TR0329M LNA Evaluation Board, 2300 – 2700 MHz, 5 V

General Description

The TR0329M is a high-linearity, ultra-low noise two-stage gain block amplifier module with internal 50 Ω input and output matching and a bypass function integrated across the second stage. At 3.6 GHz the amplifier typically provides 34 dB gain, +35 dBm OIP3 and 0.5 dB noise figure in high-gain mode, drawing 90 mA from a +5 V supply; in low-gain mode, with the second stage bypassed, it provides 15 dB gain, 0.5 dB noise figure and +22 dBm OIP3 at 45 mA. The TR0329M is housed in a compact, low-cost 3.5×3.5 mm^2 20-lead Quad Flat No-lead (QFN) plastic package.

TR0329M-EVB-B is an evaluation board tuned for the 2300 – 2700 MHz band at 5 V, for wireless infrastructure, TDD massive MIMO, active antenna systems. This application note gives the schematic, bill of materials, biasing sequence and test set-up of the board, and its measured S-parameters, noise figure, gain compression and third-order intercept point in high-gain and low-gain mode.

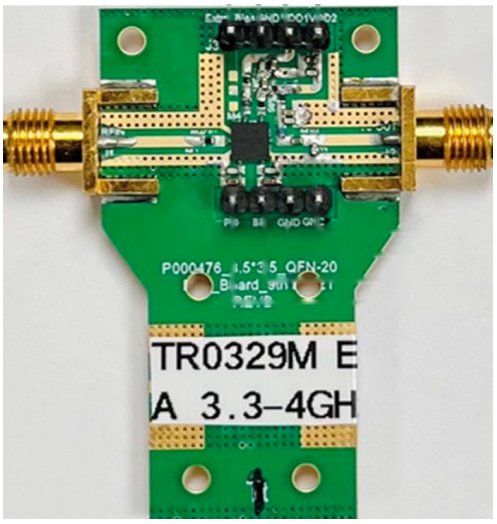

Figure 1: TR0329M evaluation board (EVB A shown; EVB B uses the same PCB).

Evaluation Board Highlights

- Frequency range 2300 MHz to 2700 MHz
- $V_{DD1} = V_{DD2} = 5$ V; 90 mA in high-gain mode (HG), 45 mA in low-gain mode (LG), 5 mA in power-down mode
- Gain: 36.9 – 37.1 dB (HG), 16.7 – 18.0 dB (LG)
- Noise figure (de-embedded): 0.53 – 0.58 dB (HG), 0.56 – 0.62 dB (LG)
- OP_{1dB}: 17 – 18.5 dBm (HG), 10 – 12 dBm (LG)
- OIP3: 30 – 31 dBm (HG, 0 dBm per tone), 21 – 23 dBm (LG, -2 dBm per tone), 1 MHz spacing
- Input return loss (S_{11}): -15.1 to -11.2 dB (HG), -13.1 to -11.4 dB (LG)
- Isolation RF_{IN} to RF_{OUT} in power-down mode: 55 dB at 2.5 GHz

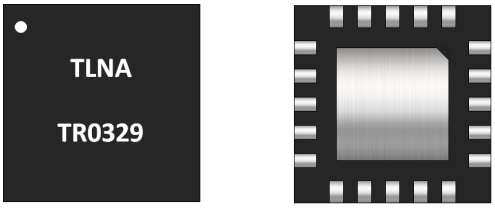

Figure 2: TR0329M in 3.5 x 3.5 mm^2 QFN 20-pin package.

RoHS10/REACH/Halogen free

Related Documents

TR0329M datasheet: electrical specifications, package information and all evaluation boards.

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

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Ordering Information

Table 1: Ordering information

Part Number	Description	Notes
TR0329M-EVB-B	Evaluation board	Tuned, 2300 – 2700 MHz, 5 V, 90 mA (HG) / 45 mA (LG)
TR0329M	20 Pin 3.5x3.5x0.75 mm^3 QFN	Core part number

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TR0329M-EVB-B Board Details

The board uses a Rogers RO4350B, 20 mil, 1 oz copper PCB with SMA connectors on $\mathrm{RF_{IN}}$ and $\mathrm{RF_{OUT}}$, a header J3 for $\mathrm{V_{DD1}}$, $\mathrm{V_{DD2}}$ and ground, and a header J4 for the control inputs $\mathrm{V_{PD}}$ (PD), $\mathrm{V_{BYP}}$ (BP) and ground. The input is connected through the 220 pF series capacitor M1, the output through the 220 pF series capacitor M2 (the shunt position M3 is not assembled). The first stage is supplied from $\mathrm{V_{DD1}}$ through R2 (0 Ω) and the 8.2 nH choke L1 on pin 19, decoupled by C1 and C2. The output stage is supplied from $\mathrm{V_{DD2}}$ through R4 (15 Ω) and the 8.2 nH choke L2 on the $\mathrm{RF_{OUT}}$ pin, decoupled by C4 to C7; pin 16 is fed from $\mathrm{V_{DD2}}$ through R3 (150 Ω) and R1 (0 Ω), decoupled by C3. The control inputs are decoupled by C8, C9 ($\mathrm{V_{PD}}$) and C10, C11 ($\mathrm{V_{BYP}}$). Component positions that are not assembled are shown dashed grey in the schematic and marked DNP (Do Not Populate) in the bill of materials.

