SPDT 100 W CW/500 W_{peak} T/R Switch 0.5 GHz to 5.0 GHz

Features

- Frequency Range 500 MHz to 5.0 GHz
- Low TX insertion loss:
  0.23 dB @ 800 MHz
  0.40 dB @ 2.2 GHz – 3.0 GHz (matched)
  0.42 dB @ 3.3 GHz – 3.8 GHz (matched)
- High RX isolation:
  52 dB @ 800 MHz
  36 dB @ 2.2 GHz – 3.0 GHz (matched)
  33 dB @ 3.3 GHz – 3.8 GHz (matched)
- 100 W CW
- 500 W_{peak} (57 dBm), 1 % duty cycle, LTE/5G
- Switching time 1.9 µs
- Tuning inductor pins for an isolation notch
- Low power consumption, less than 1 mW
- No external DC blocking capacitors on RF lines
- Versatile 2.6 V – 5.5 V power supply
- No need to supply negative voltages

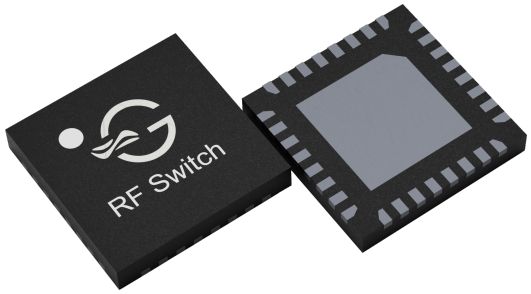

Figure 1: TS8028N in 5.0 x 5.0 mm^2 QFN 32-pin package.

Applications

- Cellular infrastructure: small cells and macrocells
- LTE and 5G transmit/receive switching
- ADS-B and IFF systems

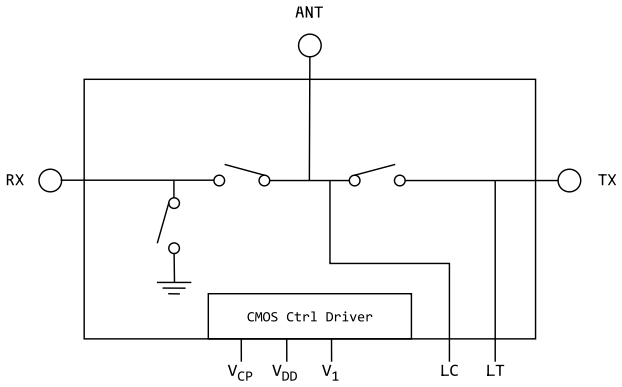

Figure 2: TS8028N functional diagram

General Description

The TS8028N is an asymmetrical reflective Single Pole Double Throw (SPDT) GaN switch designed for high-power transmit/receive switching. The TX branch has a series switch only, which gives low insertion loss and high power handling, and the RX branch has a series and a shunt switch, which gives high isolation from ANT to RX in transmit mode. With simple matching networks the TS8028N covers 500 MHz to 5.0 GHz. It handles 100 W CW, and the peak power capability is 500 W (57 dBm) with 1 % duty cycle, for example with LTE and 5G signals. An external tuning inductor between pins 17 and 18 creates a notch in the isolation curve. No negative supply voltage or external RF DC-blocking capacitors are required.

The TS8028N is housed in a compact 5.0 × 5.0 mm^2 32-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
TS8028N	32-Pin 5.0x5.0x0.75 mm^3 QFN	Core part number
TS8028N-EVB	Evaluation Board	
TS8028NMTRPBF[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

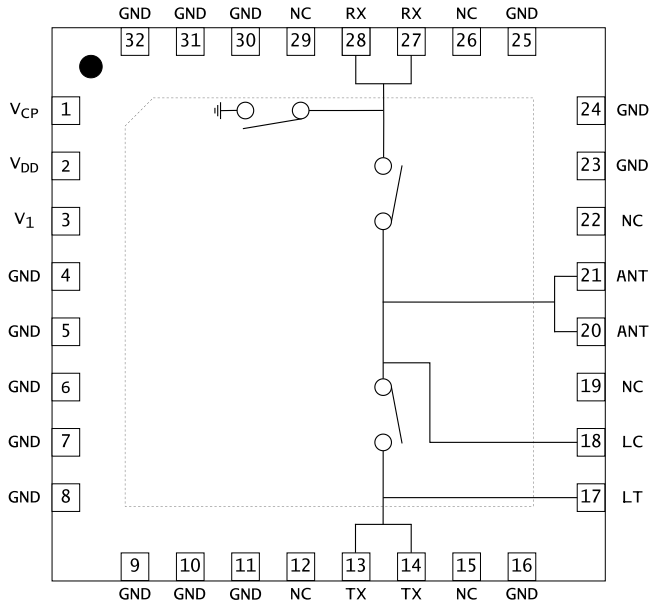

Figure 3: TS8028N pin assignment [top view]

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 pin. For high duty cycles a higher capacitance is recommended; the EVB uses 100 nF.
2	V_{DD}	DC Power Supply
3	V_1	Switch control input
13, 14	TX	TX port, please connect together
20, 21	ANT	Antenna port (RF common port), please connect together
27, 28	RX	RX port, please connect together
17	LT	Tuning inductor connection, TX side of the TX series switch[3]
18	LC	Tuning inductor connection, ANT side of the TX series switch[3]
12, 15, 19, 22, 26, 29	NC	No internal connection. Do not connect, not even to ground: needed for wider clearance and creepage distance
4–11, 16, 23–25, 30–32	GND	Connect to ground[2]
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.
[3] An external inductor L_T between pins 17 and 18 creates a notch in the isolation curve, see Theory of Operation. Leave pins 17 and 18 open when the tuning inductor is not used.

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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
RF input power CW, $T_{case} = +85$°C, 915 MHz	TX / ANT	100 (50 dBm)	W
RF input power peak, $T_{case} = +85$°C, 1 % duty cycle, 10 μs pulse width	TX / ANT	500 (57 dBm)	W
Thermal Ratings			
Thermal Resistance (junction-to-case) – Bottom side	$R_{\theta jc}$	3.5	°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[2]	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] Tagore recommends to store parts in moisture barrier bag to preserve solderability.

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Electrical Specifications

Table 5: Electrical Specifications $T_A = +25°C; V_{DD} = +2.7V; 50\Omega$ Source/Load.

Parameter	Condition	Minimum	Typical	Maximum	Unit
Operating frequency	f	500		5000	MHz
Insertion loss, TX	500–1000 MHz, IDX00[1]		0.28		dB
$ANT - TX$	800 MHz, IDX00[1]		0.23		dB
	2.2–3.0 GHz, IDX01[2]		0.40		dB
	3.3–3.8 GHz, IDX02[2]		0.42		dB
	3.7–4.2 GHz, IDX03[2]		0.45		dB
	4.2–4.6 GHz, IDX04[2]		0.53		dB
Insertion loss, RX	500–1000 MHz, IDX00[1]		0.44		dB
$ANT - RX$	800 MHz, IDX00[1]		0.39		dB
	2.2–3.0 GHz, IDX01[2]		0.58		dB
	3.3–3.8 GHz, IDX02[2]		0.51		dB
	3.7–4.2 GHz, IDX03[2]		0.54		dB
	4.2–4.6 GHz, IDX04[2]		0.58		dB
Isolation	500–1000 MHz, IDX00[1]		19		dB
$ANT - TX$	800 MHz, IDX00[1]		21		dB
	2.2–3.0 GHz, IDX01[2]		21		dB
	3.3–3.8 GHz, IDX02[2]		24		dB
	3.7–4.2 GHz, IDX03[2]		26		dB
	4.2–4.6 GHz, IDX04[2]		25		dB
Isolation	500–1000 MHz, IDX00[1]		50		dB
$ANT - RX$	800 MHz, IDX00[1]		52		dB
	2.2–3.0 GHz, IDX01[2]		36		dB
	3.3–3.8 GHz, IDX02[2]		33		dB
	3.7–4.2 GHz, IDX03[2]		32		dB
	4.2–4.6 GHz, IDX04[2]		32		dB
Return loss	500–1000 MHz, IDX00[1]		-17		dB
$ANT - TX$ ON[3]	800 MHz, IDX00[1]		-19		dB
	2.2–3.0 GHz, IDX01[2]		-21		dB
	3.3–3.8 GHz, IDX02[2]		-21		dB
	3.7–4.2 GHz, IDX03[2]		-26		dB
	4.2–4.6 GHz, IDX04[2]		-23		dB
Return loss	500–1000 MHz, IDX00[1]		-18		dB
$ANT - RX$ ON[3]	800 MHz, IDX00[1]		-20		dB
	2.2–3.0 GHz, IDX01[2]		-18		dB
	3.3–3.8 GHz, IDX02[2]		-21		dB
	3.7–4.2 GHz, IDX03[2]		-20		dB
	4.2–4.6 GHz, IDX04[2]		-18		dB

[1] No external DC blocking capacitors are required on RF pins unless DC voltage is applied on a RF pin. EVB without matching components and without tuning inductor (IDX00); worst case over 500 to 1000 MHz, and the value at 800 MHz.
[2] Matching example with the tuning inductor L_T, see Schematics and Evaluation Board; worst case over the band. 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.
[3] Return loss of the ANT port and the active RF port in the given switch state, worst of the two ports.

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Table 6: Electrical Specifications $T_A = +25°C; V_{DD} = +2.7V; 50\Omega$ Source/Load.

Parameter	Condition	Minimum	Typical	Maximum	Unit
Operating frequency	f	500		5000	MHz
Power and Compression point					
$P_{0.1dB}$ TX[1]	800 MHz, CW (178 W)		52.5		dBm
$P_{0.1dB}$ TX[1,5]	3500 MHz, CW (89 W)		49.5		dBm
$P_{peak0.1dB}$ TX[1,5]	3500 MHz, 1% duty cycle, 10 μs pulse (316 W)		55.0		dBm
P_{peak} TX[2]	1% duty cycle, LTE / 5G (500 W)	57			dBm
$P_{0.1dB}$ RX[1]	915 MHz, CW (18 W)		42.5		dBm
$P_{peak0.1dB}$ RX[1]	915 MHz, 1% duty cycle, 10 μs pulse (20 W)		43.0		dBm
Switching Time[3]					
t_{ON}	50% ctrl to 90% of RF value, RX / TX		1.6 / 1.5		μs
t_{OFF}	50% ctrl to 10% of RF value, RX / TX		1.4 / 1.9		μs
t_{RISE}	10% to 90% of RF value, RX / TX		0.5 / 0.3		μs
t_{FALL}	90% to 10% of RF value, RX / TX		1.3 / 0.3		μs
Power Supply, DC					
Control voltage	Power Supply V_{DD}	2.6	3.3	5.5	V
	Control pin high[4], V_{ih}	1.0	3.3	5.25	V
	Control pin low, V_{il}	-0.3		0.5	V
Control current	Control pin high, I_{ih}			7.5	μA
	Control pin low, I_{il}		0		μA
Current consumption	I_{DD}, active mode (V_{DD} on)		160	200	μA

[1] $P_{0.1dB}$ is a figure of merit, from the compression measurements (exponential model, rounded down to 0.5 dB), see Compression with temperature. Please do not exceed Absolute Maximum ratings.
[2] Peak power with 1 % duty cycle, for example the envelope peaks of LTE and 5G signals at the TX port: the TS8028N withstands 57 dBm (500 W_{peak}). See Peak power handling with modulated signals.
[3] $C_{VCP} = 100$ nF, internal charge pump.
[4] Control voltage V_{ih} cannot be higher than V_{DD} (to avoid forward biasing of ESD diode)
[5] Measured with the IDX01 EVB (2.2 to 3.0 GHz matching), outside its matched band, with about 1 dB insertion loss.

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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 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.

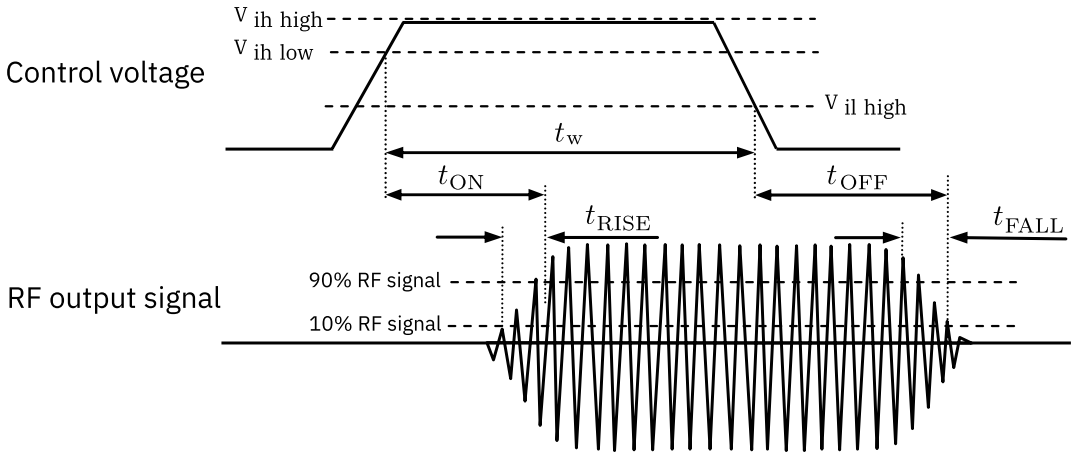

Figure 4: Switching time definition, t_{ON}, t_{OFF}, t_{RISE}, t_{FALL}. Minimum pulse width t_w.

