0.03 – 3.8 GHz 0.5 W Power LNA / Gain Block

Features

- Operating frequency 0.03 GHz to 3.8 GHz
- Small signal gain @ 1850 MHz: 16.5 dB
- Noise figure @ 1850 MHz: 1.0 dB
- OP_{1dB} @ 1850 MHz: 27.5 dBm (0.5 W)
- OIP3 @ 1850 MHz: 39 dBm
- Single 5 V supply, 140 mA typical
- Bias current adjustable with one external resistor

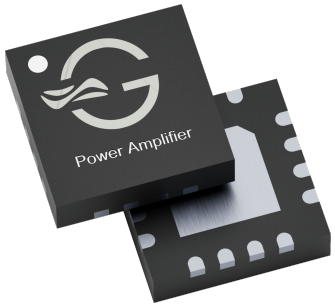

Figure 1: TP0310K in 3.0 x 3.0 mm^2 QFN 16-pin package, top and bottom view.

Applications

- 4G/5G infrastructure radios
- Small cells and cellular repeaters
- L- and S-band phased array radar
- Military and communication radios
- SDARS
- Datalinks
- Amateur Radio

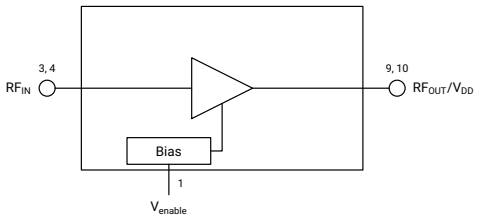

Figure 2: TP0310K functional block diagram [top view]

General Description

The TP0310K is a GaAs power low noise amplifier (LNA) providing high gain and high linearity. With a simple input and output match, the amplifier can be tuned for different frequency bands between 30 MHz and 3.8 GHz, targeting low noise, high output power and high linearity. At 1.85 GHz the amplifier typically provides 16.5 dB gain, 27.5 dBm OP_{1dB}, 39 dBm OIP3 and a 1.0 dB noise figure, while drawing 140 mA from a single +5 V supply. The combination of low noise figure and 0.5 W output compression point makes the TP0310K equally suited as a robust first-stage LNA, as a gain block, or as a driver amplifier.

The TP0310K is housed in a compact, low-cost $3.0 \times 3.0\ mm^2$ 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
TP0310K	16 Pin 3.0x3.0x0.75 mm^3 QFN	Core part number
TP0310KMTRPBF[1]	330 mm reel, 3 000 pcs	Full reel
TP0310K-EVB-A	Evaluation Board	Tuned, 1700 – 2000 MHz
TP0310K-EVB-B	Evaluation Board	Tuned, 2500 – 2700 MHz
TP0310K-EVB-C	Evaluation Board	Tuned, 3300 – 3800 MHz
TP0310K-EVB-D	Evaluation Board	Tuned, 130 – 950 MHz
TP0310K-EVB-E	Evaluation Board	Tuned, 30 – 525 MHz
TP0310K-EVB-F	Evaluation Board	Tuned, 2900 – 3500 MHz

[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

Evaluation boards and application notes

Each evaluation board is supported by its own application note with schematic, bill of materials, bias procedure and measured performance. Please click the blue links.

All evaluation boards use a Rogers RO4350B, 20 mil, 1 oz copper PCB with SMA connectors on $\mathrm{RF_{IN}}$ and $\mathrm{RF_{OUT}}$ and a four-pin header J3 ($\mathrm{V_{EN}}$, BIAS1, $\mathrm{V_{DD}}$, GND; BIAS1 is not used and left open). EVB A, B, C, D and F share one matching-ladder layout: the input is matched with the positions C0/L0 (shunt), C1/L1 (series), C2/L2 (shunt) and C3/L3 (series), the output with C8/L7 (series), C9/L8 (shunt) and C10/L9 (series); each position takes a capacitor, an inductor or a 0 Ω link. On EVB C and D an extra series position is cut into the input line (C21, R14). EVB E uses a broadband layout with resistive feedback (M18, M19). The drain is fed through the choke L11 (M11 on EVB E) from $\mathrm{V_{DD}}$, and the resistor R1 (M5) on the $\mathrm{V_{enable}}$ pin sets the quiescent current. Component positions that are not assembled on a given board are shown dashed grey in the schematics and marked DNP (Do Not Populate) in the bills of materials.

Table 3: TP0310K evaluation boards and application notes

Evaluation board	Frequency range	Bias	Application note
TP0310K-EVB-A	1700 – 2000 MHz	5 V, 140 mA	TP0310K_EVB_A.pdf
TP0310K-EVB-B	2500 – 2700 MHz	5 V, 140 mA	TP0310K_EVB_B.pdf
TP0310K-EVB-C	3300 – 3800 MHz	5 V, 140 mA	TP0310K_EVB_C.pdf
TP0310K-EVB-D	130 – 950 MHz	5 V, 140 mA	TP0310K_EVB_D.pdf
TP0310K-EVB-E	30 – 525 MHz	5 V, 140 mA	TP0310K_EVB_E.pdf
TP0310K-EVB-F	2900 – 3500 MHz	5 V, 133 mA	TP0310K_EVB_F.pdf

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Pin Assignment

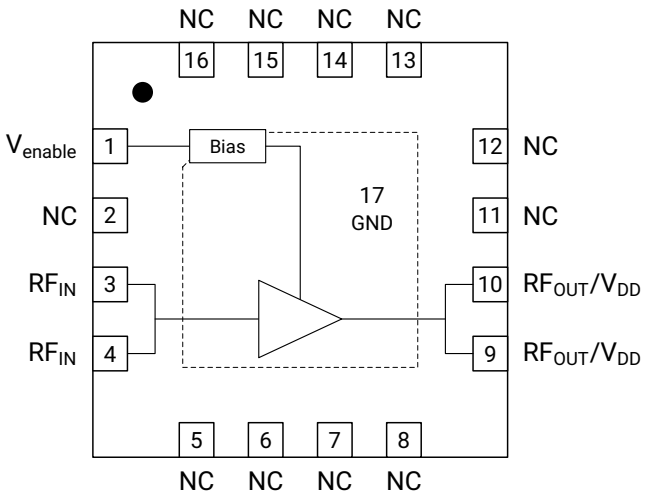

Figure 3: TP0310K pin assignment [top view]

Table 4: Pin Definition

Pin Number	Pin Name	Description
1	V_{enable}	Enable input. V_{enable} together with the series resistor sets I_{DQ}. $V_{enable} < 0.2\,V$ disables the device.
3, 4	RF_{IN}	RF input. Connect both pins together. A DC blocking capacitor is required.
9, 10	RF_{OUT}/V_{DD}	RF output. Connect both pins together. V_{DD} is supplied through an external choke inductor.
2, 5 – 8, 11 – 16	NC	No internal connection, can be connected to ground.
17 (paddle)[1]	GND	DC and RF ground, also provides the thermal path. Multiple vias are recommended.

[1] The backside ground slug of the package must be grounded directly to the ground plane through multiple vias to ensure proper operation. Adequate heat sinking is required.

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Absolute Maximum Ratings

Table 5: Absolute Maximum Ratings $T_A = +25$°C unless otherwise specified[1].

Parameter	Symbol	Value	Unit
Electrical Ratings			
Supply voltage, V_{DD} and V_{enable}	V_{DD}	+6	V
Drain current	I_{DQ}	150	mA
RF input power, CW	RF_{IN}	23	dBm
Storage Temperature Range	T_{st}	-55 to +150	°C
Operating Temperature Range	T_{op}	-40 to +105	°C
Maximum Junction Temperature	T_j	+170	°C
Thermal Ratings			
Thermal Resistance (junction-to-case) – Bottom side	$R_{\theta jc}$	10.0	°C/W
Soldering Temperature	T_{solder}	+260	°C
ESD Ratings			
Human Body Model (HBM)	Level 1B	500 – $<$1000	V
Charged Device Model (CDM)	Level C	$\geq$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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Recommended DC Operating Conditions

Table 6: Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Unit
Drain voltage	V_{DD}		+5.0		V
Enable voltage	V_{enable}		+5.0		V
Drain bias current, set by external resistor[1]	I_{DQ}		140		mA
Enable bias current	I_{bias}		3.5	4.0	mA
Operating temperature range	T_{op}	-40	+25	+105	°C

[1] V_{enable} together with the series resistor on the V_{enable} pin sets I_{DQ}; 1.1 kΩ at $V_{enable} = 5$ V gives about 140 mA on the evaluation boards. $V_{enable} < 0.2$ V disables the device.

Table 7: Switching Time

Parameter	Test Condition	Typical	Unit
Switching rise time	10/90% of the RF value	4	ns
Switching fall time	10/90% of the RF value	1000	ns

Power dissipation and thermal considerations

At the typical operating point, $V_{DD} = 5$ V and $I_{DQ} = 140$ mA, the TP0310K takes 0.70 W from the drain supply and about 18 mW from V_{enable}. Without RF drive all of this power is dissipated in the device; with RF drive the power delivered to the load reduces the dissipation. The junction temperature is $T_j = T_C + R_{\theta jc} \cdot P_{\text{diss}}$, where T_C is the temperature of the exposed paddle. With $R_{\theta jc} = 10$°C/W the junction is about 7 °C above the paddle, i.e. about +112 °C at the maximum operating temperature of +105 °C, well below the maximum junction temperature of +170 °C. The thermal resistance of the solder joint, the thermal vias and the heat sink adds to $R_{\theta jc}$: solder the exposed paddle to a ground pad with the thermal via pattern of Figure 33 and keep the paddle within the operating temperature range.

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RF Electrical Specifications

The values below are typical ranges across the band of each tuned evaluation board. Noise figure is given both de-embedded to the device reference plane and as measured on the evaluation board (EVB noise figure, including connector and PCB losses).

Table 8: EVB A, 1700 – 2000 MHz: $V_{enable} = 5$ V, $I_{DD} = 140$ mA, $V_{DD} = 5$ V, $T_A = +25$°C unless otherwise specified.

Parameter	Test Condition	Minimum	Typical	Maximum	Unit
Gain	Across the band		16 – 17		dB
Noise figure	Across the band		1.0		dB
EVB noise figure	Across the band		1.05		dB
Input return loss	Across the band		-14 to -11		dB
Output return loss	Across the band		-13 to -10		dB
OP_{1dB}	Across the band		27 – 27.5		dBm
OIP3	Across the band, 8 dBm per tone, tone spacing 2 MHz		39		dBm

Table 9: EVB B, 2500 – 2700 MHz: $V_{enable} = 5$ V, $I_{DD} = 140$ mA, $V_{DD} = 5$ V, $T_A = +25$°C unless otherwise specified.

Parameter	Test Condition	Minimum	Typical	Maximum	Unit
Gain	2600 MHz	13	14		dB
Noise figure	2600 MHz		1.1		dB
EVB noise figure	2600 MHz		1.2		dB
Input return loss	2600 MHz		-16		dB
Output return loss	2600 MHz		-18		dB
OP_{1dB}	2600 MHz	25.5	27		dBm
OIP3	2600 MHz, 8 dBm per tone, tone spacing 2 MHz	35	37		dBm

Table 10: EVB C, 3300 – 3800 MHz: $V_{enable} = 5$ V, $I_{DD} = 140$ mA, $V_{DD} = 5$ V, $T_A = +25$°C unless otherwise specified.

Parameter	Test Condition	Minimum	Typical	Maximum	Unit
Gain	Across the band		11 – 11.5		dB
Noise figure	Across the band		0.85 – 1.15		dB
EVB noise figure	Across the band		1 – 1.3		dB
Input return loss	Across the band		-11 to -7		dB
Output return loss	Across the band		-24 to -17		dB
OP_{1dB}	Across the band		27.5		dBm
OIP3	Across the band, 8 dBm per tone, tone spacing 2 MHz		41 – 42		dBm

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Table 11: EVB D, 130 – 950 MHz: $V_{enable} = 5$ V, $I_{DD} = 140$ mA, $V_{DD} = 5$ V, $T_A = +25$°C unless otherwise specified.

Parameter	Test Condition	Minimum	Typical	Maximum	Unit
Gain	Across the band		21 – 27.6		dB
Noise figure	Across the band		1.5 – 2.4		dB
EVB noise figure	Across the band		1.6 – 2.5		dB
Input return loss	Across the band		-25 to -6		dB
Output return loss	Across the band		-17 to -7		dB
OP_{1dB}	Across the band		24.7 – 27		dBm
OIP3	Across the band, 8 dBm per tone, tone spacing 2 MHz		34 – 37		dBm

Table 12: EVB E, 30 – 525 MHz: $V_{enable} = 5$ V, $I_{DD} = 140$ mA, $V_{DD} = 5$ V, $T_A = +25$°C unless otherwise specified.

Parameter	Test Condition	Minimum	Typical	Maximum	Unit
Gain	Across the band		21 – 24		dB
Noise figure	Across the band		1.7 – 2.3		dB
EVB noise figure	Across the band		1.7 – 2.3		dB
Input return loss	Across the band		-8 to -7		dB
Output return loss	Across the band		-6 to -4		dB
OP_{1dB}	Across the band		25 – 26.5		dBm
OIP3	Across the band, 16 dBm per tone, tone spacing 2 MHz		37 – 40		dBm

Table 13: EVB F, 2900 – 3500 MHz: $V_{enable} = 5$ V, $I_{DD} = 133$ mA, $V_{DD} = 5$ V, $T_A = +25$°C unless otherwise specified.

Parameter	Test Condition	Minimum	Typical	Maximum	Unit
Gain	Across the band		11.4 – 11.8		dB
EVB noise figure	Across the band		0.9 – 1.2		dB
Input return loss	Across the band		-20 to -8		dB
Output return loss	Across the band		-13 to -10		dB
OP_{1dB}	Across the band		27.5 – 27.7		dBm
OIP3	Across the band, 8 dBm per tone, tone spacing 1 MHz		37.5 – 38.8		dBm

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Evaluation Boards

EVB A, 1700 – 2000 MHz

Measured performance of this board is given in Table 8. Bias: 5 V, 140 mA.
Application note: TP0310K-EVB-A application note.

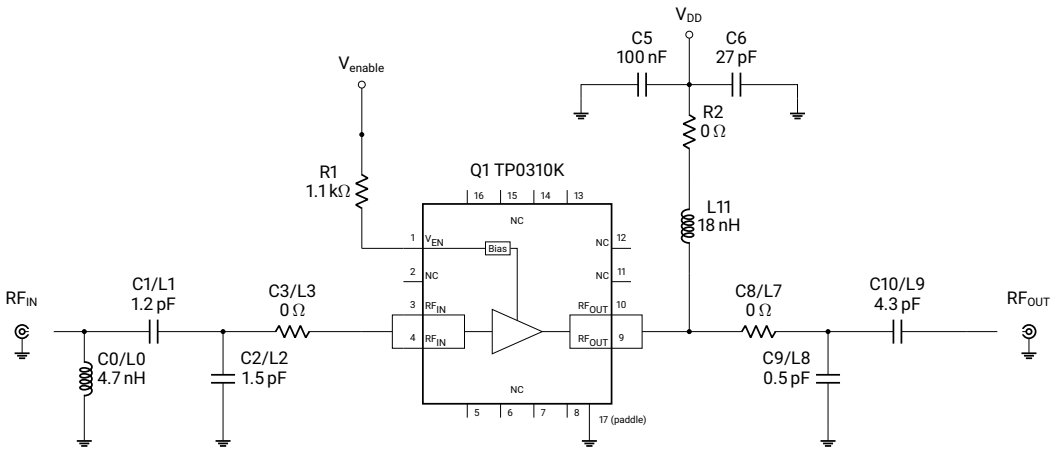

Figure 4: Schematic of TP0310K-EVB-A, 1700 – 2000 MHz. Dashed grey positions are not assembled (DNP).

