SP4T 50 W CW / 125 W Peak Power Switch 1 MHz to 4.5 GHz

Features

- Frequency Range 1 MHz to 4.5 GHz
- Low insertion loss:
  0.35 dB @ 1.0 GHz
  0.60 dB @ 3.0 GHz
  0.80 dB @ 4.5 GHz
- High isolation:
  30 dB @ 2.0 GHz
  18 dB @ 4.5 GHz
- 50 W CW power, 125 W peak power
- Low power consumption, less than 1 mW
- No external DC blocking capacitors on RF lines
- Integrated ESD protection on all RF ports, IEC 61000-4-2 4 kV contact discharge
- Versatile 2.6 V – 5.25 V power supply
- No need to supply negative voltages

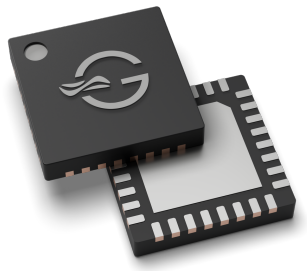

Figure 1: TS8546L in 4.0 x 4.0 mm^2 QFN 32-pin package.

Applications

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

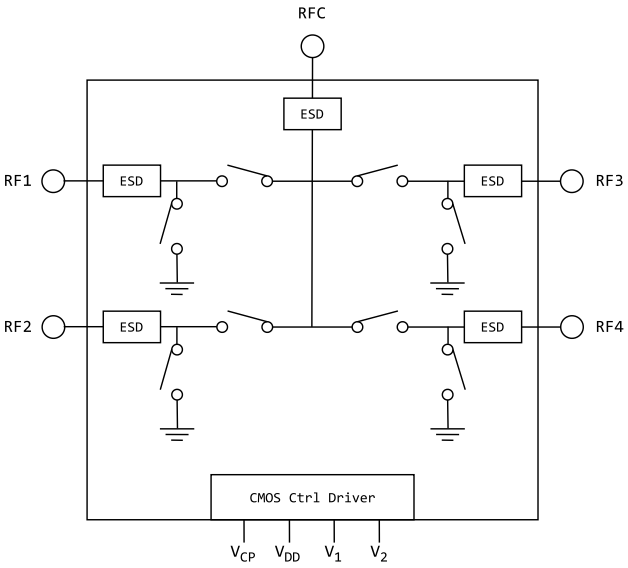

Figure 2: TS8546L functional diagram

General Description

The **TS8546L** is a 2nd-generation, symmetrical, reflective Single Pole Four Throw (SP4T) switch designed for medium-power switching applications. It operates over a wide frequency range from 1 MHz to 4.5 GHz, delivering low insertion loss, high isolation, and high linearity. The TS8546L supports up to 50 W continuous wave (CW) power and 125 W peak power capability, making it ideal for demanding switching environments. Integrated ESD protection on all RF ports (RFC and RF1 to RF4) enhances system reliability and performance. Housed in a compact 4.0 mm × 4.0 mm, 32-lead Quad Flat No-Lead (QFN) plastic package, the TS8546L is well-suited for applications where board space is limited and performance requirements are high.

RoHS

RoHS/REACH/Halogen free

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Ordering information

Table 1: Ordering Information

Device Part Number	Package Type	Notes
TS8546L	32 Pin 4.0x4.0x0.75 mm^3 QFN	Core part number
TS8546L-EVB	Evaluation Board	Unmatched (IDX00)
TS8546LMTRPBF[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

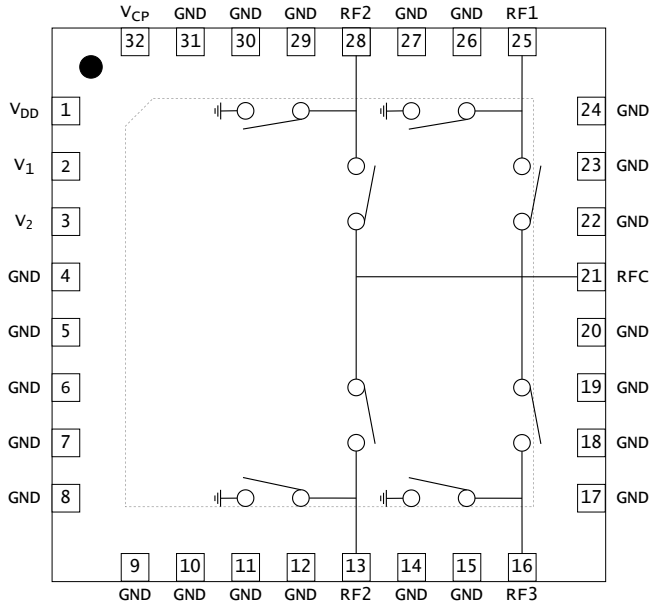

Figure 3: TS8546L pin assignment [top view]

Table 3: Pin Definition

Pin Number	Pin Name	Description
32	V_{CP}	Internal charge pump voltage output, connect a 1 nF capacitor to GND on this pin to improve the switching time.
1	V_{DD}	DC Power Supply
2	V_1	Switch control input 1
3	V_2	Switch control input 2
13	RF4	RF port 4, ESD protected
16	RF3	RF port 3, ESD protected
21	RFC	RF Common port / Antenna port, ESD protected
25	RF1	RF port 1, ESD protected
28	RF2	RF port 2, ESD protected
4,5,6,7,8,9,10,11,12	GND	Connect to ground[2]
14,15,17,18,19,20		
22,23,24,26,27		
29,30,31		
33 [1]	GND	Ground thermal pad, please connect to GND

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

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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/ANT	48	dBm
Maximum RF peak input power, 1% duty cycle, 10μs pulse [2] [3]	RFx/ANT	52	dBm
Thermal Ratings			
Thermal Resistance (junction-to-case) – Bottom side	$R_{\theta jc}$	5.4	°C/W
Soldering Temperature	T_{solder}	+260	°C
ESD Ratings			
RF ports (RFC, RF1 to RF4), 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	$\geq$1000	V
Moisture Rating			
Moisture Sensitivity Level[4]	MSL	1	

[1] Maximum ratings are absolute ratings. Exposure to absolute maximum rating conditions for extended periods may affect device reliability and can cause permanent damage to the device. Exceeding one or a combination of the absolute maximum ratings may cause permanent and irreversible damage to the device and/or to surrounding circuit. Functional operation of the device is not implied in any conditions above those indicated in the Electrical Specifications section.
[2] Test frequency 800 MHz.
[3] See Power Derating table for frequencies below 10 MHz and above 3.0 GHz.
[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		4500	MHz
Insertion loss	30 MHz		0.20		dB
unmatched, up to 3.0 GHz	1.0 GHz		0.35		dB
$RFC - RFx$	2.0 GHz		0.55		dB
	3.0 GHz		0.85		dB
Insertion loss[1]	30 MHz		0.20		dB
matched up to 4.5 GHz	1.0 GHz		0.45		dB
$RFC - RFx$	2.0 GHz		0.55		dB
	3.0 GHz		0.60		dB
	4.0 GHz		0.70		dB
	4.5 GHz		0.80		dB
Isolation	30 MHz		60		dB
unmatched, up to 3.0 GHz	1.0 GHz		37		dB
$RFC - RFx$	2.0 GHz		30		dB
	3.0 GHz		25		dB
Isolation[1]	30 MHz		60		dB
matched up to 4.5 GHz	1.0 GHz		36		dB
$RFC - RFx$	2.0 GHz		29		dB
	3.0 GHz		25		dB
	4.0 GHz		21		dB
	4.5 GHz		18		dB

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

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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		4500	MHz
Return Loss	30 MHz		-30		dB
unmatched, up to 3.0 GHz	1.0 GHz		-17		dB
$RFC - RFx$	2.0 GHz		-14		dB
	3.0 GHz		-10		dB
Return Loss[1]	30 MHz		-30		dB
matched up to 4.5 GHz	1.0 GHz		-15		dB
$RFC - RFx$	2.0 GHz		-13		dB
	3.0 GHz		-15		dB
	4.0 GHz		-20		dB
	4.5 GHz		-17		dB

