SPDT 20 W CW / 60 W 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 @ 4.5 GHz
  0.60 dB @ 7.0 GHz
- High isolation:
  30 dB @ 3.0 GHz
  20 dB @ 6.0 GHz
- 20 W CW power, 60 W 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 V – 5.25 V power supply
- No need to supply negative voltages; optional external −18 V on V_{CP} for pulse repetition rates above 20 kHz
- Integrated ESD protection on all RF ports, IEC 61000-4-2 4 kV contact discharge

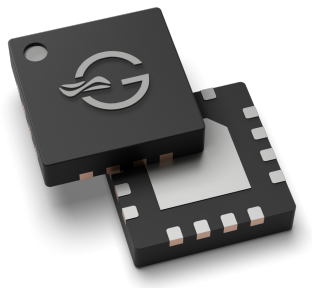


Figure 1: TS8326K in 3.0 x 3.0 mm^2 QFN 16-pin package.

Applications

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

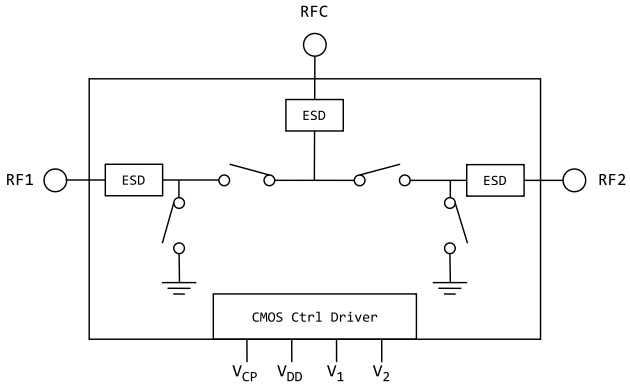


Figure 2: TS8326K functional diagram

General Description

The TS8326K is a 2nd Generation symmetrical reflective Single Pole Double Throw (SPDT) switch designed for medium power switching applications. Covering a bandwidth of 1 MHz to 7.2 GHz, the TS8326K provides low insertion loss, high isolation, and high linearity in a small package size. The switch handles 20 W of CW power with a peak power capability of 60 W, making it well suited for demanding medium power applications. The TS8326K is a derivative of the TS8423K, offering higher ESD robustness: integrated ESD protection on all RF ports (RFC, RF1 and RF2). As on the TS8423K, the internal charge pump voltage is available at pin 1 (V_{CP}): it needs a 1 nF capacitor to ground, and an external -18 V supply can be fed in to increase the pulse repetition rate.

The TS8326K is housed in a compact 3.0×3.0 mm^2 16-lead Quad Flat No-lead (QFN) plastic package.

RoHS

RoHS10/REACH/Halogen free

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Ordering information

Table 1: Ordering Information

Device Part Number	Package Type	Notes
TS8326K	16 Pin 3.0x3.0x0.75 mm^3 QFN	Core part number
TS8326K-EVB	Evaluation Board	Unmatched (IDX00)
TS8326KMTRPBF[1]	330 mm reel, 3 000 pcs	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

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Pin Assignment

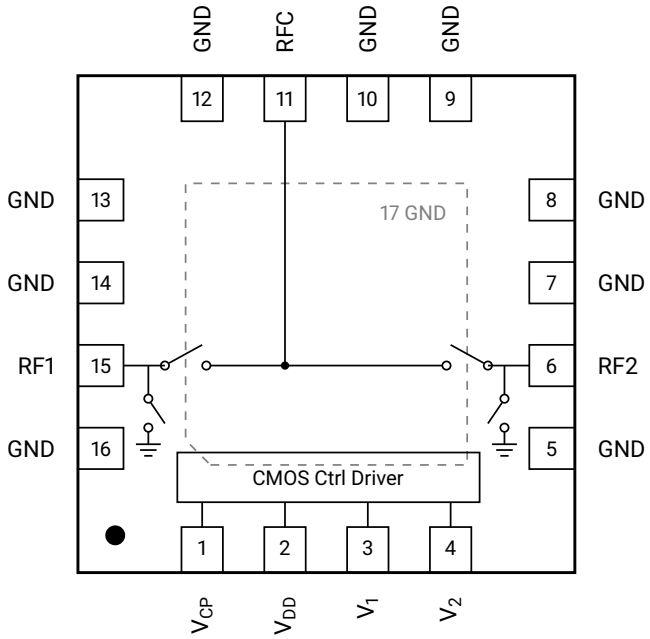


Figure 3: TS8326K pin assignment [top view]

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Table 3: Pin Definition

Pin Number	Pin Name	Description
1	V_{CP}	Internal charge pump voltage output, connect a 1 nF capacitor to GND on this node. Optionally, an external -18 V supply can be applied (see Theory of Operation).
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, ESD protected
5,7,8,9,10,12,13,14,16	GND	Connect to ground[2]
11	RFC	RF Common port, ESD protected
15	RF1	RF port 1, ESD protected
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.

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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
External bias voltage on V_{CP} pin	V_{CP}	-20	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			
RF ports (RFC, RF1, RF2), IEC 61000-4-2, contact discharge	Level 2	4	kV
Human Body Model (HBM), DC and control pins	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 Derating table for low frequencies.
[4] Tagore recommends to store parts in moisture barrier bags to preserve solderability.

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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	30 MHz		0.17		dB
unmatched, up to 5 GHz	1.0 GHz		0.22	0.30	dB
RFC – RFx	3.0 GHz		0.37		dB
	5.0 GHz		0.51		dB
Insertion loss[1]	30 MHz		0.15		dB
matched up to 7.2 GHz	1.0 GHz		0.20		dB
RFC – RFx	3.0 GHz		0.40		dB
	5.0 GHz		0.50		dB
	6.0 GHz		0.55		dB
	7.2 GHz		0.65		dB
Isolation	30 MHz		72		dB
unmatched, up to 5 GHz	1.0 GHz	40	42		dB
RFC – RFx	3.0 GHz		30		dB
	5.0 GHz		22		dB
Isolation[1]	30 MHz		60		dB
matched up to 7.2 GHz	1.0 GHz		43		dB
RFC – RFx	3.0 GHz		30		dB
	5.0 GHz		22		dB
	6.0 GHz		18		dB
	7.2 GHz		15		dB
Isolation	30 MHz		65		dB
Isolation state	1.0 GHz		36		dB
RFC – RFx	3.0 GHz		25		dB
	5.0 GHz		19		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.

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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	30 MHz		-37		dB
unmatched, up to 5 GHz	1.0 GHz		-35	-25	dB
$RFC - RFx$	3.0 GHz		-19		dB
	5.0 GHz		-18		dB
Return Loss[1]	30 MHz		-30		dB
matched up to 7.2 GHz	1.0 GHz		-30	-25	dB
$RFC - RFx$	3.0 GHz		-18		dB
	5.0 GHz		-18		dB
	6.0 GHz		-15		dB
	7.2 GHz		-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.

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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		7200	MHz
Harmonic Distortion					
H_2	800 MHz, P_{in} =40 dBm		-92		dBc
H_3	800 MHz, P_{in} =40 dBm		-95		dBc
IIP3	800 MHz		77		dBm
Power and Compression point					
P_{maxCW}[2]	Max RF CW Power		43		dBm
P_{maxpeak}	Max RF Peak Power		48		dBm
$P_{0.1\text{dB}}$	800 MHz, CW	43	44.5		dBm
$P_{\text{peak}0.1\text{dB}}$	800 MHz, 1% duty cycle, 10 μs pulse		48		dBm
$P_{1\text{dB}}$[1]	800 MHz, CW		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

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

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

Parameter	Condition	Minimum	Typical	Maximum	Unit
Noise					
CP switching noise[4]	RBW=1 kHz		-140		dBm
Switching Time					
t_{ON}[8]	Switch ON time		1150	1300	ns
t_{OFF}[8]	Switch OFF time		1100	1300	ns
t_{RISE}[8]	Switch RISE time		350	600	ns
t_{FALL}[8]	Switch FALL time		750	900	ns
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]	Start-up time		0.8		ms
$t_{startup}$, $C_{VCP} = 10nF$[3]	Start-up time		7		ms
$t_{startup}$, $C_{VCP} = 100nF$[3]	Start-up time		40		ms
Power Supply, DC					
Control voltage	Power Supply V_{DD}	2.6	3.3	5.25	V
	All control pins high[7], 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.
[6] External -18 V applied to the V_{CP} pin.
[7] Control voltage V_{ih} cannot be higher than V_{DD} (to avoid forward biasing of ESD diode)
[8] Switching time characterization done at 30 Hz and 500 Hz pulse repetition rate (rate to change switch state, for example between RFC-RF1 and RFC-RF2), with $C_{VCP} = 1$ nF.

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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 impedance. Let's assume that the 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 0.3 dB 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 $\mathrm{V_{ihlow}}$. In certain measurements when control signal rise time is significantly shorter than RF output signal, we approximate start of the clock with the 50% point of the control signal.