Our component uses integrated charge pump. The switching times of the TS8028N are given with $C_{VCP} = 100$ nF on the V_{CP} pin.

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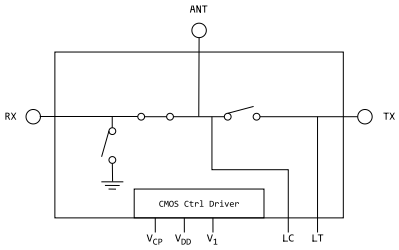
Switch Control table

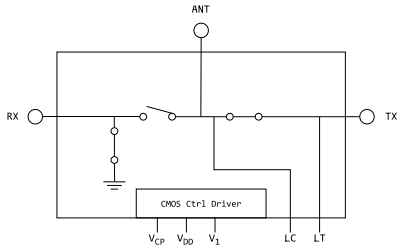
Table 7: Switch Control Table

V_{DD}[1]	V_1	**Switch state**
1	0	$ANT - RX$ ON[2], TX series switch OFF
1	1	$ANT - TX$ ON, RX series switch OFF and RX shunt switch ON
0	0	All switches conducting[3]: TX series, RX series and RX shunt switch ON

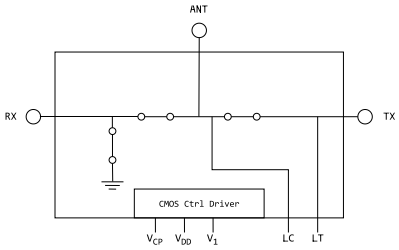
[1] V_{DD} should be applied first before V_1, otherwise may cause damage to the device.
[2] There is an internal pull-down to ground on the V_1 control pin, the state at start-up without any control voltage applied will be $ANT - RX$ ON.
[3] Without supply voltage ($V_{DD} = 0$, $V_1 = 0$) all switches are conducting, see Theory of Operation.



ANT-RX ON ($V_1 = 0$)



ANT-TX ON ($V_1 = 1$)



V_{DD} off, all switches conducting ($V_{DD} = 0$, $V_1 = 0$)

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Theory of Operation

Asymmetrical switch topology

The TS8028N is an asymmetrical SPDT switch optimized for transmit/receive switching. The TX branch between ANT and TX has a series switch only. Without a shunt switch on the TX side, the insertion loss of the TX path is low (0.23 dB at 800 MHz) and the TX path handles high power: 100 W CW and a peak power of 500 W (57 dBm) with 1 % duty cycle, for example with LTE and 5G signals. The RX branch between ANT and RX has a series switch and a shunt switch. In the ANT-TX ON state, the RX series switch is open and the RX shunt switch connects the RX port to ground, which gives high ANT-RX isolation (52 dB at 800 MHz) to protect the receiver. In the ANT-RX ON state, the TX series switch is open; as the TX branch has no shunt switch, the ANT-TX isolation is lower (21 dB at 800 MHz) and decreases with frequency.

Tuning inductor and isolation notch

Pins 17 (LT) and 18 (LC) are connections for an external tuning inductor L_T across the TX series switch. The tuning inductor tunes out the capacitance of the open TX branch: it creates a notch in the ANT-TX isolation curve, and the notch frequency is set by the inductance. The matching examples show the effect: without L_T the ANT-TX isolation is 13 dB at 2.5 GHz; with $L_T = 9.0$ nH (IDX01) the notch is at 2.5 GHz with 36 dB. Smaller inductors move the notch up in frequency: 4.3 nH (IDX02) to 3.8 GHz, 3.9 nH (IDX03) to 4.0 GHz and 3.2 nH (IDX04) to 4.3 GHz. Below the notch frequency the tuning inductor bypasses the open TX series switch, and the RX insertion loss increases; choose L_T so that the notch is in or slightly above the operating band (see the tuning inductor sweep of the sibling part TS8029N). Choose L_T for the desired frequency range first, and design the matching networks with the chosen L_T in place. When the tuning inductor is not used, pins 17 and 18 are left open.

V_{DD} off state

Without supply voltage ($V_{DD} = 0$, $V_1 = 0$) all switches of the TS8028N are conducting: the TX series switch connects ANT to TX, the RX series switch connects ANT to RX, and the RX shunt switch connects the RX branch to ground. The switch control table shows this state as the third row.

Application Information

TS8028N is offering 100 W CW power capability from 500 MHz to 5.0 GHz, and the peak power capability is 500 W (57 dBm) with 1 % duty cycle, for example with LTE and 5G signals. Applications include cellular infrastructure (small cells and macrocells), LTE and 5G transmit/receive switching, and ADS-B and IFF systems. In the past, such applications were covered with power hungry and complex PIN diodes, TS8028N significantly reduces design complexity for such RF switching needs. Below 1 GHz the switch works without matching components and without the tuning inductor (IDX00). For the bands 2.2 to 3.0 GHz (IDX01), 3.3 to 3.8 GHz (IDX02), 3.7 to 4.2 GHz (IDX03) and 4.2 to 4.6 GHz (IDX04) the datasheet provides matching examples with the tuning inductor.

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Schematics and Evaluation Board

S-parameters of all presented EVB configurations (IDX00 to IDX04) can be downloaded from this link: Download TS8028N S-parameters

Table 8: Port definitions in s-parameter files and plots.

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

Content of s-parameter repository:

```
TS8028N.zip
└── TS8028N
    ├── TS8028N_IDX00 ..... IDX00, no L_T, no matching components
    │   ├── Readme.txt ..... matching network description
    │   ├── TS8028N_IDX00_RF1ON_3PORT.s3p ..... S3P file for ANT-RX ON mode
    │   └── TS8028N_IDX00_RF2ON_3PORT.s3p ..... S3P file for ANT-TX ON mode
    ├── TS8028N_IDX01_2200MHz_3000MHz ..... IDX01, L_T 9.0 nH, 2.2 to 3.0 GHz
    │   ├── Readme.txt ..... matching network description
    │   ├── TS8028N_IDX01_RF1ON_3PORT.s3p ..... S3P file for ANT-RX ON mode
    │   └── TS8028N_IDX01_RF2ON_3PORT.s3p ..... S3P file for ANT-TX ON mode
    ├── TS8028N_IDX02_3300MHz_3800MHz ..... IDX02, L_T 4.3 nH, 3.3 to 3.8 GHz
    │   ├── Readme.txt ..... matching network description
    │   ├── TS8028N_IDX02_RF1ON_3PORT.s3p ..... S3P file for ANT-RX ON mode
    │   └── TS8028N_IDX02_RF2ON_3PORT.s3p ..... S3P file for ANT-TX ON mode
    ├── TS8028N_IDX03_3700MHz_4200MHz ..... IDX03, L_T 3.9 nH, 3.7 to 4.2 GHz
    │   ├── Readme.txt ..... matching network description
    │   ├── TS8028N_IDX03_RF1ON_3PORT.s3p ..... S3P file for ANT-RX ON mode
    │   └── TS8028N_IDX03_RF2ON_3PORT.s3p ..... S3P file for ANT-TX ON mode
    └── TS8028N_IDX04_4200MHz_4600MHz ..... IDX04, L_T 3.2 nH, 4.2 to 4.6 GHz
        ├── Readme.txt ..... matching network description
        ├── TS8028N_IDX04_RF1ON_3PORT.s3p ..... S3P file for ANT-RX ON mode
        └── TS8028N_IDX04_RF2ON_3PORT.s3p ..... S3P file for ANT-TX ON mode
```


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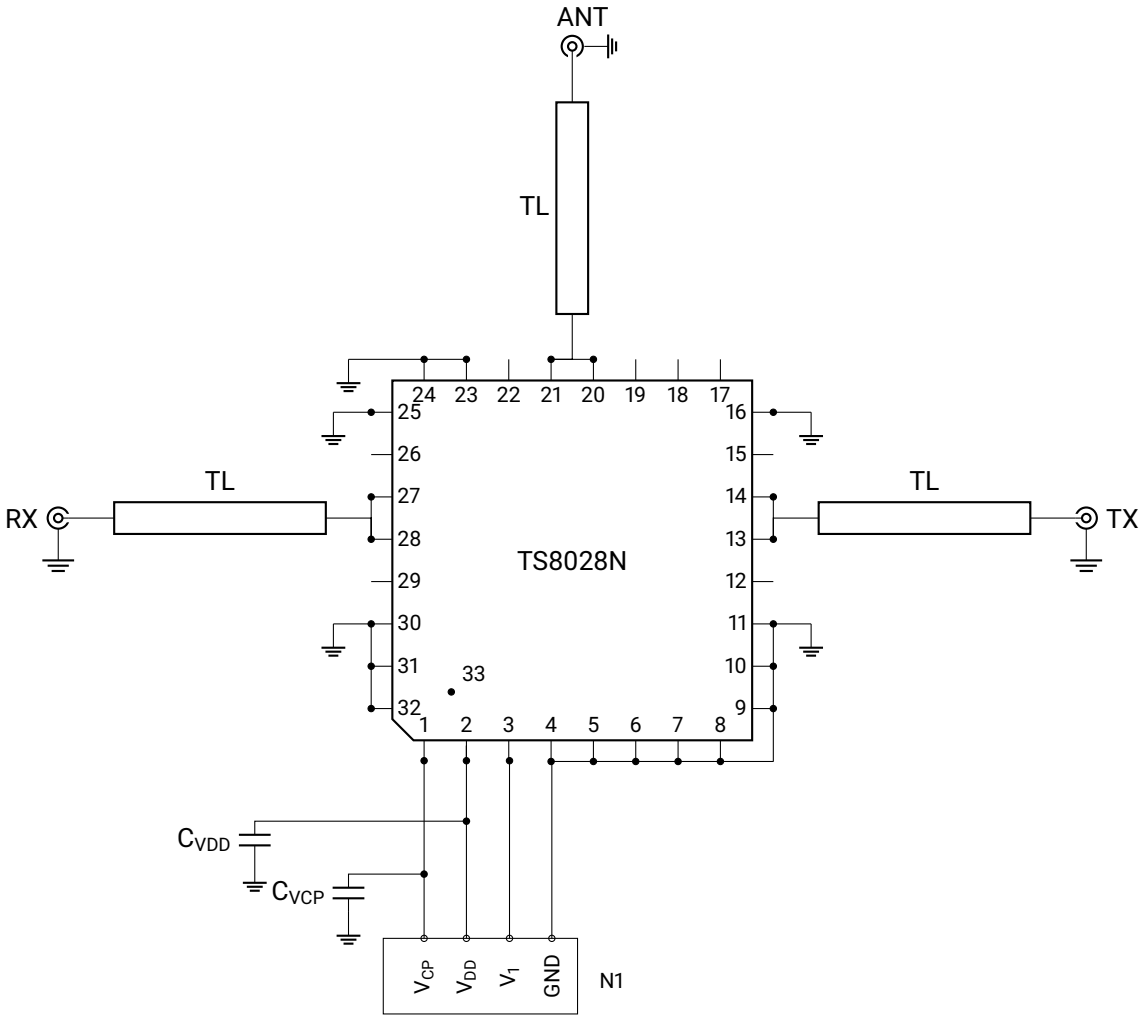
Unmatched EVB (IDX00), up to 1.0 GHz

TS8028N works without matching components below 1.0 GHz. Only two external components are recommended, 100 nF for V_{CP} and 10 nF for V_{DD} lines for supporting charge pump and power supply. Pins 17 and 18 are left open. The NC pins next to the RF pins (12, 15, 19, 22, 26 and 29) are not connected on the EVB, not even to ground. Leaving these pins unconnected gives the wider clearance and creepage distance around the RF pins that is needed at high RF voltages. On the EVB, the RX port is the connector RF1 and the TX port is the connector RF2; the plots use the same names.



Schematics of TS8028N EVB without matching components

Table 9: Components used for TS8028N EVB

Reference	Part number / Value	Description	Notes
C_{VDD}	10 nF	Capacitor	GRM155R71H103KA88
C_{VCP}	100 nF	Capacitor	GRM155R61E104KA87D

Pin 33 is the center pad of the device. Multiple plugged through-hole vias should be added on this ground pad and adequate heat sinking should be used.
The purpose of the connection between V_{CP} and connector N1 is to monitor V_{CP}, do not apply an external voltage to V_{CP}.

