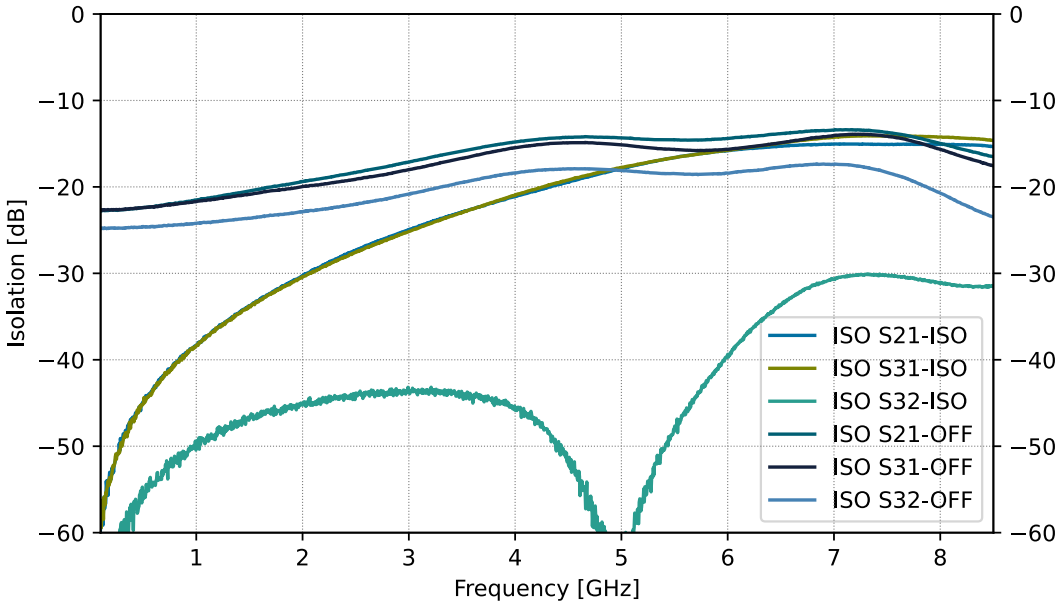


Isolation between RFC to non-active RFx and active RFx to non-active RFx.

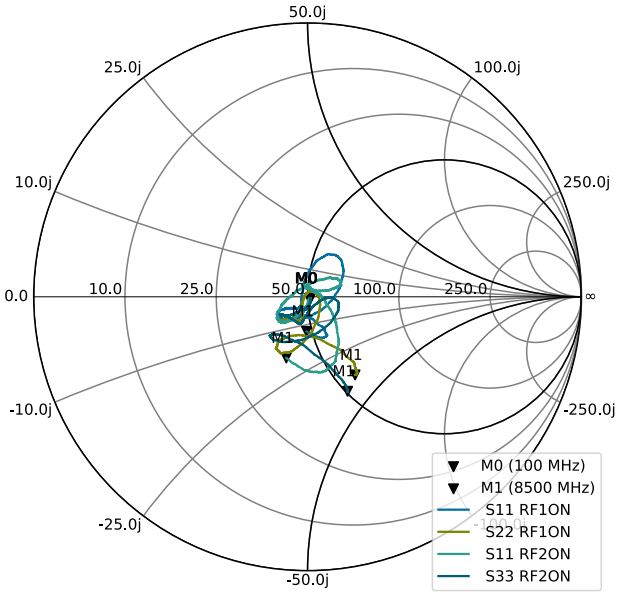
Unitarity, ie. power absorption of the switch describes power absorption of the switch and required cooling. In case of 20W input power, and power absorption of 0.07 means that 1.4 W is converted to heat.



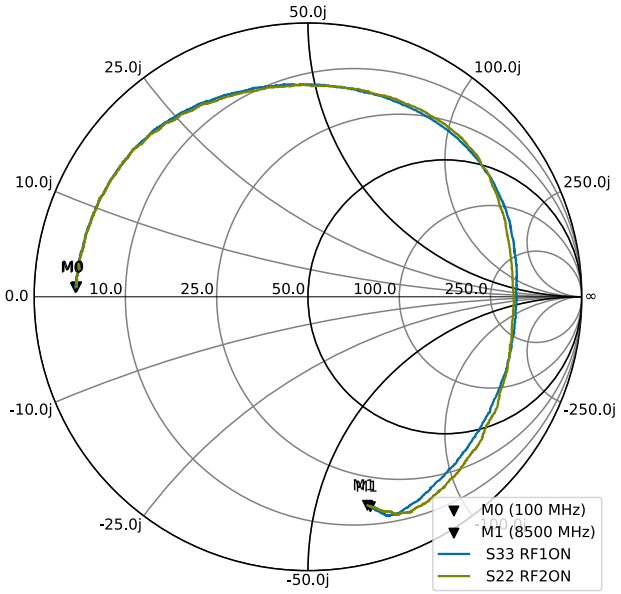
Power absorption of the switch $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2$, RFC − RFx.