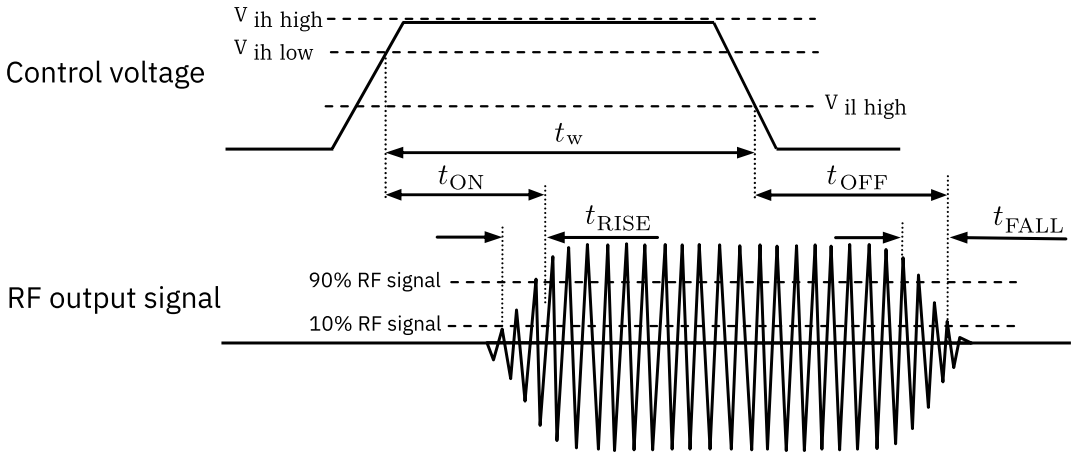


Figure 4: Switching time definition, t_{ON}, t_{OFF}, t_{RISE}, t_{FALL}. Minimum pulse width t_{w}.

Our component uses an integrated charge pump. Maximum pulse repetition rate f_{PRR} defines the maximum frequency for switching events. Please do not exceed the given maximum frequency. By feeding an external $-18\,\mathrm{V}$ supply to $\mathrm{V_{CP}}$, the maximum pulse repetition rate f_{PRR} can be increased: with external $-18\,\mathrm{V}$, the switch can be driven at least to 20 kHz f_{PRR}. Expect a current consumption of 10 mA from the $-18\,\mathrm{V}$ supply.

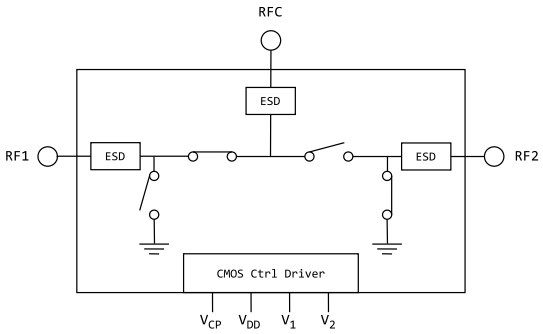
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Switch Control table

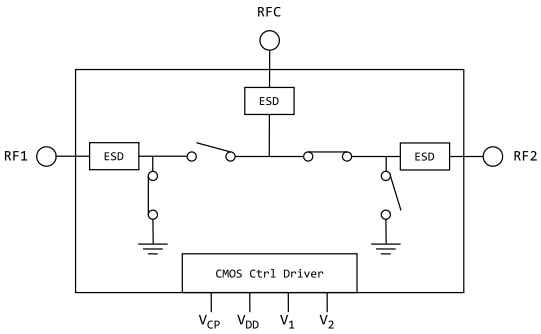
Table 9: Switch Control Table

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

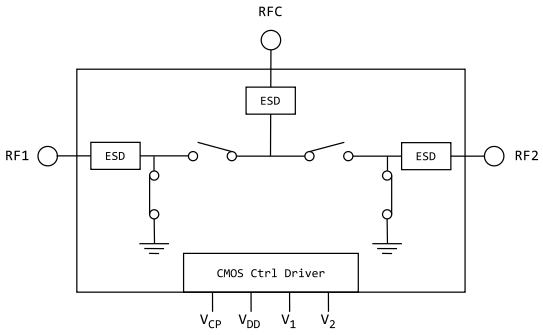
[1] V_{DD} should be applied first before V_1 and V_2, otherwise may cause damage to the device.
[2] There are internal pull-downs to ground on both V_1 and V_2 control pins, the state at start-up without any control voltage applied will be $RFC - RF1$ ON.
[3] If ISO state is not used, the switch can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



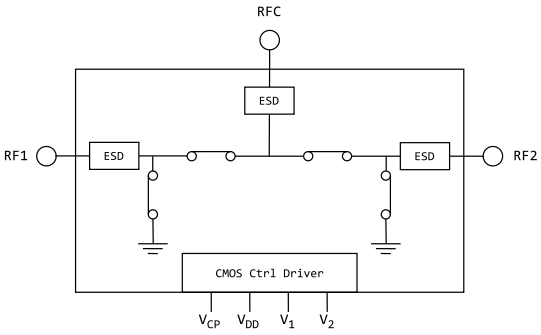
RFC-RF1 ON



RFC-RF2 ON



ISO (Isolation state)



V_{DD} off state

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Theory of Operation

Isolation modes

TS8326K 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 0 V, all switch RF transistors are on, ie. every MOSFET is on. This means that series MOSFETs and shunt MOSFETs 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 65 dB (measured, 30 MHz) as basically there is DC block due to open FETs.

ESD protection

All RF ports of the TS8326K, the common port RFC and the two throws RF1 and RF2, have integrated ESD protection (functional diagram). The RF ports are rated to IEC 61000-4-2, level 2, 4 kV contact discharge, see Absolute Maximum Ratings. The ESD protection does not require any external components and does not limit the RF power handling of the switch.

Internal charge pump, feeding external V_{CP} voltage of -18 V

As on the TS8423K, the output of the internal charge pump is available at pin 1 (V_{CP}) and needs a capacitor C_{VCP} to ground, 1 nF recommended; a larger C_{VCP} increases the pulse repetition rate f_{PRR} slightly, but also the start-up time. The TS8326K supports an external voltage supply to V_{CP} to increase f_{PRR} to more than 20 kHz, in some cases even up to 100 kHz; expect a current consumption of 10 mA from the -18 V supply (absolute maximum -20 V). In order to use the external voltage, it is mandatory to supply V_{DD} first, have a delay of 1 ms and then apply -18 V to V_{CP}. Shutdown should be in the opposite order.

Application Information

TS8326K is offering 20 W CW and 60 W peak power capability from 1 MHz to 7.2 GHz. 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, TS8326K significantly reduces design complexity for such RF switching needs. TS8326K works well up to 5 GHz frequency without external matching components; for frequencies above 5 GHz, matching is recommended. All RF ports are ESD protected (IEC 61000-4-2, 4 kV contact discharge), which makes the TS8326K well suited for switches directly connected to an antenna. Datasheet provides an example matching and its performance.

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Schematics and Evaluation Board

S-parameters of both presented EVB configurations can be downloaded from this link: Download TS8326K 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

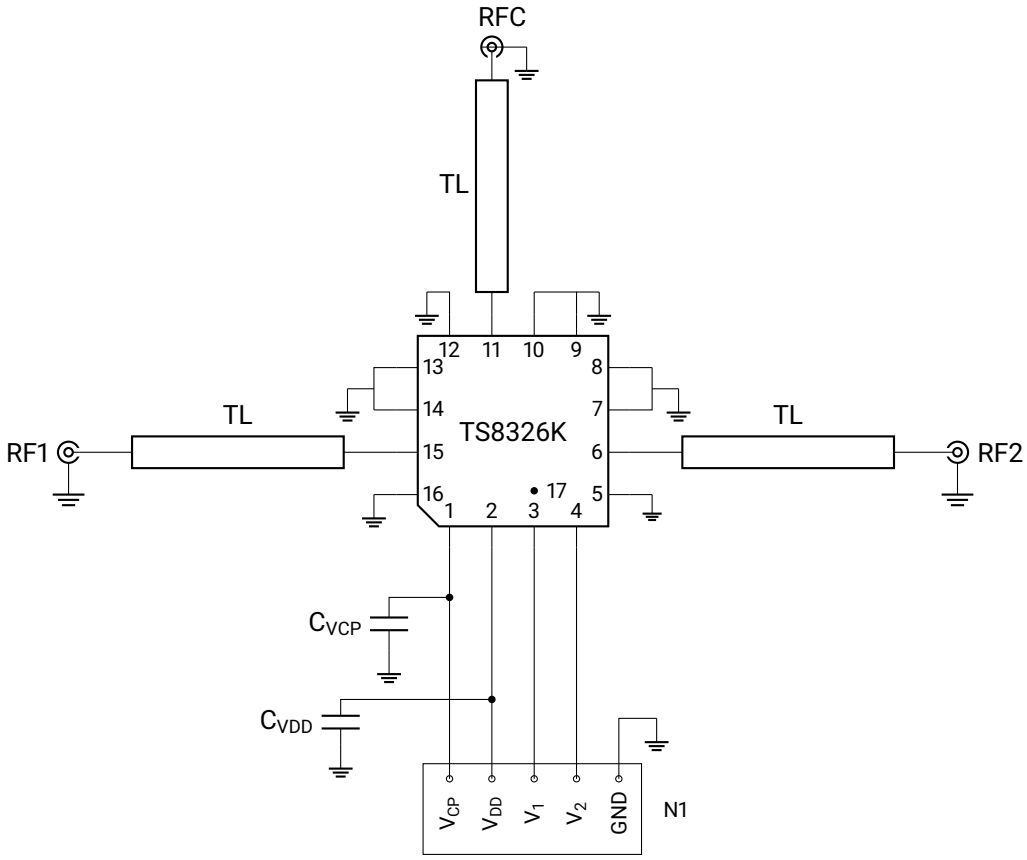
Content of s-parameter repository:

```
TS8326K.zip
├── IDX_00 ..... Directory for s-parameters without matching components
│   ├── Readme.txt
│   ├── TS8326K_ISO_3PORT.s3p ..... S3P file for ISO mode
│   ├── TS8326K_RF1ON_3PORT.s3p ..... S3P file for RFC-RF1ON mode
│   └── TS8326K_RF2ON_3PORT.s3p ..... S3P file for RFC-RF2ON mode
└── IDX_01 ..... Directory for s-parameters with matching components, 7.2 GHz (TS8423K measurement)
    ├── Readme.txt
    ├── TS8326K_ISO_3PORT.s3p ..... S3P file for ISO mode
    ├── TS8326K_OFF_3PORT.s3p ..... S3P file for VDD off mode
    ├── TS8326K_RF1ON_3PORT.s3p ..... S3P file for RFC-RF1ON mode
    └── TS8326K_RF2ON_3PORT.s3p ..... S3P file for RFC-RF2ON mode
```


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Unmatched EVB (IDX00), up to 5.0 GHz

TS8326K shows best performance up to 5 GHz frequency without any matching components. Only two external components are recommended, 1 nF for the V_{CP} line and 10 nF for the V_{DD} line. Pin 17 in the schematic refers to the center (thermal) pad of the device. For an external -18 V supply, V_{CP} is available at the header N1.