Table 14: Bill of materials, TP0310K-EVB-A

Component ID	Value	Manufacturer	Recommended part number
C0/L0	4.7 nH	Coilcraft	0402HP-4N7XGRW
C1/L1	1.2 pF	Murata	GJM1555C1H1R2BB01
C2/L2	1.5 pF	Murata	GJM1555C1H1R5BB01
C3/L3, C8/L7, R2[1]	0 Ω	Panasonic	ERJ-2GE0R00X
R1	1.1 kΩ	Panasonic	ERJ-2RKF1101X
C9/L8	0.5 pF	Murata	GJM1555C1HR50BB01
C10/L9	4.3 pF	Murata	GJM1555C1H4R3BB01
L11	18 nH	Coilcraft	0402HP-18NXGRW
C5	100 nF	TDK	C1005X7R1H104K050BE
C6	27 pF	Murata	GJM1555C1H270JB01D
Q1	GaAs power LNA	TagoreTech	TP0310K
PCB	Rogers RO4350B, 20 mil, 1 oz copper		

[1] 0 Ω links shown in the schematic and listed in the application note; missing from the earlier datasheet BOM.

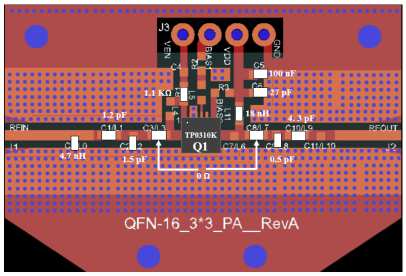

Figure 5: Layout of TP0310K-EVB-A.

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EVB B, 2500 – 2700 MHz

Measured performance of this board is given in Table 9. Bias: 5 V, 140 mA.
Application note: TP0310K-EVB-B application note.

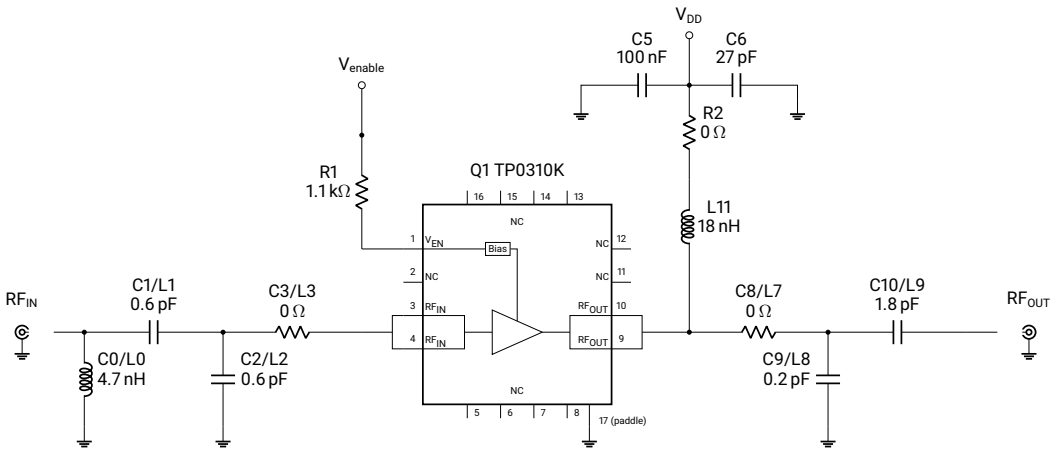

Figure 6: Schematic of TP0310K-EVB-B, 2500 – 2700 MHz. Dashed grey positions are not assembled (DNP).

Table 15: Bill of materials, TP0310K-EVB-B

Component ID	Value	Manufacturer	Recommended part number
C0/L0	4.7 nH	Coilcraft	0402HP-4N7XGRW
C1/L1, C2/L2	0.6 pF	Murata	GJM1555C1HR60BB01
C3/L3, C8/L7, R2	0 Ω	Panasonic	ERJ-2GE0R00X
R1	1.1 kΩ	Panasonic	ERJ-2RKF1101X
C9/L8	0.2 pF	Murata	GJM1555C1HR20BB01
C10/L9	1.8 pF	Murata	GJM1555C1H1R8BB01
L11	18 nH	Coilcraft	0402HP-18NXGRW
C5	100 nF	TDK	C1005X7R1H104K050BE
C6	27 pF	Murata	GJM1555C1H270JB01D
Q1	GaAs power LNA	TagoreTech	TP0310K
PCB	Rogers RO4350B, 20 mil, 1 oz copper		

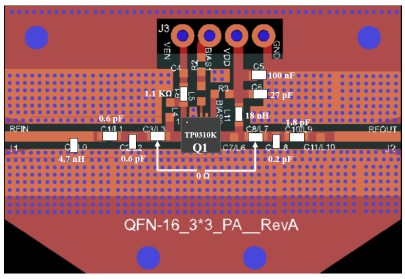

Figure 7: Layout of TP0310K-EVB-B.

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EVB C, 3300 – 3800 MHz

Measured performance of this board is given in Table 10. Bias: 5 V, 140 mA.
Application note: TP0310K-EVB-C application note.

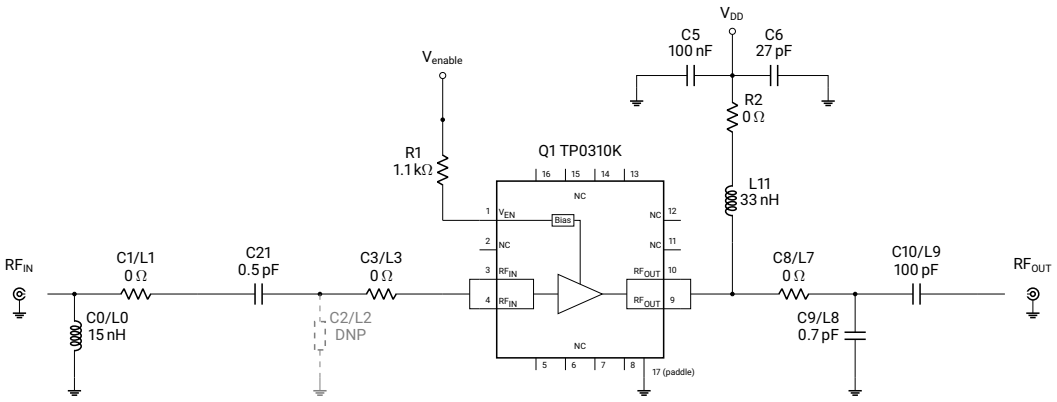

Figure 8: Schematic of TP0310K-EVB-C, 3300 – 3800 MHz. Dashed grey positions are not assembled (DNP).

Table 16: Bill of materials, TP0310K-EVB-C

Component ID	Value	Manufacturer	Recommended part number
C0/L0	15 nH	Coilcraft	0402HP-15NXGRW
C21[1]	0.5 pF	Murata	GJM1555C1HR50BB01
C1/L1, C3/L3, C8/L7, R2	0 Ω	Panasonic	ERJ-2GE0R00X
R1	1.1 kΩ	Panasonic	ERJ-2RKF1101X
C9/L8[2]	0.7 pF	Murata	GJM1555C1HR70BB01
C10/L9	100 pF	AVX	04025A101JAT4A
L11	33 nH	Coilcraft	0402HP-33NXGRW
C5	100 nF	TDK	C1005X7R1H104K050BE
C6	27 pF	Murata	GJM1555C1H270JB01D
C2/L2	DNP		
Q1	GaAs power LNA	TagoreTech	TP0310K
PCB	Rogers RO4350B, 20 mil, 1 oz copper		

[1] Extra series position cut into the input RF line between C1/L1 and the C2/L2 node.
[2] Position according to the schematic; the earlier BOM listed the 0.7 pF capacitor as C7/L6.

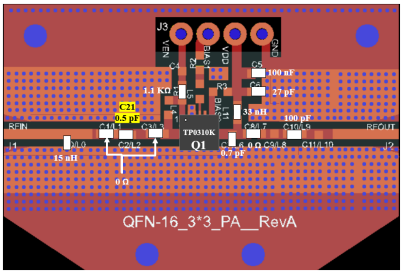

Figure 9: Layout of TP0310K-EVB-C.

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EVB D, 130 – 950 MHz

Measured performance of this board is given in Table 11. Bias: 5 V, 140 mA.
Application note: TP0310K-EVB-D application note.

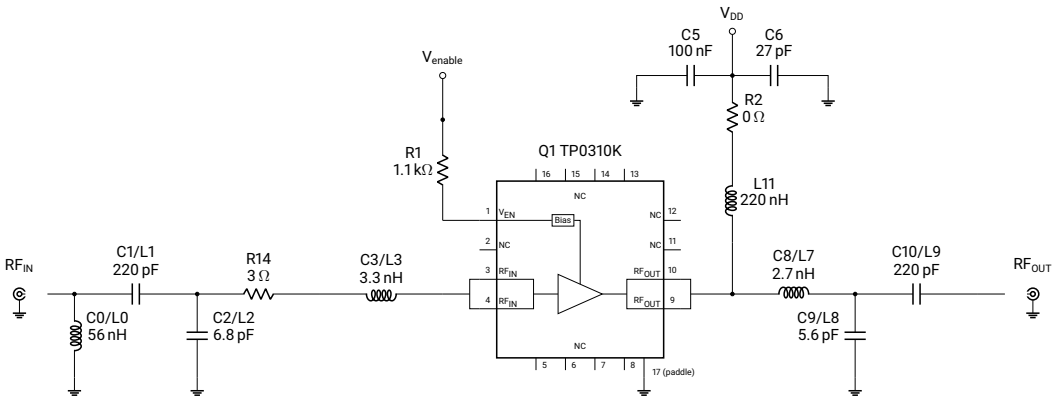

Figure 10: Schematic of TP0310K-EVB-D, 130 – 950 MHz. Dashed grey positions are not assembled (DNP).

Table 17: Bill of materials, TP0310K-EVB-D

Component ID	Value	Manufacturer	Recommended part number
C0/L0	56 nH	Coilcraft	0402HPH-56NXGLU
C1/L1, C10/L9	220 pF	Murata	GRM0335C1H221FA01D
C2/L2	6.8 pF	Murata	GJM1555C1H6R8BB01D
R14[1]	3 Ω	Panasonic	ERJ-U02F3R00X
C3/L3	3.3 nH	Coilcraft	0402HP-3N3XGLU
R1	1.1 kΩ	Panasonic	ERJ-2RKF1101X
R2[2]	0 Ω	Panasonic	ERJ-2GE0R00X
L11	220 nH	Coilcraft	0402HPH-R22XGLU
C8/L7	2.7 nH	Coilcraft	0402HP-2N7XGLU
C9/L8	5.6 pF	Murata	GJM1555C1H5R6BB01D
C5	100 nF	TDK	C1005X7R1H104K050BE
C6	27 pF	Murata	GJM1555C1H270JB01D
Q1	GaAs power LNA	TagoreTech	TP0310K
PCB	Rogers RO4350B, 20 mil, 1 oz copper		

[1] Extra series position cut into the input RF line between the C2/L2 node and C3/L3 (marked C21 in the earlier schematic).
[2] 0 Ω link shown in the schematic; missing from the earlier BOM.

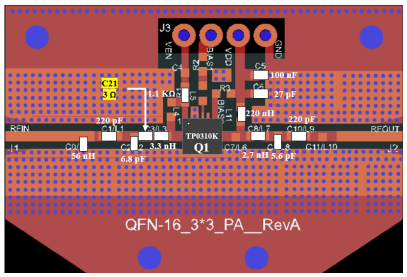

Figure 11: Layout of TP0310K-EVB-D.

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EVB E, 30 – 525 MHz

TP0310K-EVB-E uses the broadband feedback PCB: the RC network M18, M19 feeds back from the drain node to the RF input and flattens the gain from 30 MHz upwards. Measured performance of this board is given in Table 12. Bias: 5 V, 140 mA.
Application note: TP0310K-EVB-E application note.

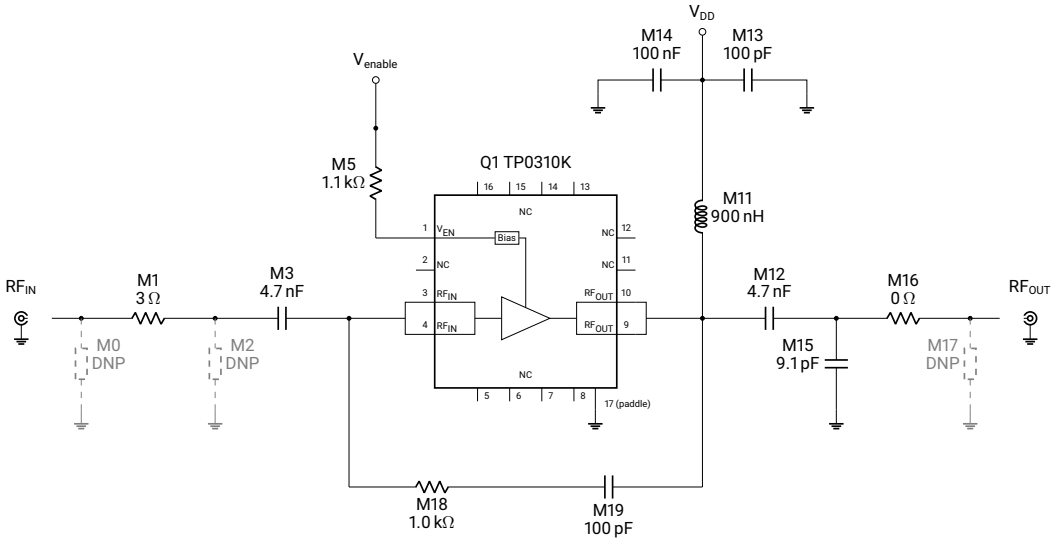

Figure 12: Schematic of TP0310K-EVB-E, 30 – 525 MHz. Dashed grey positions are not assembled (DNP).

Table 18: Bill of materials, TP0310K-EVB-E

Component ID	Value	Manufacturer	Recommended part number
M1	3 Ω	Panasonic	ERJ-U02F3R00X
M3, M12	4.7 nF	Murata	GRM1885C1H472JA01D
M5	1.1 kΩ	Panasonic	ERJ-2RKF1101X
M11	900 nH	Coilcraft	1008AF-901XJLC
M13, M19	100 pF	AVX	04025A101JAT4A
M14	100 nF	TDK	C1005X7R1H104K050BE
M15	9.1 pF	Murata	GJM1555C1H9R1BB01
M16	0 Ω	Panasonic	ERJ-2GE0R00X
M18	1.0 kΩ	Panasonic	ERJ-2RKF1001X
M0, M2, M17	DNP		
Q1	GaAs power LNA	TagoreTech	TP0310K
PCB	Rogers RO4350B, 20 mil, 1 oz copper		

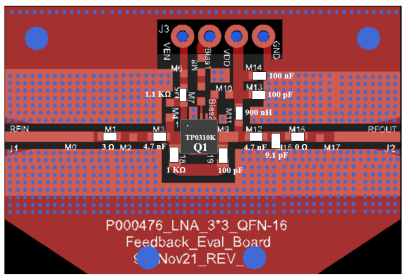

Figure 13: Layout of TP0310K-EVB-E.