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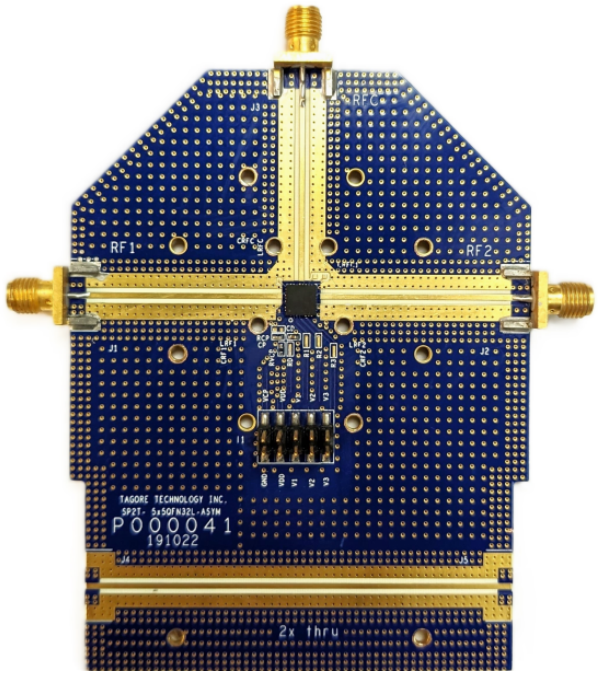

Photo of TS8028N EVB

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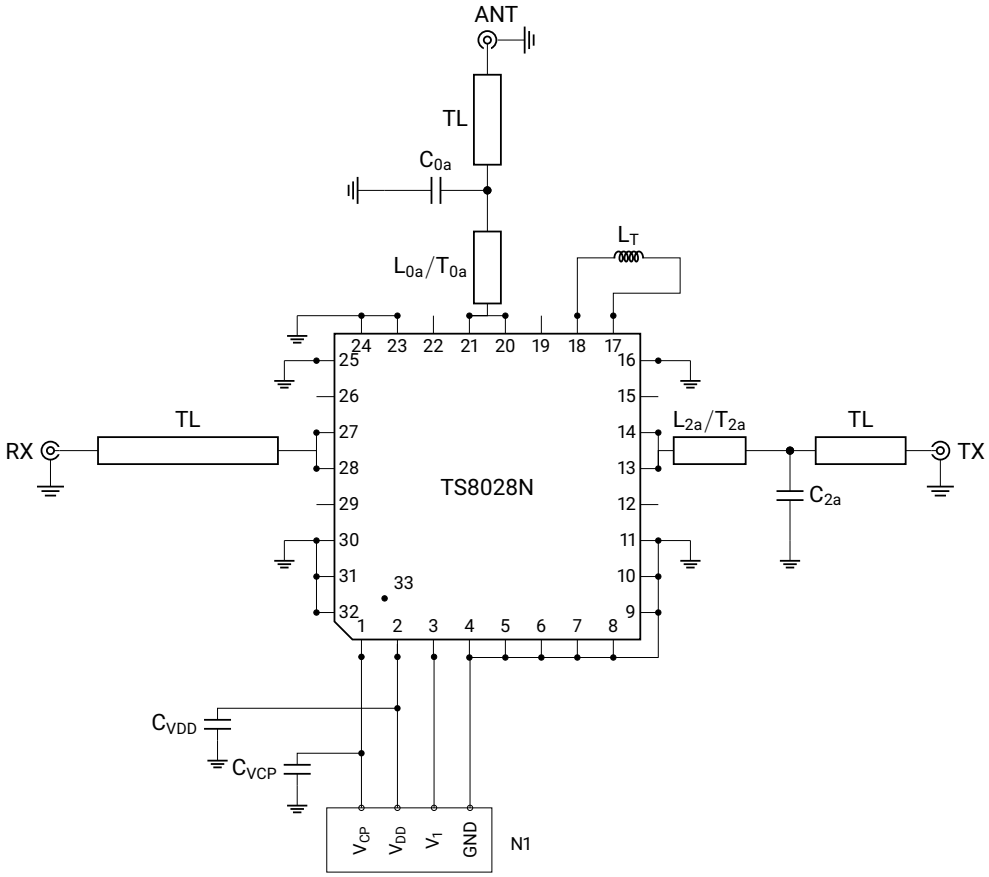
Matching examples

The matching examples use the same EVB as the unmatched configuration. The tuning inductor L_T between pins 17 and 18 sets the ANT-TX isolation notch to the band; choose L_T first and design the matching networks with L_T in place. At the ANT port and at the TX port, the matching network is a series element next to the switch, an inductor (L_{0a}, L_{2a}) or a PCB transmission line (T_{0a}, T_{2a}), followed by a shunt capacitor (C_{0a}, C_{2a}). The RX port is not matched. Positions marked – in Table 10 are not populated; a series position that is not populated is a short (0 Ω). Solder the matching components as close as possible to the pins of the switch.



Schematics of TS8028N EVB with matching component positions

Table 10: Matching components for the frequency bands

Band	EVB	L_T	L_{0a} / T_{0a}	C_{0a}	L_{2a} / T_{2a}	C_{2a}
			ANT port		**TX port**	
0.5 to 1.0 GHz	IDX00	–	–	–	–	–
2.2 to 3.0 GHz	IDX01	9.0 nH	1.7 nH	0.5 pF	1.7 nH	0.7 pF
3.3 to 3.8 GHz	IDX02	4.3 nH	8.0 mm[a]	0.5 pF	7.0 mm[a]	0.5 pF
3.7 to 4.2 GHz	IDX03	3.9 nH	6.1 mm[a]	0.5 pF	5.5 mm[a]	0.5 pF
4.2 to 4.6 GHz	IDX04	3.2 nH	4.9 mm[a]	0.5 pF	4.2 mm[a]	0.5 pF

Inductors: Coilcraft 0402DC series (L_T: 0402DC-9N0X_R_, 0402DC-4N3X_R_, 0402DC-3N9X_R_, 0402DC-3N2X_R_; 1.7 nH: 0402DC-1N7X_R_). Capacitors: Passive Plus 0603N series, 250 V (0.5 pF: 0603N0R5BW251, 0.7 pF: 0603N0R7BW251). C_{VCP} 100 nF and C_{VDD} 10 nF in all configurations.

[a] PCB transmission line (CPW) length from the switch edge reference plane to the center of the shunt capacitor.

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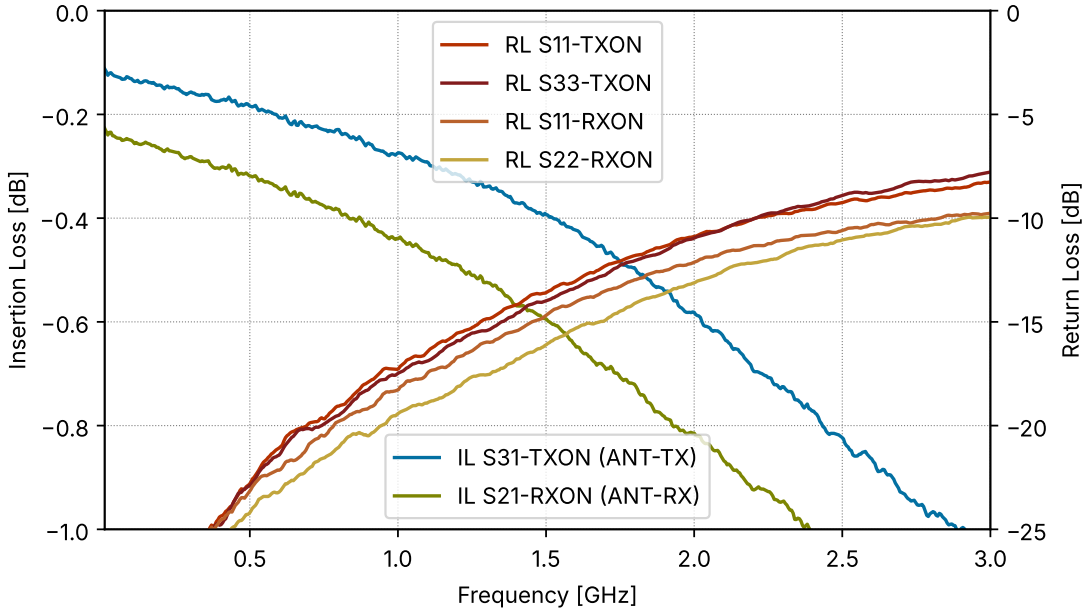
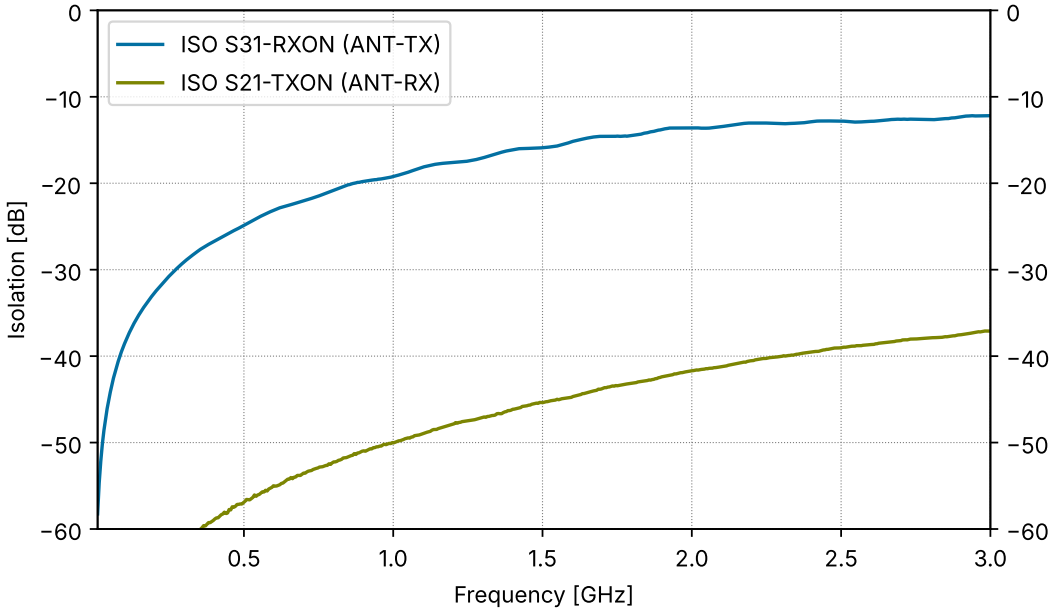
Typical characteristics

Performance up to 3.0 GHz, unmatched (IDX00)

These measurements were obtained using the TS8028N EVB without matching components and without the tuning inductor (IDX00), with CPW losses de-embedded. Without matching components the switch is used up to 1.0 GHz; from 500 MHz to 1.0 GHz the TX insertion loss is at most 0.28 dB and the RX insertion loss at most 0.44 dB, the ANT-RX isolation is at least 50 dB and the ANT-TX isolation at least 19 dB. At 800 MHz the TX insertion loss is 0.23 dB and the ANT-RX isolation 52 dB. The plots extend to 3.0 GHz; the RX insertion loss reaches 1 dB at 2.4 GHz.



Insertion loss and return loss, IDX00.



Isolation of the non-active port, ANT-TX in the ANT-RX ON state and ANT-RX in the ANT-TX ON state, IDX00.

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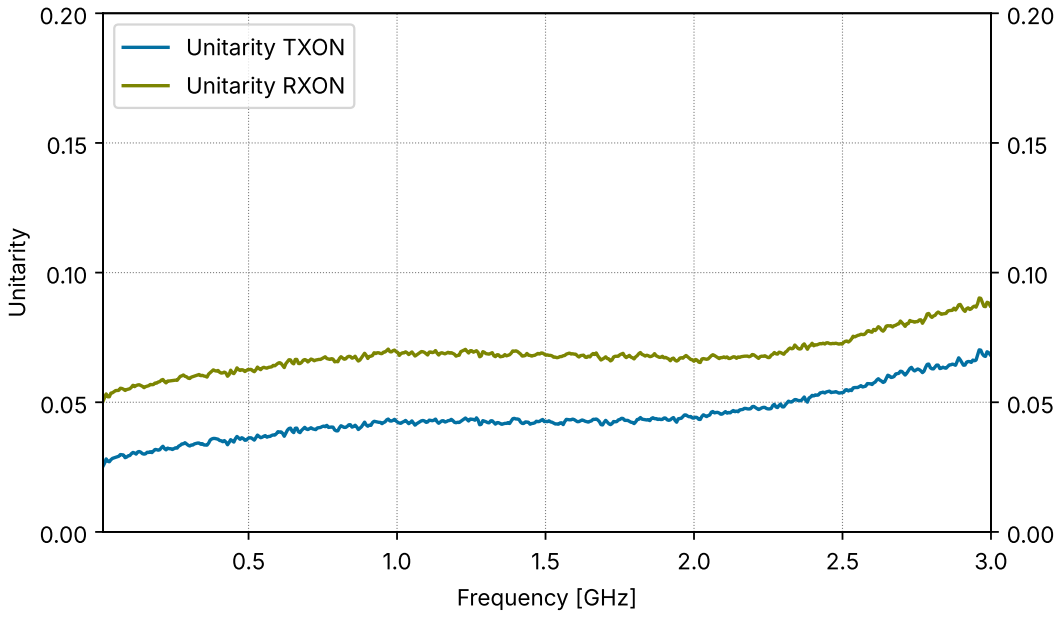
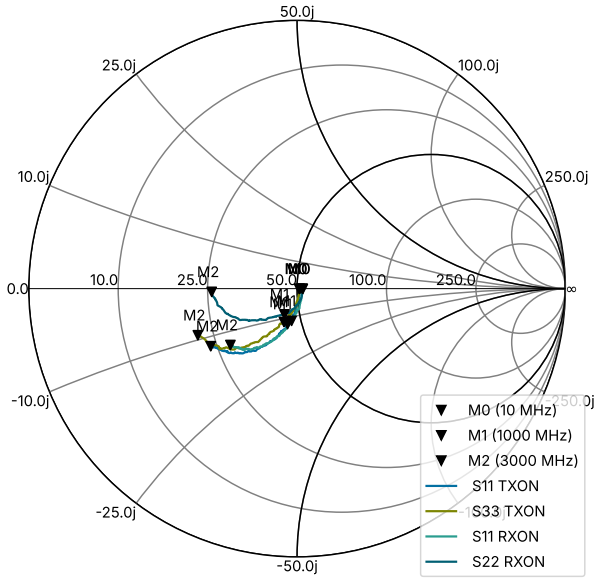
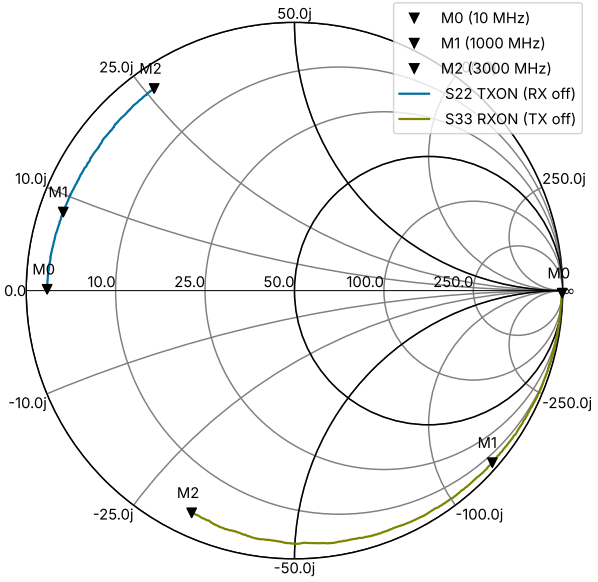