Schematic of TS8326K-EVB, unmatched (IDX00)

Table 11: Components used for TS8326K-EVB

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

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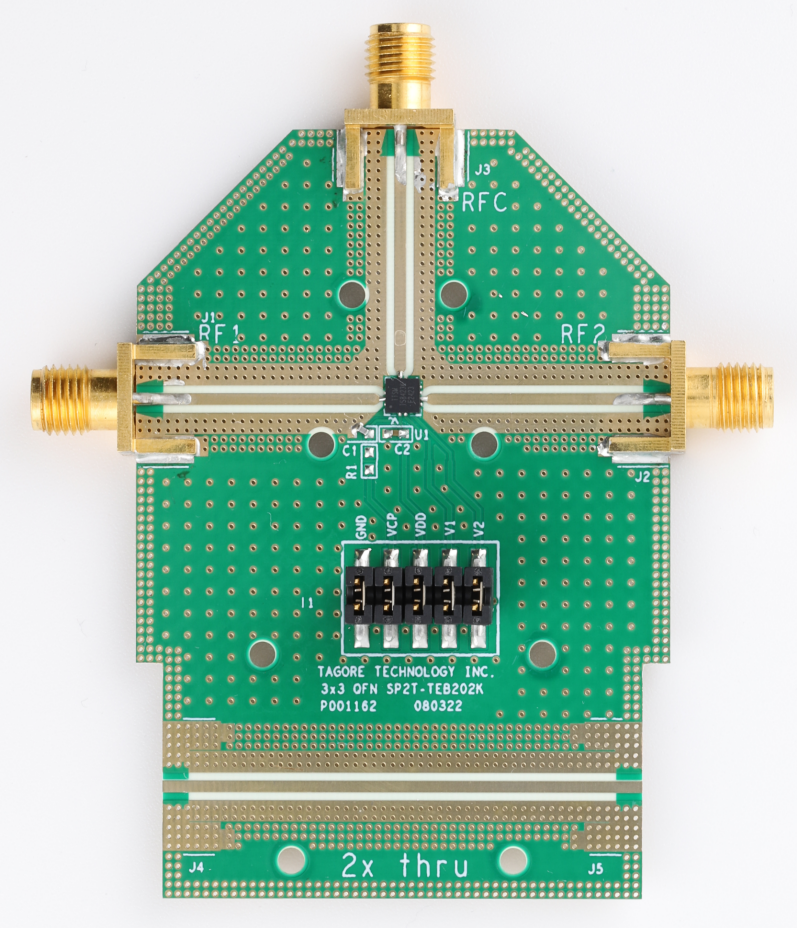
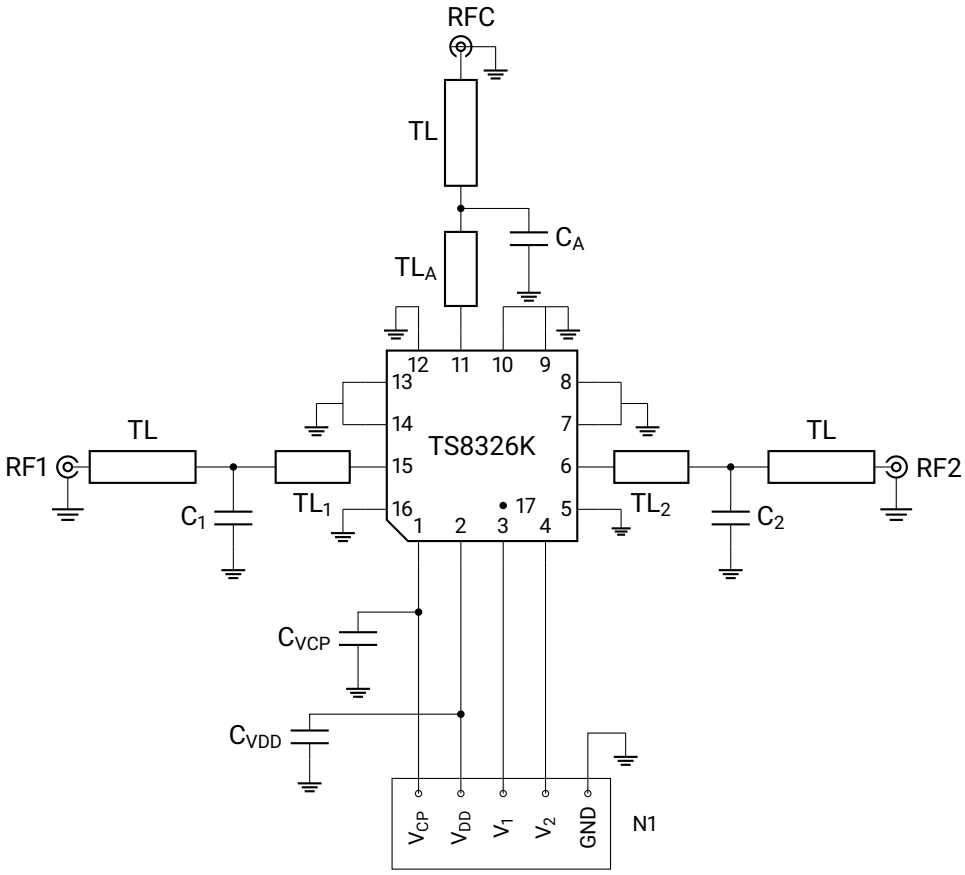


Photo of TS8326K-EVB

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Matching example (IDX01), up to 7.2 GHz

The matching example uses a short CPW line and a shunt capacitor at each RF port (Table 12). The matching example and its measurements are from the TS8423K, which is the same switch without the ESD protection; the same matching principle works also for the TS8326K, as the part is very similar, only the ESD protection is added.



Schematic of TS8326K-EVB with 7.2 GHz matching (IDX01)

Table 12: Matching components used for 7.2 GHz performance

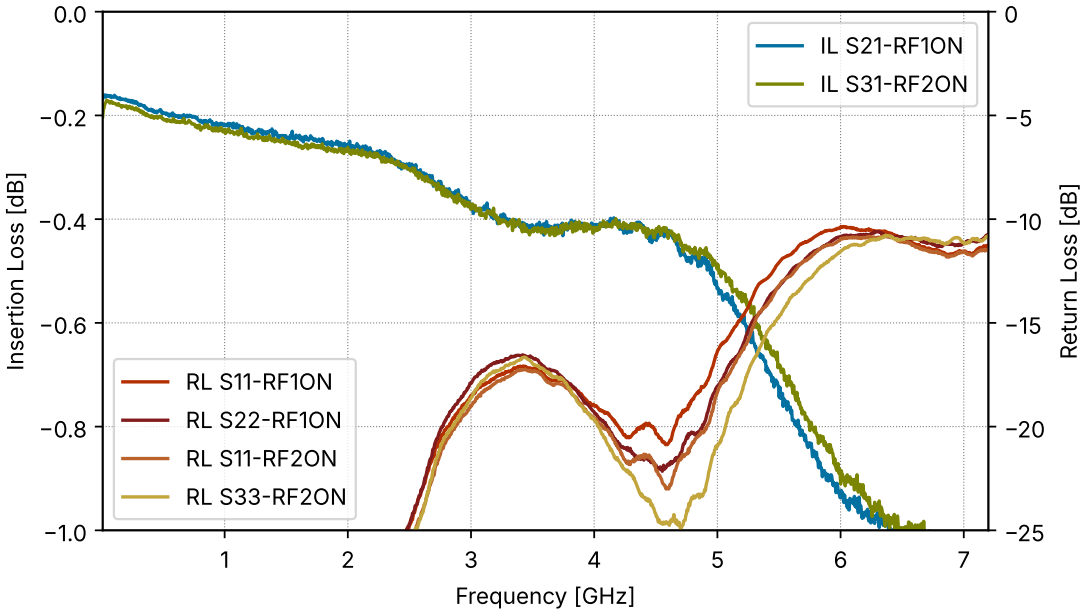
Reference	Part number / Value	Description	Notes
TL_A	3.0 mm	CPW length	Edge of SW to center of capacitor
C_A	0603N0R1BW251	Ceramic capacitor	0.1 pF, 250 V, ±0.1 pF
TL_1	0.9 mm	CPW length	Edge of SW to center of capacitor
C_1	0603N0R2BW251	Ceramic capacitor	0.2 pF, 250 V, ±0.1 pF
TL_2	0.9 mm	CPW length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