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EVB F, 2900 – 3500 MHz

Measured performance of this board is given in Table 13. Bias: 5 V, 133 mA.
Application note: TP0310K-EVB-F application note.

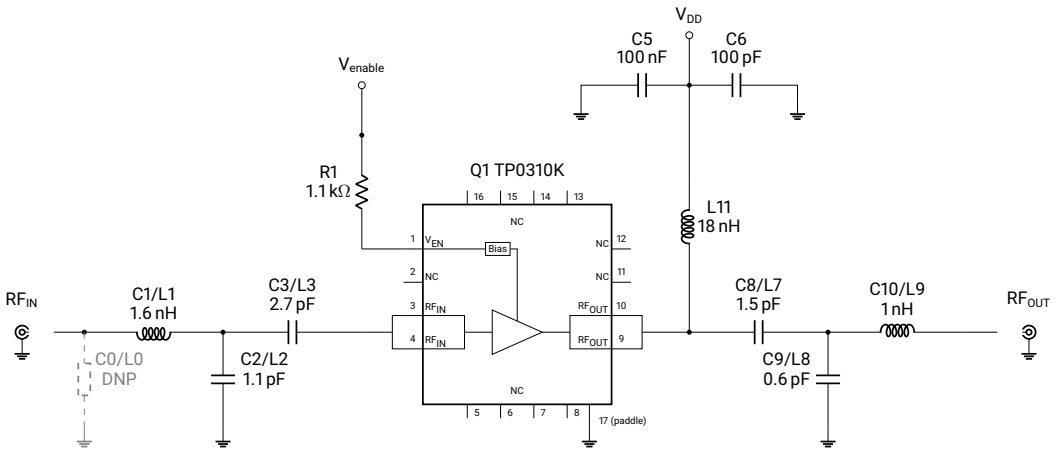

Figure 14: Schematic of TP0310K-EVB-F, 2900 – 3500 MHz. Dashed grey positions are not assembled (DNP).

Table 19: Bill of materials, TP0310K-EVB-F

Component ID	Value	Manufacturer	Recommended part number
C1/L1[1]	1.6 nH	Coilcraft	0603HC-1N6XJRW
C2/L2	1.1 pF	AVX	600S1R1BT250XT
C3/L3	2.7 pF	AVX	600S2R7BT250XT
R1[2]	1.1 kΩ	Panasonic	ERJ-2RKF1101X
C8/L7	1.5 pF	AVX	600S1R5BT250XT
C9/L8	0.6 pF	AVX	600S0R6BT250XT
C10/L9	1 nH	Coilcraft	0402HP-1N0XJRW
L11	18 nH	Coilcraft	0402HP-18NXGRW
C5	100 nF	TDK	C1005X7R1H104K050BE
C6	100 pF	AVX	04025A101JAT4A
C0/L0	DNP		
Q1	GaAs power LNA	TagoreTech	TP0310K
PCB	Rogers RO4350B, 20 mil, 1 oz copper		

[1] Designators according to the schematic (C1/L1 ... C10/L9 positions); the earlier BOM used L1, C2, C3, C8, C9 and L9.
[2] Part number for 1.1 kΩ; the earlier BOM listed ERJ-2RKF1111X (1.11 kΩ).

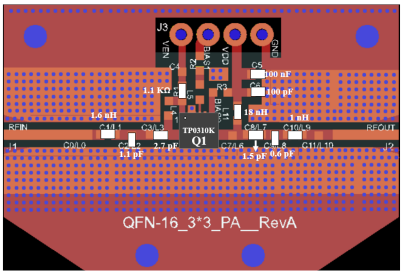

Figure 15: Layout of TP0310K-EVB-F.

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Typical characteristics

The S-parameters below are measured Touchstone data of the evaluation boards at $T_A = +25$°C, at the bias of each board given in the figure captions. The reference planes are at the SMA connectors, so connector and PCB losses are included. The shaded area and the thick line in the Smith charts mark the band the board is tuned for. For each board the wideband plots and the Smith charts of S_{11} and S_{22} (normalised to 50 Ω) are shown first, followed by the tuned band on an expanded frequency scale. The wideband plots start at the specified lower frequency limit of 30 MHz (at 1 GHz for EVB B and C, where the measured data starts) and end at the upper end of the measured data. The gain on the expanded scale uses a 10 dB window (1 dB/div) placed around the gain of each board. The reverse isolation of the low-frequency boards EVB D and E is shown on a 0 to -60 dB scale also on the expanded frequency scale.

Stability factors

The stability factors μ (load) and μ' (source) shown for each board are calculated from the S-parameters:

$$\mu = \frac{1 - |S_{11}|^2}{|S_{22} - \Delta S_{11}^*| + |S_{12}S_{21}|}, \qquad \mu' = \frac{1 - |S_{22}|^2}{|S_{11} - \Delta S_{22}^*| + |S_{12}S_{21}|}, \qquad \Delta = S_{11}S_{22} - S_{12}S_{21}.$$

$\mu > 1$ (or $\mu' > 1$) is the necessary and sufficient condition for unconditional stability; the value is the distance from the centre of the Smith chart to the nearest unstable load (source) impedance.

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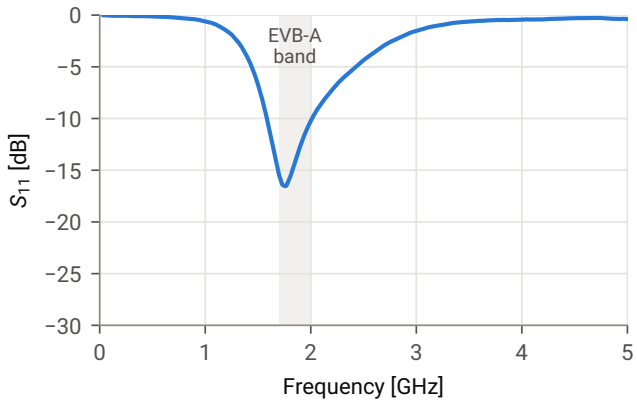
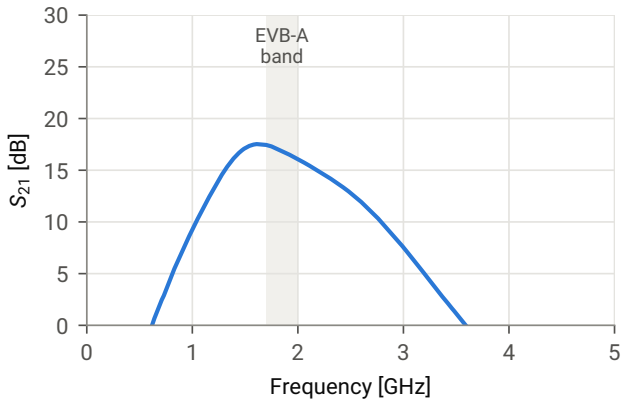
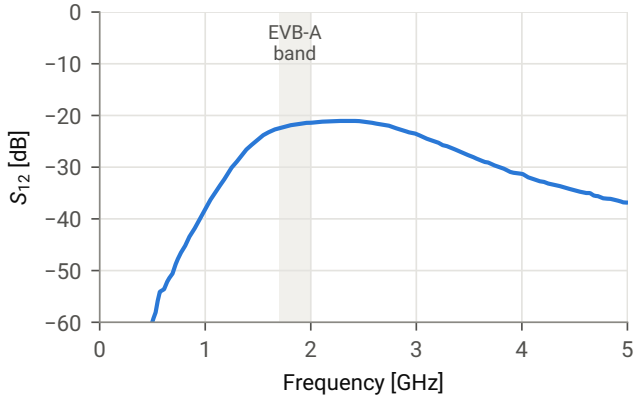
EVB A, wideband S-parameters and Smith charts



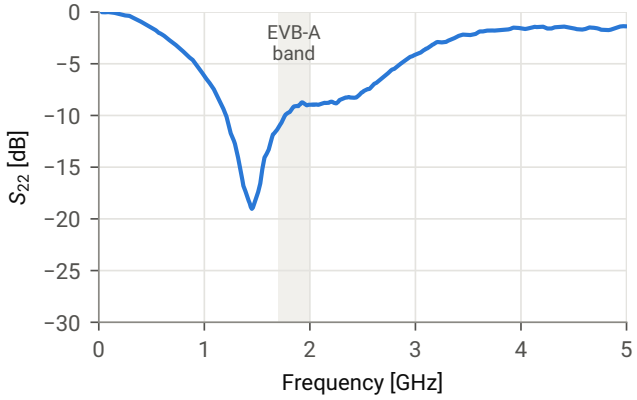
(a) S_{11} (input return loss) vs. frequency.



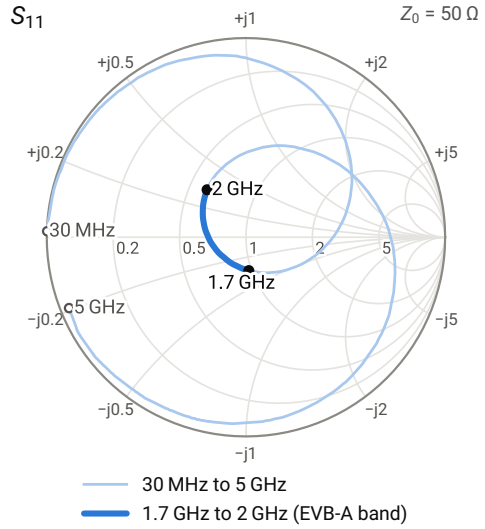
(b) S_{21} (gain) vs. frequency.



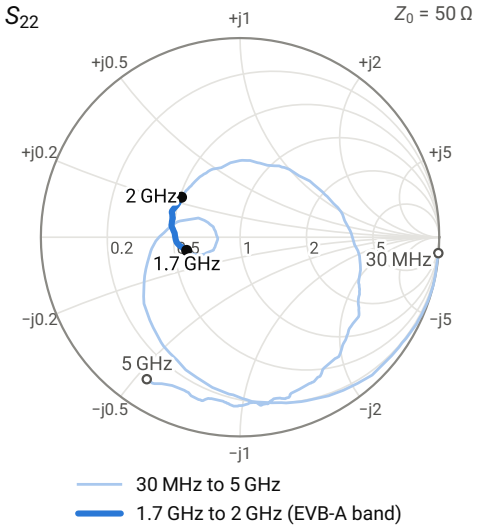
(c) S_{12} (reverse isolation) vs. frequency.



(d) S_{22} (output return loss) vs. frequency.



(e) S_{11} Smith chart, input impedance.



(f) S_{22} Smith chart, output impedance.

Figure 16: TP0310K-EVB-A S-parameters, 30 MHz to 5 GHz, $+25$°C, 5 V, 140 mA. Shaded and thick line: 1700 – 2000 MHz tuned band.

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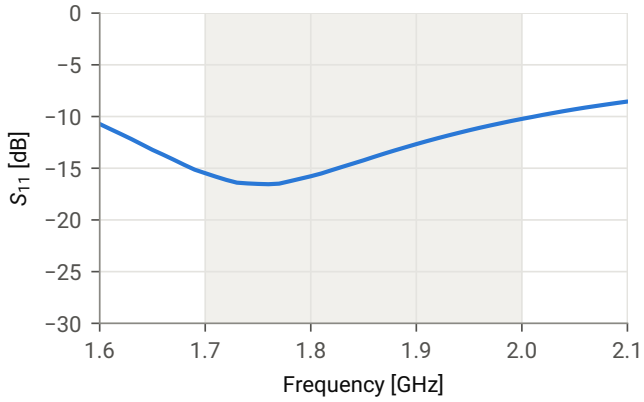
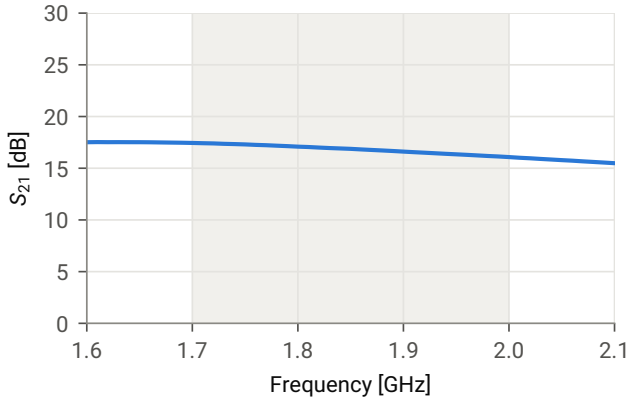
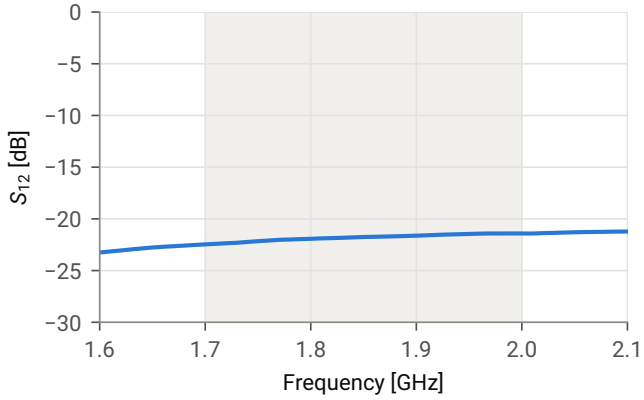
EVB A, narrowband S-parameters



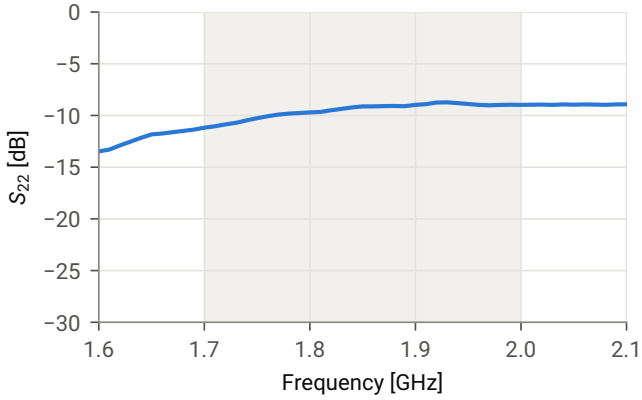
(a) S_{11} (input return loss) vs. frequency.



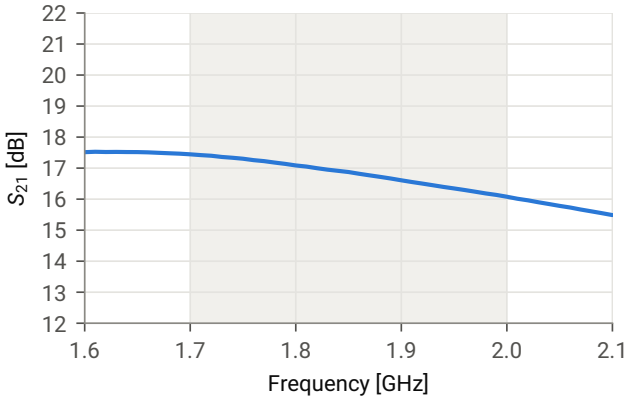
(b) S_{21} (gain) vs. frequency.