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

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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		4500	MHz
Harmonic Distortion					
H_2	30 MHz, P_{in} =47 dBm		TBD		dBc
H_3	30 MHz, P_{in} =47 dBm		TBD		dBc
H_2	800 MHz, P_{in} =47 dBm		TBD		dBc
H_3	800 MHz, P_{in} =47 dBm		TBD		dBc
IIP3	800 MHz		TBD		dBm
Power and Compression point					
P_{maxCW}[2]	Max RF CW Power		47		dBm
P_{maxpeak}	Max RF Peak Power		51		dBm
$P_{\text{maxhot RFx}}$[5]	Max RF CW Power, hot switching		TBD		dBm
$P_{\text{maxhot RFC}}$[5]	Max RF CW Power, hot switching		TBD		dBm
$P_{0.1\text{dB}}$[7]	800 MHz, CW		47		dBm
$P_{1\text{dB}}$[1]	800 MHz, CW		49		dBm
$P_{\text{peak0.1dB}}$	800 MHz, 1% duty cycle, 10 μs pulse		51		dBm
$P_{\text{peak0.1dB}}$	800 MHz, 20% duty cycle, 150 μs pulse		49		dBm
Noise					
CP switching noise[4]	RBW=1 kHz		-140		dBm
Switching Time					
t_{ON}	Switch ON time		3.4		μs
t_{OFF}	Switch OFF time		2.3		μs
t_{RISE}	Switch RISE time		1.3		μs
t_{FALL}	Switch FALL time		1.5		μs
t_{wON}	Minimum Switch ON time		3.6		μs
t_{wOFF}	Minimum Switch OFF time		3.6		μs
f_{PRR}, $C_{VCP} = 1$nF[3]	Maximum pulse repetition rate		1		kHz
f_{PRR}, $C_{VCP} = 10$nF[3]	Maximum pulse repetition rate		1.4		kHz
f_{PRR}, $C_{VCP} = 100$nF[3]	Maximum pulse repetition rate		1.8		kHz
f_{PRR}, $V_{CPext} = -18$ V[6]	Maximum pulse repetition rate		>20		kHz
t_{startup}, $C_{VCP} = 1$nF[3]	startup time		0.8		ms
t_{startup}, $C_{VCP} = 10$nF[3]	startup time		7		ms
t_{startup}, $C_{VCP} = 100$nF[3]	startup time		40		ms
Power Supply, DC					
Control voltage	Power Supply V_{DD}	2.6	3.3	5.25	V
	All control pins high, V_{ih}	1.0	3.3	5.25	V
	All control pins low, V_{il}	-0.3	0	0.5	V
Control current	All control pins high, I_{ih}			7.5	μA
	All control pins low, I_{il}		0		μA
Current consumption	I_{DD}, active mode (V_{DD} on)		160	260	μA

[1] $P_{1\,\text{dB}}$ has been given for comparison reasons only. Please do not exceed Absolute Maximum ratings.
[2] See Power Derating table.
[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] Typical value with margin; the measured average of 3 samples is 47.9 to 48.6 dBm, see Compression measurement.

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

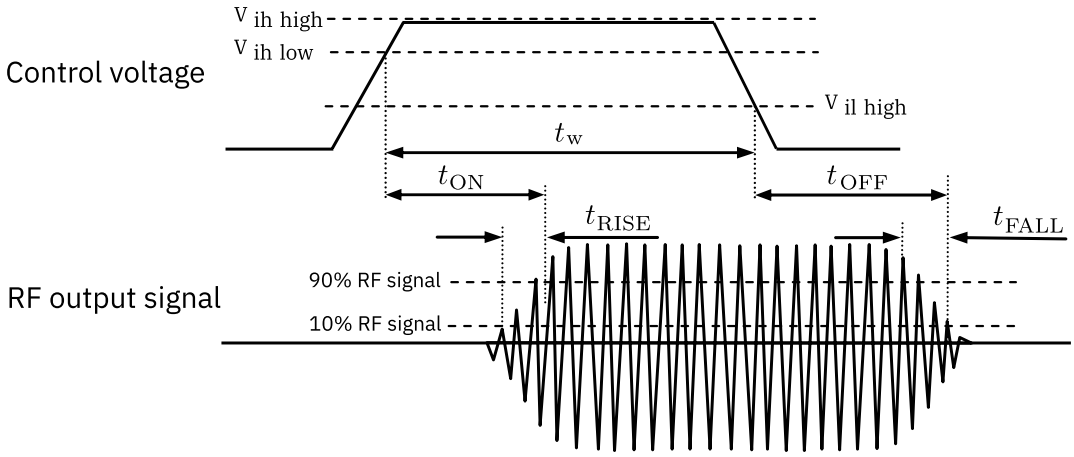

Figure 4: Switching time definition, t_{ON}, t_{OFF}, t_{RISE}, t_{FALL}. Minimum pulse width t_{w}.

Our component uses 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 $\mathrm{V_{CP}}$, one can improve maximum pulse repetition rate f_{PRR}. Feeding external -18 V to $\mathrm{V_{CP}}$, one can drive switch at least to 20 kHz f_{PRR}. Expect current consumption of 10 mA of -18 V.

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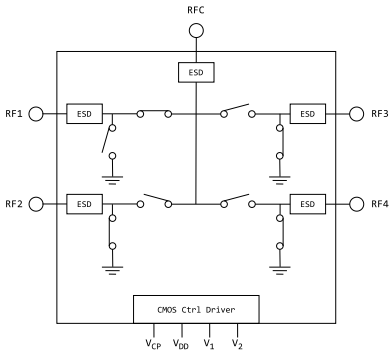
Switch Control table

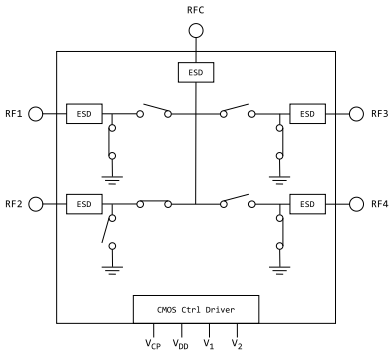
Table 8: Switch Control Table

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 RFC and RFx ports

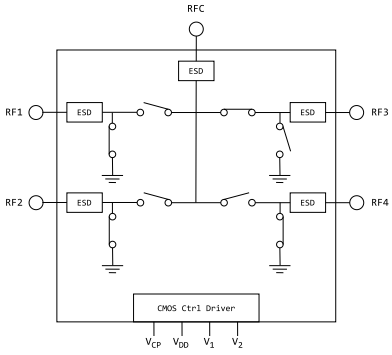
[1] V_{DD} should be applied first before V_1 and V_2, otherwise may cause damage to the device.
[2] There are internal pull-downs to ground on both V_1 and V_2 control pins, the state at start-up without any control voltage applied will be RFC – RF1 ON.



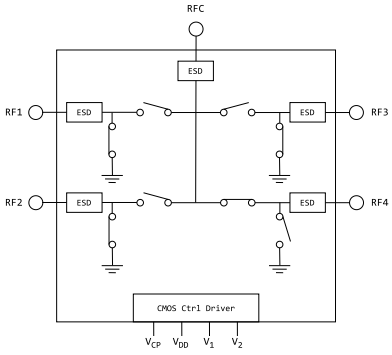
RFC-RF1 ON



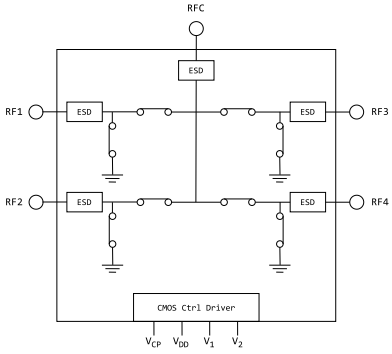
RFC-RF2 ON



RFC-RF3 ON



RFC-RF4 ON



V_{DD} off state

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Theory of Operation

ESD protection

All RF ports of the TS8546L, the common port RFC and the four throws RF1 to RF4, 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.

Isolation modes

TS8546L has isolation mode when $\mathrm{V_{DD}}$ is turned off.

Device powered off

When $\mathrm{V_{DD}}$ 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.

Feeding external $\mathrm{V_{CP}}$ voltage of -18 V

TS8546L supports external voltage supply to $\mathrm{V_{CP}}$ to increase pulse repetition rate f_{PRR}. With external voltage supply, f_{PRR} can be increased at least to support pulse repetition rate more than 100 kHz. In order to use external voltage, it is mandatory to supply first $\mathrm{V_{DD}}$, have a delay of 50 μs and then apply -18 V to $\mathrm{V_{CP}}$. Shutdown should be in opposite order.

Application Information

TS8546L is offering 50 W CW and 125 W peak power capability from 1 MHz to 4.5 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; TS8546L significantly reduces design complexity for such RF switching needs. TS8546L works without external matching components up to 2.0 GHz; above 2.0 GHz, matching is recommended. The datasheet provides a matching example up to 4.5 GHz and its performance. All RF ports are ESD protected, which simplifies the protection of antenna and front-end circuits.

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Schematics and Evaluation Board

S-parameters of both presented EVB configurations can be downloaded from this link: Download TS8546L S-parameters

Table 9: 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

Content of s-parameter repository:

```
TS8546L.zip
├── TS8546L_IDX00 ..... Directory for s-parameters without matching components
│   ├── TS8546L_IDX00_README.txt
│   ├── TS8546L_IDX00_VDDOFF.s5p ..... S5P file for VDD off mode
│   ├── TS8546L_IDX00_RF1ON.s5p ..... S5P file for RFC-RF1ON mode
│   ├── TS8546L_IDX00_RF2ON.s5p ..... S5P file for RFC-RF2ON mode
│   ├── TS8546L_IDX00_RF3ON.s5p ..... S5P file for RFC-RF3ON mode
│   ├── TS8546L_IDX00_RF4ON.s5p ..... S5P file for RFC-RF4ON mode
│   ├── TS8546L_IDX00_IL_RL.png ..... Insertion Loss and Return Loss plot
│   └── TS8546L_IDX00_ISO.png ..... Isolation plot
└── TS8546L_IDX01 ..... Directory for s-parameters with matching components, 4.5 GHz
    ├── TS8546L_IDX01_README.txt
    ├── TS8546L_IDX01_VDDOFF.s5p ..... S5P file for VDD off mode
    ├── TS8546L_IDX01_RF1ON.s5p ..... S5P file for RFC-RF1ON mode
    ├── TS8546L_IDX01_RF2ON.s5p ..... S5P file for RFC-RF2ON mode
    ├── TS8546L_IDX01_RF3ON.s5p ..... S5P file for RFC-RF3ON mode
    ├── TS8546L_IDX01_RF4ON.s5p ..... S5P file for RFC-RF4ON mode
    ├── TS8546L_IDX01_IL_RL.png ..... Insertion Loss and Return Loss plot
    └── TS8546L_IDX01_ISO.png ..... Isolation plot
```