Unitarity, power absorption of the component, $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2$, IDX00.



Matching of the active ports



Termination impedance of the non-active port

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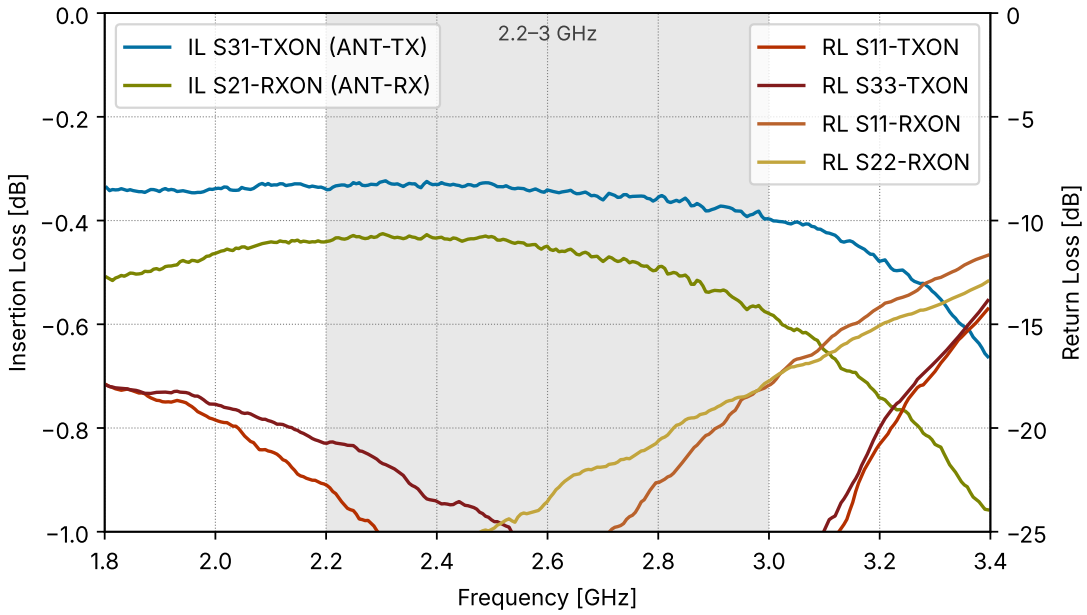
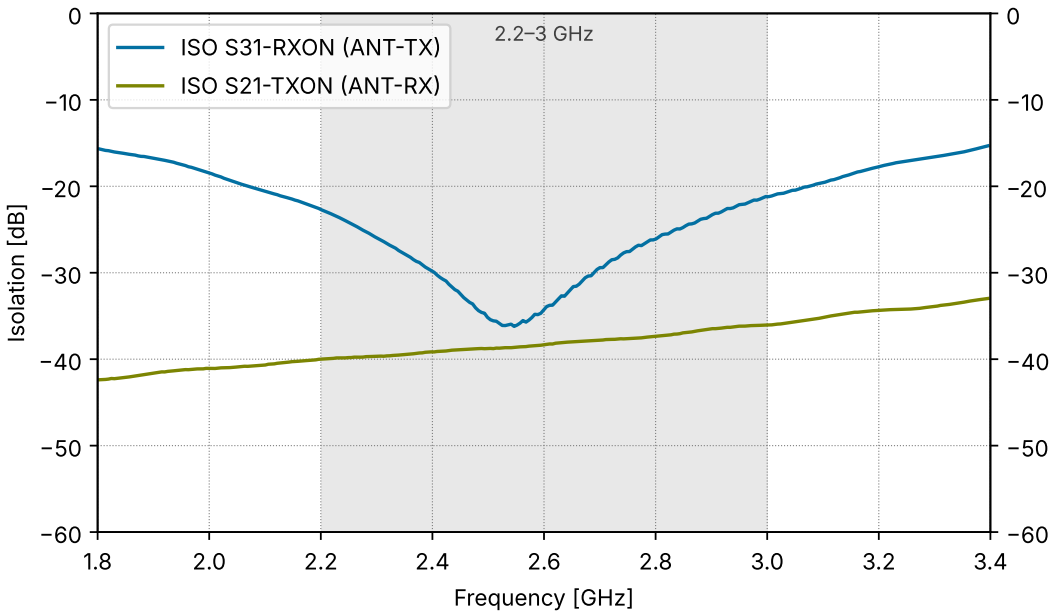
Performance 2.2 to 3.0 GHz, matched (IDX01)

These measurements were obtained using the TS8028N EVB with the IDX01 matching components ($L_T = 9.0$ nH, Table 10), including the losses of the matching components. The operating band 2.2 to 3.0 GHz is shaded grey. Over the band the TX insertion loss is at most 0.40 dB, the RX insertion loss at most 0.58 dB, the ANT-RX isolation at least 36 dB and the ANT-TX isolation at least 21 dB, with the isolation notch at 2.5 GHz (34 dB at 2.6 GHz).



Insertion loss and return loss, IDX01.



Isolation of the non-active port, ANT-TX in the ANT-RX ON state and ANT-RX in the ANT-TX ON state, IDX01.

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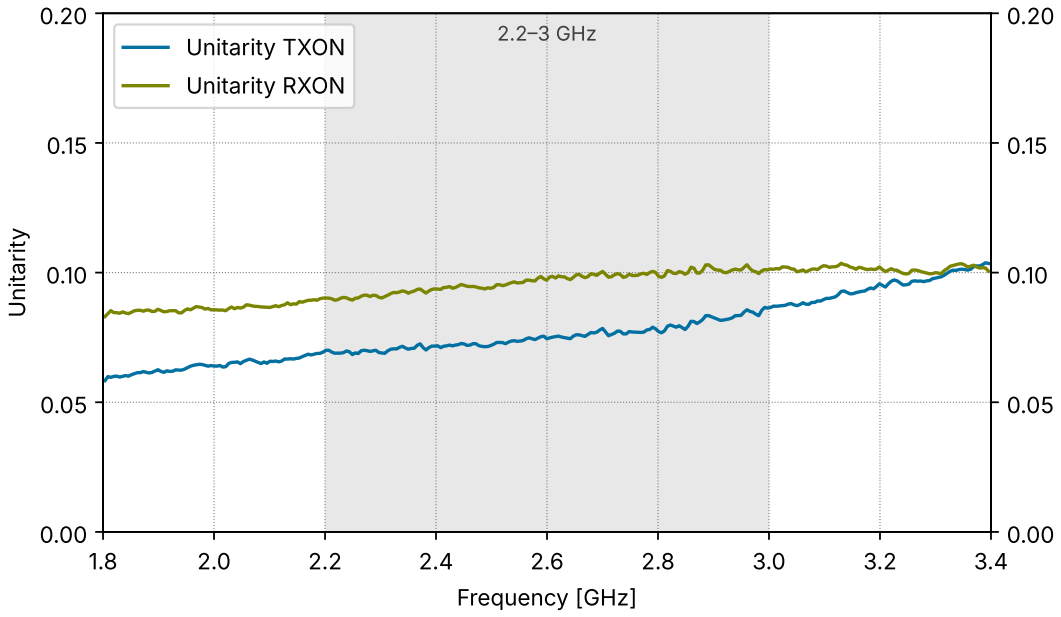
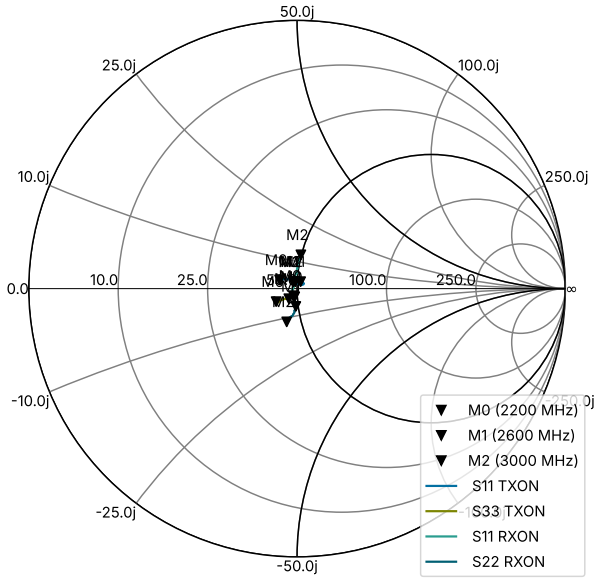
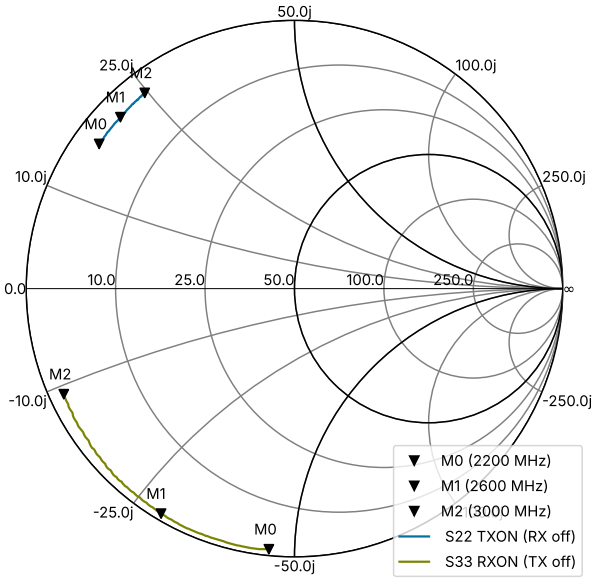


Unitarity, power absorption of the component, $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2$, IDX01.