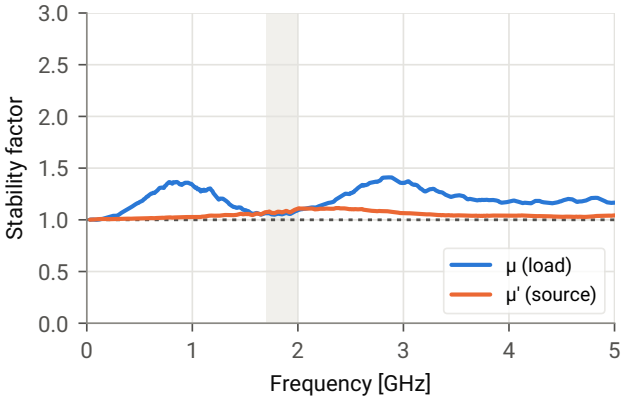
(c) S_{12} (reverse isolation) vs. frequency.



(d) S_{22} (output return loss) vs. frequency.



(e) S_{21} (gain) vs. frequency, expanded scale.



(f) Stability factors μ and μ' vs. frequency, 30 MHz to 5 GHz.

Figure 17: TP0310K-EVB-A S-parameters, 1700 – 2000 MHz band, $+25$°C, 5 V, 140 mA.

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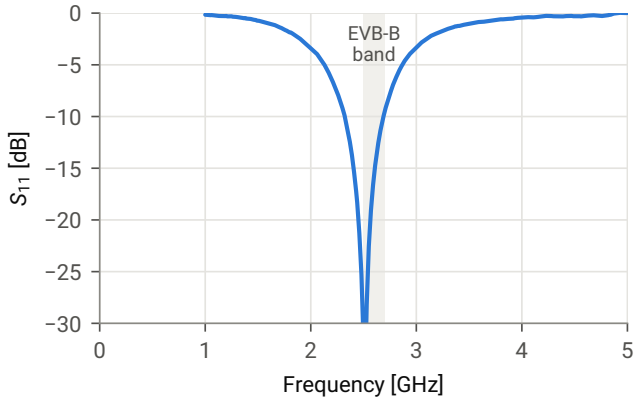
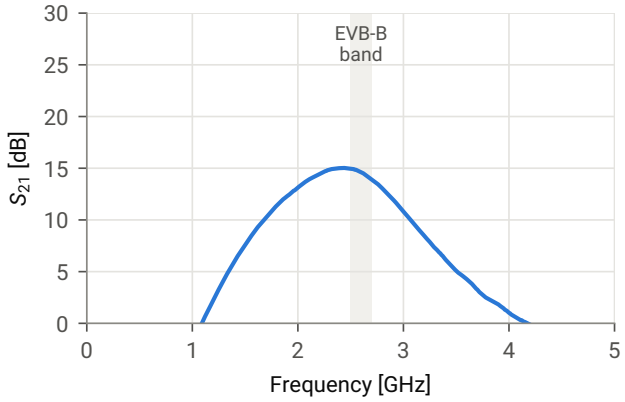
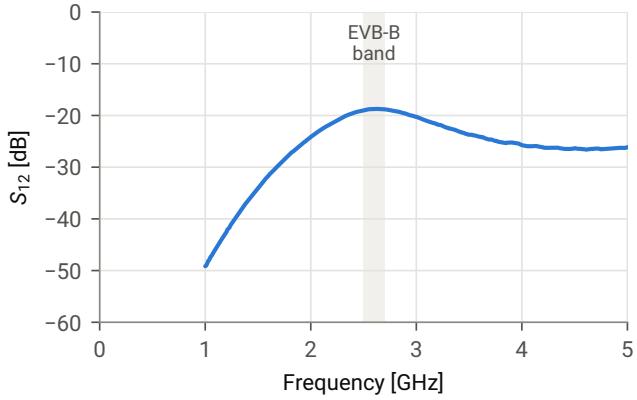
EVB B, wideband S-parameters and Smith charts



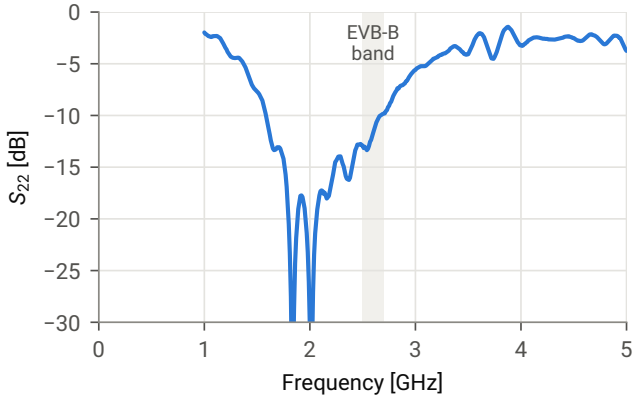
(a) S_{11} (input return loss) vs. frequency.



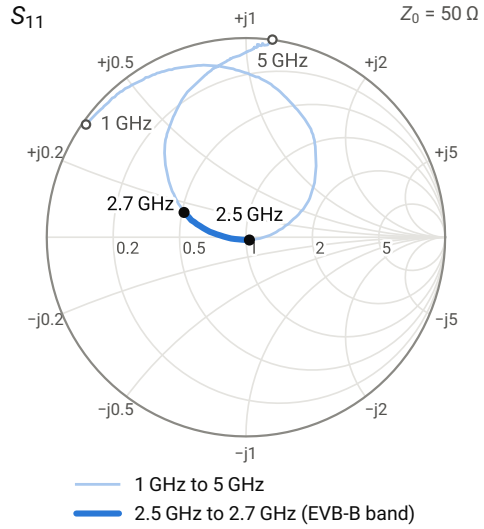
(b) S_{21} (gain) vs. frequency.



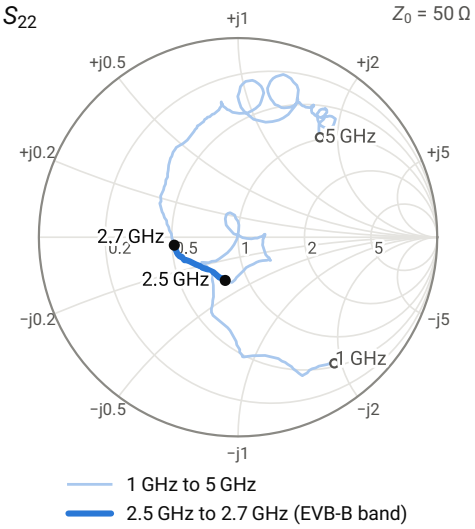
(c) S_{12} (reverse isolation) vs. frequency.



(d) S_{22} (output return loss) vs. frequency.



(e) S_{11} Smith chart, input impedance.



(f) S_{22} Smith chart, output impedance.

Figure 18: TP0310K-EVB-B S-parameters, 1 GHz to 5 GHz, $+25$°C, 5 V, 140 mA. Shaded and thick line: 2500 – 2700 MHz tuned band.

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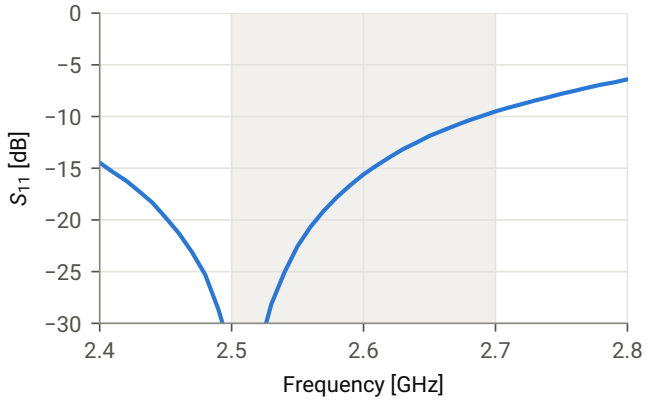
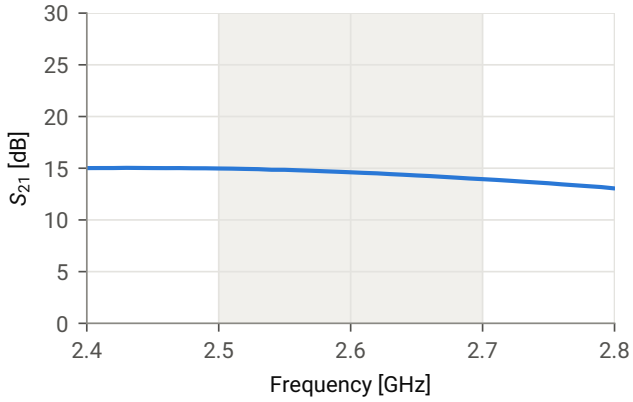
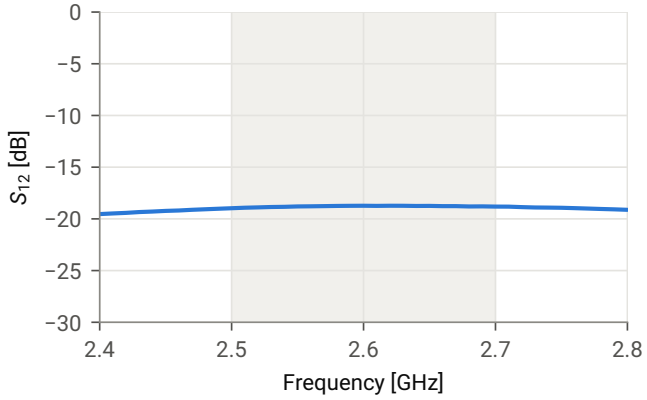
EVB B, narrowband S-parameters



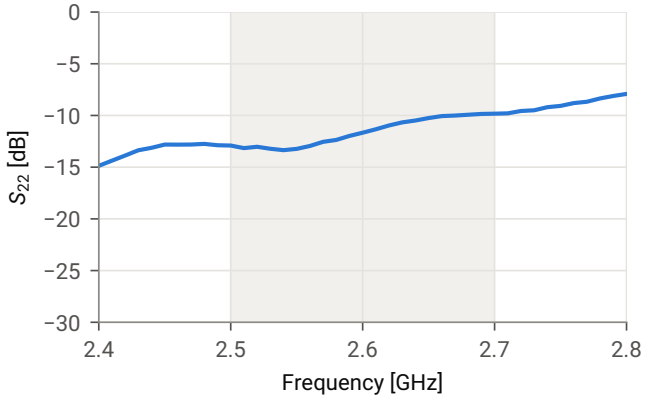
(a) S_{11} (input return loss) vs. frequency.



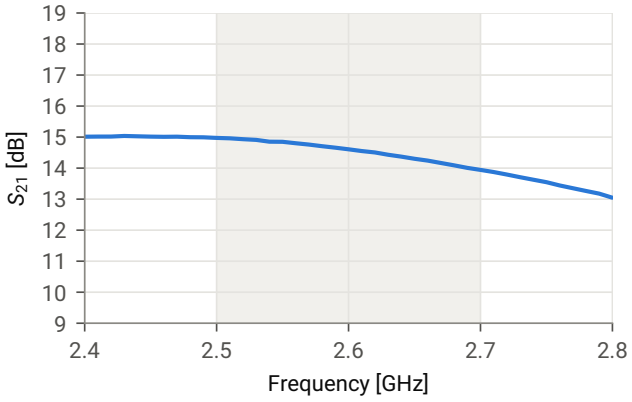
(b) S_{21} (gain) vs. frequency.



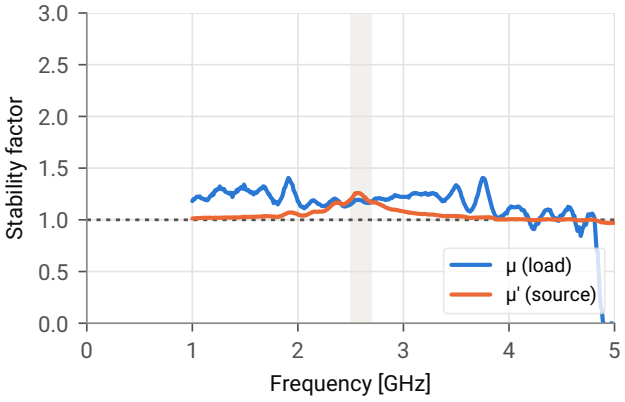
(c) S_{12} (reverse isolation) vs. frequency.



(d) S_{22} (output return loss) vs. frequency.



(e) S_{21} (gain) vs. frequency, expanded scale.



(f) Stability factors μ and μ' vs. frequency, 1 GHz to 5 GHz.

Figure 19: TP0310K-EVB-B S-parameters, 2500 – 2700 MHz band, $+25$°C, 5 V, 140 mA.

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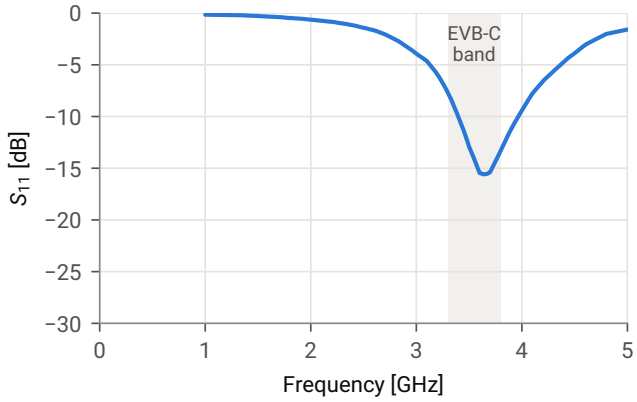
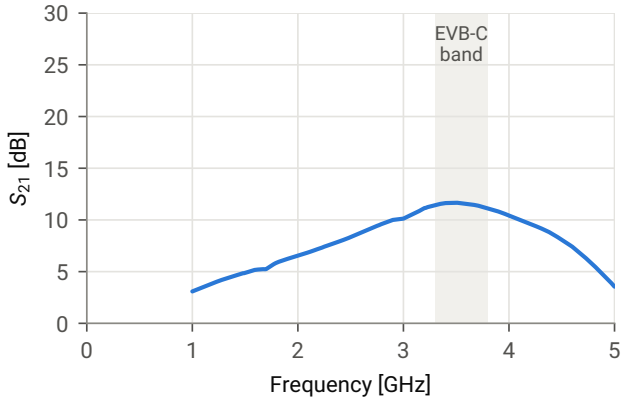
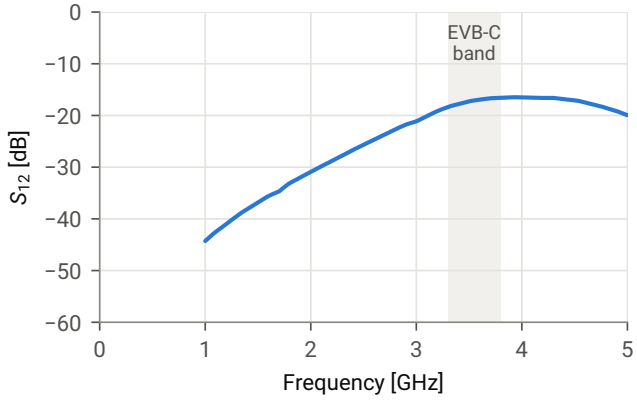
EVB C, wideband S-parameters and Smith charts



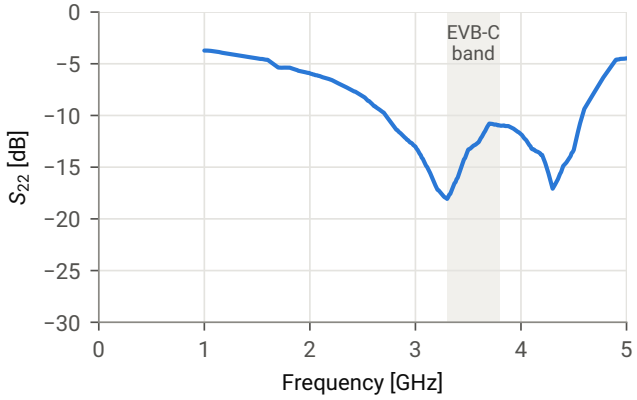
(a) S_{11} (input return loss) vs. frequency.