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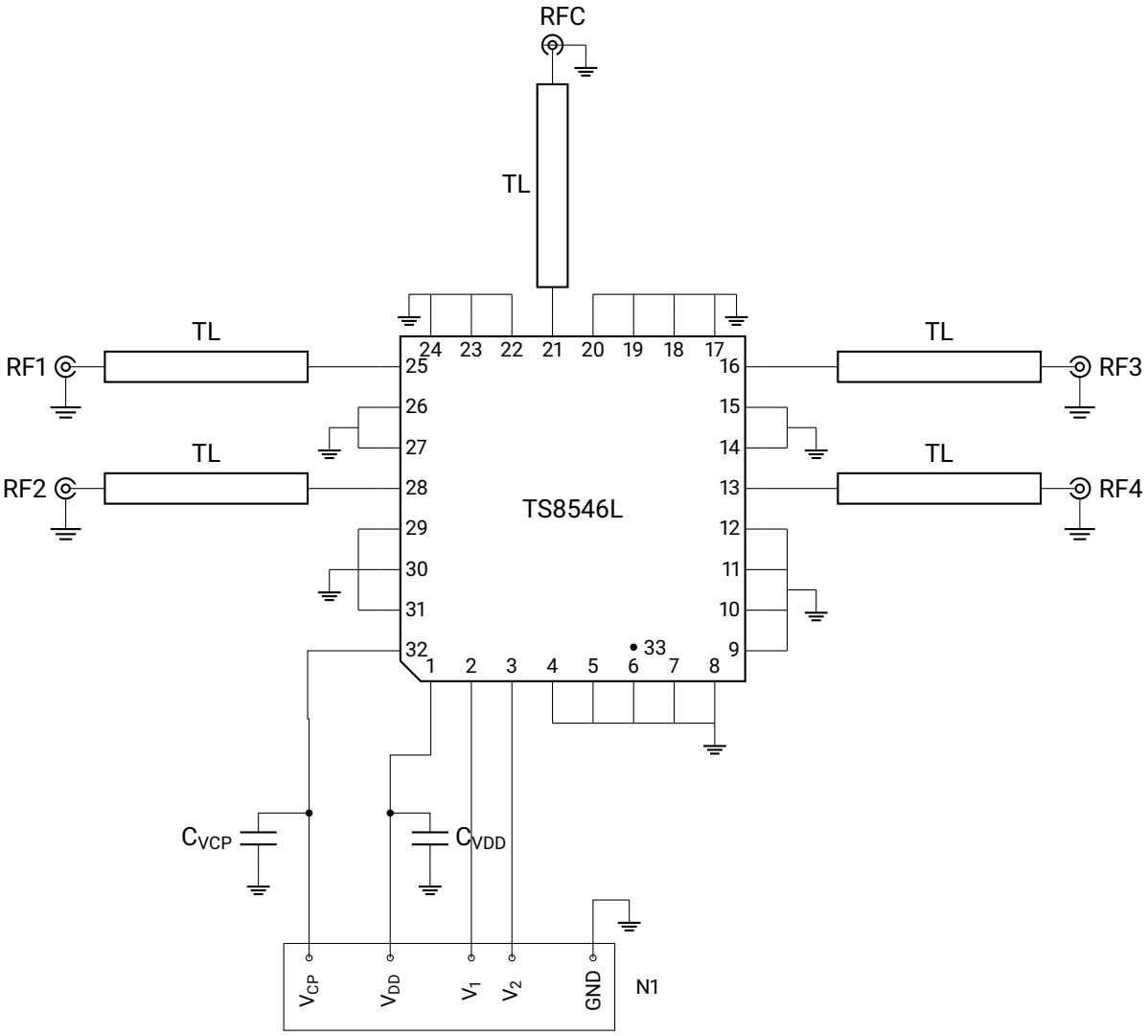
Unmatched EVB (IDX00), up to 3.0 GHz

TS8546L shows best performance up to 2.0 GHz frequency without any matching components. Only two external components are recommended, 1 nF for V_{CP} and 10 nF for V_{DD} lines for supporting charge pump and power supply. Pin 33 in the schematic refers to the center (thermal) pad of the device. Above 2.0 GHz matching is recommended.



Schematic of TS8546L-EVB, unmatched (IDX00)

Table 10: Components used for TS8546L-EVB

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

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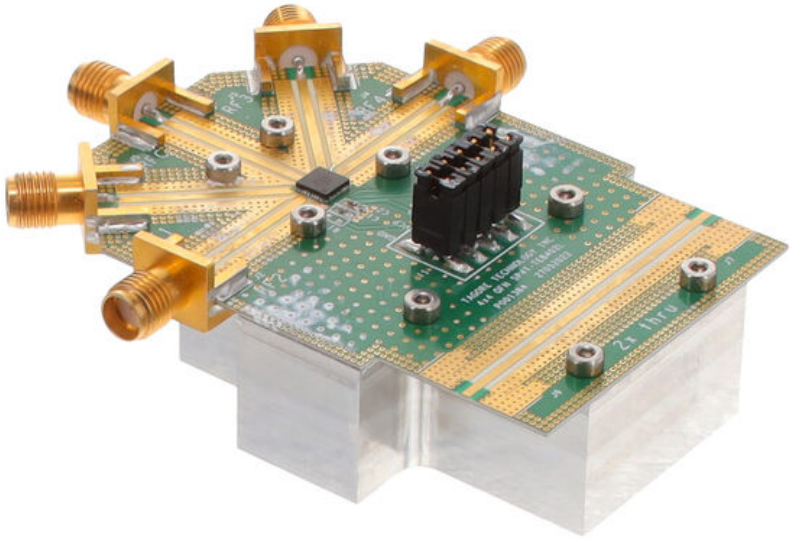

Photo of TS8546L-EVB without matching components.

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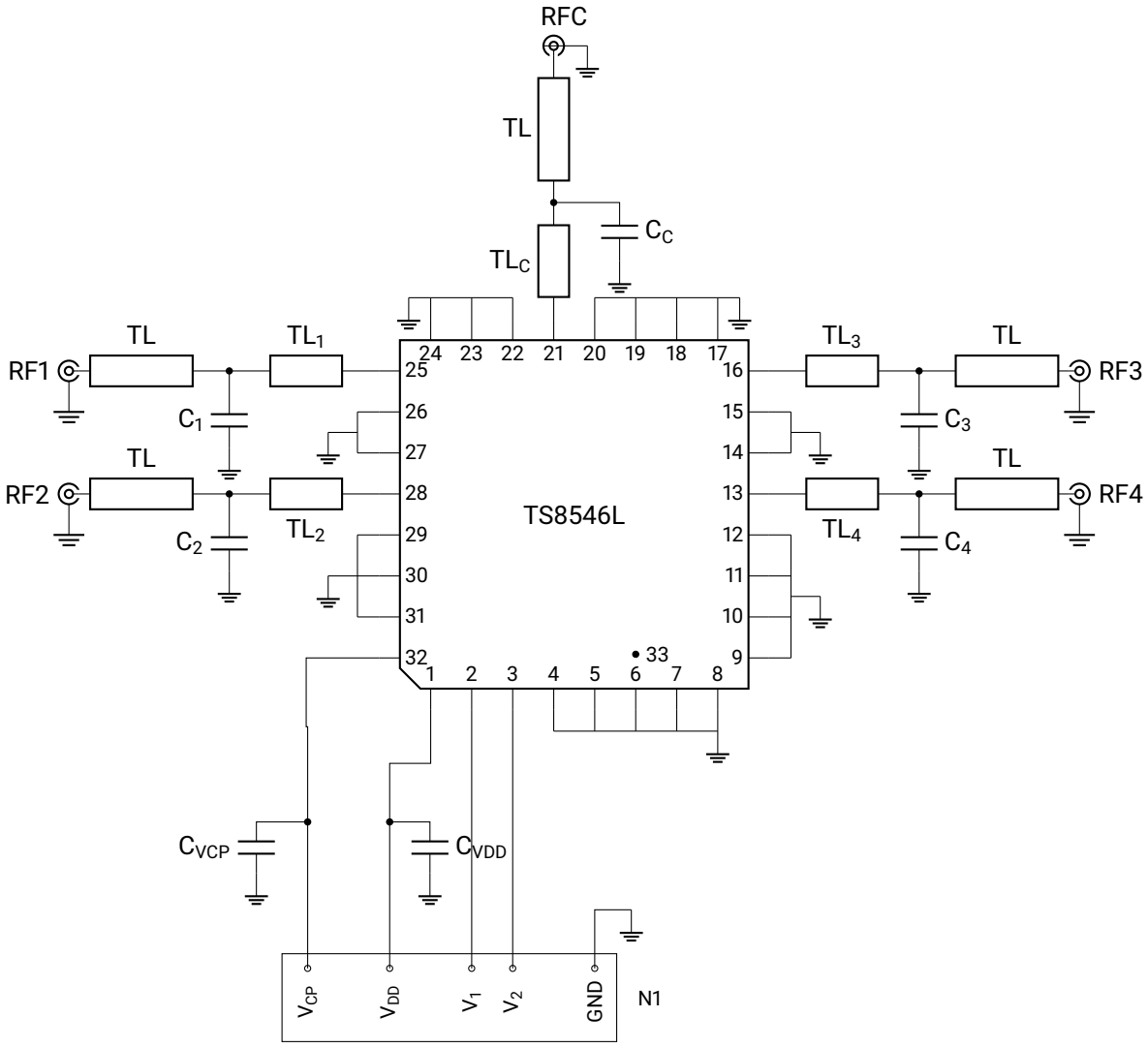
Matching example (IDX01), up to 4.5 GHz

The matching example uses a short CPW line and a shunt capacitor at each RF port (Table 11).