Matching of the active ports



Termination impedance of the non-active port

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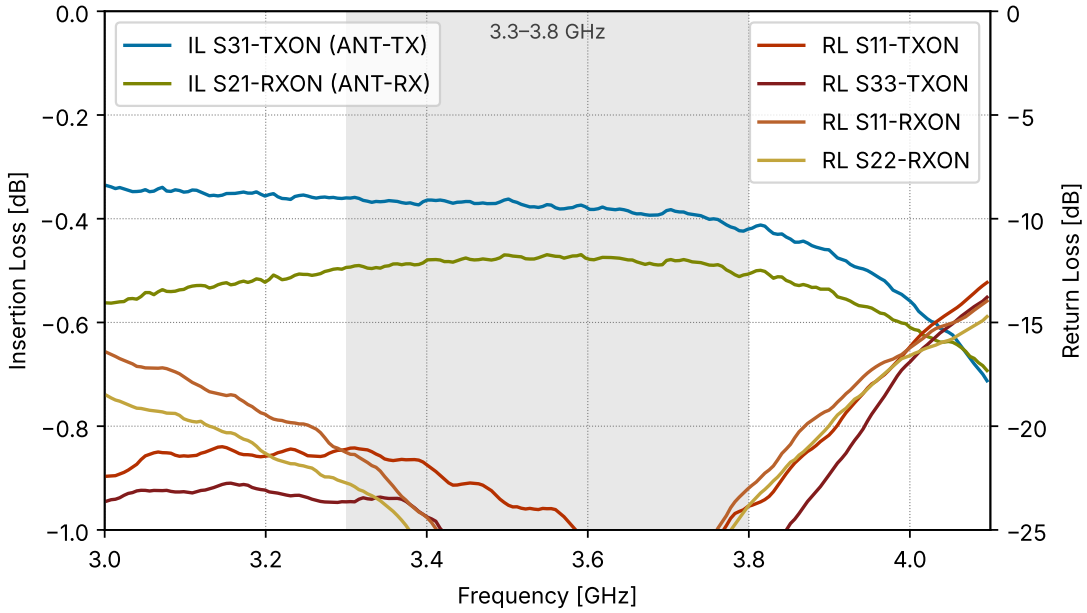
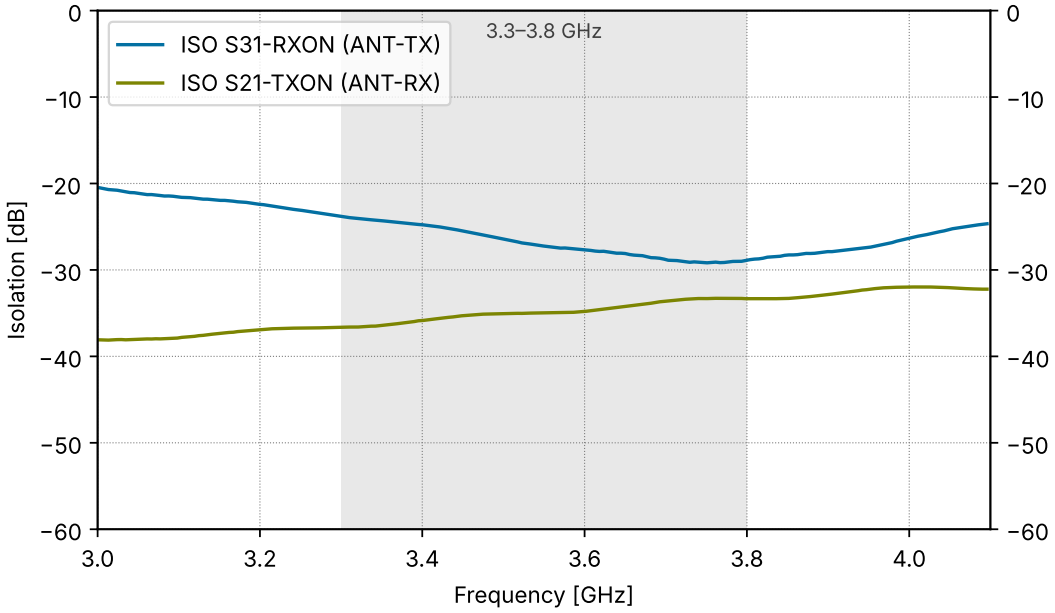
Performance 3.3 to 3.8 GHz, matched (IDX02)

These measurements were obtained using the TS8028N EVB with the IDX02 matching components ($L_T = 4.3$ nH, Table 10), including the losses of the matching components. The operating band 3.3 to 3.8 GHz is shaded grey. Over the band the TX insertion loss is at most 0.42 dB, the RX insertion loss at most 0.51 dB, the ANT-RX isolation at least 33 dB and the ANT-TX isolation at least 24 dB.



Insertion loss and return loss, IDX02.



Isolation of the non-active port, ANT-TX in the ANT-RX ON state and ANT-RX in the ANT-TX ON state, IDX02.

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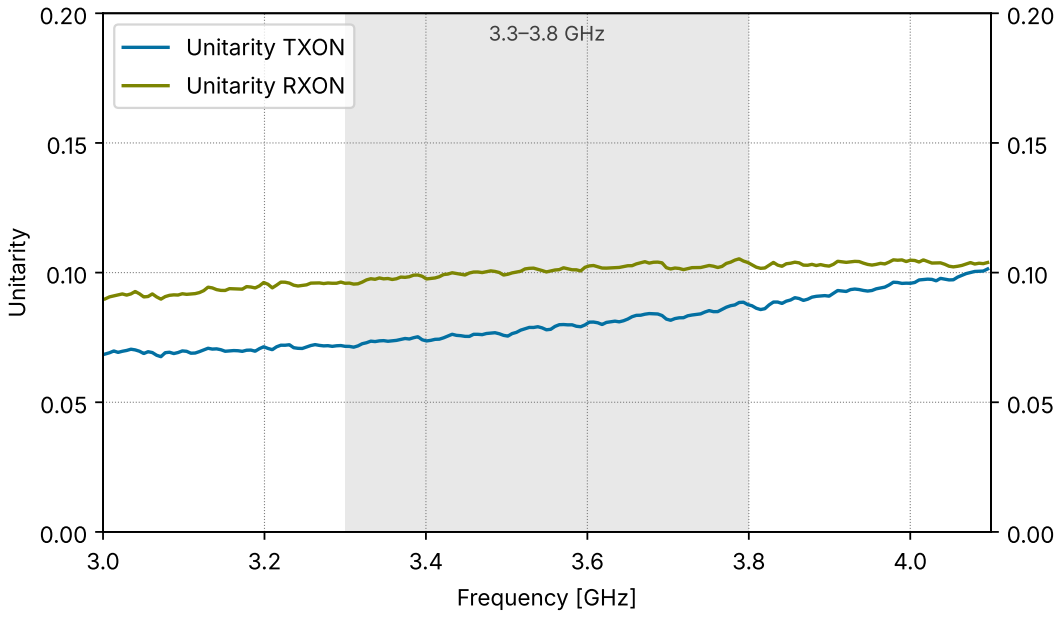
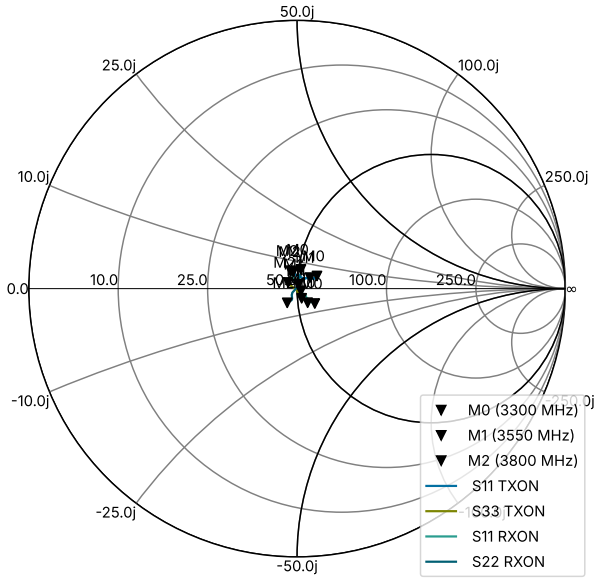
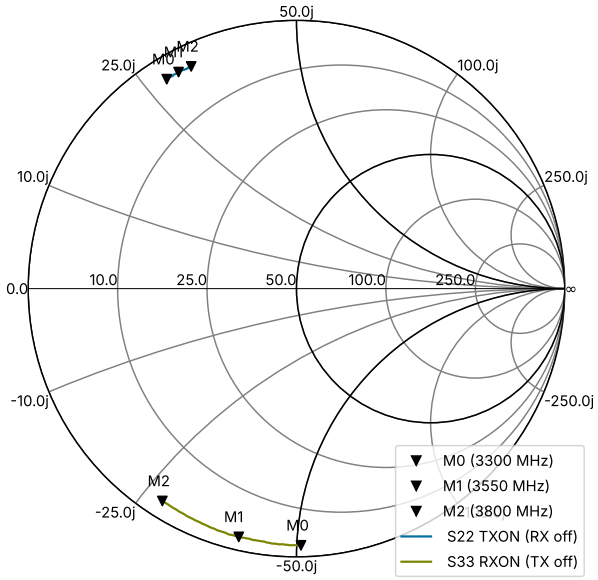


Unitarity, power absorption of the component, $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2$, IDX02.



Matching of the active ports



Termination impedance of the non-active port

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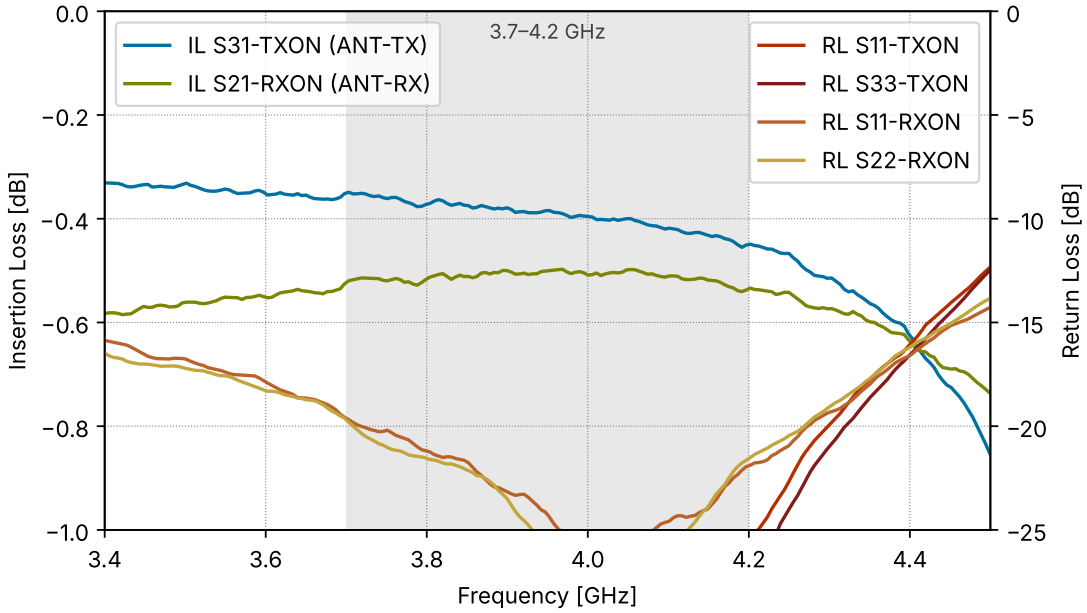
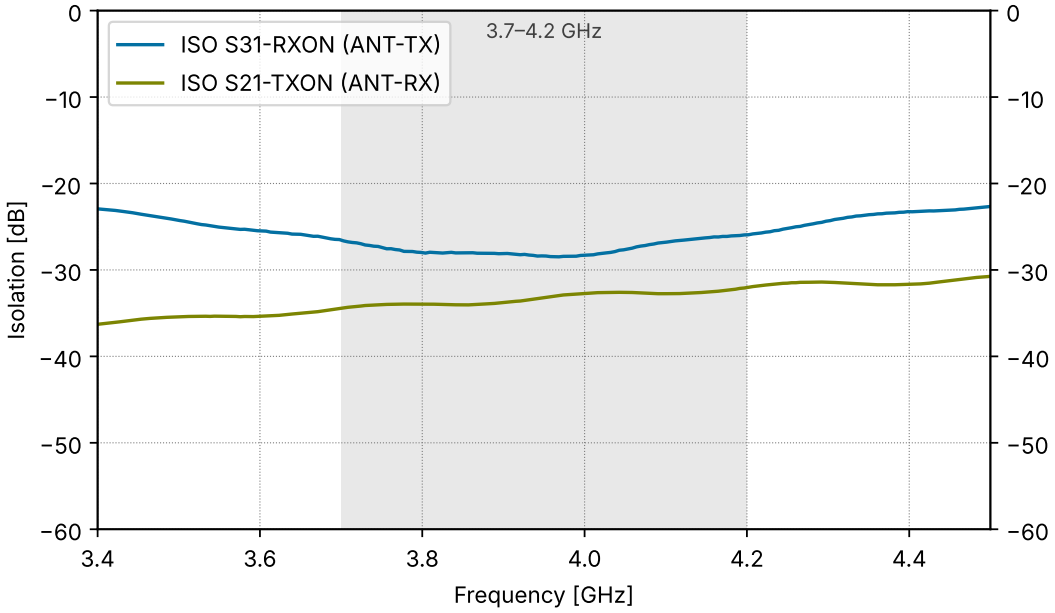
Performance 3.7 to 4.2 GHz, matched (IDX03)

These measurements were obtained using the TS8028N EVB with the IDX03 matching components ($L_T = 3.9$ nH, Table 10), including the losses of the matching components. The operating band 3.7 to 4.2 GHz is shaded grey. Over the band the TX insertion loss is at most 0.45 dB, the RX insertion loss at most 0.54 dB, the ANT-RX isolation at least 32 dB and the ANT-TX isolation at least 26 dB.



Insertion loss and return loss, IDX03.



Isolation of the non-active port, ANT-TX in the ANT-RX ON state and ANT-RX in the ANT-TX ON state, IDX03.