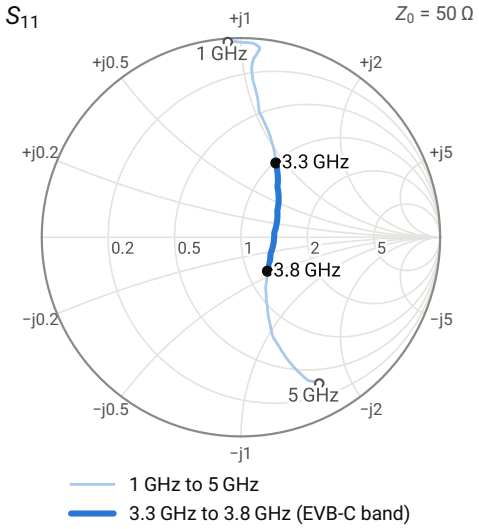
(b) S_{21} (gain) vs. frequency.



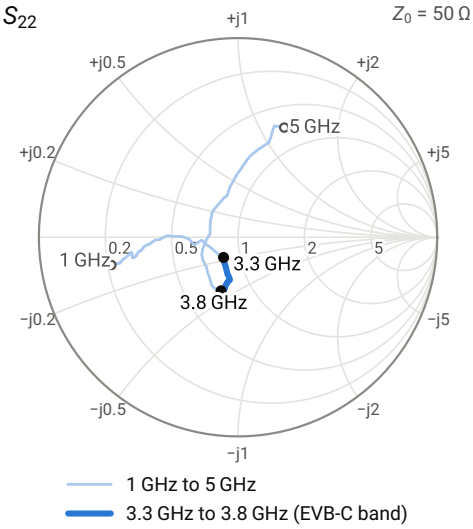
(c) S_{12} (reverse isolation) vs. frequency.



(d) S_{22} (output return loss) vs. frequency.



(e) S_{11} Smith chart, input impedance.



(f) S_{22} Smith chart, output impedance.

Figure 20: TP0310K-EVB-C S-parameters, 1 GHz to 5 GHz, $+25$°C, 5 V, 140 mA. Shaded and thick line: 3300 – 3800 MHz tuned band.

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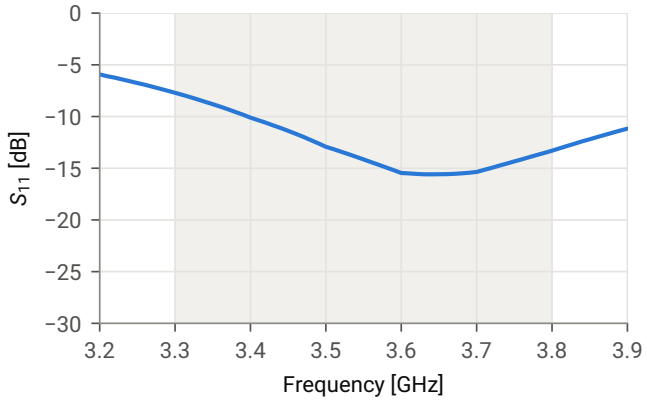
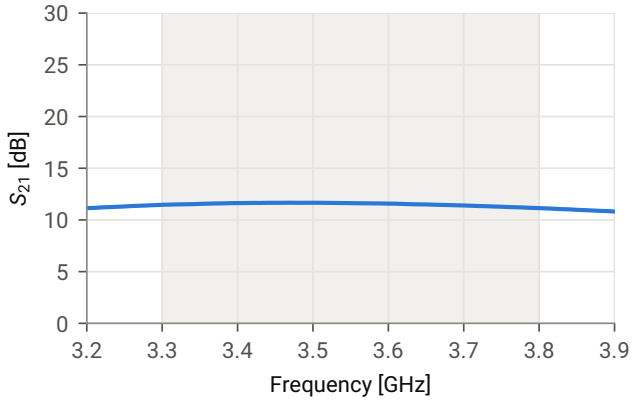
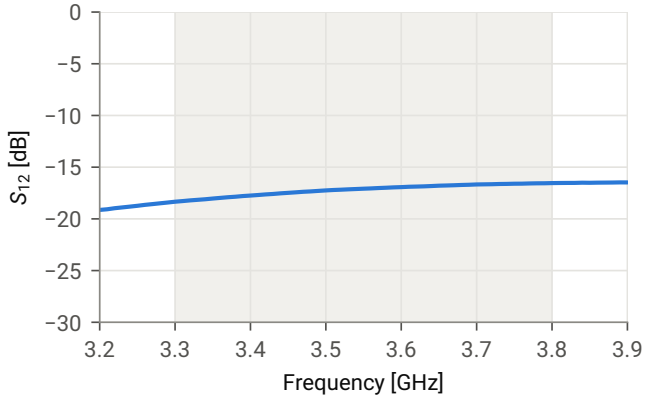
EVB C, narrowband S-parameters



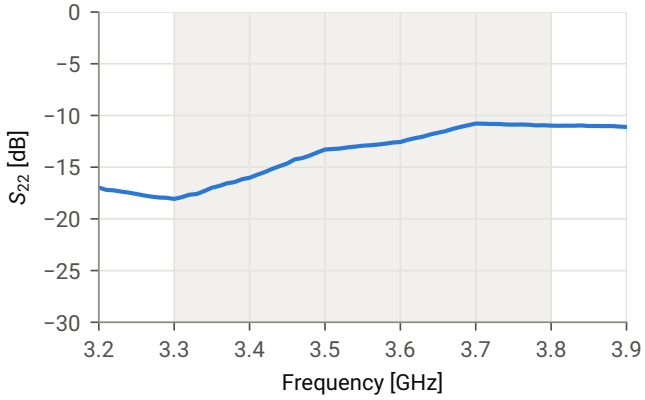
(a) S_{11} (input return loss) vs. frequency.



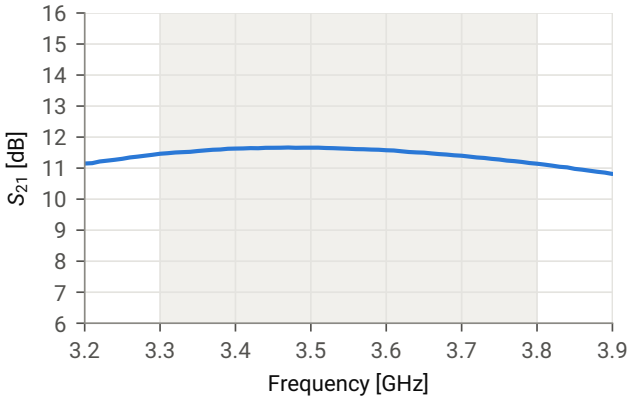
(b) S_{21} (gain) vs. frequency.



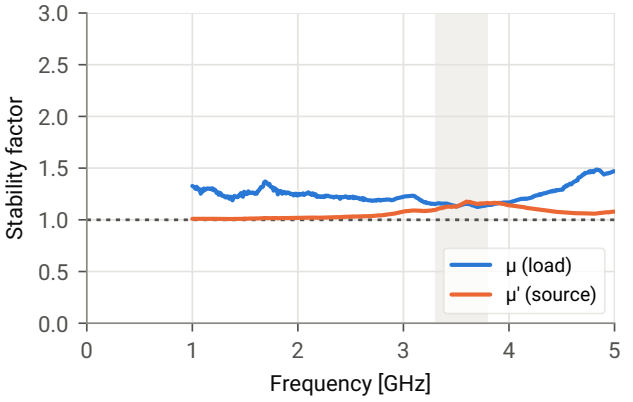
(c) S_{12} (reverse isolation) vs. frequency.



(d) S_{22} (output return loss) vs. frequency.



(e) S_{21} (gain) vs. frequency, expanded scale.



(f) Stability factors μ and μ' vs. frequency, 1 GHz to 5 GHz.

Figure 21: TP0310K-EVB-C S-parameters, 3300 – 3800 MHz band, $+25$°C, 5 V, 140 mA.

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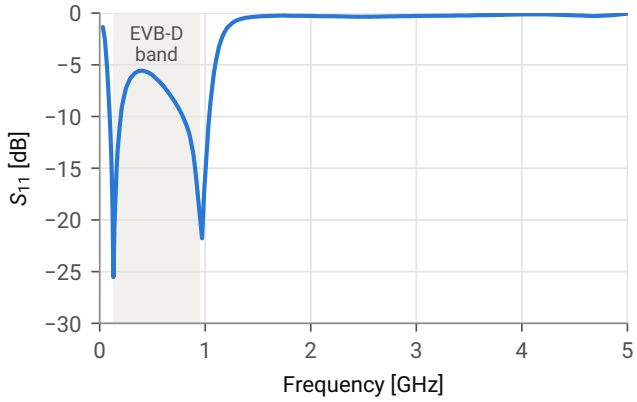
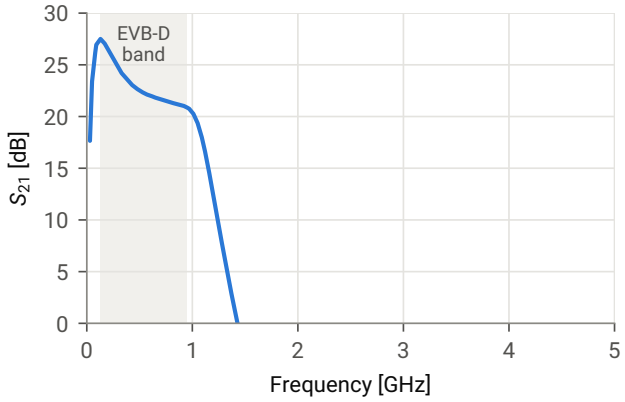
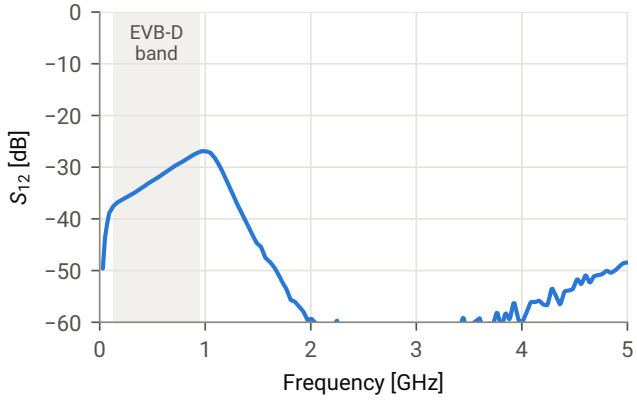
EVB D, wideband S-parameters and Smith charts



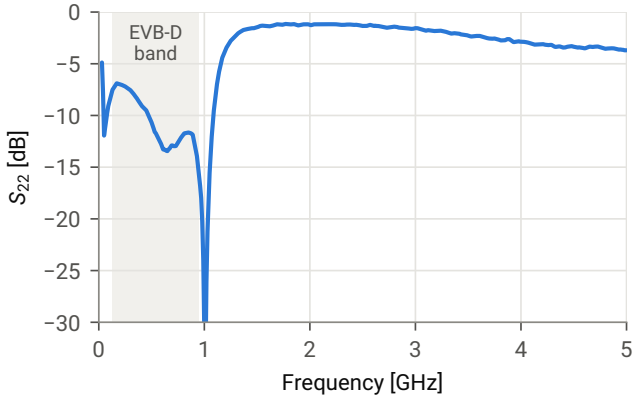
(a) S_{11} (input return loss) vs. frequency.



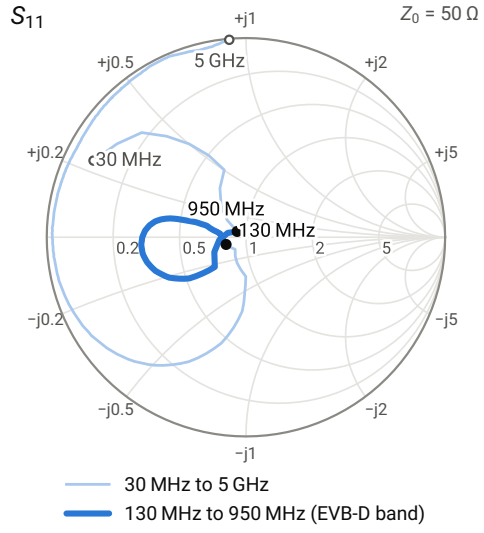
(b) S_{21} (gain) vs. frequency.



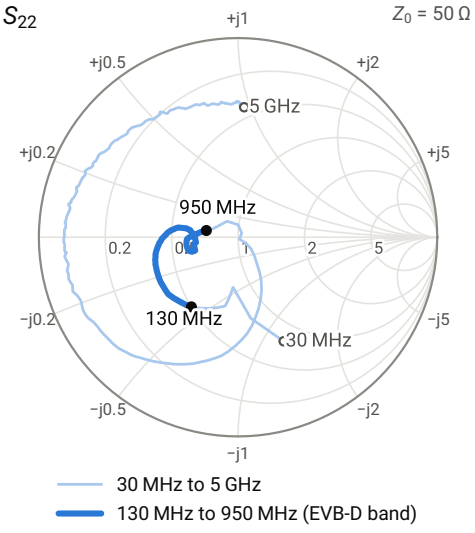
(c) S_{12} (reverse isolation) vs. frequency.



(d) S_{22} (output return loss) vs. frequency.



(e) S_{11} Smith chart, input impedance.



(f) S_{22} Smith chart, output impedance.

Figure 22: TP0310K-EVB-D S-parameters, 30 MHz to 5 GHz, $+25$°C, 5 V, 140 mA. Shaded and thick line: 130 – 950 MHz tuned band.