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Typical characteristics

Performance up to 5.0 GHz, unmatched

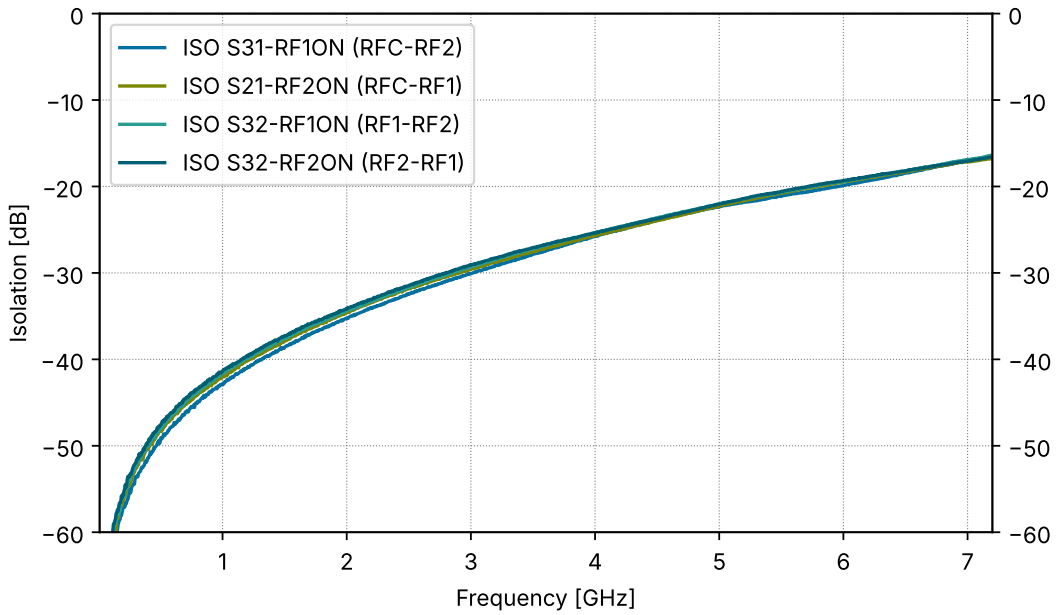
These measurements have been taken from the TS8326K-EVB without matching components (IDX00), $V_{DD} = 3.3\,V$, $T_A = +25°C$; CPW losses of the PCB have been de-embedded from the measurements. The plots run from 10 MHz to 7.2 GHz. The device does not require any matching components for operation up to 5 GHz. Going above 5 GHz, performance can be improved by adding matching to the ports. Our matching example shows excellent performance up to 7.2 GHz.



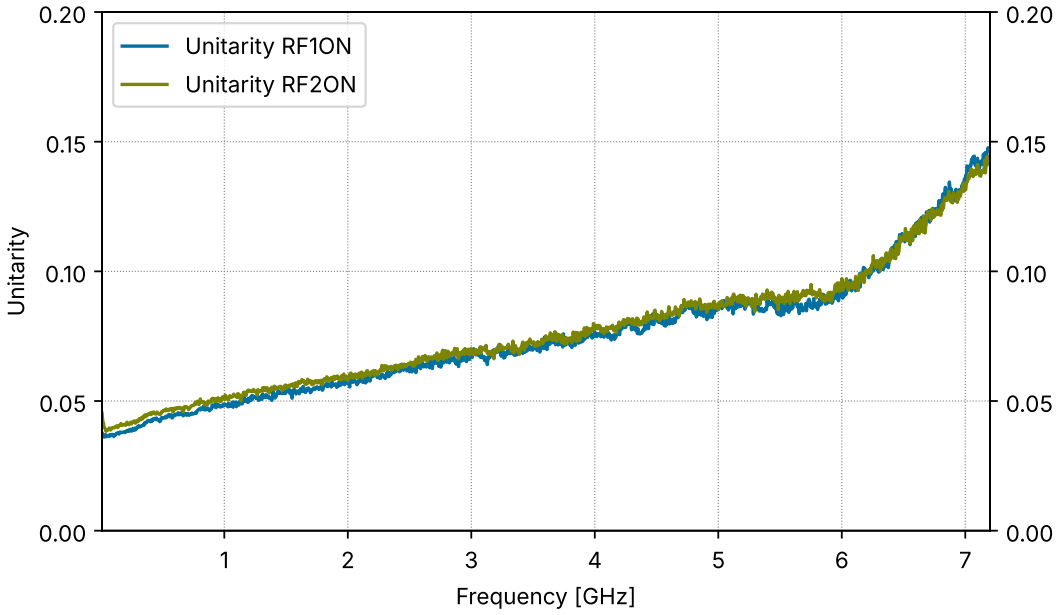
Insertion loss and Return loss, $RFC - RFx$.

Unitarity, i.e. the power absorption of the switch, describes the power converted to heat and the required cooling. With 20 W input power, a power absorption of 0.07 means that 1.4 W is converted to heat.

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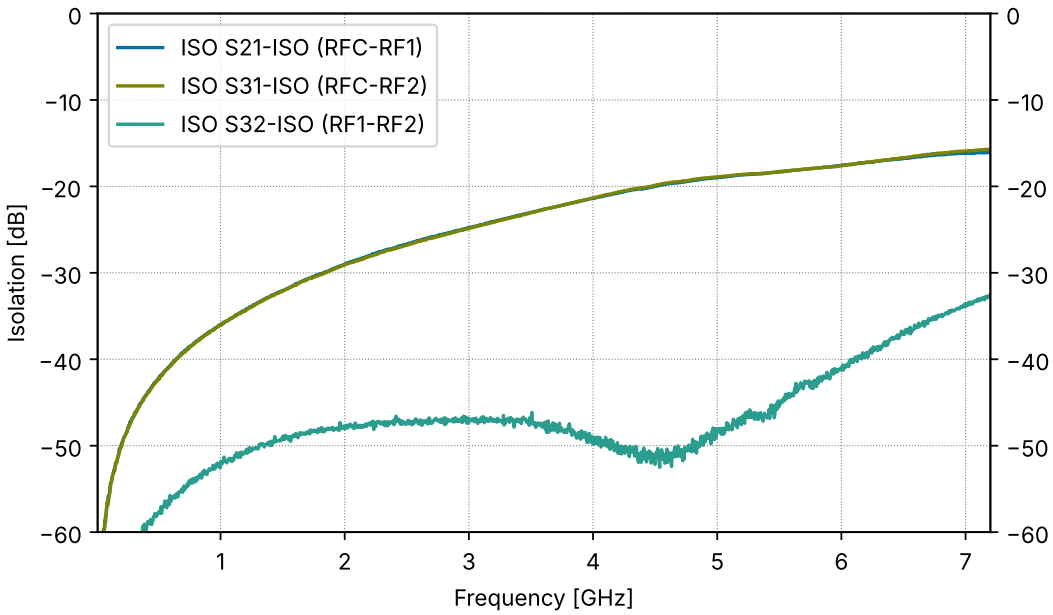


Isolation between RFC to non-active RFx and active RFx to non-active RFx.

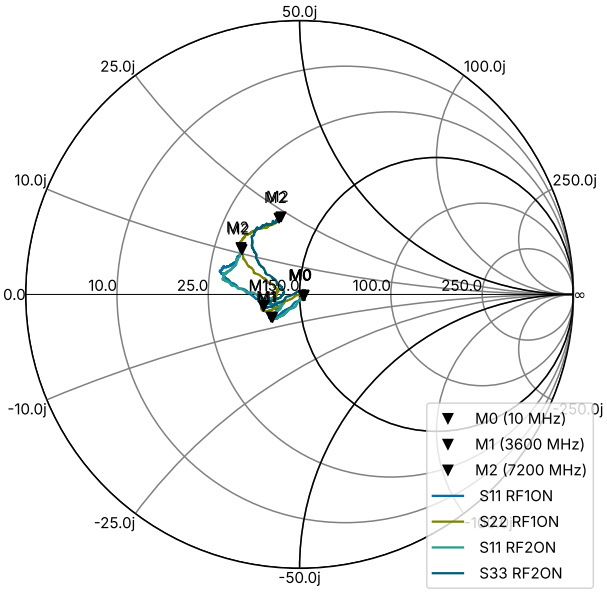


Power absorption of the switch $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2$, RFC − RFx.

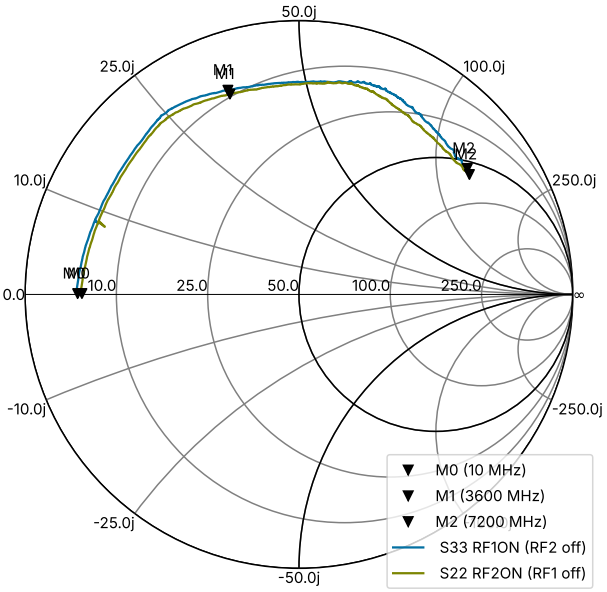
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RFC – RFx and RF1 – RF2 isolation in the ISO state.



Active RF port impedance plotted to Smith chart.