RFC − RFx isolation at ISO mode and V_{DD} off (Isolation).



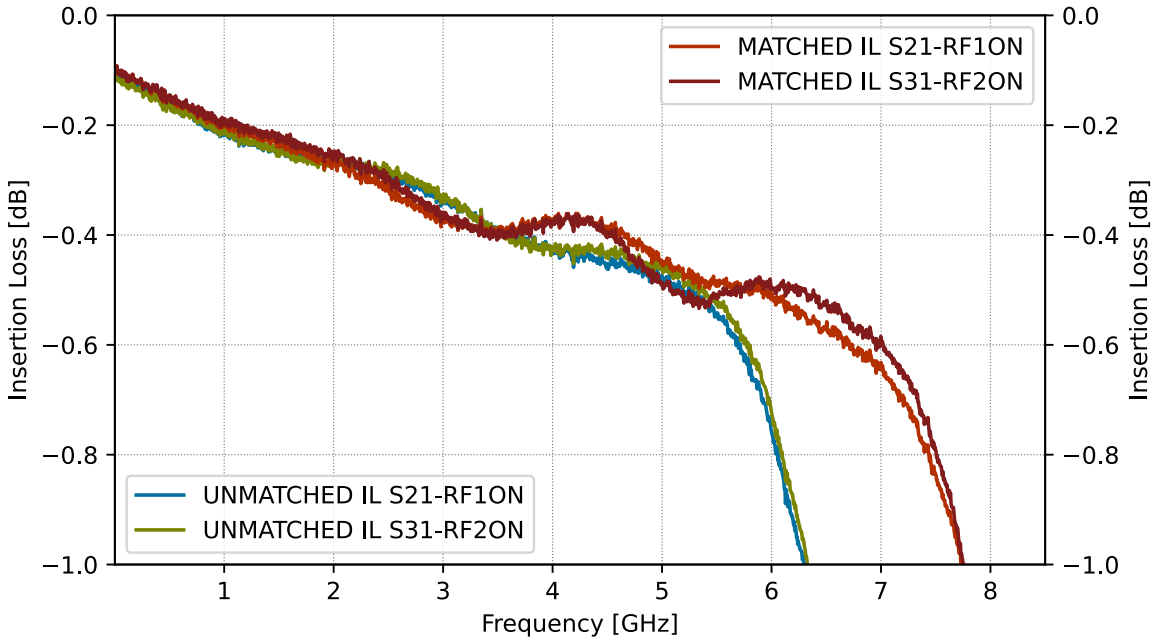
Active RF port impedance plotted to Smith chart



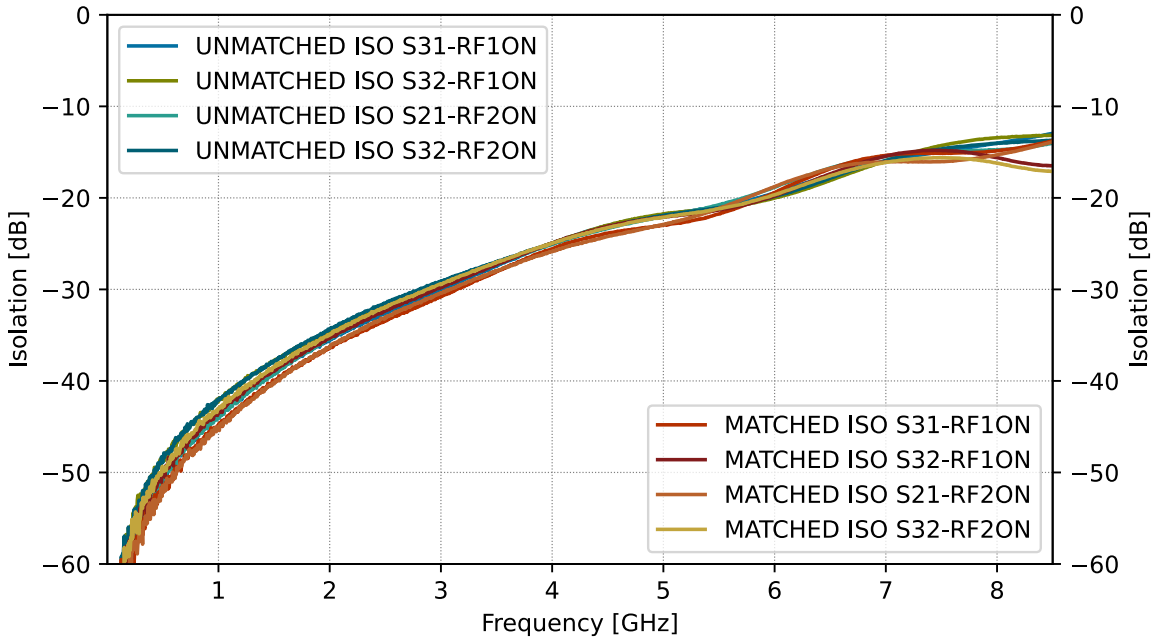
Non-active RF1 and RF2 termination impedance on Smith chart.