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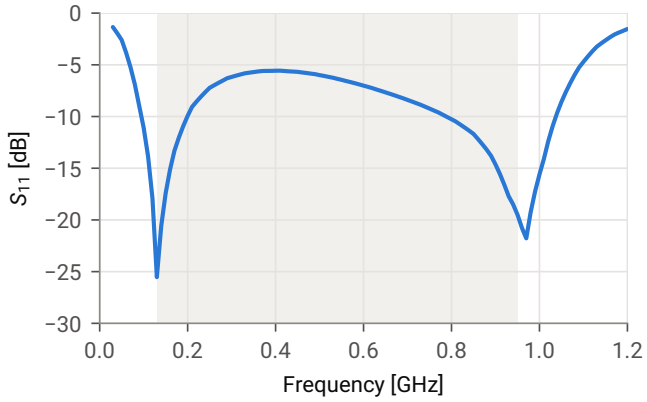
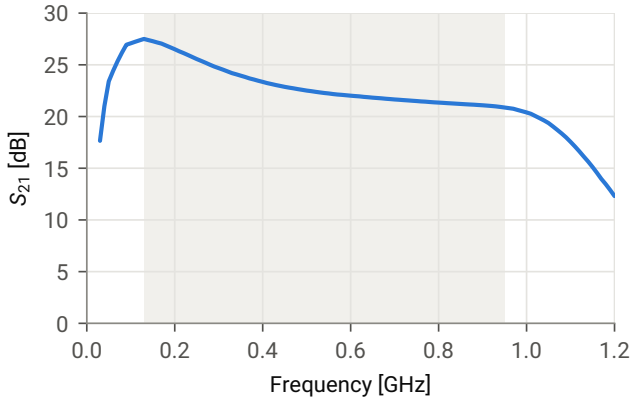
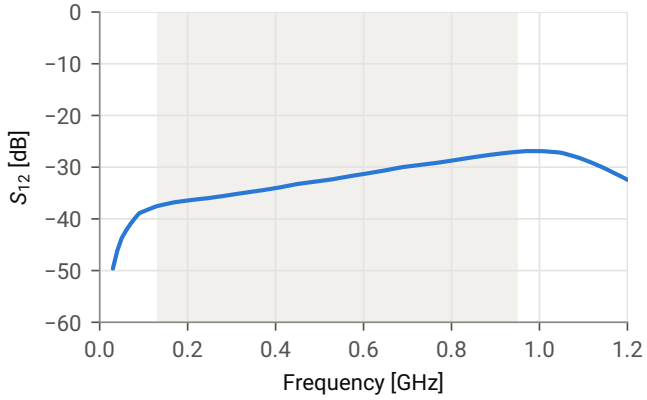
EVB D, narrowband S-parameters



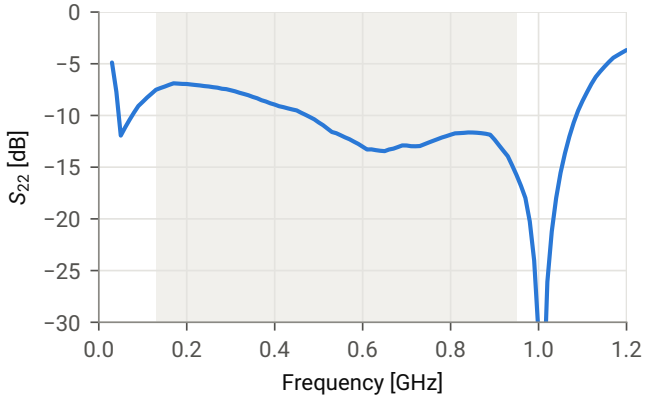
(a) S_{11} (input return loss) vs. frequency.



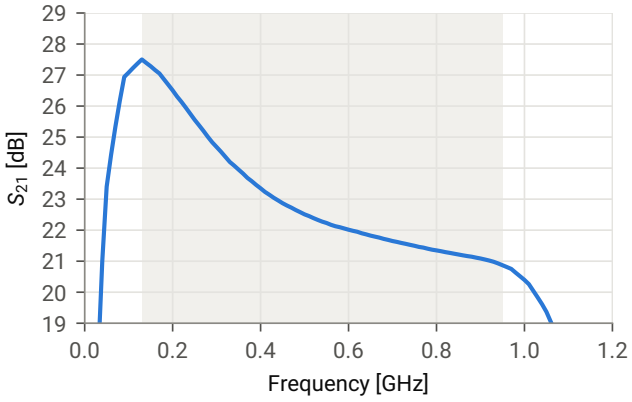
(b) S_{21} (gain) vs. frequency.



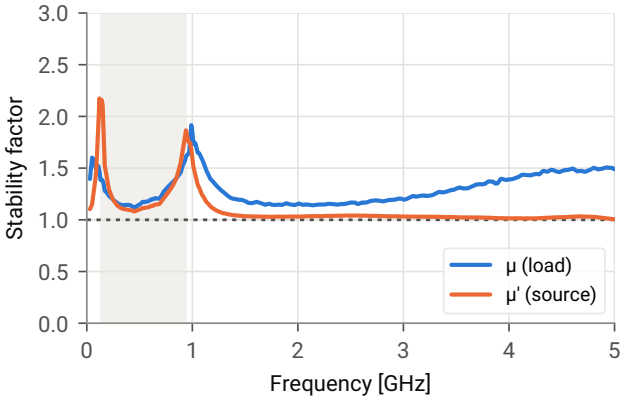
(c) S_{12} (reverse isolation) vs. frequency.



(d) S_{22} (output return loss) vs. frequency.



(e) S_{21} (gain) vs. frequency, expanded scale.



(f) Stability factors μ and μ' vs. frequency, 30 MHz to 5 GHz.

Figure 23: TP0310K-EVB-D S-parameters, 130 – 950 MHz band, $+25$°C, 5 V, 140 mA.

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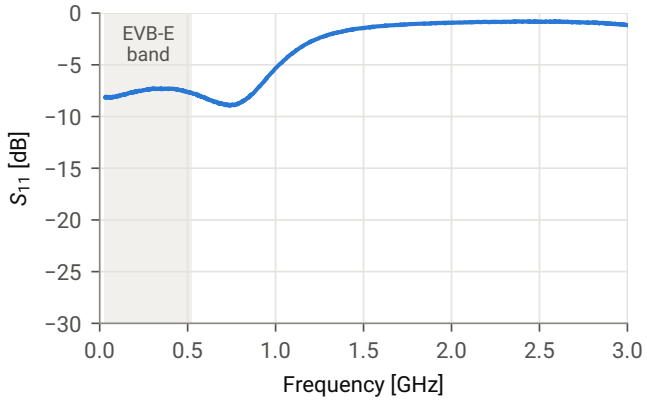
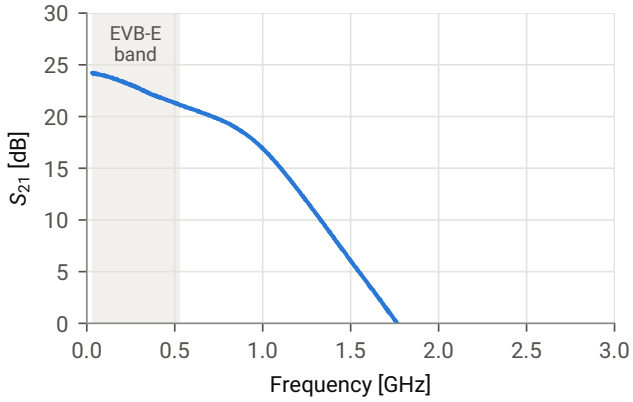
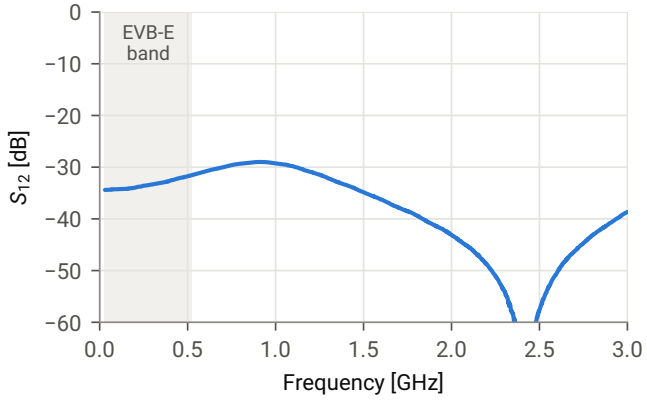
EVB E, wideband S-parameters and Smith charts



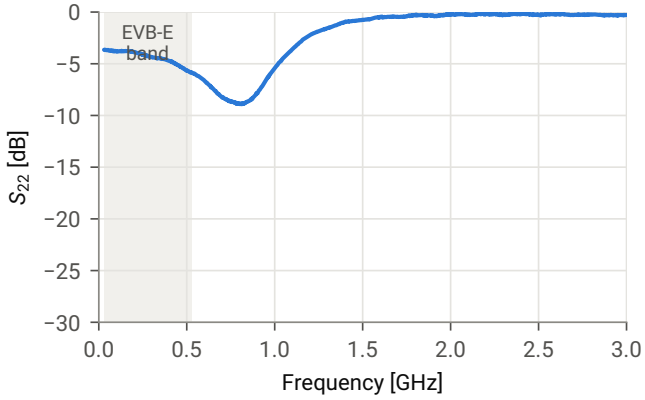
(a) S_{11} (input return loss) vs. frequency.



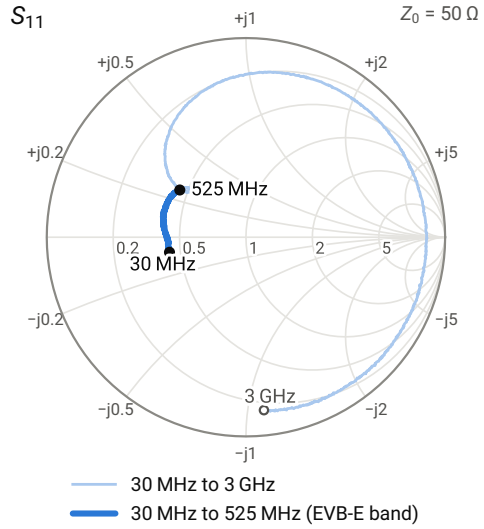
(b) S_{21} (gain) vs. frequency.



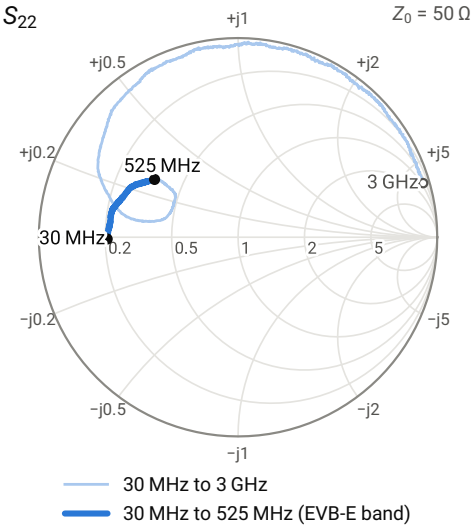
(c) S_{12} (reverse isolation) vs. frequency.



(d) S_{22} (output return loss) vs. frequency.



(e) S_{11} Smith chart, input impedance.



(f) S_{22} Smith chart, output impedance.

Figure 24: TP0310K-EVB-E S-parameters, 30 MHz to 3 GHz, $+25$°C, 5 V, 140 mA. Shaded and thick line: 30 – 525 MHz tuned band.

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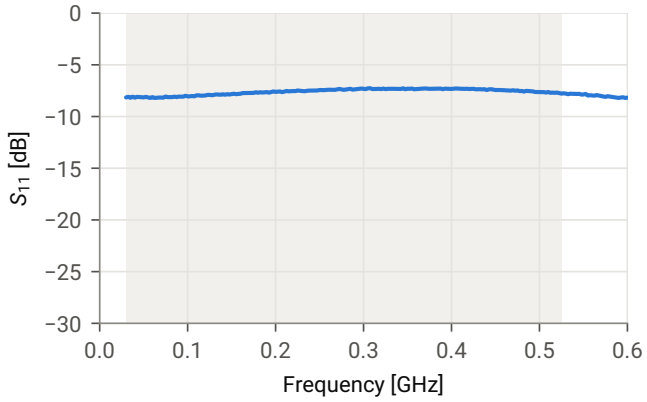
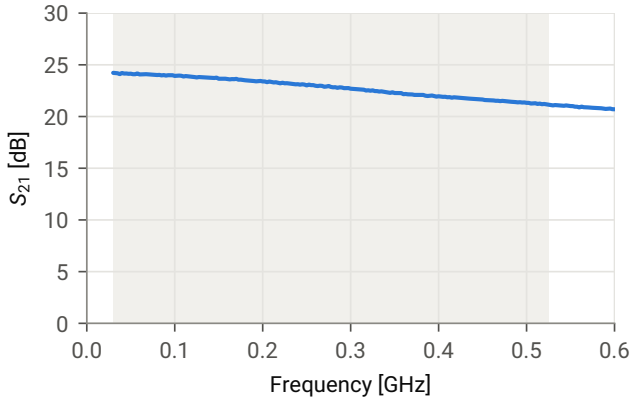
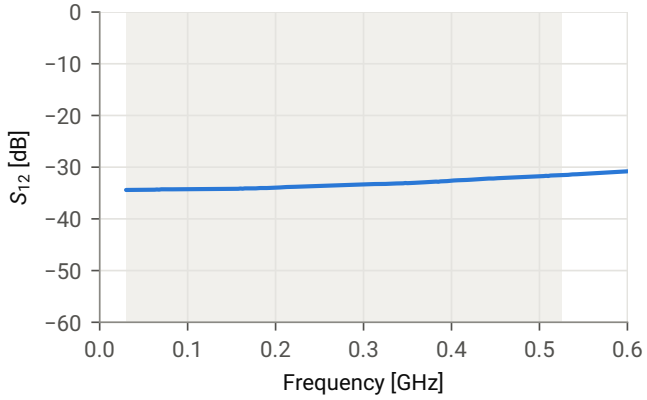
EVB E, narrowband S-parameters



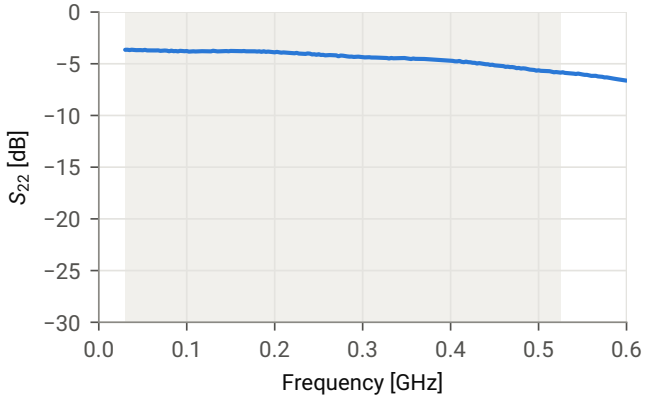
(a) S_{11} (input return loss) vs. frequency.



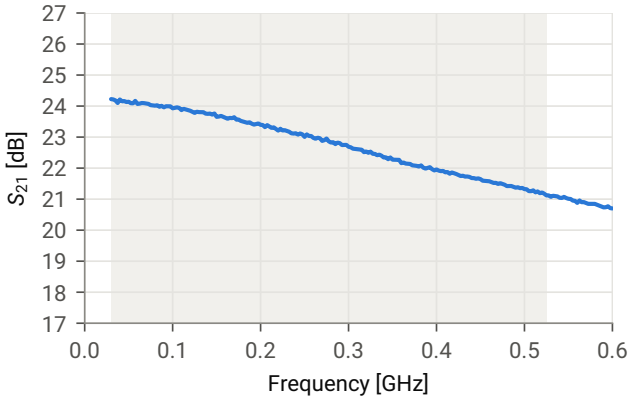
(b) S_{21} (gain) vs. frequency.



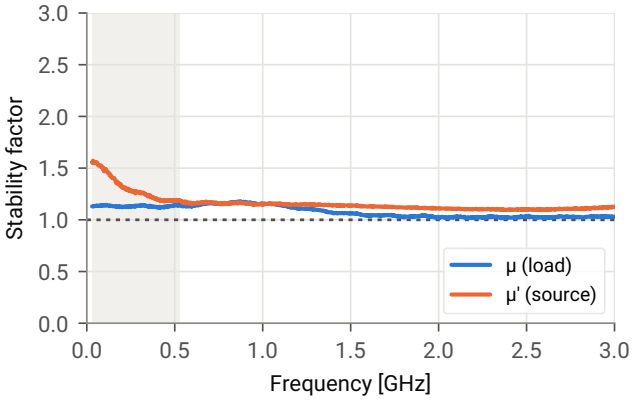
(c) S_{12} (reverse isolation) vs. frequency.