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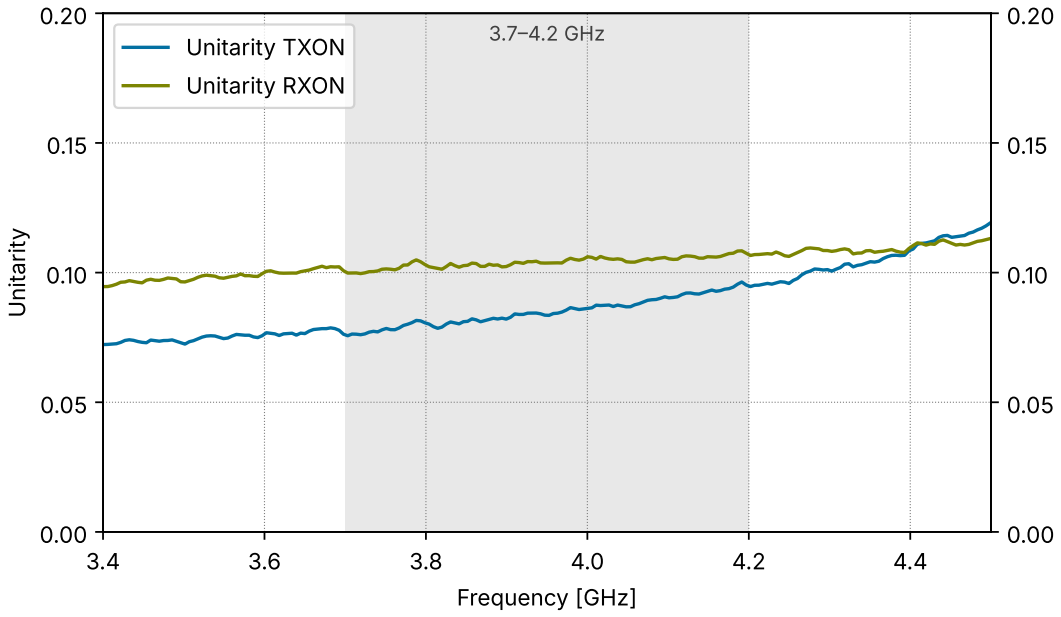
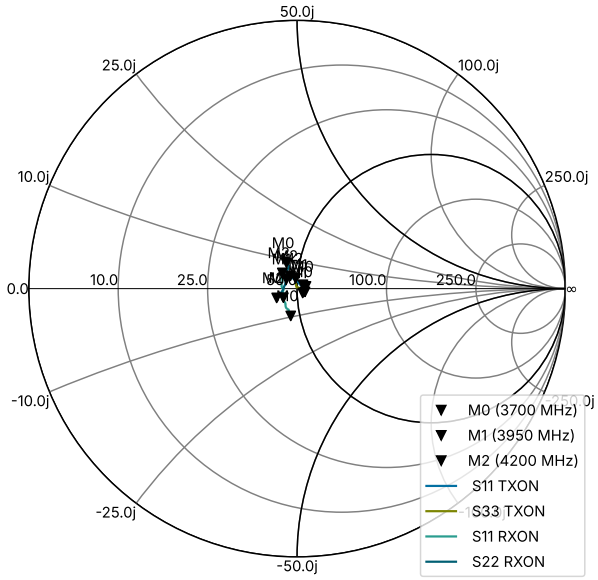
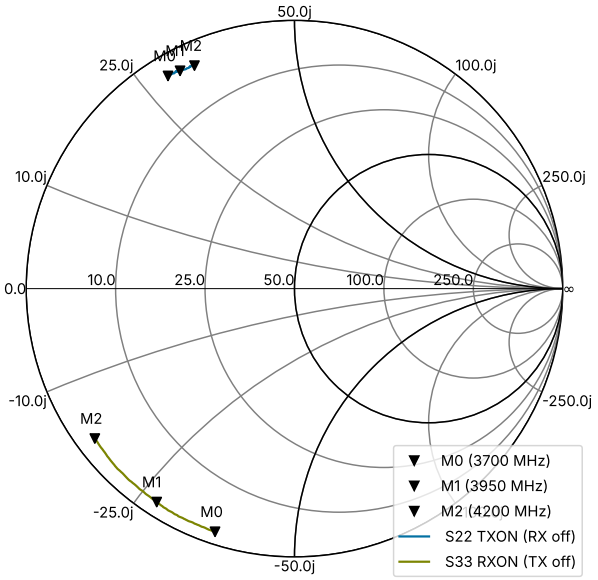


Unitarity, power absorption of the component, $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2$, IDX03.



Matching of the active ports



Termination impedance of the non-active port

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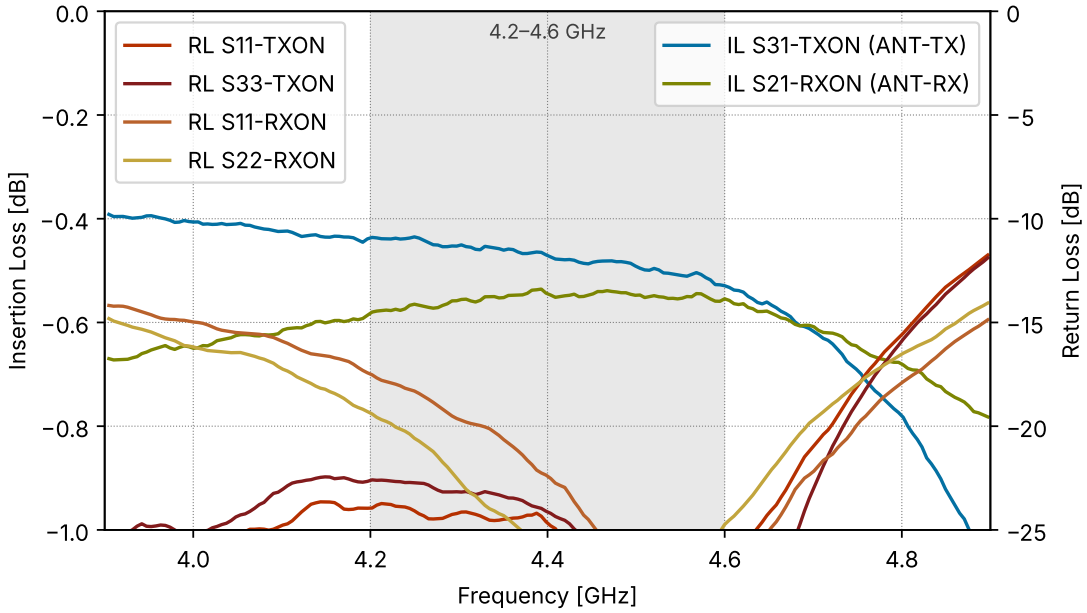
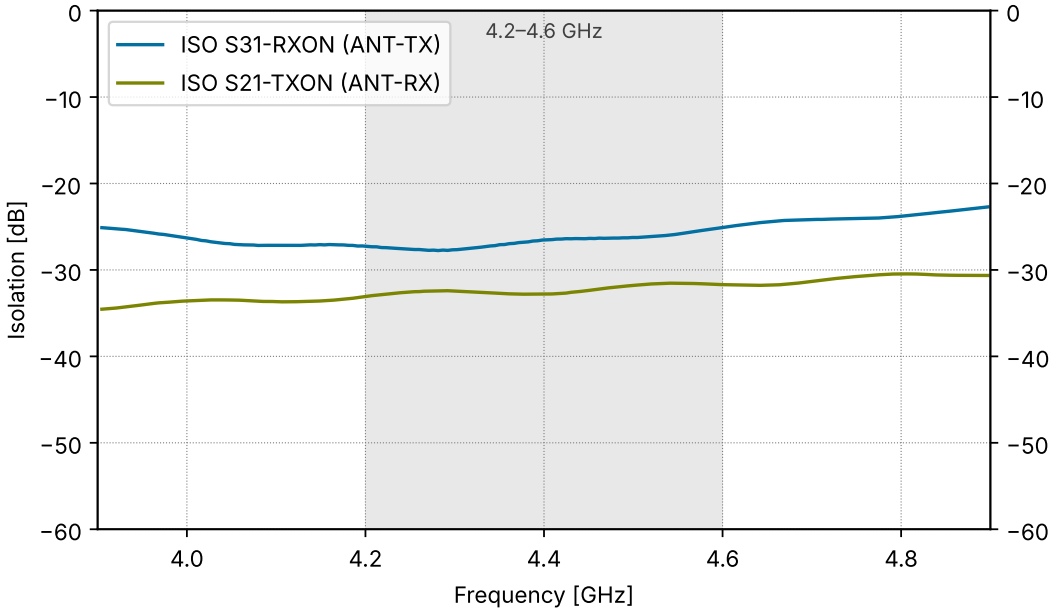
Performance 4.2 to 4.6 GHz, matched (IDX04)

These measurements were obtained using the TS8028N EVB with the IDX04 matching components ($L_T = 3.2$ nH, Table 10), including the losses of the matching components. The operating band 4.2 to 4.6 GHz is shaded grey. Over the band the TX insertion loss is at most 0.53 dB, the RX insertion loss at most 0.58 dB, the ANT-RX isolation at least 31 dB and the ANT-TX isolation at least 25 dB.



Insertion loss and return loss, IDX04.



Isolation of the non-active port, ANT-TX in the ANT-RX ON state and ANT-RX in the ANT-TX ON state, IDX04.

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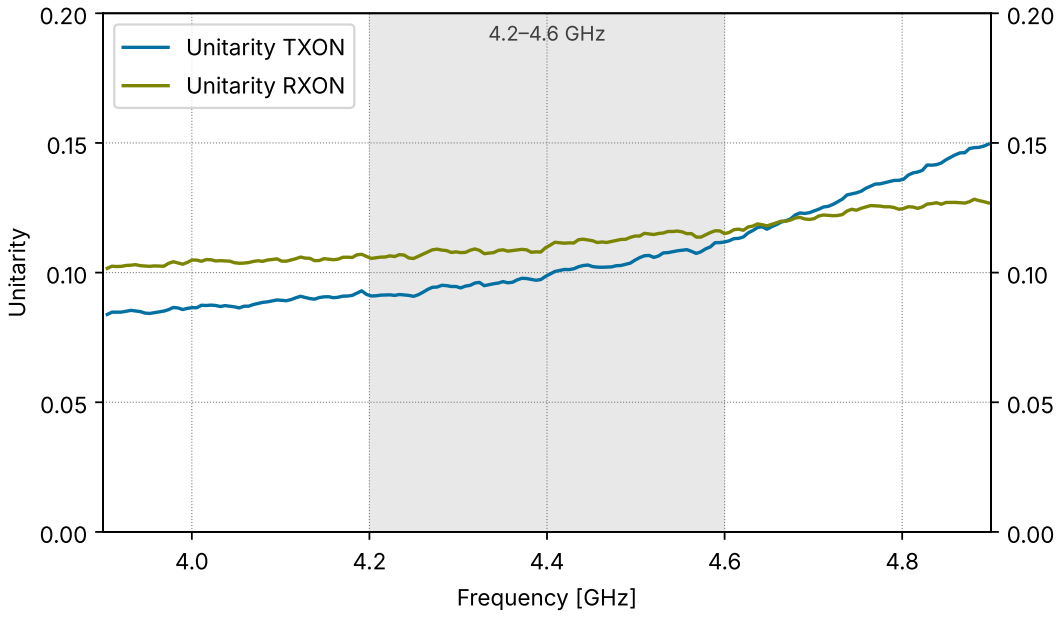
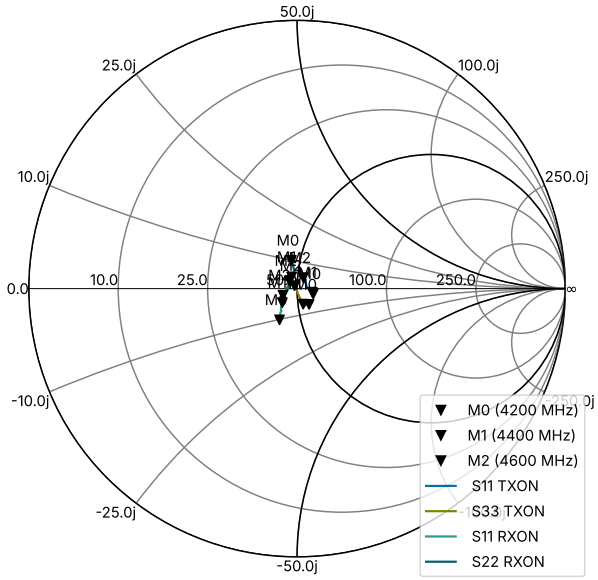
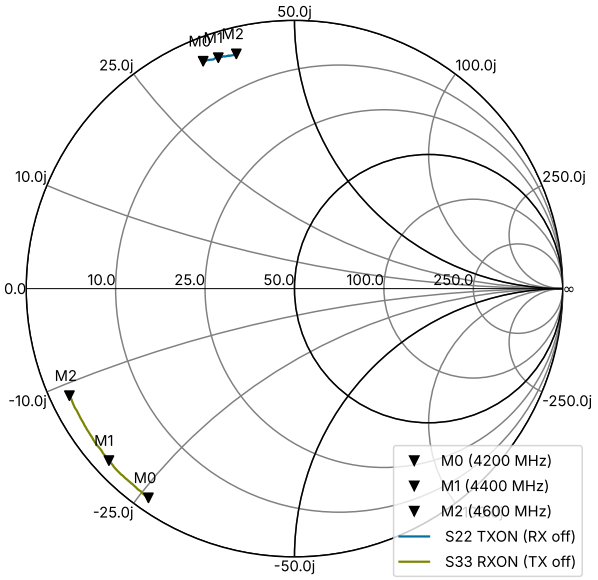


Unitarity, power absorption of the component, $1 - |S_{11}|^2 - |S_{21}|^2 - |S_{31}|^2$, IDX04.