Schematic of TS8546L-EVB with 4.5 GHz matching (IDX01)

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Table 11: Matching components used for 4.5 GHz matching

Reference	Part number / Value	Description	Notes
TL_C	5.2 mm	CPW length	Edge of SW to edge of capacitor
C_C	0603N0R4BW251	Ceramic capacitor	0.4 pF, 250 V, ± 0.1 pF
TL_1	4.5 mm	CPW length	Edge of SW to edge of capacitor
C_1	0603N0R2BW251	Ceramic capacitor	0.2 pF, 250 V, ± 0.1 pF
TL_2	4.5 mm	CPW length	Edge of SW to edge of capacitor
C_2	0603N0R2BW251	Ceramic capacitor	0.2 pF, 250 V, ± 0.1 pF
TL_3	4.5 mm	CPW length	Edge of SW to edge of capacitor
C_3	0603N0R2BW251	Ceramic capacitor	0.2 pF, 250 V, ± 0.1 pF
TL_4	4.5 mm	CPW length	Edge of SW to edge of capacitor
C_4	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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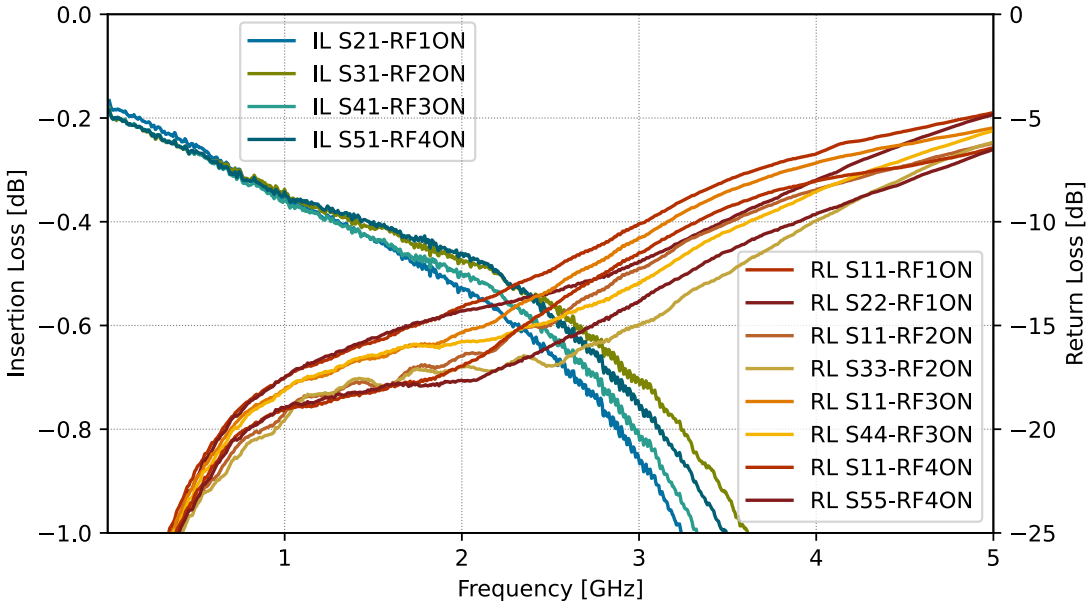
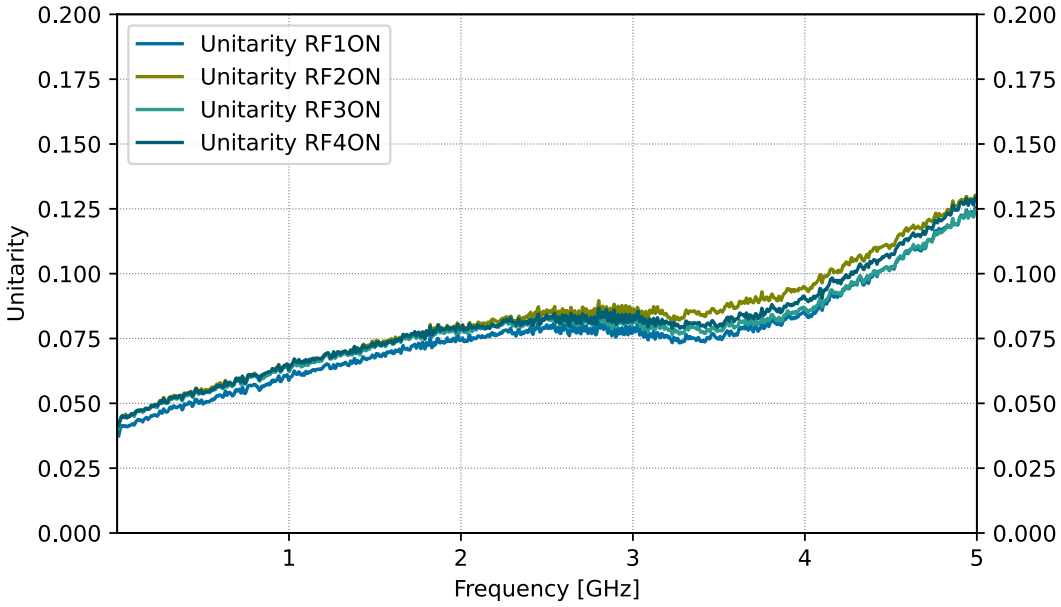
Typical characteristics

Performance up to 3.0 GHz, unmatched

These measurements have been taken from the TS8546L-EVB, CPW losses have been de-embedded from the measurements. The device does not require any matching components for operation up to 2.0 GHz. Going above 2.0 GHz, performance can be improved by adding matching to the ports. Our matching example shows excellent performance up to 4.5 GHz.



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



Power absorption of the switch $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2 - |S_{41}|^2 - |S_{51}|^2$, $\mathrm{RFC} - \mathrm{RFx}$.

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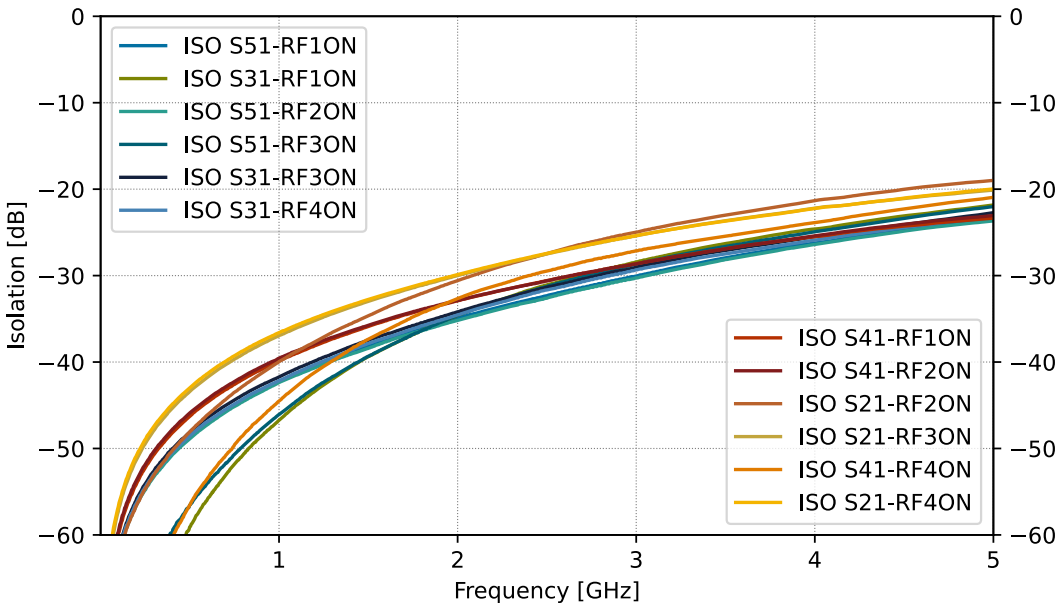
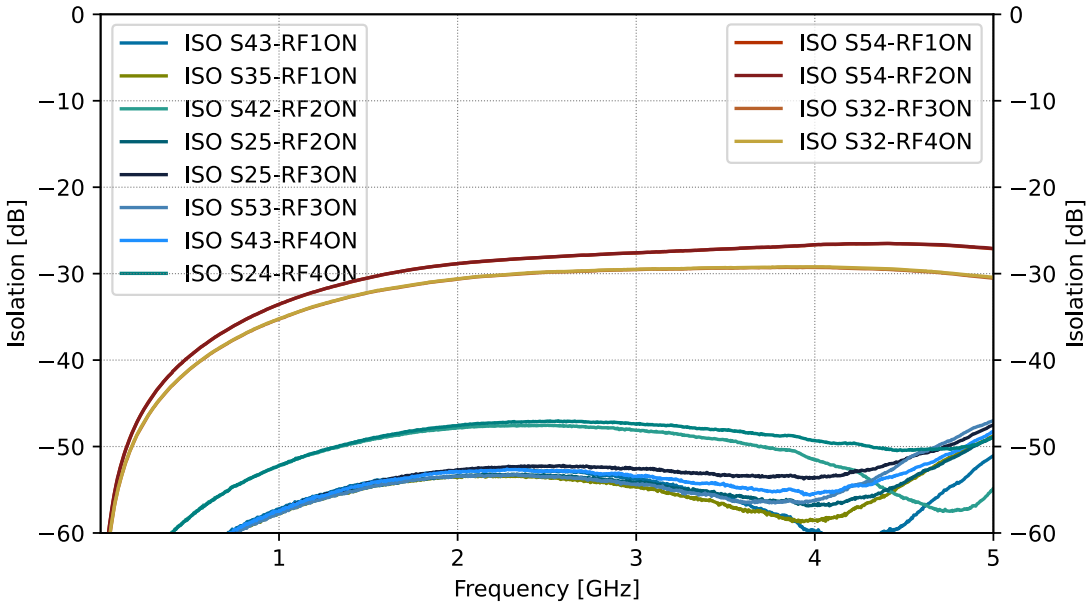


Isolation between RFC to non-active RFx and active RFx to non-active RFx.