(d) S_{22} (output return loss) vs. frequency.



(e) S_{21} (gain) vs. frequency, expanded scale.



(f) Stability factors μ and μ' vs. frequency, 30 MHz to 3 GHz.

Figure 25: TP0310K-EVB-E S-parameters, 30 – 525 MHz band, $+25$°C, 5 V, 140 mA.

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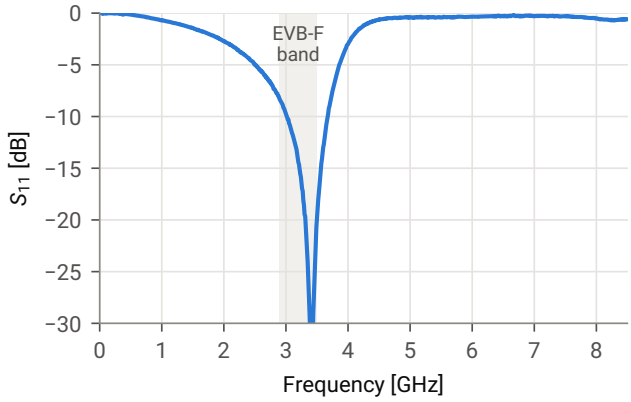
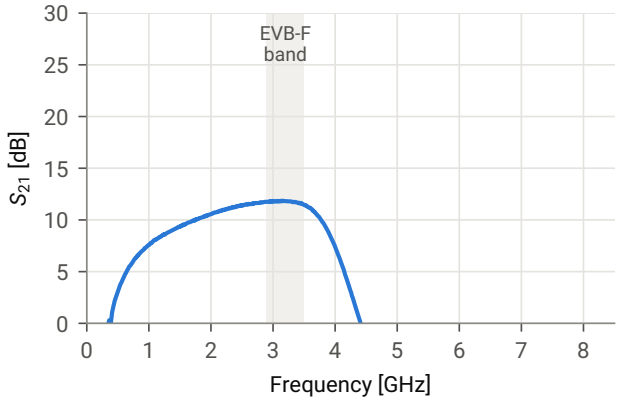
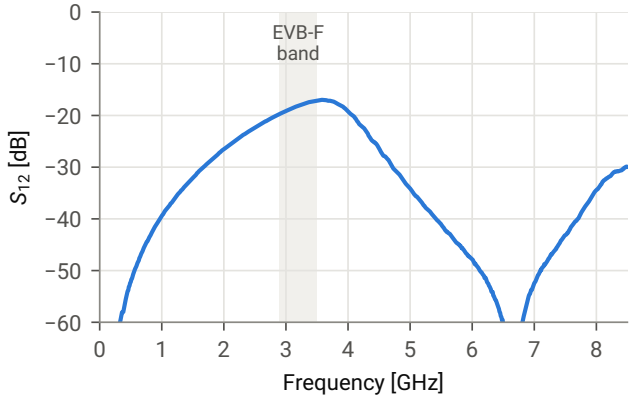
EVB F, wideband S-parameters and Smith charts



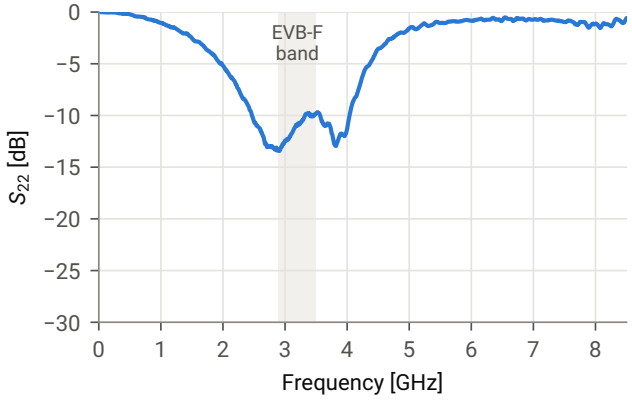
(a) S_{11} (input return loss) vs. frequency.



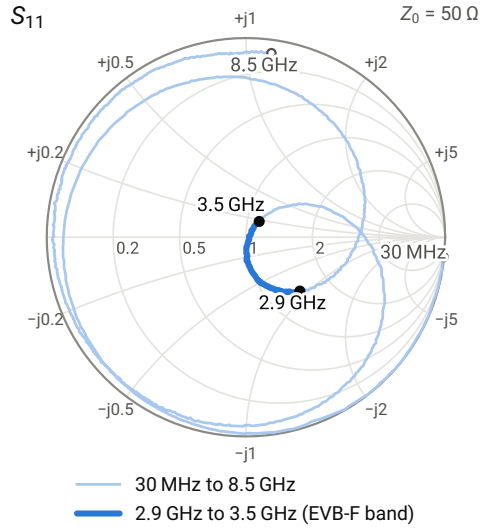
(b) S_{21} (gain) vs. frequency.



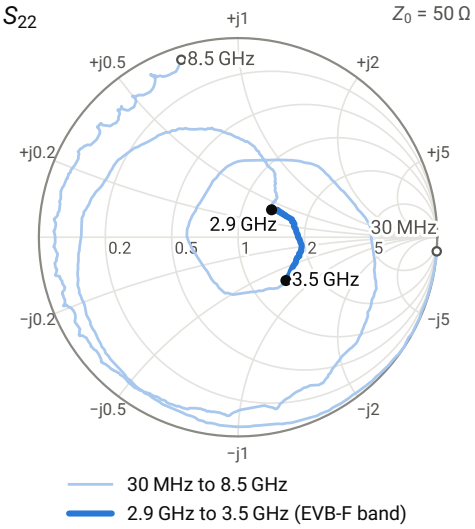
(c) S_{12} (reverse isolation) vs. frequency.



(d) S_{22} (output return loss) vs. frequency.



(e) S_{11} Smith chart, input impedance.



(f) S_{22} Smith chart, output impedance.

Figure 26: TP0310K-EVB-F S-parameters, 30 MHz to 8.5 GHz, $+25$°C, 5 V, 133 mA. Shaded and thick line: 2900 – 3500 MHz tuned band.

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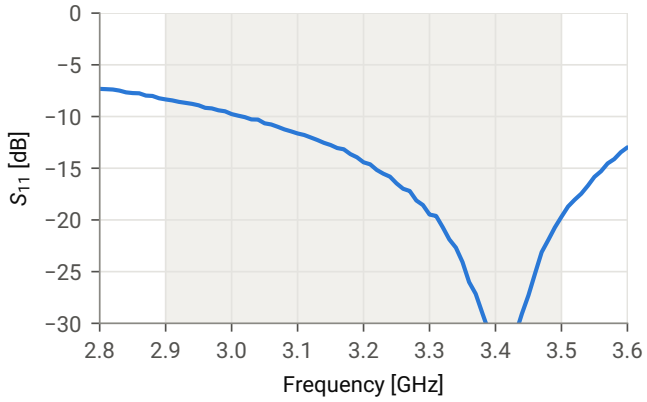
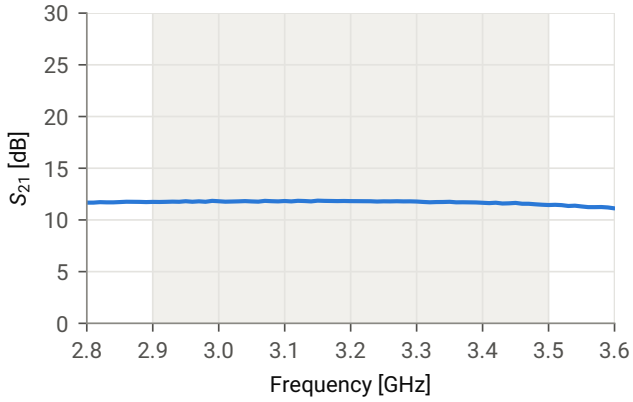
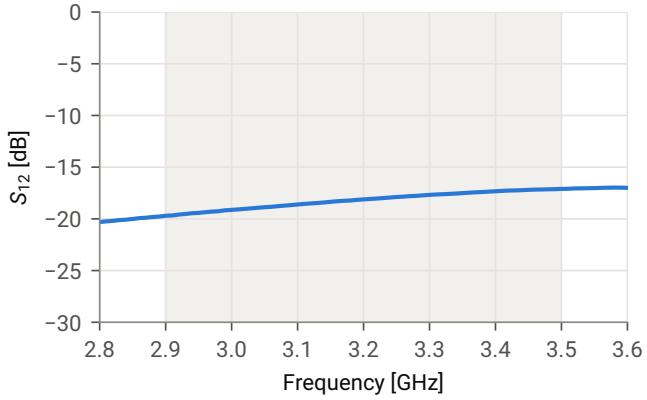
EVB F, narrowband S-parameters



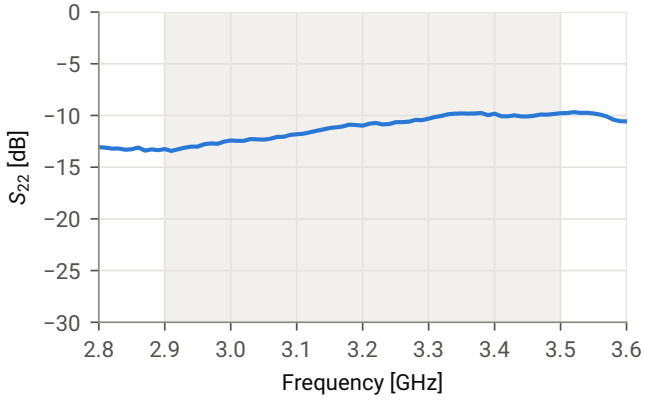
(a) S_{11} (input return loss) vs. frequency.



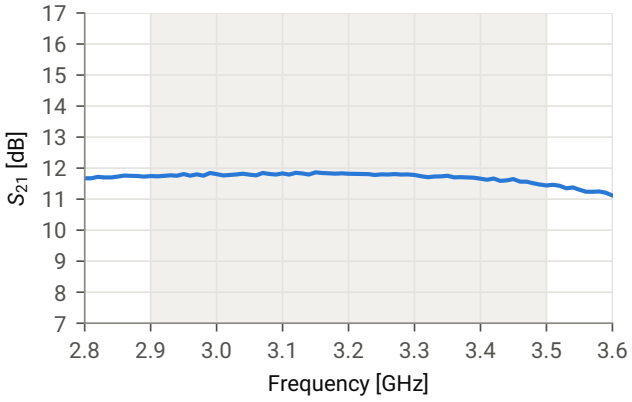
(b) S_{21} (gain) vs. frequency.



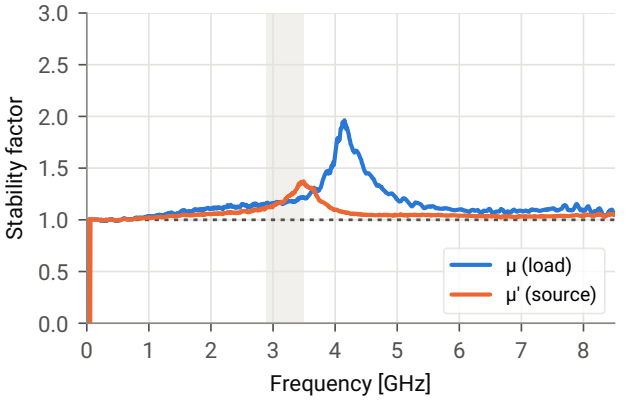
(c) S_{12} (reverse isolation) vs. frequency.



(d) S_{22} (output return loss) vs. frequency.



(e) S_{21} (gain) vs. frequency, expanded scale.



(f) Stability factors μ and μ' vs. frequency, 30 MHz to 8.5 GHz.

Figure 27: TP0310K-EVB-F S-parameters, 2900 – 3500 MHz band, $+25$°C, 5 V, 133 mA.

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Test Procedures

TP0310K-EVB-A Biasing Sequence

TagoreTech recommends following the biasing sequence below every time the evaluation board is powered up or down. Applying RF power to an amplifier that is not yet biased, removing the bias while RF power is still present, or letting a supply overshoot during switching can stress the transistors and damage the device or reduce its long-term reliability. The sequence is part of the board's normal operating procedure, not an optional step.

Before switching on, set the current limit of the supply to 150 mA, the absolute maximum drain current, and make sure that the supply does not overshoot V_{DD} or V_{enable} above the +6 V absolute maximum rating when it is switched on. The RF input power must stay below the absolute maximum of 23 dBm CW. The TP0310K is ESD sensitive (HBM class 1B); handle the board with ESD precautions and connect the ground before any other connection.

Table 20: TP0310K-EVB-A bias and sequencing

Turn on	Turn off
1. Connect the supply ground to the ground test point.	1. Turn the RF power off.
2. Set V_{enable} to +5 V.	2. Turn V_{DD} off.
3. Set V_{DD} to +5 V and check that the quiescent current is $I_{DQ} \approx 140$ mA.	3. Turn V_{enable} off.
4. Apply the RF power.	4. Disconnect the ground last.

I_{DQ} is set by V_{enable} and the series resistor R1; a quiescent current clearly different from 140 mA indicates a wrong supply voltage, a wrong R1 value or an assembly problem, and the RF power should not be applied before the cause is found. $V_{enable} < 0.2$ V disables the device. When V_{enable} and V_{DD} are supplied from the same 5 V source, as in the test set-up of Figure 29, they rise and fall together; the RF power must still be applied only after the supply has settled and removed before the supply is switched off. The BIAS1 pin of the header J3 is not used and is left open.

The TP0310K dissipates about 0.7 W at the typical operating point. Operate the evaluation board on a surface that does not insulate it thermally, or on a heat sink, and do not operate the device without the exposed paddle soldered to the board.

S-parameter test set-up

The TP0310K-EVB-A is shipped fully assembled and tested; Figure 28 shows an evaluation board. Figure 29 shows the basic test set-up for evaluating the S-parameters (gain, input and output return loss, reverse isolation) with a vector network analyzer.

1. Connect the ground test point to the ground terminal of the power supply.
2. Connect the V_{enable} and V_{DD} test points to the output of a 5 V supply capable of sourcing approximately 140 mA.
3. Connect a calibrated network analyzer to the RF_{IN} and RF_{OUT} SMA connectors. Sweep the frequency from 1 GHz to 6 GHz with a source power of -25 dBm.

The TP0310K-EVB-A is expected to show a gain of 16.5 dB at 1.85 GHz; see Table 8 for the expected results.

Additional test equipment is required for a comprehensive evaluation. For noise figure, use a noise figure analyzer or a spectrum analyzer with noise option, together with a low excess noise ratio (ENR) noise source. For the third-order intercept point, use two signal generators, a high-isolation power combiner and a spectrum analyzer. For power compression and power handling, use a signal generator and a two-channel power meter; make sure that the driver amplifier has sufficient output power and that couplers and attenuators have adequate power handling.

Measurements taken at the SMA connectors include the losses of the connectors and the PCB. The through line on the board, consisting of an RF input and an RF output line of equal length, should be measured to calibrate these effects.

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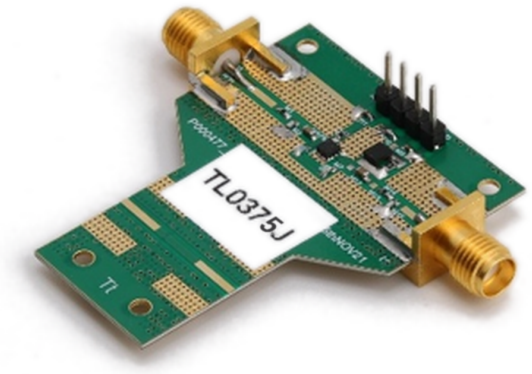

Figure 28: TP0310K evaluation board.