Matching of the active ports



Termination impedance of the non-active port

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Peak power handling with modulated signals

The TS8028N is rated for 100 W average power (CW, 100% duty cycle) and 500 W (57 dBm) peak power, where the peak power capability is given for 1% duty cycle with 10 μs pulses. 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 500 W in a 50 Ω system, the RF peak voltage is 224 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 TS8028N exceeds its average power rating by a factor of 5.0 (7.0 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; for the TS8028N the 7.0 dB headroom covers the envelope peaks of single-carrier QAM signals at the full 100 W average rating, while OFDM signals require a small 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.

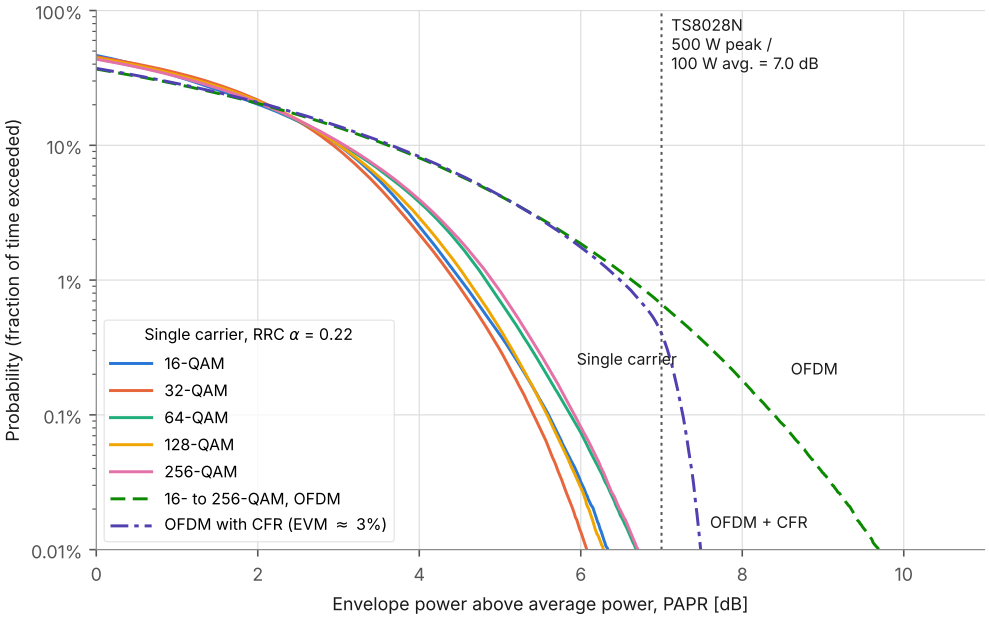

Figure 11: CCDF of the envelope power of QAM signals: fraction of time the envelope power exceeds the average power by the given PAPR. OFDM with CFR: iterative clipping and filtering, EVM $\approx$ 3%. The dotted line marks the 500 W / 100 W (7.0 dB) peak-to-average capability of the TS8028N.

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 11 includes typical values for OFDM with CFR.

Average power capability with modulated signals

Typical PAPR values are listed in Table 11. Figure 11 shows the complete CCDF curves together with the 7.0 dB peak-to-average capability of the TS8028N. At the full 100 W average rating, the envelope of a single-carrier 16- to 256-QAM signal practically never exceeds the 500 W peak level (less than 0.01% of the time), while the envelope of an OFDM signal exceeds it about 0.7% of the time without CFR and about 0.4% of the time with CFR (EVM $\approx$ 3%). This is below the 1% duty cycle of the peak power characterization. If the envelope peaks are required to stay within 500 W also at the 0.1% probability level, the average power is limited to the values given in the last column of the table: the full 100 W for single-carrier QAM, 72 W for OFDM without CFR and 79 to 100 W with CFR. 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 TS8028N, and is not binding on TagoreTech; the ratings given in the Absolute Maximum Ratings and Electrical Specifications sections apply.

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Table 11: Peak-to-average power ratio (PAPR) of QAM signals, exceeded for the given fraction of time.

Modulation	PAPR [dB] at probability[2]			TS8028N 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	100
32-QAM	2.9	4.4	5.4	100
64-QAM	3.1	4.8	5.8	100
128-QAM	3.0	4.6	5.6	100
256-QAM	3.1	4.9	5.9	100
Single carrier, RRC pulse shaping, $\alpha = 0.35$				
16-QAM	3.0	4.4	5.1	100
32-QAM	3.0	4.2	4.8	100
64-QAM	3.0	4.8	5.6	100
128-QAM	3.0	4.5	5.2	100
256-QAM	3.1	4.8	5.7	100
OFDM, 1024 subcarriers, no crest factor reduction				
16-QAM	3.6	6.6	8.4	72
32-QAM	3.6	6.6	8.4	72
64-QAM	3.6	6.6	8.4	72
128-QAM	3.6	6.6	8.4	72
256-QAM	3.6	6.6	8.4	72
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	79
CFR for EVM ≈ 3%, e.g. 64/128-QAM	3.7	6.5	7.3	93
CFR for EVM ≈ 5%, e.g. 16/32-QAM	3.7	6.2	6.5	100

[1] Average power at which the envelope peaks at the 0.1% probability level remain within the 500 W peak power rating, $P_{\text{avg}} = 500\,\text{W}/10^{\text{PAPR}_{0.1\%}/10}$, limited to the 100 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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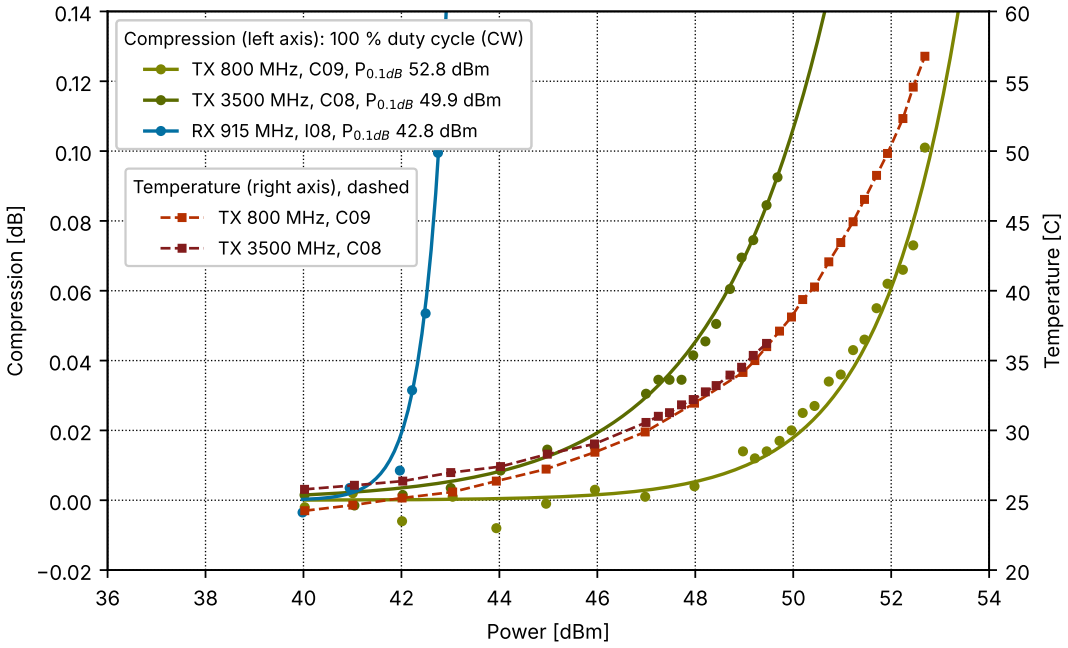
Compression with temperature

TS8028N compression measurements are presented for 100 % duty cycle (CW) and for 1 % duty cycle (1 ms period, 10 μs pulse), at $C_{VCP} = 100$ nF. TX is the ANT-TX path (connector RF2) and RX the ANT-RX path (connector RF1). Compression is referenced to the insertion loss at 40 to 41.5 dBm of the same sweep. Measurements are presented as dot (•) and the exponential model as line (–); the curves of the same path and frequency have the same shape (common exponential slope). The temperature measured during the sweep is shown on the right axis where it was recorded.

With 100 % duty cycle the TX path compresses by 0.1 dB at 52.8 dBm at 800 MHz, with the temperature rising from 24 to 57 °C, and at 49.9 dBm at 3500 MHz. The RX path reaches 0.1 dB compression at 42.8 dBm at 915 MHz. With 1 % duty cycle the temperature rises by less than 5 °C; the TX path reaches 0.1 dB compression at 55.3 dBm at 3500 MHz, and the RX path at 43.1 to 43.3 dBm at 915 MHz. The 3500 MHz measurements were made with the IDX01 EVB (2.2 to 3.0 GHz matching), outside its matched band, with about 1 dB insertion loss. The $P_{0.1\mathrm{dB}}$ values are figures of merit; please do not exceed the Absolute Maximum ratings.



TS8028N compression measurement with temperature, 100 % duty cycle (CW).

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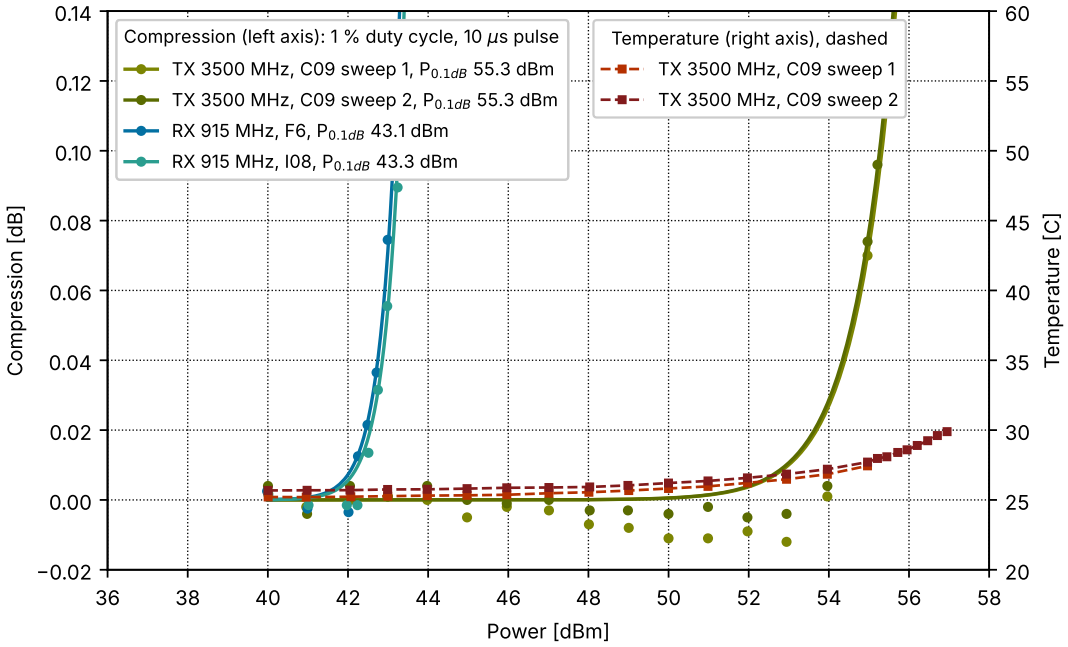

TS8028N compression measurement with temperature, 1 % duty cycle, 10 μs pulse.

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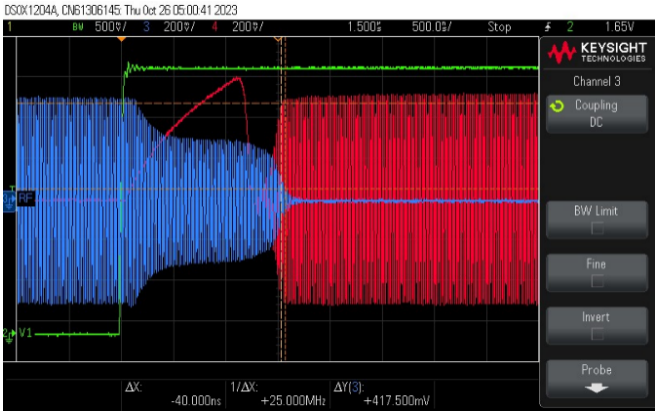
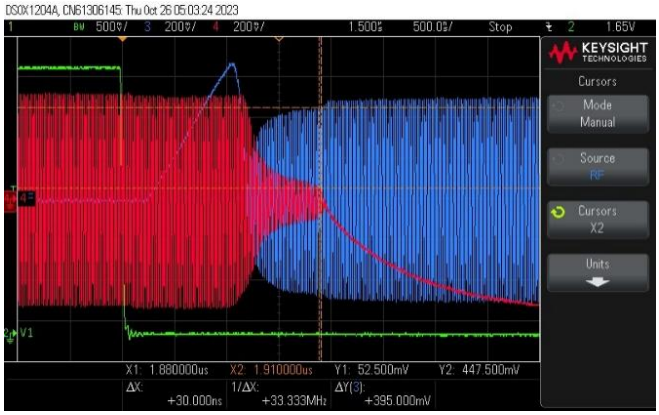
Switching time

Switching time measurements of the TS8028N EVB with $C_{VCP} = 100$ nF. Typical values are given in the Electrical Specifications.