RFx – RFx port isolation. Reddish curves present adjacent port to port isolation and blueish curves opposite side port to port isolations.

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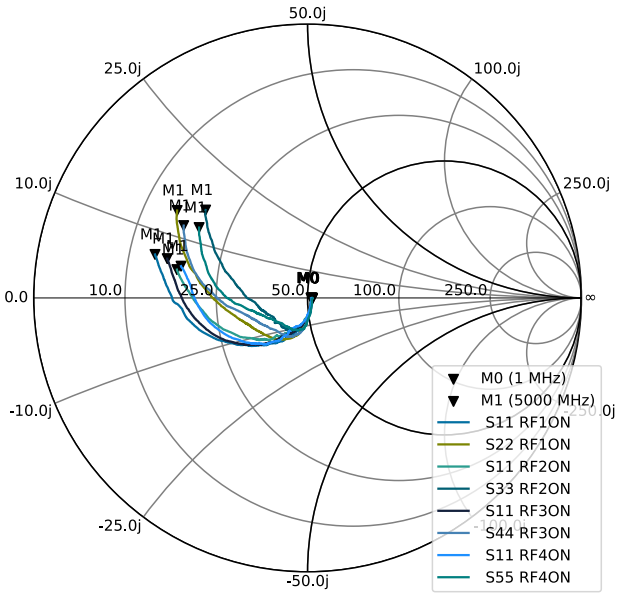
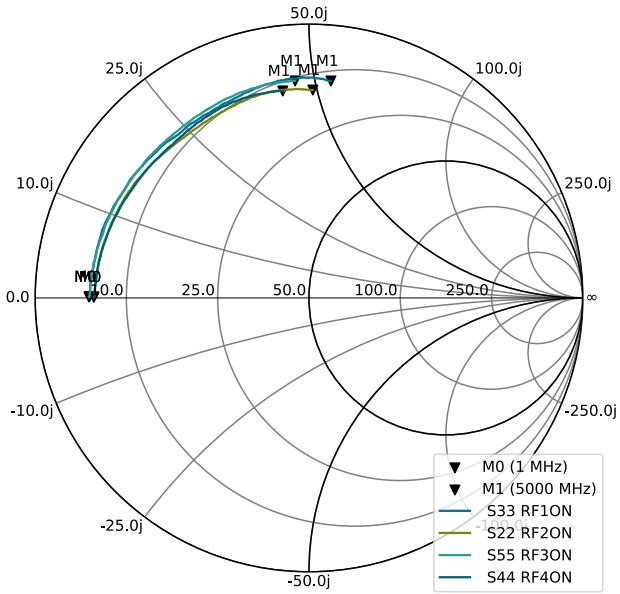


RFC and RFx matching at ON state.



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

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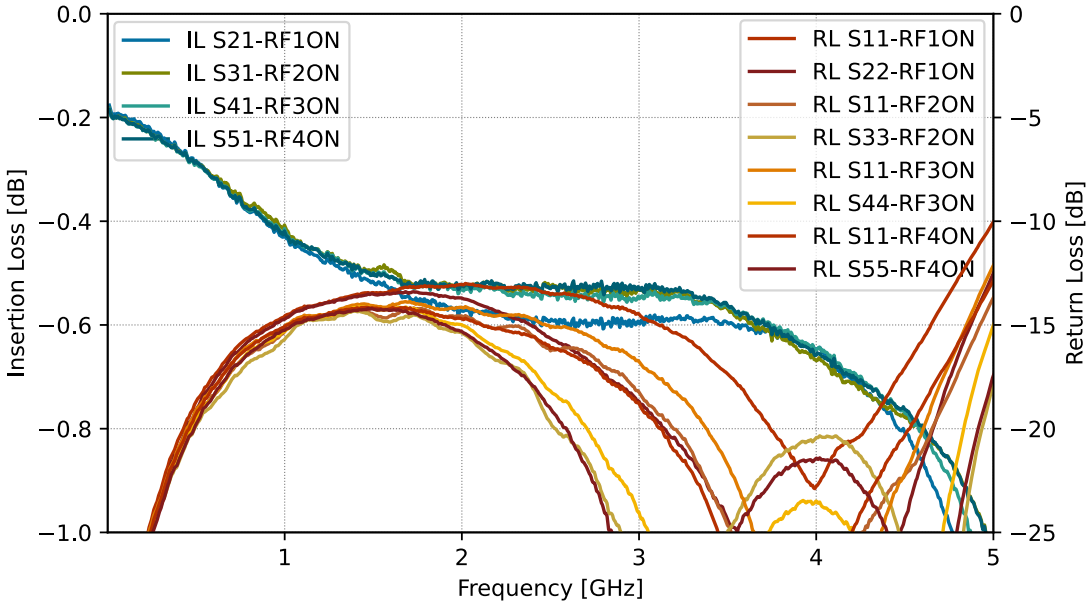
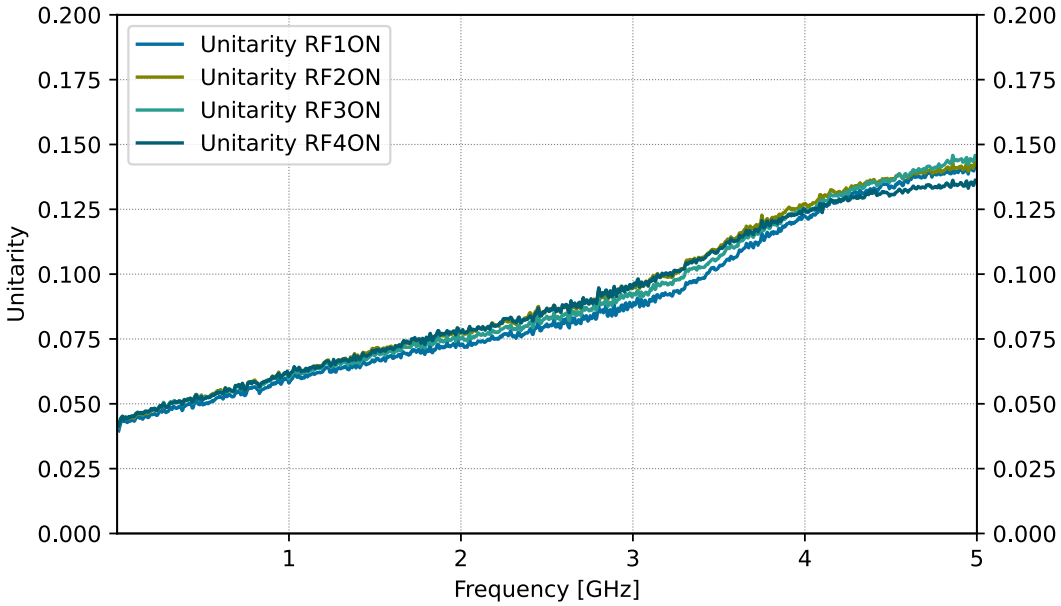
Performance up to 4.5 GHz, matching applied to EVB

These measurements have been taken from the TS8546L-EVB, matching components applied. CPW losses have been de-embedded from the measurements, but matching component losses are present.



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



Power absorption of the switch $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2 - |S_{41}|^2 - |S_{51}|^2$, $\mathrm{RFC} - \mathrm{RFx}$.