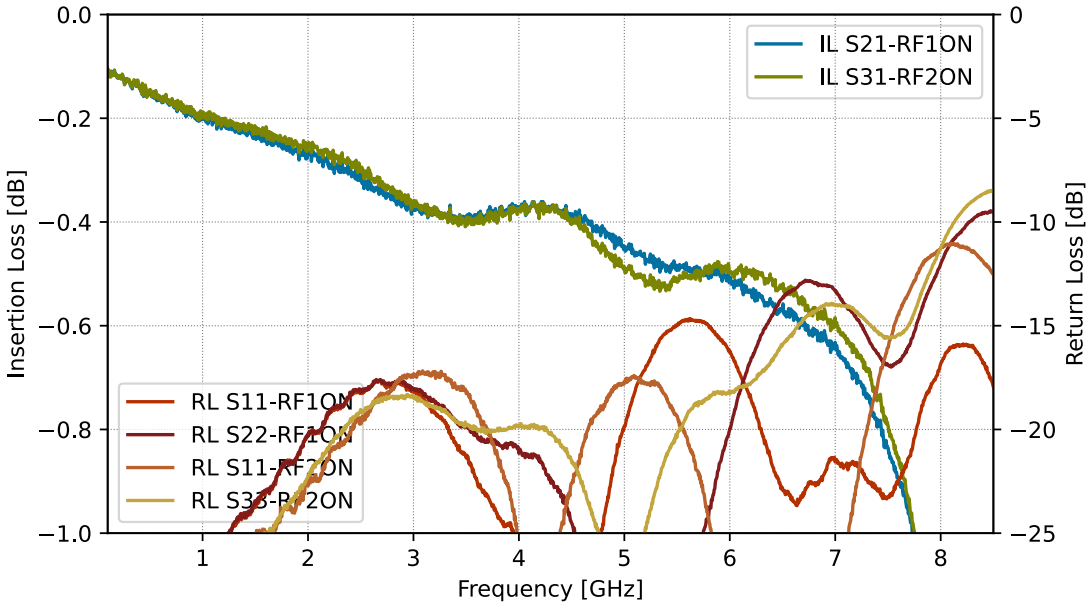


Non-active RF1 and RF2 termination impedance on Smith chart.

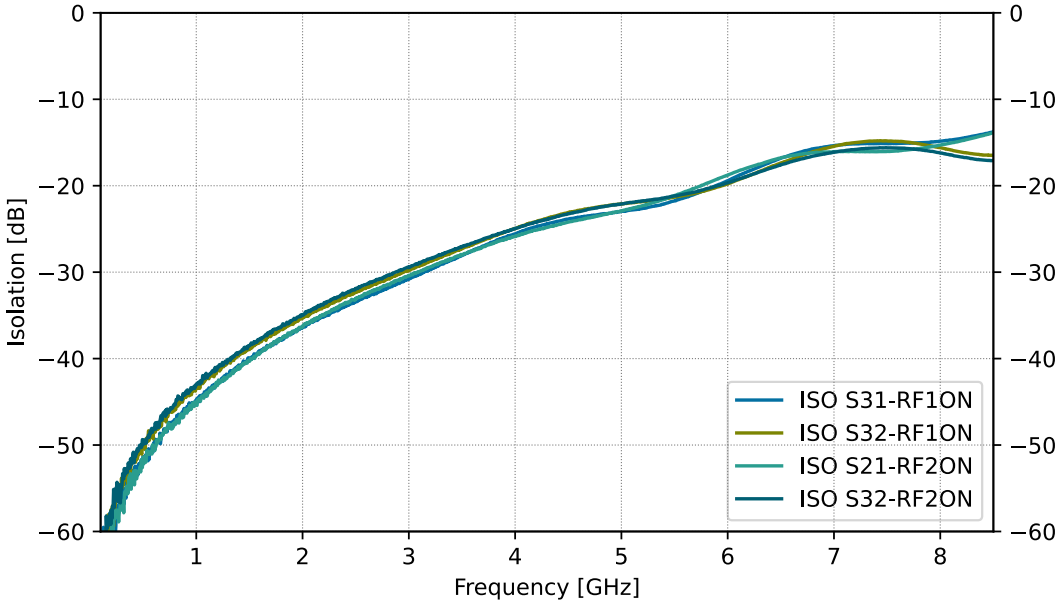
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Performance up to 7.2 GHz, matching applied to EVB

The matched measurements in this section were taken on the TS8423K, which is the same switch without the ESD protection. The same matching principle works also for the TS8326K, as the part is very similar; only the ESD protection is added. The matching components were applied to the EVB; CPW losses have been de-embedded from the measurements, but matching component losses are present.



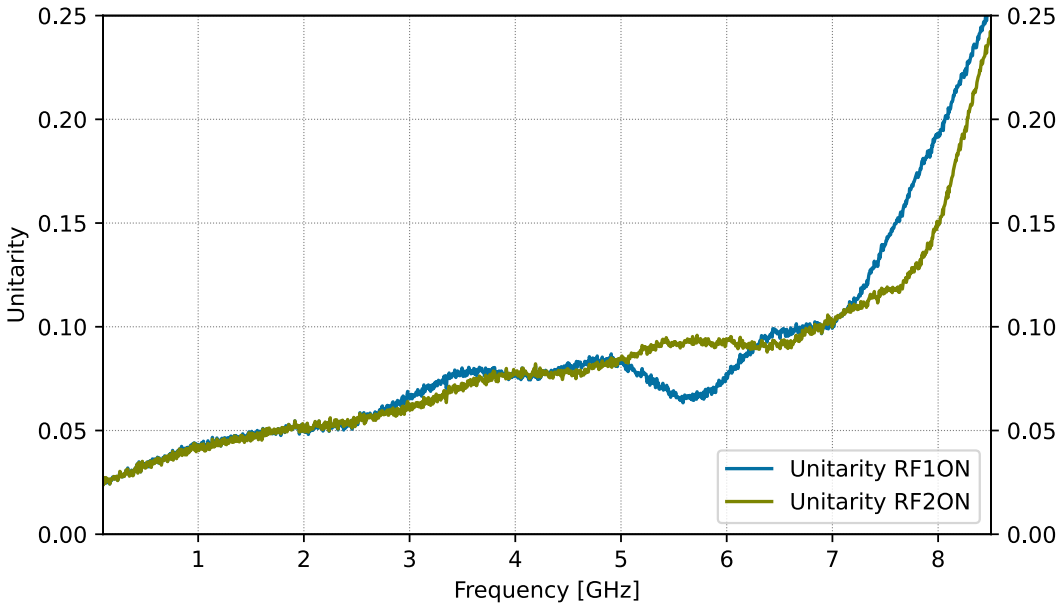
Insertion loss and Return loss, RFC – RFx.



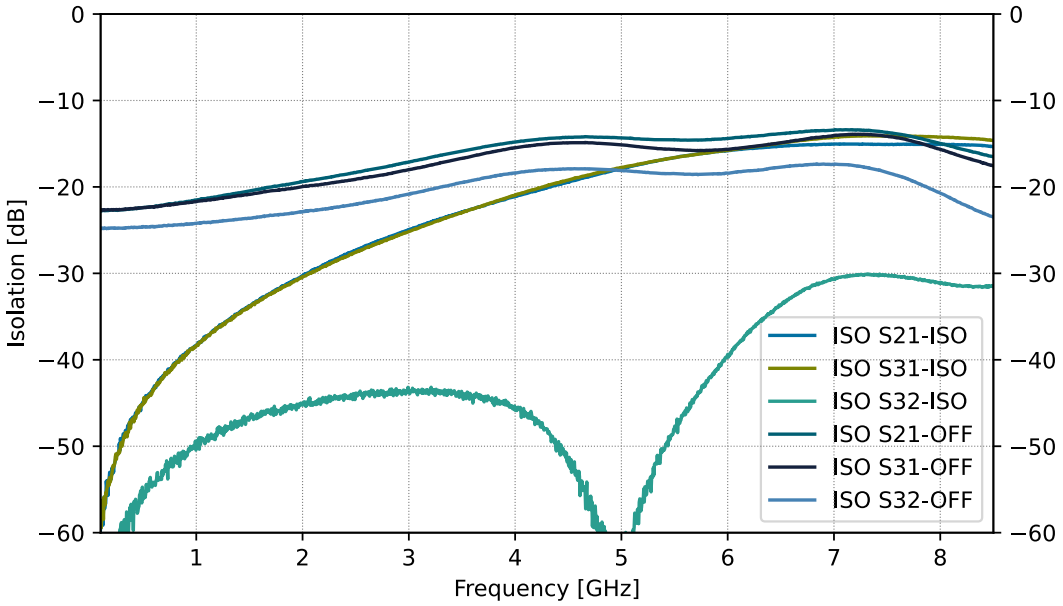
Isolation between RFC to non-active RFx and active RFx to non-active RFx.

Unitarity, i.e. the power absorption of the switch, describes the power converted to heat and the required cooling. With 20 W input power, a power absorption of 0.07 means that 1.4 W is converted to heat.

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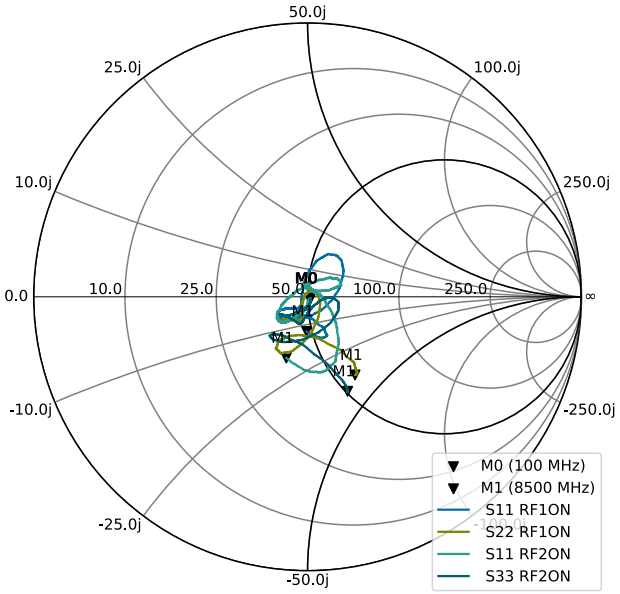


Power absorption of the switch $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2$, $\mathrm{RFC} - \mathrm{RFx}$.