Comparison plots of matched and unmatched switch.

Below Insertion Loss and Isolation comparison plots of matched and unmatched switch. Matching extends frequency response to 7.2 GHz without affecting isolation.



Insertion loss comparison of matched to 7.2 GHz and unmatched switch.



Isolation comparison of matched to 7.2 GHz and unmatched switch.

Power De-rating

TS8423K has power handling de-rating below 30MHz. Power de-rating table has been defined for 50ohm environment.

Table 12: Power De-Rating table

Start f	**Stop** f	**Max Power**	**Unit**
1 MHz	2 MHz	34	dBm
2 MHz	5 MHz	36	dBm
5 MHz	10 MHz	42	dBm
10 MHz	$f_{\max}$	43	dBm

Device Package information

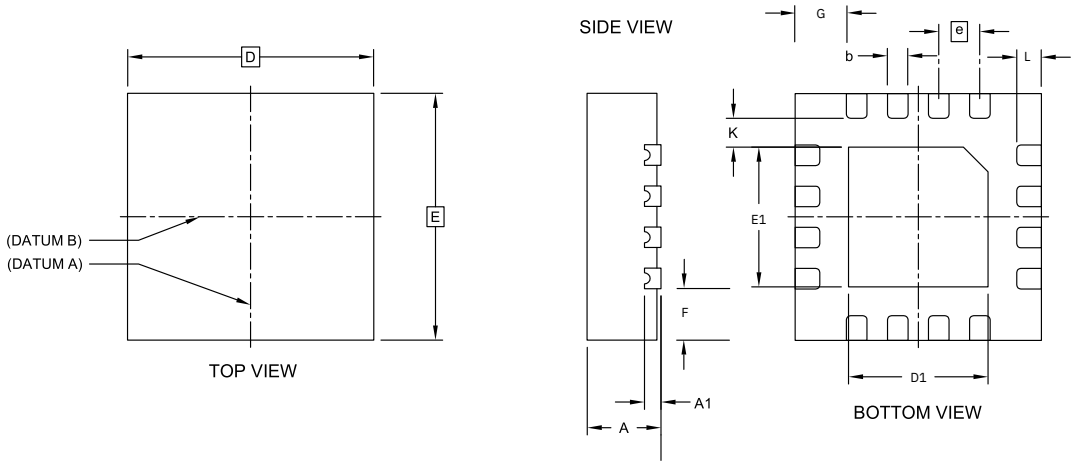


Figure 8: 16-pin QFN 3.0 x 3.0 x 0.85 mm^3 package drawing.

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

Table 13: 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

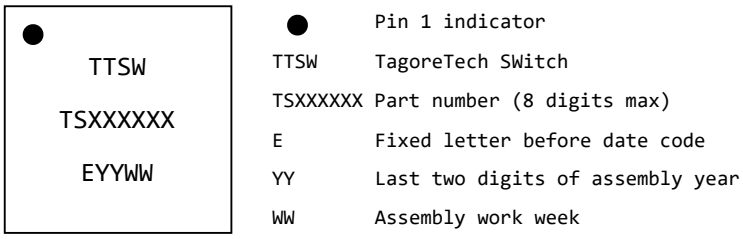


Figure 9: Part marking specification.