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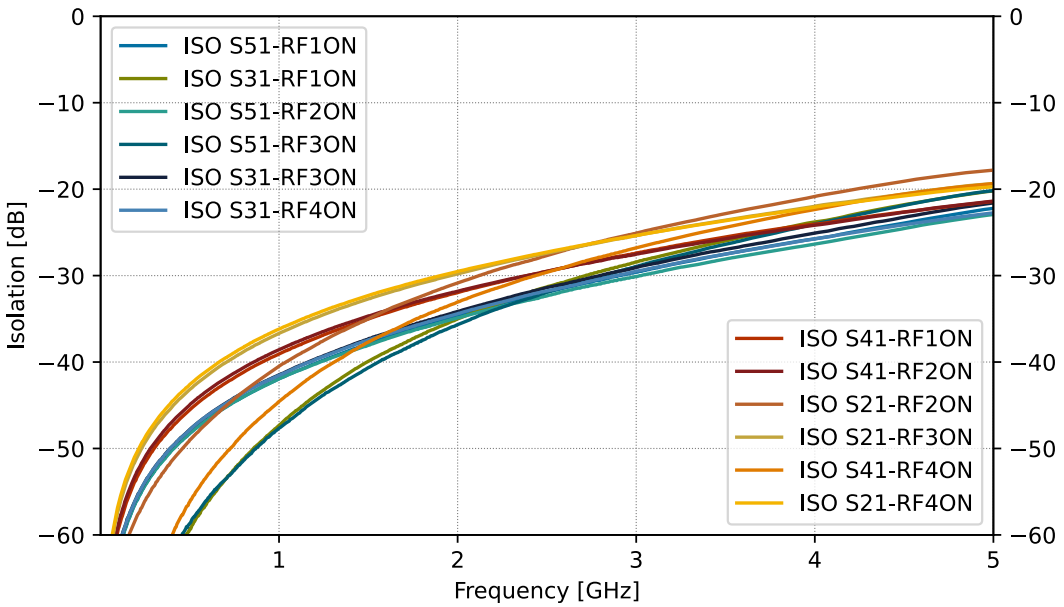
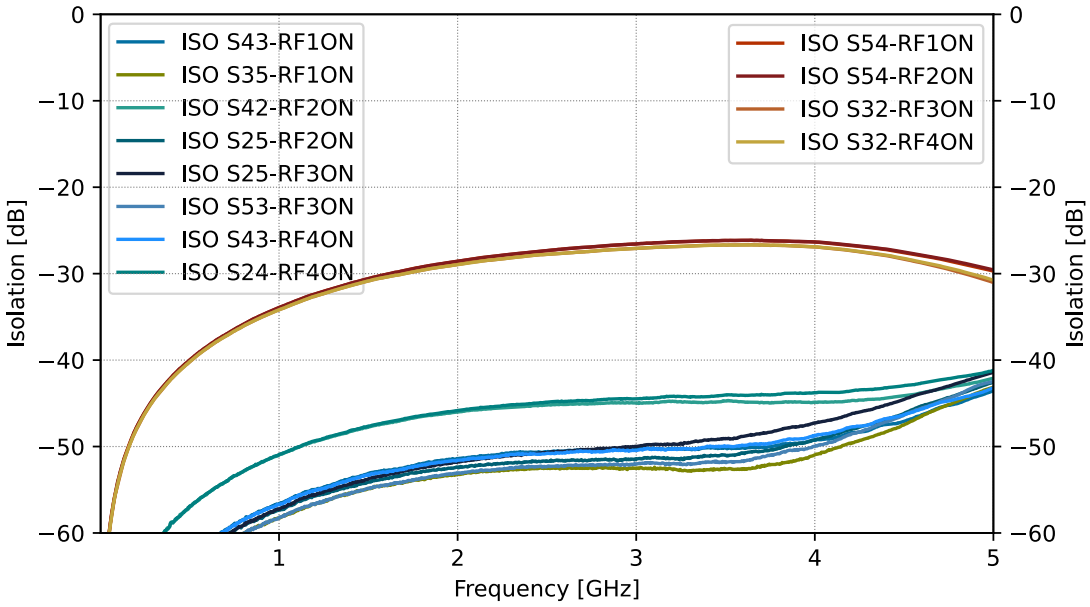


Isolation between RFC to non-active RFx and active RFx to non-active RFx.



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

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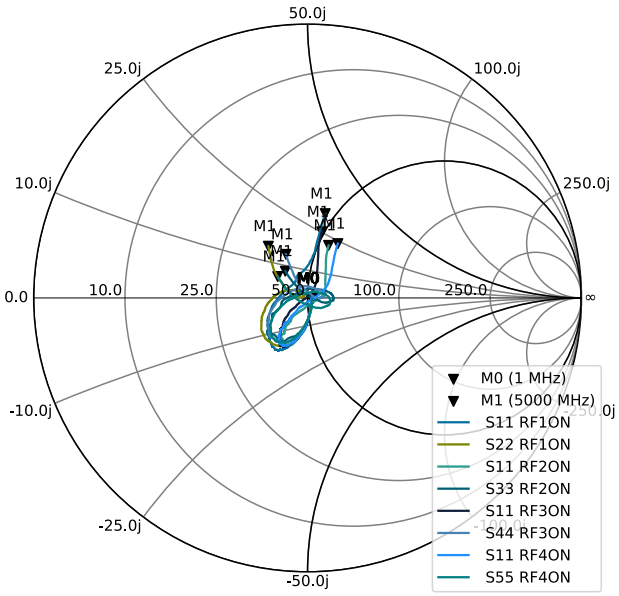
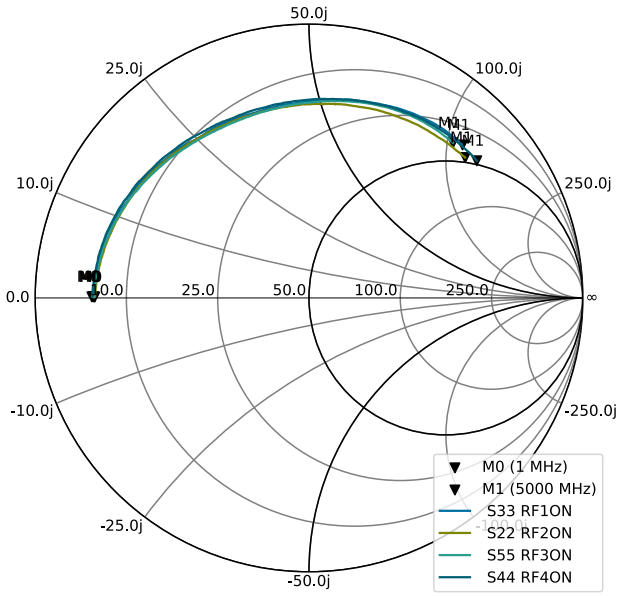


RFC and RFx matching at ON state.



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

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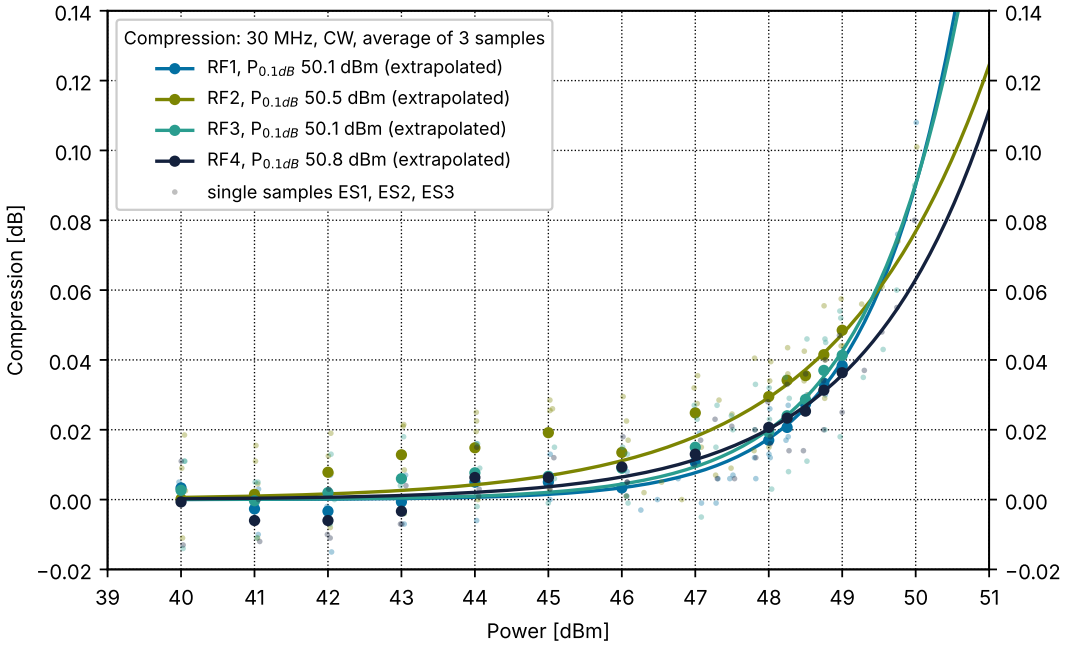
Compression measurement

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 the four RF ports, 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.

At 30 MHz, the average compression stays below 0.05 dB up to 49 dBm, the highest input power measured on all three samples; the model gives $P_{0.1\mathrm{dB}}$ of 50.1 to 50.8 dBm (extrapolated). One sample (ES3) was measured up to 50 dBm and showed 0.08 to 0.11 dB compression at 50 dBm on the four ports, in line with the model.



CW compression at 30 MHz, RF1 to RF4, average of 3 samples.

At 800 MHz, the average $P_{0.1\mathrm{dB}}$ is 47.9 dBm (RF1) to 48.6 dBm (RF4). The electrical specification gives 47 dBm, with margin to the measured values.