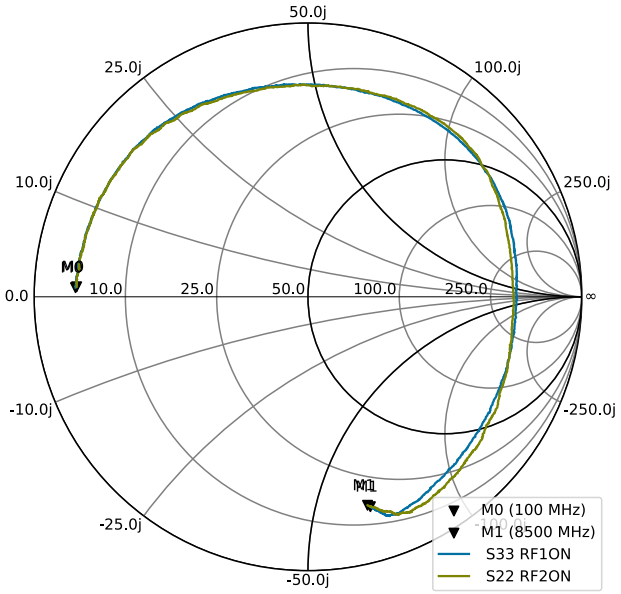


$\mathrm{RFC} - \mathrm{RFx}$ isolation at ISO mode and $\mathrm{V_{DD}}$ off (Isolation).

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Active RF port impedance plotted to Smith chart



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

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Peak power handling with modulated signals

The TS8326K is rated for 20 W (43 dBm) average power (CW, 100% duty cycle) and 63 W (48 dBm) peak power, where the peak power rating is characterized with 10 μs pulses at 1% duty cycle. The two ratings describe two different physical limits of the switch. The average power rating is a thermal limit: the power dissipated in the switch, and therefore the junction temperature, is set by the average RF power. The peak power rating is a voltage limit: the instantaneous RF voltage across the OFF-state transistors must remain below their breakdown voltage. At 63 W in a 50 Ω system, the RF peak voltage is 79 V.

Gallium Nitride is particularly well suited for this task. The high breakdown field of GaN allows a switch to sustain high RF peak voltages, so that the peak power capability of the TS8326K exceeds its average power rating by a factor of 3.2 (5 dB). A switch whose peak capability is equal to its average rating must be derated by the full peak-to-average ratio of the signal, whereas the TS8326K can handle the envelope peaks of single-carrier modulated signals with little or no back-off.

Peak-to-average power ratio of QAM signals

Quadrature amplitude modulation (QAM), such as 16-QAM, 64-QAM or 256-QAM, does not have a constant envelope. The instantaneous envelope power fluctuates around the average power, and its peaks can be several dB above the average. The peaks are statistical in nature: the higher the level, the smaller the fraction of time for which the envelope exceeds it. This behavior is described by the complementary cumulative distribution function (CCDF) of the signal. The peak-to-average power ratio (PAPR) at a probability p is the level, relative to the average power, which the envelope exceeds for a fraction p of the time.

For single-carrier QAM, the PAPR is set by the constellation and by the pulse-shaping filter: a smaller root-raised-cosine (RRC) roll-off factor α gives a narrower spectrum but higher envelope peaks. For OFDM, the sum of many independently modulated subcarriers produces a nearly Gaussian signal, and the PAPR is practically independent of the QAM order of the subcarriers. OFDM therefore has a clearly higher PAPR than single-carrier QAM.

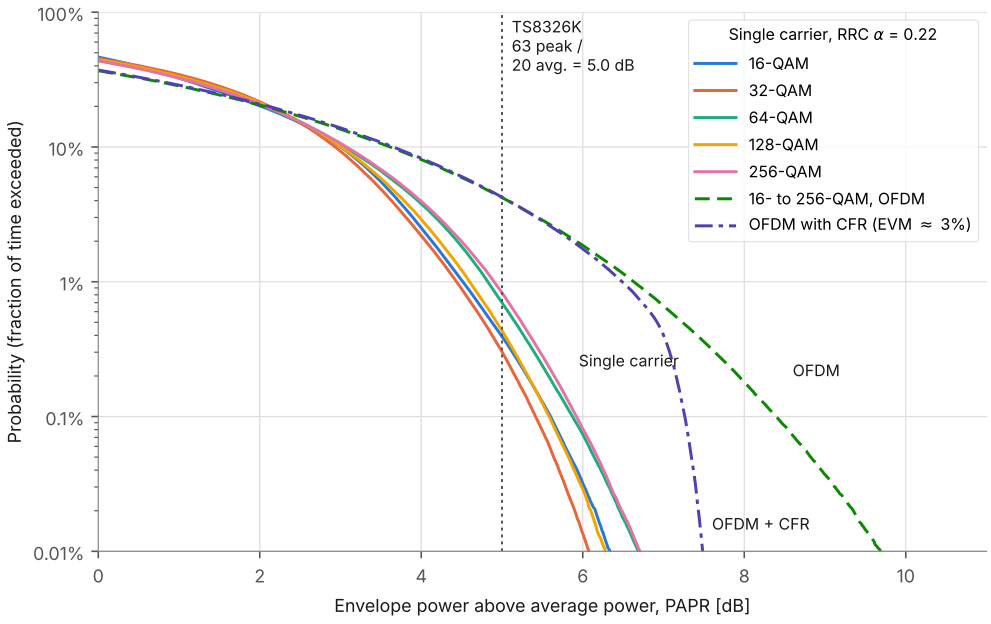


Figure 8: CCDF of the envelope power of QAM signals: fraction of time the envelope power exceeds the average power by the given PAPR. OFDM with CFR: iterative clipping and filtering, EVM ≈ 3%. The dotted line marks the 63 W / 20 W (5 dB) peak-to-average capability of the TS8326K.

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Crest factor reduction for OFDM

Because the highest envelope peaks of an OFDM signal are rare, practical OFDM transmitters apply crest factor reduction (CFR) in the digital baseband before the power amplifier. A common method is iterative clipping and filtering: the envelope is limited to a threshold above its average, and the spectral regrowth caused by the clipping is filtered away, so that the transmitted spectrum and adjacent-channel leakage are preserved. The price is in-band distortion, expressed as an increase in error vector magnitude (EVM). The amount of CFR that can be applied is therefore set by the EVM budget of the modulation: 16-QAM tolerates considerably more distortion than 256-QAM. CFR removes only the rare, highest peaks; the PAPR at 1% to 10% probability is practically unchanged, while the PAPR at 0.1% is reduced by 0.4 dB to 1.9 dB for EVM contributions of 1.5% to 5%. Table 13 includes typical values for OFDM with CFR.

Average power capability with modulated signals

Typical PAPR values are listed in Table 13. Figure 8 shows the complete CCDF curves together with the 5 dB peak-to-average capability of the TS8326K. At the full 20 W average rating, the envelope of a single-carrier 16- to 256-QAM signal exceeds the 63 W peak level only 0.3% to 0.8% of the time, within the 1% duty cycle of the peak power rating, while an OFDM signal with or without CFR exceeds it about 4% of the time. To keep the envelope peaks of an OFDM signal within 63 W also at the 1% probability level, the average power is reduced by 1.6 dB; at the 0.1% probability level, the average power is limited to the values given in the last column of the table. The envelope peaks of modulated signals last only a fraction of a symbol period, which is much shorter than the 10 μs pulses used for the peak power characterization.

The QAM and OFDM information in this section is provided for information only. It is based on calculated signal statistics, has not been fully characterized on the TS8326K, and is not binding on TagoreTech; the ratings given in the Absolute Maximum Ratings and Electrical Specifications sections apply.

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Table 13: Peak-to-average power ratio (PAPR) of QAM signals, exceeded for the given fraction of time.

Modulation	PAPR [dB] at probability[2]			TS8326K max. avg. power [W][1]
	10%	1%	0.1%	
Single carrier, RRC pulse shaping, $\alpha = 0.22$				
16-QAM	3.0	4.5	5.6	17.4
32-QAM	2.9	4.4	5.4	18.2
64-QAM	3.1	4.8	5.8	16.6
128-QAM	3.0	4.6	5.6	17.4
256-QAM	3.1	4.9	5.9	16.2
Single carrier, RRC pulse shaping, $\alpha = 0.35$				
16-QAM	3.0	4.4	5.1	19.5
32-QAM	3.0	4.2	4.8	20.0
64-QAM	3.0	4.8	5.6	17.4
128-QAM	3.0	4.5	5.2	19.1
256-QAM	3.1	4.8	5.7	17.0
OFDM, 1024 subcarriers, no crest factor reduction				
16-QAM	3.6	6.6	8.4	9.1
32-QAM	3.6	6.6	8.4	9.1
64-QAM	3.6	6.6	8.4	9.1
128-QAM	3.6	6.6	8.4	9.1
256-QAM	3.6	6.6	8.4	9.1
OFDM, 1024 subcarriers, with crest factor reduction (clipping and filtering)[3]				
CFR for EVM ≈ 1.5%, e.g. 256-QAM	3.6	6.6	8.0	10.0
CFR for EVM ≈ 3%, e.g. 64/128-QAM	3.7	6.5	7.3	11.7
CFR for EVM ≈ 5%, e.g. 16/32-QAM	3.7	6.2	6.5	14.1

[1] Average power at which the envelope peaks at the 0.1% probability level remain within the 63 W peak power rating, $P_{\mathrm{avg}} = 63\,\mathrm{W}/10^{\mathrm{PAPR}_{0.1\%}/10}$, limited to the 20 W average power rating. Indicative values; in a mismatched load (VSWR > 1) the RF peak voltage increases and further back-off may be required.

[2] PAPR values are calculated from the envelope power of ideal, unclipped signals. Measured values depend on the transmitter, its filtering, and any crest factor reduction applied.