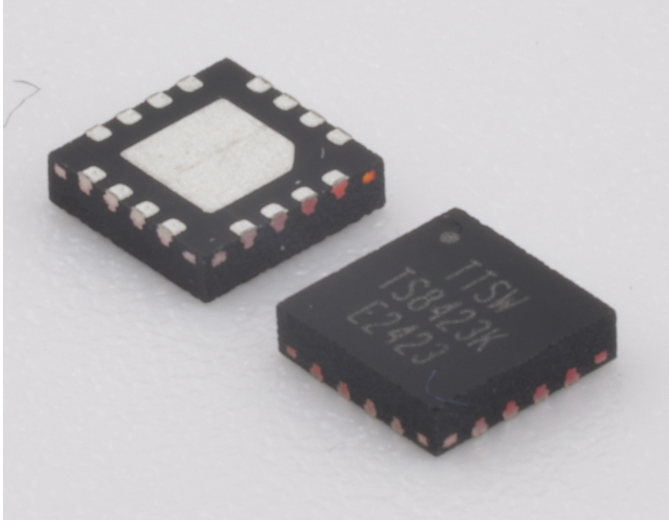


Figure 10: TS84230K photo, top and bottom side.

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.

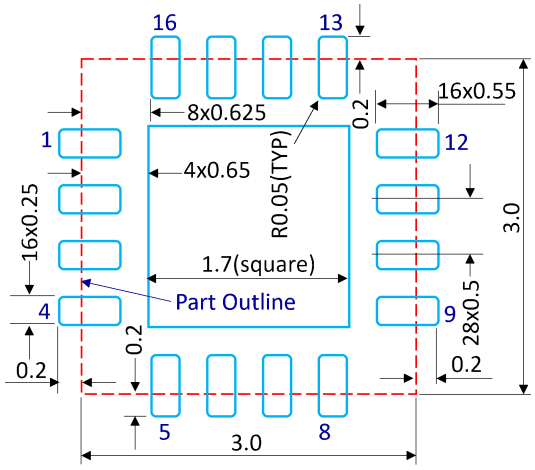


Figure 11: PCB land pattern, dimensions in [mm].

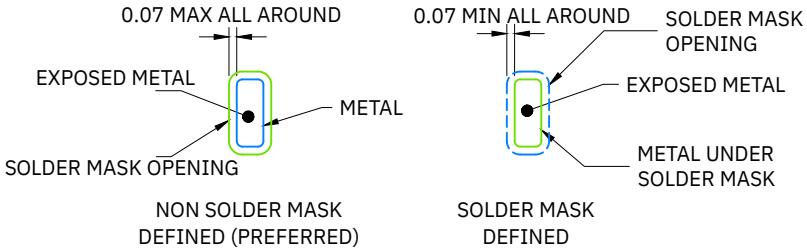


Figure 12: Solder mask opening, dimensions in [mm].

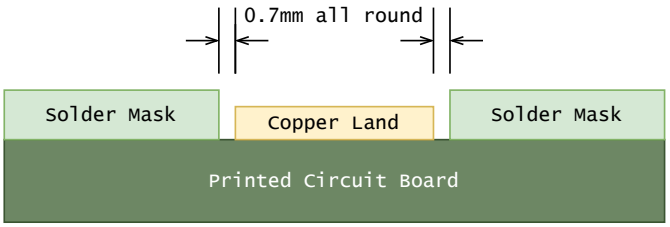


Figure 13: Preferred solder mask opening, side view, dimensions in [mm].

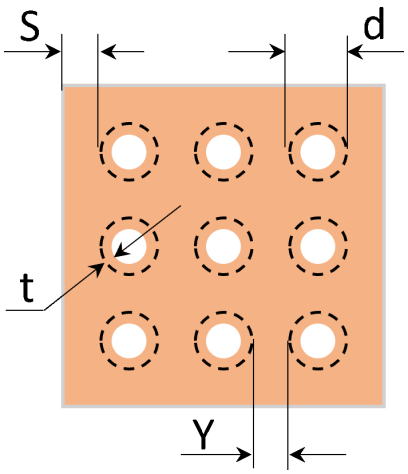


Figure 14: Thermal Via Pattern, Recommended Values: S≥0.15mm; Y≥0.20mm; d=0.2mm; Plating Thickness t=25μm or 50μm.

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.

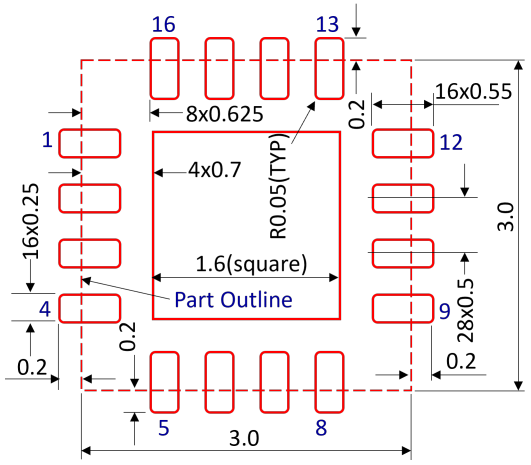


Figure 15: Stencil Openings, dimensions in [mm].