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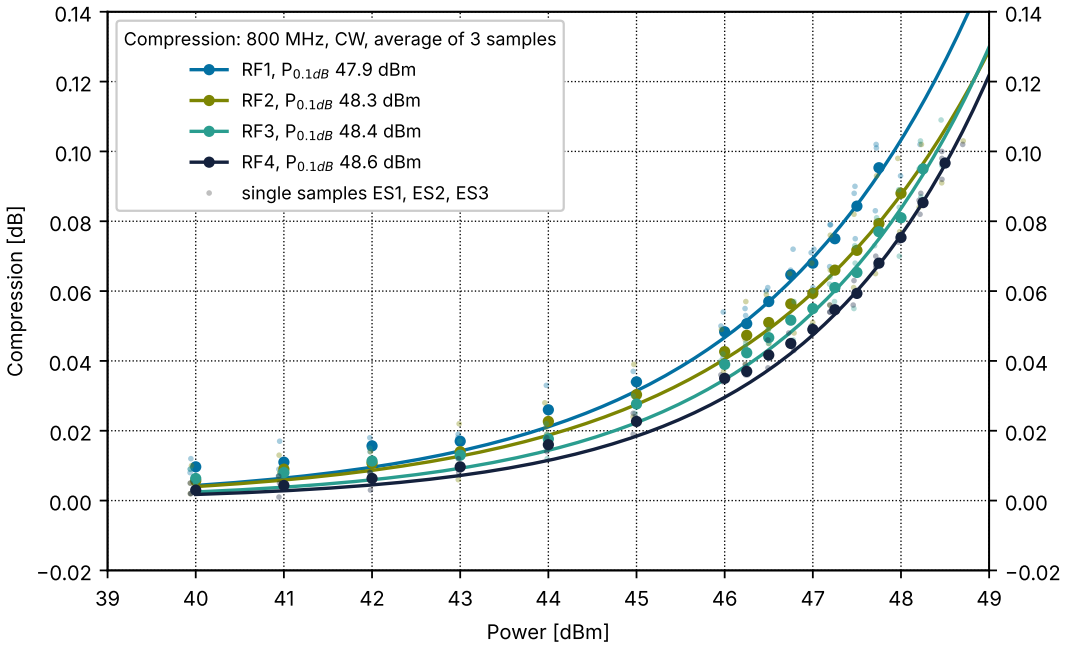

CW compression at 800 MHz, RF1 to RF4, average of 3 samples.

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Peak power handling with modulated signals

The TS8546L is rated for 50 W (47 dBm) average power (CW, 100% duty cycle) and 125 W (51 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 125 W in a 50 Ω system, the RF peak voltage is 112 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 TS8546L exceeds its average power rating by a factor of 2.5 (4 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; with 4 dB of headroom, the TS8546L needs only a small back-off for single-carrier signals.

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.

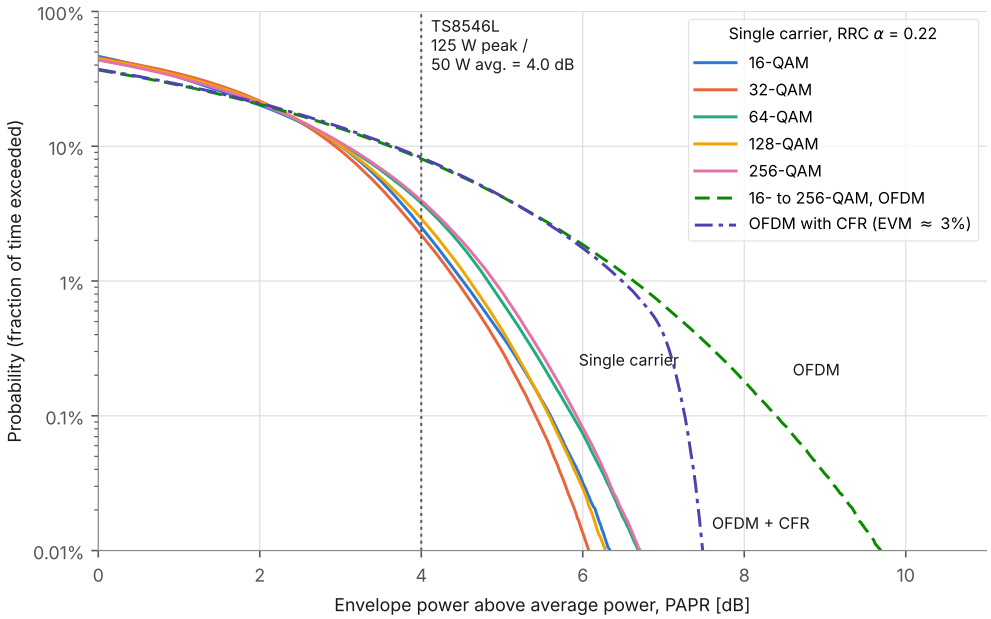

Figure 8: CCDF of the envelope power of QAM signals: fraction of time the envelope power exceeds the average power by the given PAPR. OFDM with CFR: iterative clipping and filtering, EVM ≈ 3%. The dotted line marks the 125 W / 50 W (4 dB) peak-to-average capability of the TS8546L.

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

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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 12 includes typical values for OFDM with CFR.

Average power capability with modulated signals

Typical PAPR values are listed in Table 12. Figure 8 shows the complete CCDF curves together with the 4 dB peak-to-average capability of the TS8546L. At the full 50 W average rating, the envelope of a single-carrier 16- to 256-QAM signal exceeds the 125 W peak level 2.2% to 4.0% of the time, and an OFDM signal with or without CFR about 8% of the time. To keep the envelope peaks within 125 W also at the 1% probability level, the average power is reduced by 0.4 to 0.9 dB for single-carrier QAM and by 2.6 dB for OFDM; 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 TS8546L, and is not binding on TagoreTech; the ratings given in the Absolute Maximum Ratings and Electrical Specifications sections apply.

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Table 12: Peak-to-average power ratio (PAPR) of QAM signals, exceeded for the given fraction of time.

Modulation	PAPR [dB] at probability[2]			TS8546L 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	34.7
32-QAM	2.9	4.4	5.4	36.3
64-QAM	3.1	4.8	5.8	33.1
128-QAM	3.0	4.6	5.6	34.7
256-QAM	3.1	4.9	5.9	32.4
Single carrier, RRC pulse shaping, $\alpha = 0.35$				
16-QAM	3.0	4.4	5.1	38.9
32-QAM	3.0	4.2	4.8	41.7
64-QAM	3.0	4.8	5.6	34.7
128-QAM	3.0	4.5	5.2	38.0
256-QAM	3.1	4.8	5.7	33.9
OFDM, 1024 subcarriers, no crest factor reduction				
16-QAM	3.6	6.6	8.4	18.2
32-QAM	3.6	6.6	8.4	18.2
64-QAM	3.6	6.6	8.4	18.2
128-QAM	3.6	6.6	8.4	18.2
256-QAM	3.6	6.6	8.4	18.2
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	20.0
CFR for EVM ≈ 3%, e.g. 64/128-QAM	3.7	6.5	7.3	23.4
CFR for EVM ≈ 5%, e.g. 16/32-QAM	3.7	6.2	6.5	28.2

[1] Average power at which the envelope peaks at the 0.1% probability level remain within the 125 W peak power rating, $P_{\text{avg}} = 125\,\text{W}/10^{\text{PAPR}_{0.1\%}/10}$, limited to the 50 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

TS8546L has power handling derating below 10 MHz and above 3.0 GHz. The power derating table has been defined for a 50 Ω environment, CW signal, 100 % duty cycle, at room temperature (25 °C).

Table 13: Power derating table

Start f	**Stop** f	**Max Power**	**Unit**
1 MHz	2 MHz	41.0	dBm
2 MHz	5 MHz	45.0	dBm
5 MHz	10 MHz	46.0	dBm
10 MHz	3.0 GHz	47.0	dBm
3.0 GHz	4.5 GHz	46.0	dBm

The measured TS8546L compression at 30 MHz and 800 MHz is shown in Compression measurement.

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Device Package information

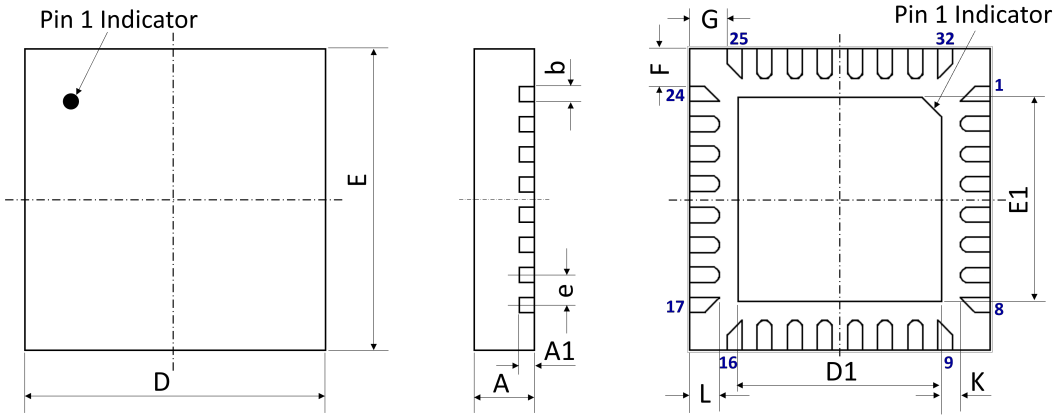

Figure 9: 32-pin QFN 4.0 x 4.0 x 0.75 mm^3 package drawing.