[3] Iterative clipping and filtering, 4 iterations, clipping level 8.0 dB, 7.0 dB and 6.0 dB above the average power; EVM is the in-band distortion added by the CFR only. The PAPR after CFR is practically independent of the QAM order; the QAM orders given are examples of modulations whose EVM budget typically allows the stated CFR. Actual CFR performance depends on the implementation.

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Power Derating

TS8326K has power handling derating below 10 MHz. The power derating table has been defined for a 50 Ω environment, CW signal.

Note: the power derating table below 10 MHz is based on the TS8423K measurements. We expect very similar behavior for the TS8326K, as the part is the same switch with ESD protection added. The table will be updated once the TS8326K low-frequency data are available.

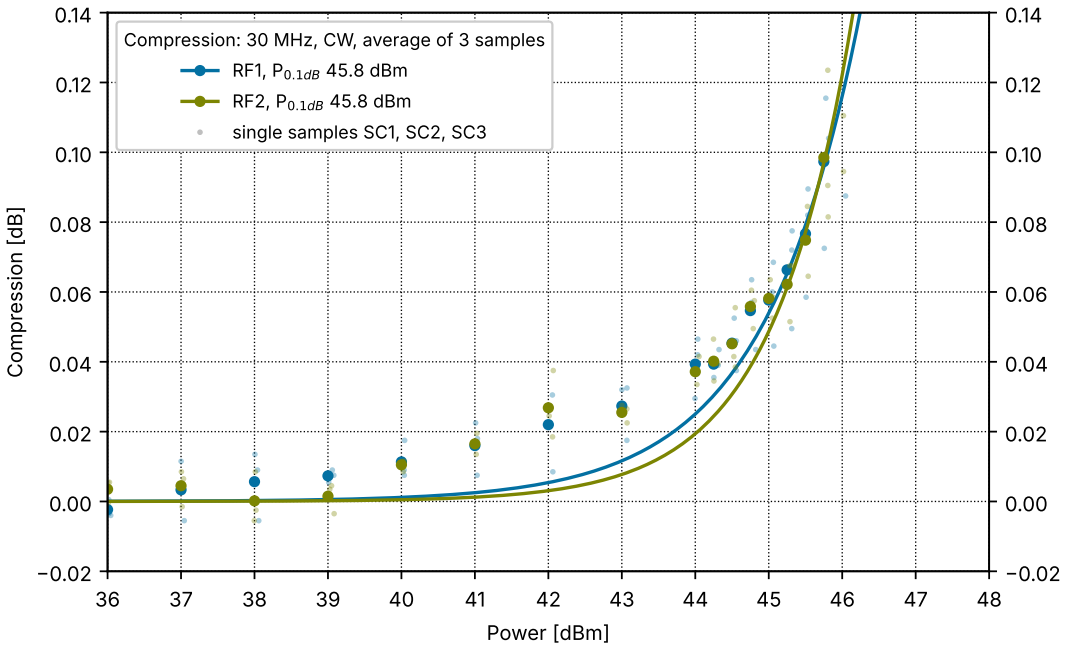
Table 14: Power derating table

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

Compression measurement

TS8326K Continuous Wave (CW) compression measurements are presented. Measurements are conducted at room temperature $T_A = +25°C$. In TagoreTech RF switches, compression is primarily attributed to thermal effects resulting from increased ohmic losses within the device. Compression is referenced to the insertion loss at low power (35 dBm). The plots show the CW compression of RF1 and RF2, measured on three samples. For each port, the compression is averaged over the three samples at each input power level (dots), and the exponential model (lines) is fitted to the averaged points of that port; the single-sample points are shown as small light markers. Values of the derating table take into account manufacturing tolerances and margins.

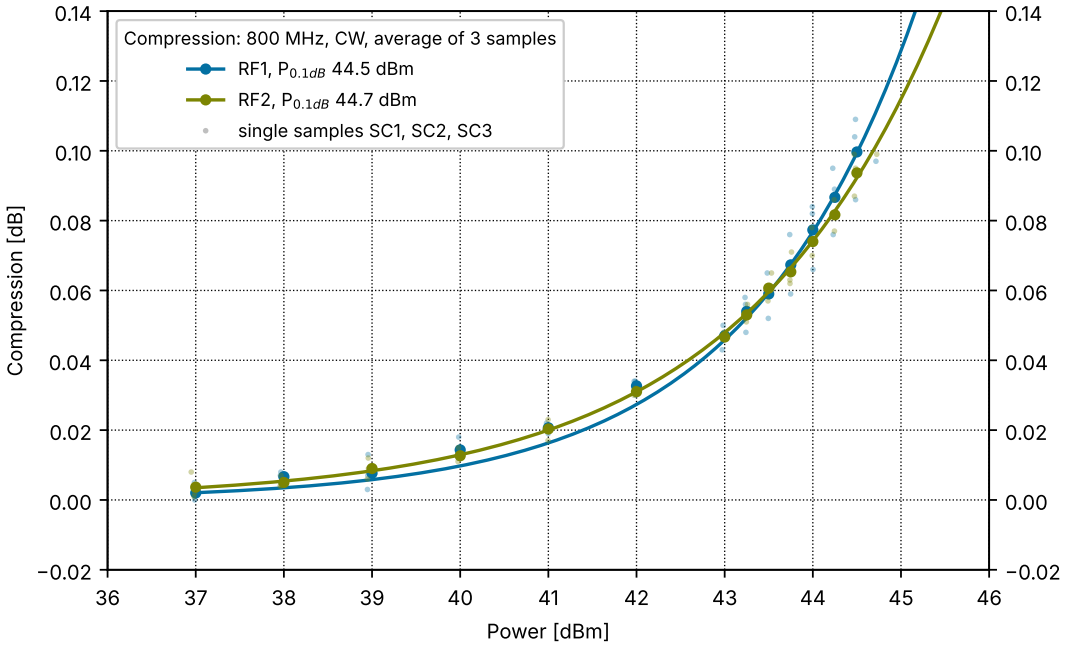
At 30 MHz, the average $P_{0.1\text{dB}}$ is 45.8 dBm on both RF ports.



CW compression at 30 MHz, RF1 and RF2, average of 3 samples.

At 800 MHz, the average $P_{0.1\text{dB}}$ is 44.5 dBm (RF1) and 44.7 dBm (RF2). The electrical specification gives 44.5 dBm typical and 43 dBm minimum.

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CW compression at 800 MHz, RF1 and RF2, average of 3 samples.

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Device Package information

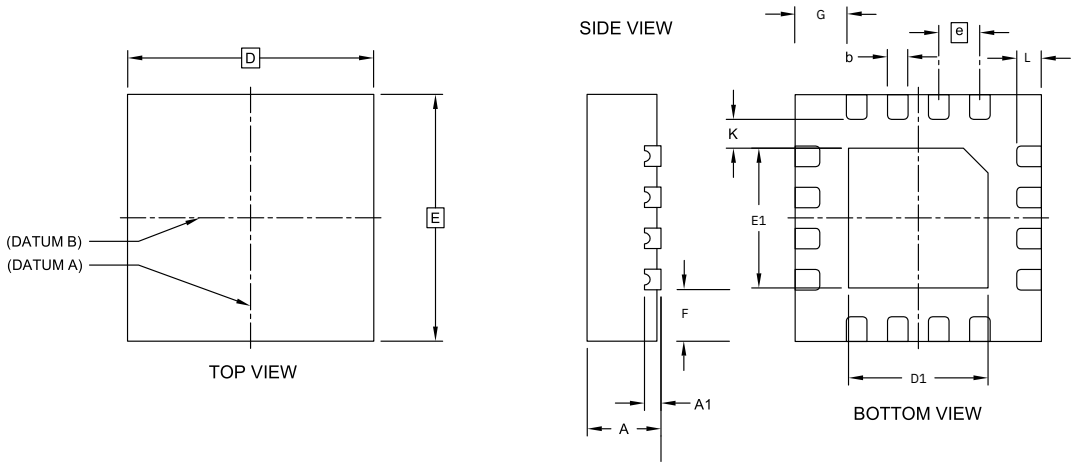


Figure 9: 16-pin QFN 3.0 x 3.0 x 0.75 mm^3 package drawing.

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

Table 15: Device Package Dimensions

Dimension	Value [mm]	Tolerance [mm]	Dimension	Value [mm]	Tolerance [mm]
A	0.75	±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

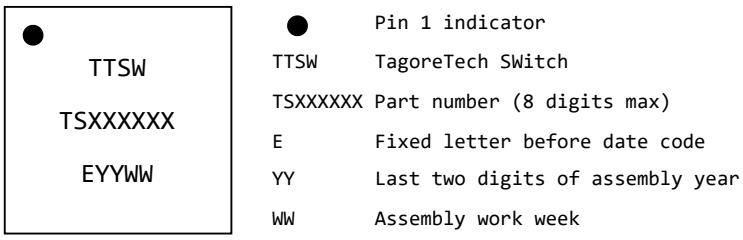


Figure 10: Part marking specification.

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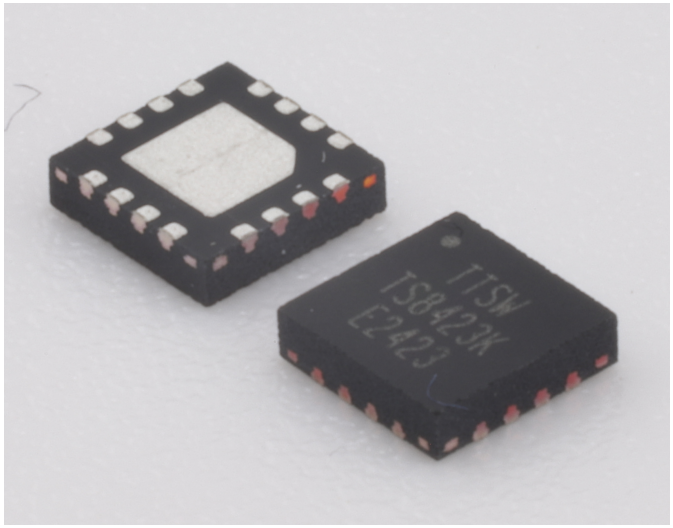


Figure 11: TS8326K photo, top and bottom side.