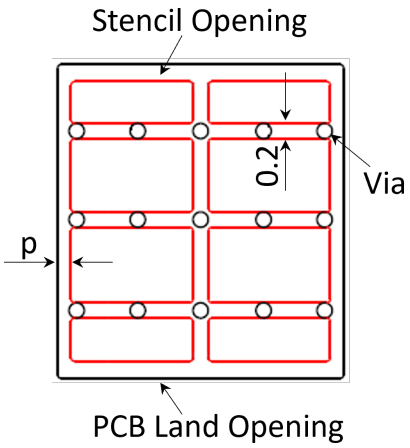
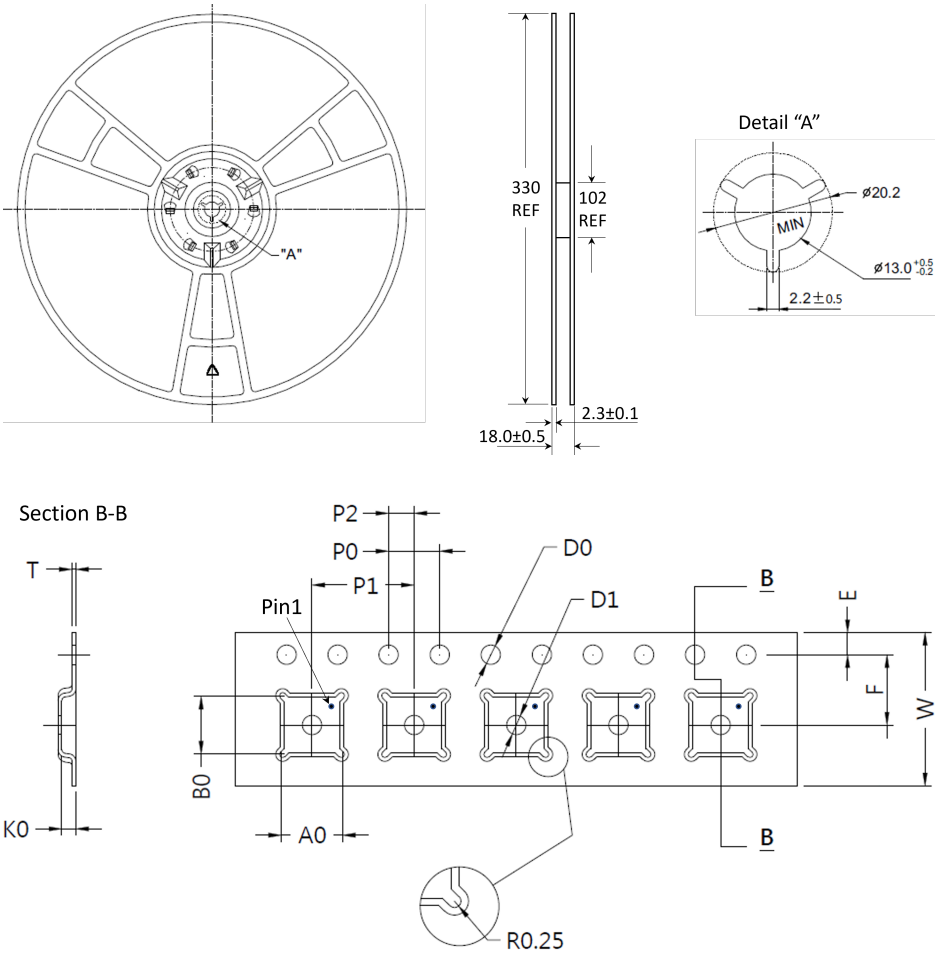


Figure 16: Stencil Openings Shall not Cover Via Areas If Possible, dimensions in [mm].

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]
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
ANT	Antenna port or common port, referred as RFC
RFx	RF Port number x

Changelog

Table 14: Changelog

Date	Revision	Notes
06/15/2025	3.0	New release with updated information, frequency range extended to 7.2GHz
07/11/2025	3.01	Comparison charts added, matched vs. unmatched
10/04/2025	3.1	Frequency range extended down to 1MHz with power de-rating.
10/04/2025	3.11	Recommendation of storing in dry pack added
01/28/2026	3.21	Links to Tagore website added, a few graphs updated

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