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 14: Device Package Dimensions

Dimension	Value [mm]	Tolerance [mm]	Dimension	Value [mm]	Tolerance [mm]
A	0.75	±0.05	E	4.00 BSC	±0.05
A1	0.203	±0.02	E1	2.70	±0.05
b	0.20	+0.05/-0.07	F	0.50	±0.05
D	4.00 BSC	±0.05	G	0.50	±0.05
D1	2.70	±0.05	L	0.40	±0.05
e	0.40 BSC	±0.05	K	0.25	±0.05

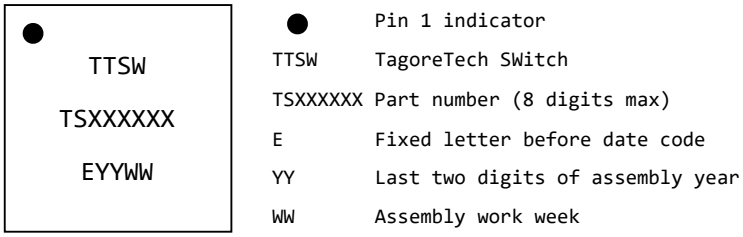

Figure 10: Part marking specification.

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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.

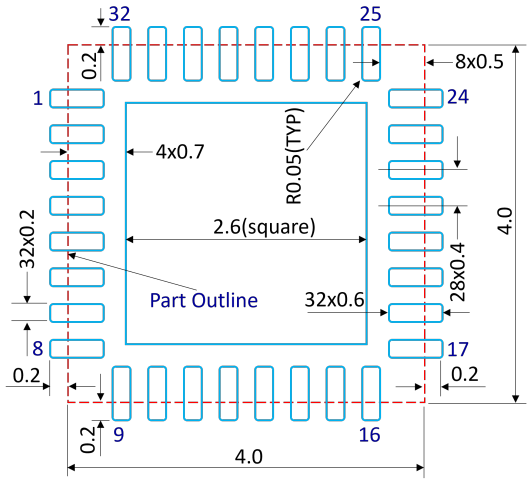

Figure 11: PCB land pattern, dimensions in [mm].

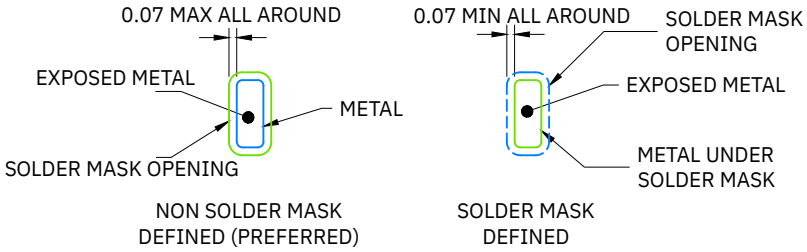

Figure 12: Solder mask opening, dimensions in [mm].

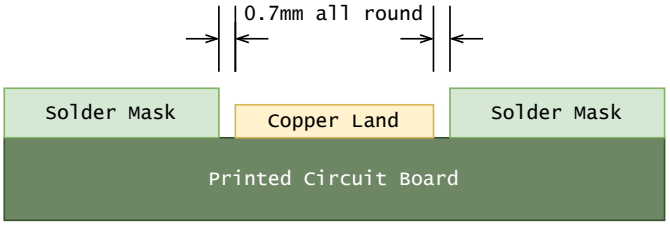

Figure 13: Preferred solder mask opening, side view, dimensions in [mm].

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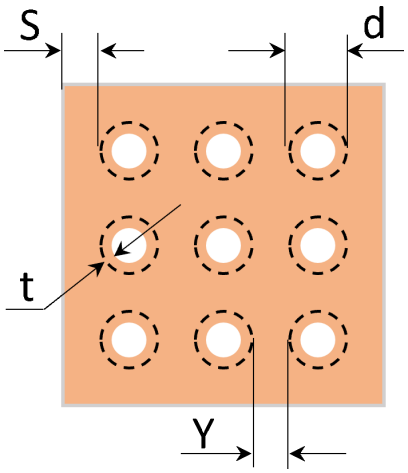

Figure 14: Thermal Via Pattern, Recommended Values: S≥0.15 mm; Y≥0.20 mm; d=0.2 mm; Plating Thickness t=25μm or 50μm.

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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 125 μm.

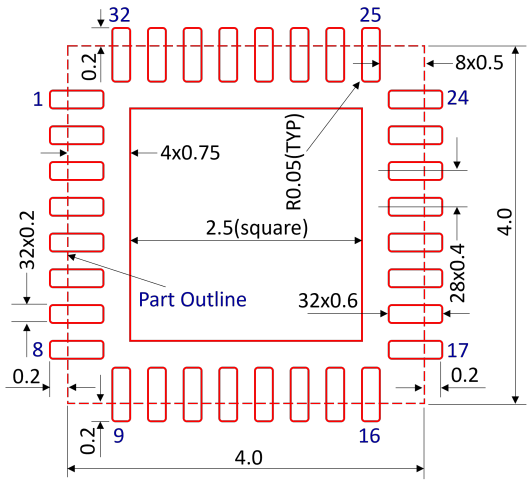

Figure 15: Stencil Openings, dimensions in [mm].

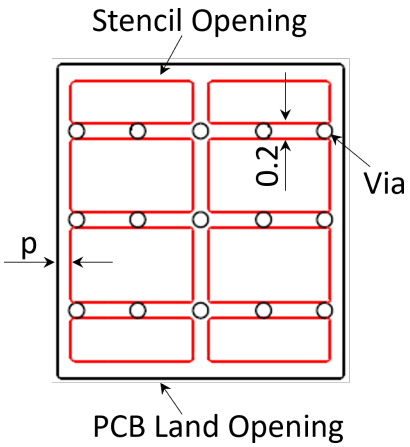

Figure 16: Stencil Openings Shall not Cover Via Areas If Possible, dimensions in [mm].

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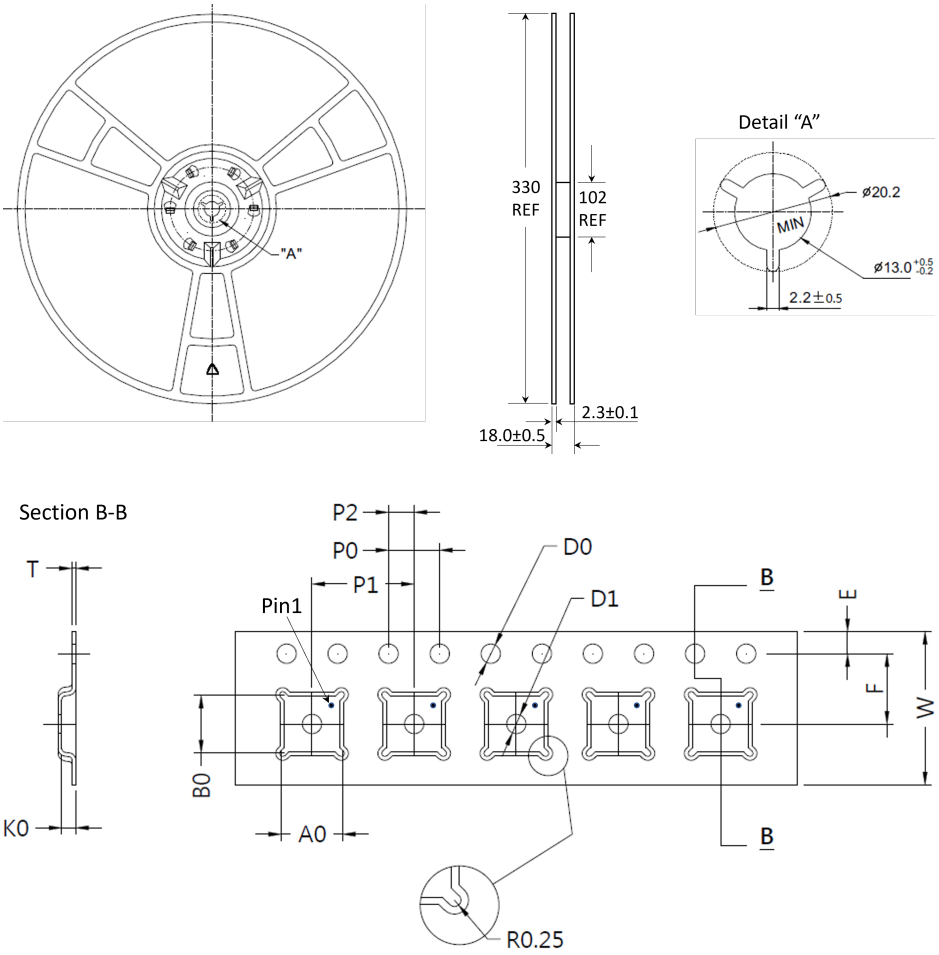
Tape and Reel Information



A0[mm]	B0[mm]	D0[mm]	D1[mm]	E[mm]	F[mm]	K0[mm]	P0[mm]	P1[mm]	P2[mm]	T[mm]	W[mm]
4.35	4.35	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	RF Common port, sometimes referred as ANT
RFx	RF Port number x
Unitarity	Describes power absorption of the component, for the SP4T $1 - \|S_{11}\|^2 - \|S_{21}\|^2 - \|S_{31}\|^2 - \|S_{41}\|^2 - \|S_{51}\|^2$
ESD	Electrostatic discharge
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: 4.5 GHz matching)
CPW	Coplanar waveguide
f_{PRR}	Pulse repetition rate (maximum rate of switching events)
$P_{0.1\mathrm{dB}}$	Input power at 0.1 dB compression
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 15: Changelog

Date	Revision	Notes
11/06/2026	3.00	First datasheet release, version numbering aligned with TS8541L.

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