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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.

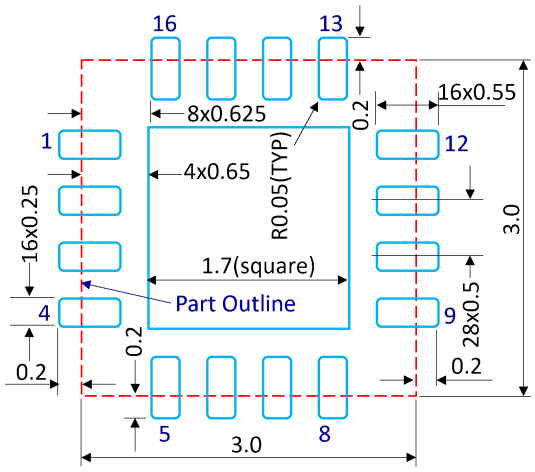


Figure 12: PCB land pattern, dimensions in [mm].

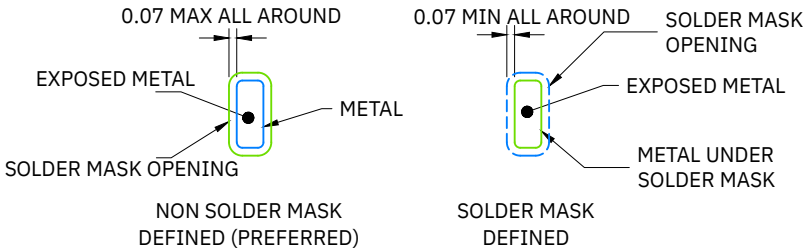


Figure 13: Solder mask opening, dimensions in [mm].

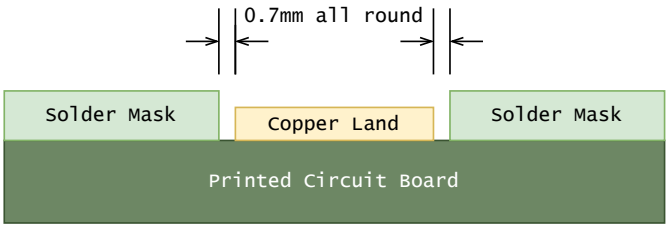


Figure 14: Preferred solder mask opening, side view, dimensions in [mm].

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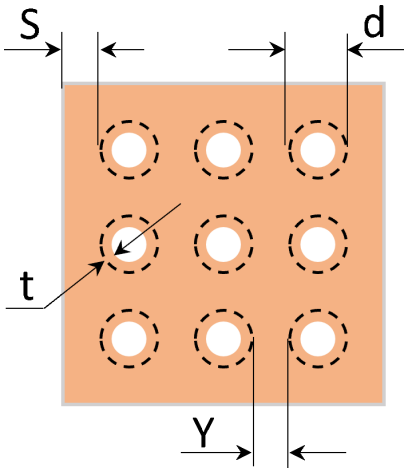


Figure 15: Thermal Via Pattern, Recommended Values: S≥0.15mm; Y≥0.20mm; d=0.2mm; Plating Thickness t=25μm or 50μm.

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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.

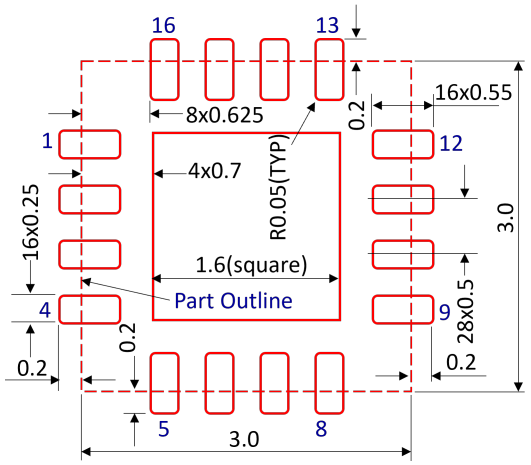


Figure 16: Stencil Openings, dimensions in [mm].

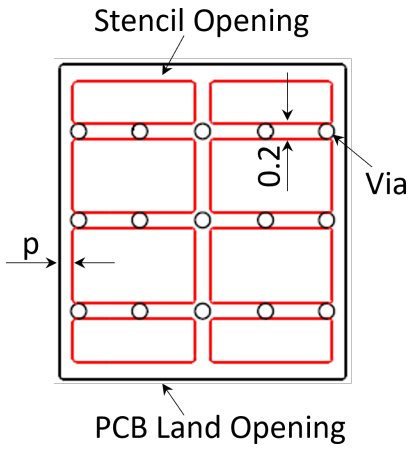
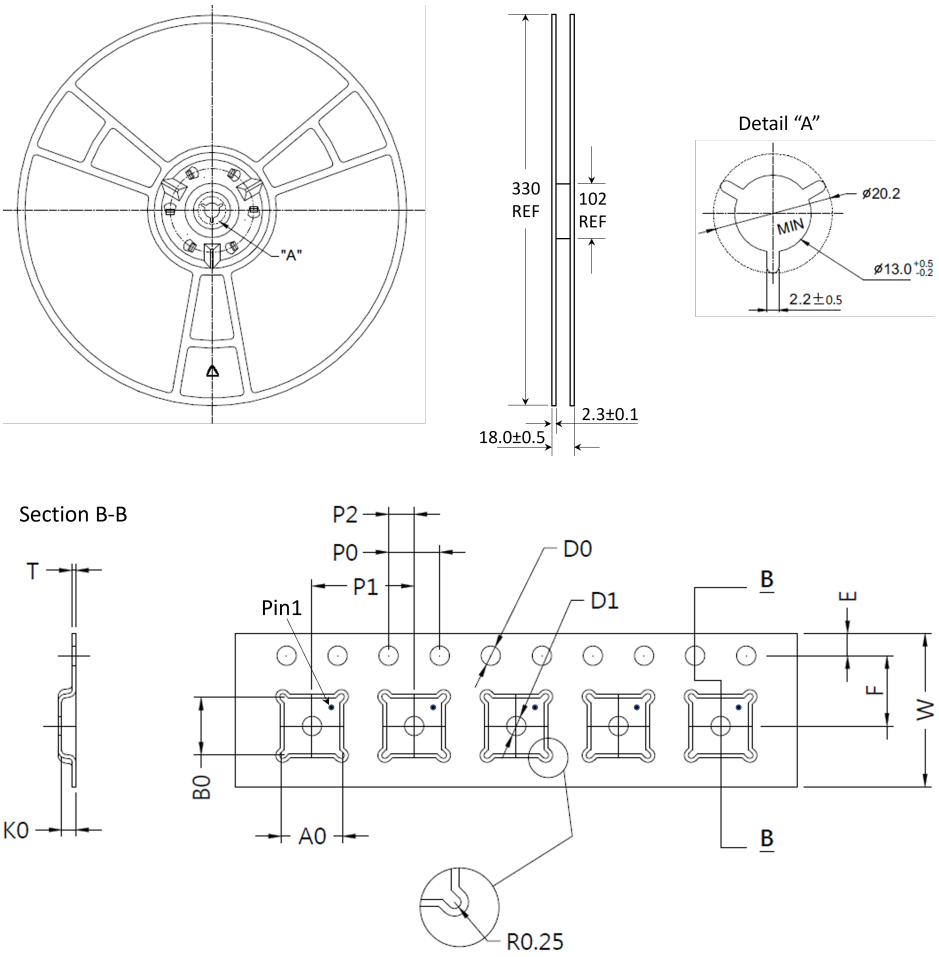


Figure 17: Stencil Openings Shall not Cover Via Areas If Possible, dimensions in [mm].

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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

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Glossary

IL	Insertion loss
ISO	Isolation
RL	Return loss
VSWR	Voltage Standing Wave Ratio
RFC	Antenna port or common port, referred as RFC
RFx	RF Port number x
ISO state	Isolation state: RFC port open, RF ports shorted ($\mathrm{V}_2 = 1$, $\mathrm{V}_1 = 0$)
V_{CP}	Charge pump voltage, pin 1: 1 nF capacitor to ground or external -18 V supply
f_{PRR}	Pulse repetition rate (maximum rate of switching events)
Unitarity	Describes power absorption of the component, $1 - \lvert S_{11}\rvert^2 - \lvert S_{21}\rvert^2 - \lvert S_{31}\rvert^2$
ESD, HBM, CDM	Electrostatic discharge, human body model, charged device model
IEC 61000-4-2	ESD immunity test standard (contact and air discharge)
IDX	EVB configuration index of the S-parameter files (IDX00: no matching components, IDX01: 7.2 GHz matching)
CPW	Coplanar waveguide
CCDF	Complementary cumulative distribution function
CFR	Crest factor reduction
EVM	Error vector magnitude
OFDM	Orthogonal frequency-division multiplexing
PAPR	Peak-to-average power ratio
QAM	Quadrature amplitude modulation
RRC	Root-raised-cosine (pulse-shaping filter)
EVB	Evaluation board

Changelog

Table 16: Changelog

Date	Revision	Notes
11/06/2026	3.00	First publication. Derivative of the TS8423K with integrated ESD protection on all RF ports (IEC 61000-4-2, 4 kV contact discharge) and the charge pump voltage V_{CP} on pin 1, as on the TS8423K, supporting an external -18 V supply for pulse repetition rates above 20 kHz. CW compression at 30 MHz and 800 MHz and switching times measured on the TS8326K.

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