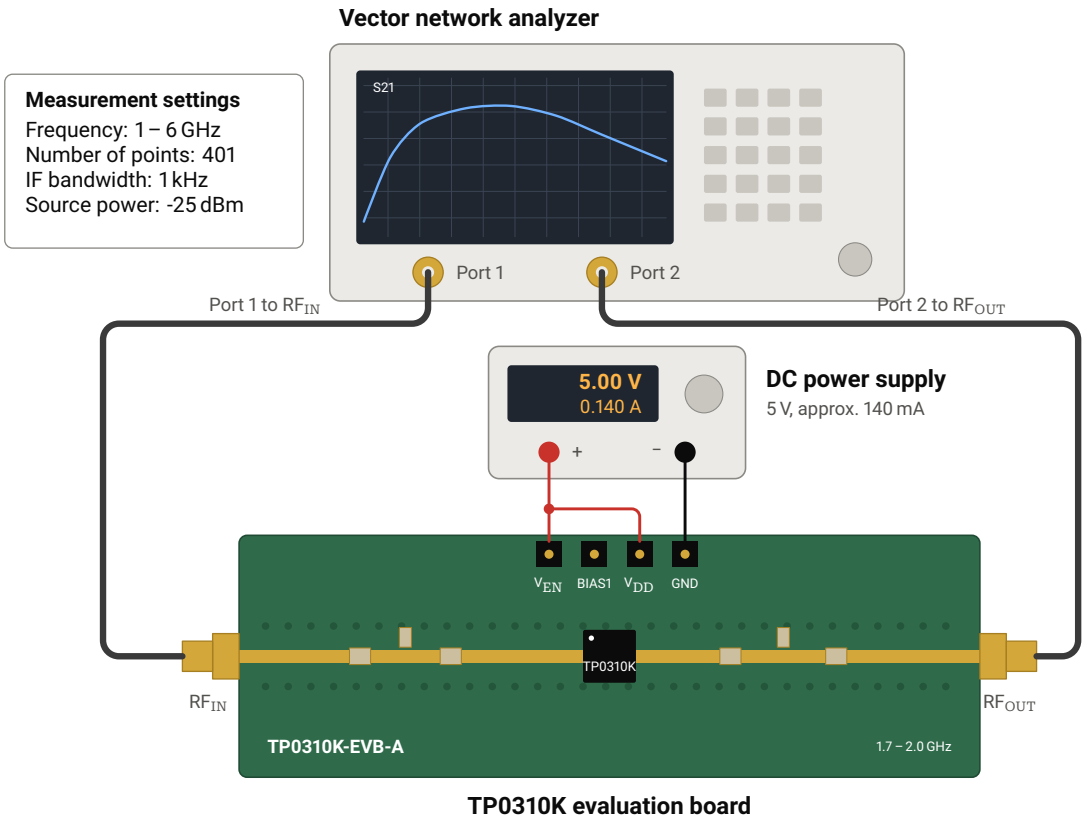

Figure 29: Test set-up for S-parameter measurements.

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Device Package information

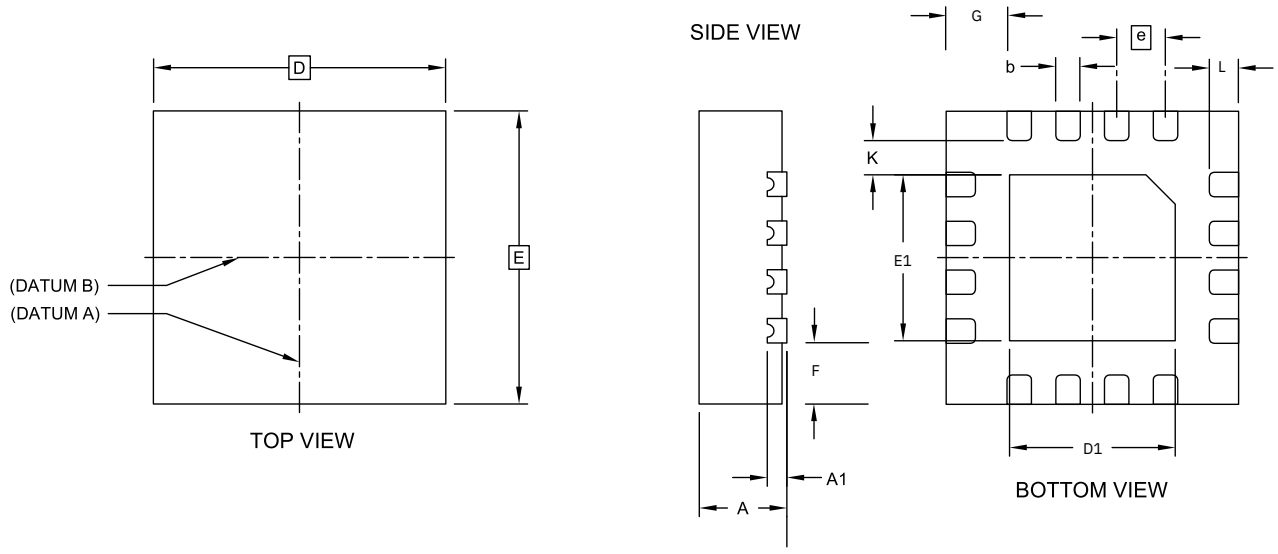

Figure 30: 16-pin QFN 3.0 x 3.0 x 0.75 mm^3 package drawing, dimensions in [mm].

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 21: 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

Note: Lead finish: Pure Sn without underlayer; Thickness: 7.5μm – 20μm (Typical 10μm – 12μm).

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PCB Land Design

Notes:

- 2-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 and should be filled/plugged with solder or copper.
- The maximum via number for the center pad is 3(X)×3(Y)=9.

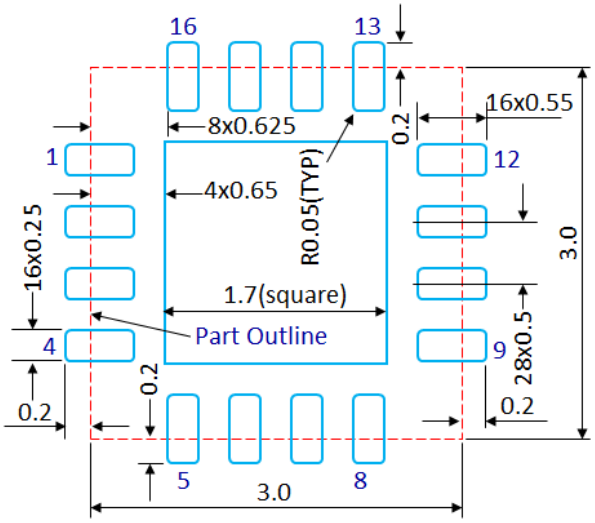

Figure 31: PCB land pattern, dimensions in [mm].



Figure 32: Solder mask pattern: non-solder mask defined (preferred, left) and solder mask defined (right), dimensions in [mm].

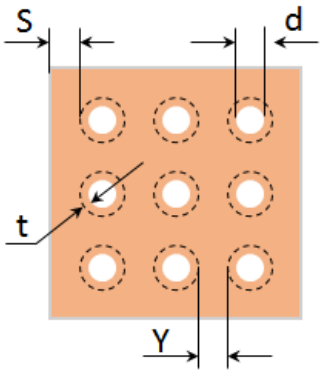

Figure 33: Thermal via pattern, recommended values: S≥0.15mm; Y≥0.20mm; d=0.3mm; plating thickness t=25μm or 50μm.

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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.

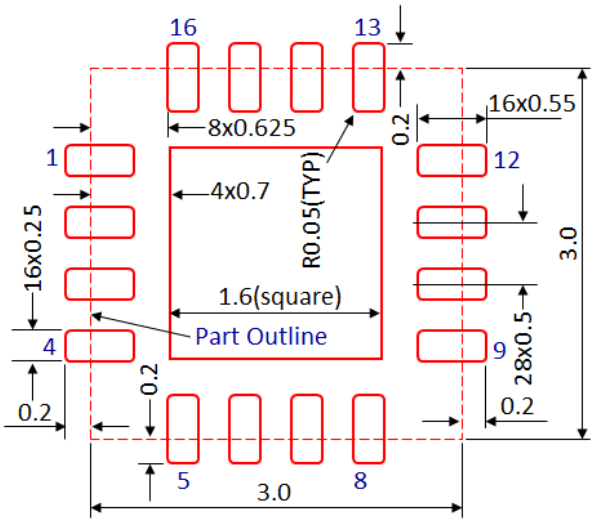

Figure 34: Stencil openings, dimensions in [mm].

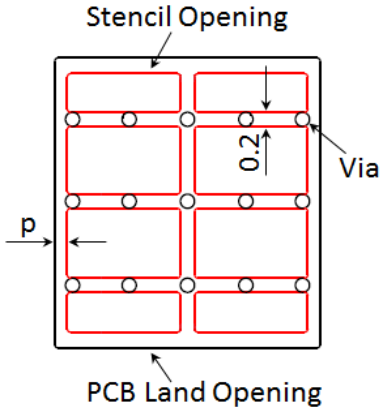

Figure 35: Stencil openings shall not cover via areas if possible, dimensions in [mm].

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Tape and Reel Information

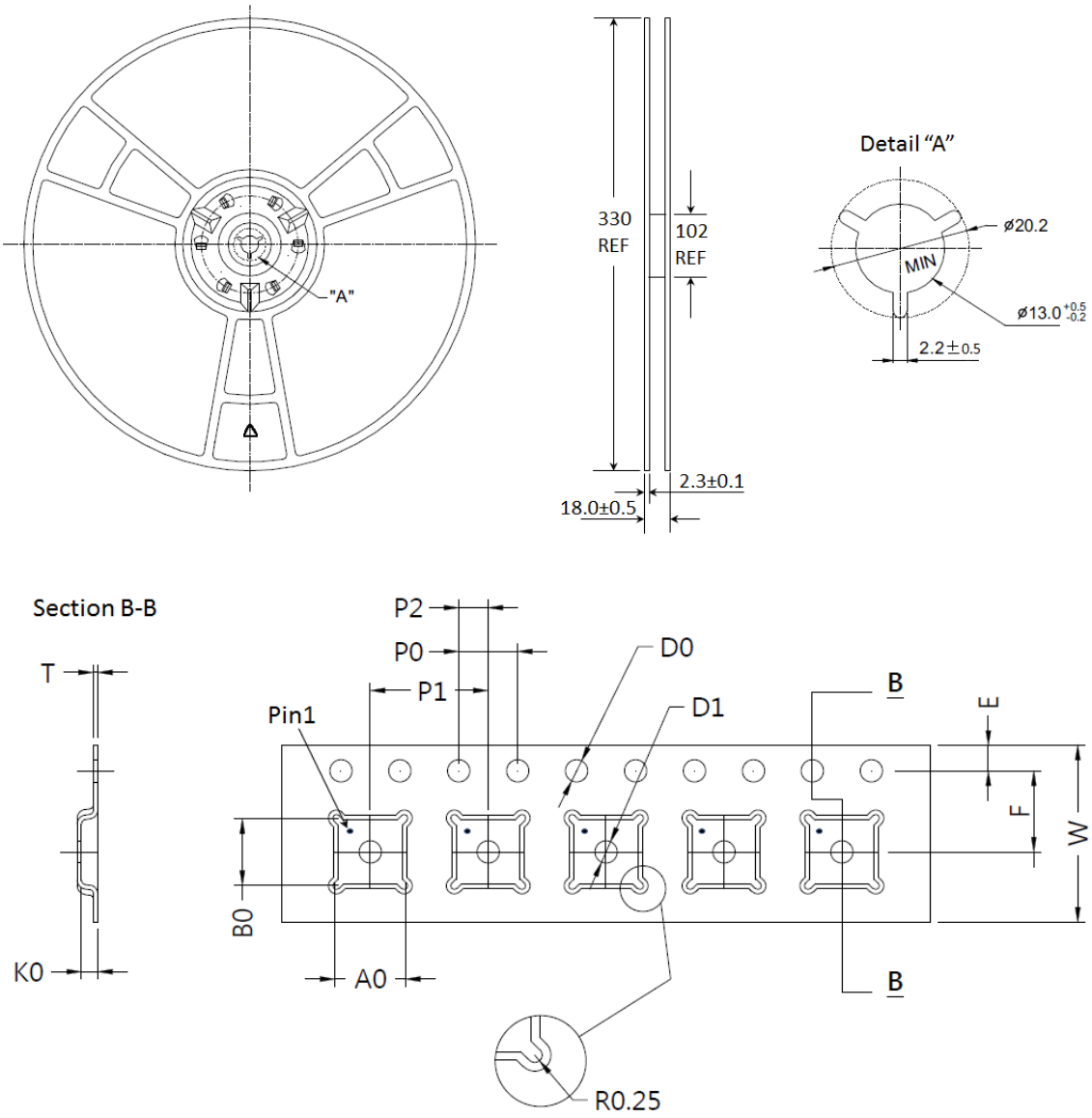

Figure 36: Tape and reel drawing.

Table 22: Tape and Reel Dimensions

Dimension	Value [mm]	Tolerance [mm]	Dimension	Value [mm]	Tolerance [mm]
A0	3.30	±0.10	K0	1.10	±0.10
B0	3.30	±0.10	P0	4.00	±0.10
D0	1.50	+0.10/-0.00	P1	8.00	±0.10
D1	1.50	+0.10/-0.00	P2	2.00	±0.05
E	1.75	±0.10	T	0.30	±0.05
F	5.50	±0.05	W	12.00	+0.30/-0.10

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Glossary

DNP	Do Not Populate: component position on the PCB that is not assembled
ENR	Excess noise ratio of a noise source
EVB	Evaluation board
IRL / ORL	Input / output return loss
LNA	Low noise amplifier
NF	Noise figure
OIP3	Output third-order intercept point
OP_{1dB}	Output power at 1 dB gain compression
QFN	Quad Flat No-lead package
μ, μ', μ_1	Single-parameter (Edwards–Sinsky) stability factors, load (μ, μ_1) and source (μ') side; $\mu > 1$ indicates unconditional stability
S_{ij}	S-parameters: S_{11} input match, S_{21} gain, S_{12} reverse isolation, S_{22} output match

Changelog

Table 23: Changelog

Date	Revision	Notes
01/06/2026	2.9	Datasheet in the previous format.
09/29/2026	3.00	Datasheet converted to the common TagoreTech document template: evaluation board schematics redrawn with not-assembled positions marked DNP, bills of materials aligned with the schematics (EVB A, C, D and F), table of evaluation boards with links to the application notes, links to application notes TN-001/TN-002, QR code link to the latest datasheet, return loss given in house sign convention. Pin assignment and functional block diagram redrawn, package drawing updated. S-parameter plots redrawn as vector graphics from the Touchstone data with Smith charts of S_{11} and S_{22} and stability factors μ and μ' for all evaluation boards A to F. RF specifications of EVB F added. Biasing sequence extended, power dissipation and thermal considerations added, S-parameter test set-up redrawn, photo of the evaluation board added.

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Application notes of all evaluation boards are linked in the table Evaluation boards and application notes.

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