Switching time measurement, control signal and RF envelope.

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Device Package information

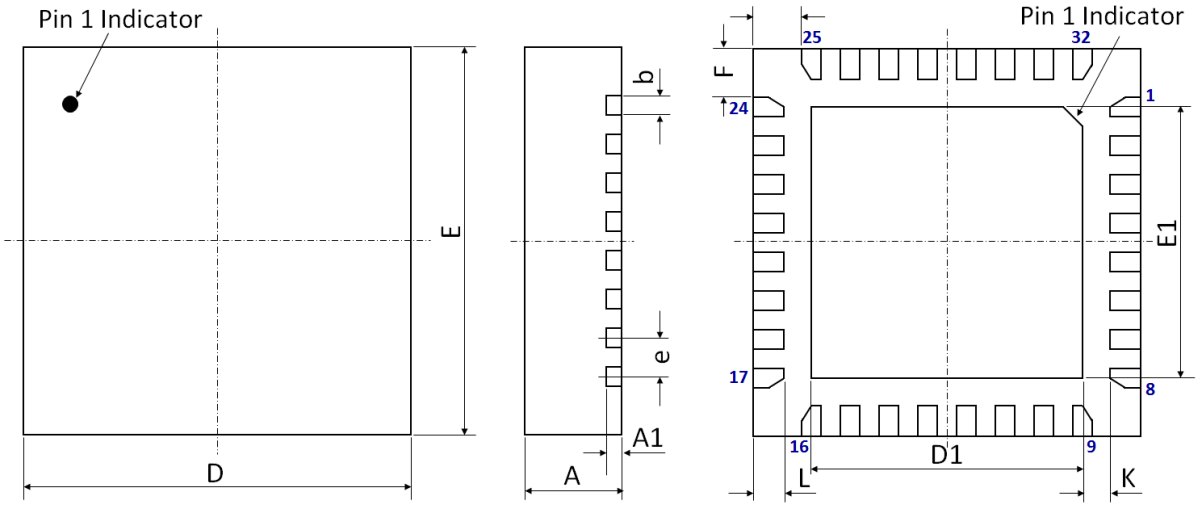

Figure 13: 32-pin QFN 5.0 x 5.0 x 0.75 mm^3 package drawing.

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 12: Device Package Dimensions

Dimension	Value [mm]	Tolerance [mm]	Dimension	Value [mm]	Tolerance [mm]
A	0.75	±0.05	E	5.00 BSC	±0.05
A1	0.203	±0.02	E1	3.20	±0.06
b	0.25	+0.05/-0.07	F	0.625	±0.05
D	5.00 BSC	±0.05	G	0.625	±0.05
D1	3.20	±0.06	L	0.40	±0.05
e	0.50 BSC	±0.05	K	0.50	±0.05

Lead finish: pure Sn without underlayer; thickness 7.5 μm to 20 μm (typical 10 μm to 12 μm).

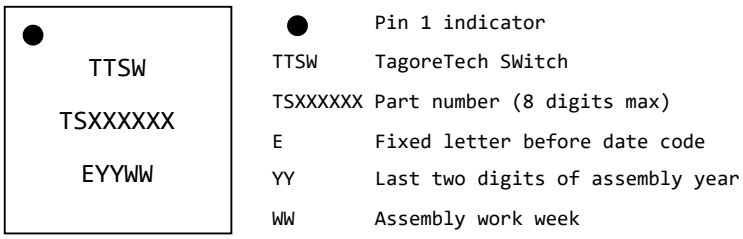

Figure 14: Part marking specification.

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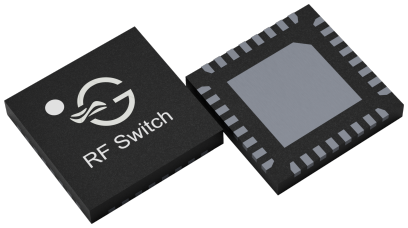

Figure 15: TS8028N, top and bottom side.

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PCB Land Design

Notes:

- 4-layer PCB is recommended.
- Via diameter is recommended to be 0.2 mm 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 5(X)×5(Y)=25.

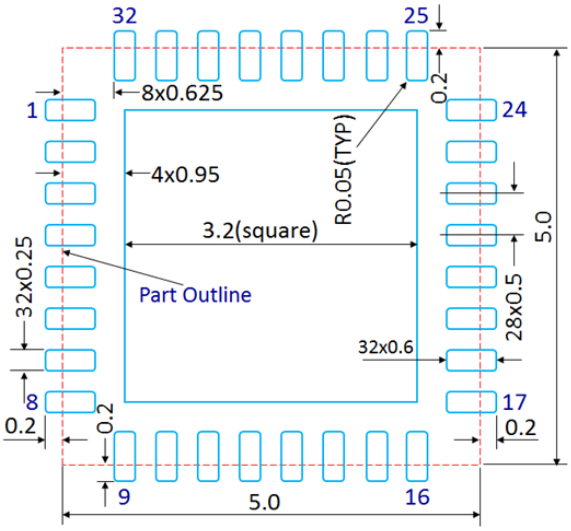

Figure 16: PCB land pattern, dimensions in [mm].



Figure 17: Solder mask pattern, non-solder mask defined (preferred, left) and solder mask defined (right), dimensions in [mm].

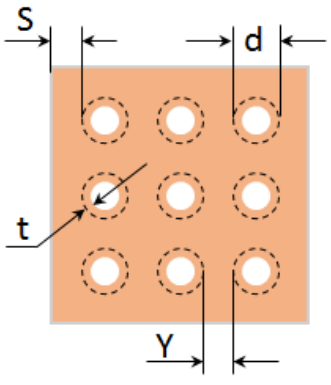

Figure 18: Thermal Via Pattern, Recommended Values: S≥0.15mm; Y≥0.20mm; d=0.2mm; Plating Thickness t=25μm or 50μm.

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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.

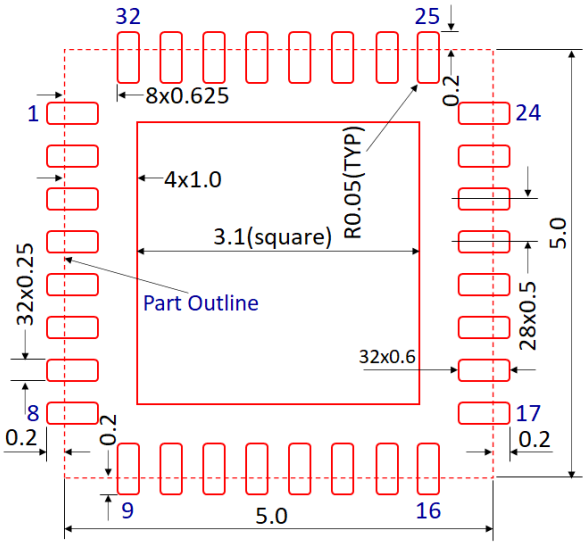

Figure 19: Stencil Openings, dimensions in [mm].

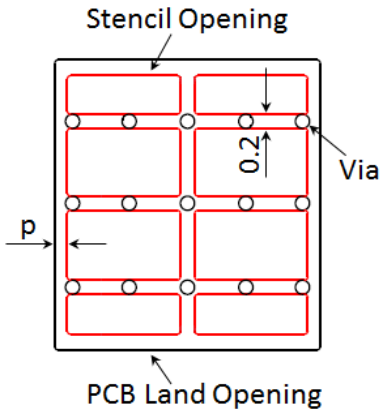

Figure 20: Stencil Openings Shall not Cover Via Areas If Possible, dimensions in [mm].

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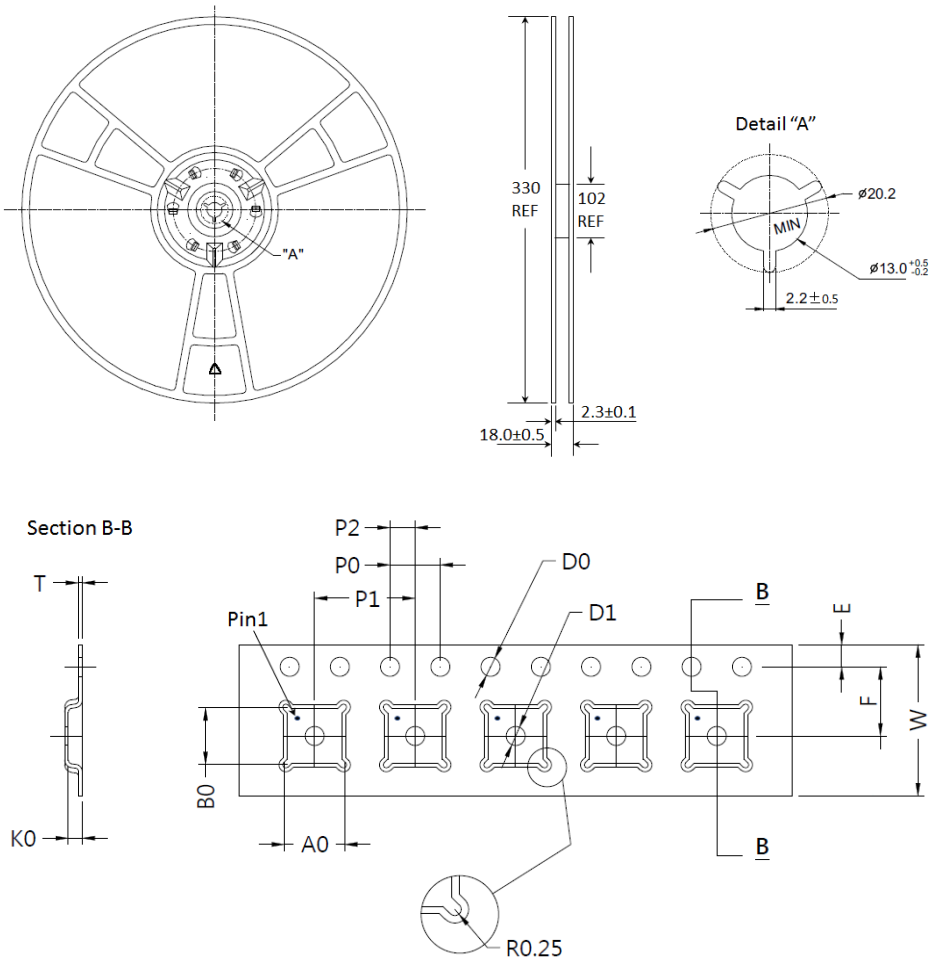
Tape and Reel Information



A0[mm]	B0[mm]	D0[mm]	D1[mm]	E[mm]	F[mm]	K0[mm]	P0[mm]	P1[mm]	P2[mm]	T[mm]	W[mm]
5.35	5.35	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
ANT	Antenna port, RF common port
TX	Transmit port
RX	Receive port
L_T	External tuning inductor between pins 17 (LT) and 18 (LC)
CPW	Coplanar waveguide
IDX	EVB configuration index of the S-parameter files (IDX00 unmatched; IDX01 to IDX04 matching examples)
Unitarity	Describes power absorption of the component, $1 - \lvert S_{11}\rvert^2 - \lvert S_{21}\rvert^2 - \lvert S_{31}\rvert^2$
ADS-B / IFF	Automatic dependent surveillance-broadcast / Identification friend or foe
QAM	Quadrature amplitude modulation
OFDM	Orthogonal frequency-division multiplexing
PAPR	Peak-to-average power ratio
CCDF	Complementary cumulative distribution function
CFR	Crest factor reduction
EVM	Error vector magnitude
LTE / 5G	Long Term Evolution / fifth generation mobile network (5G NR)
W_{peak}	Peak power: 1 % duty cycle, for example the envelope peaks of LTE and 5G signals

Changelog

Table 13: Changelog

Date	Revision	Notes
06/19/2026	2.1	Previous datasheet revision (Word).
10/31/2026	3.00	New release in the TagoreTech datasheet format. Asymmetrical topology described: TX branch series switch only, RX branch series and shunt switch. Tuning inductor pins 17 (LT) and 18 (LC) and the isolation notch described. V_{DD} off state (all switches conducting) added to the switch control table. Power ratings: 100 W CW and 500 W_{peak} (57 dBm, 1 % duty cycle, LTE / 5G) added to the absolute maximum ratings; peak power handling with modulated signals (QAM, OFDM) added. Compression measurements with temperature at 100 % and 1 % duty cycle added; $P_{0.1dB}$ specifications from these measurements. Package height 0.75 mm. Functional diagram, pin assignment and switch-state drawings in the house style, EVB schematics redrawn. V_{CP} absolute maximum rating -20 V added. Units of the switching times corrected to μs. Typical characteristics of IDX00 and the matching examples IDX01 (2.2 to 3.0 GHz), IDX02 (3.3 to 3.8 GHz), IDX03 (3.7 to 4.2 GHz) and IDX04 (4.2 to 4.6 GHz) from the measured S-parameters, matching component table, S-parameter repository; insertion loss, isolation and return loss specifications and front-page values from the same data. Links to application notes TN-001/TN-002, distributor table, QR code link to the latest datasheet, glossary.

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