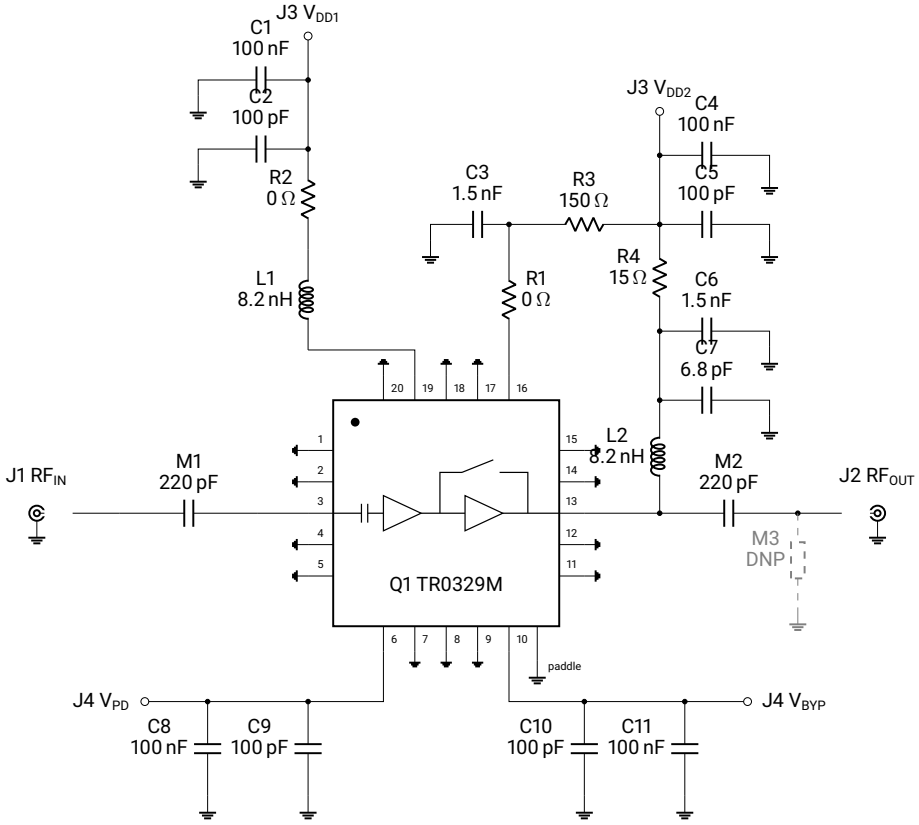

Figure 3: Schematic of TR0329M-EVB-B, 2300 – 2700 MHz. Dashed grey positions are not assembled (DNP).

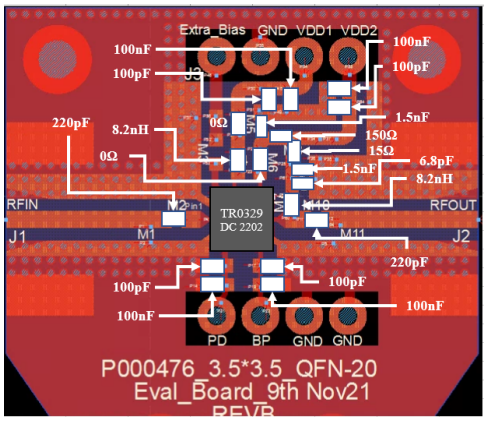

Figure 4: Layout of TR0329M-EVB-B with component values.

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TR0329M-EVB-B Bill of Materials

Table 2: Bill of materials, TR0329M-EVB-B

Component ID	Value	Manufacturer	Recommended part number
R1, R2	0 Ω	Panasonic	ERJ-2GE0R00X
R3	150 Ω	Panasonic	ERJ-2RHD1500X
R4	15 Ω	Panasonic	ERJ-H2RD15R0X
L1, L2	8.2 nH	Coilcraft / Würth Elektronik	0402HP-8N2XGE / 744916039
M1[1], M2	220 pF	Kemet	C0402C221K5GACAUTO
C7	6.8 pF	Murata	GJM1555C1H6R8BB01D
C2, C5, C9, C10	100 pF	AVX	04025A101JAT4A
C3, C6	1.5 nF	Murata	04025C152JAT2A
C1, C4, C8, C11	100 nF	TDK	C1005X7R1H104K050BE
M3	DNP		
Q1	LNA module	TagoreTech	TR0329M
PCB	Rogers RO4350B, 20 mil, 1 oz copper		

[1] M1 (220 pF series capacitor at the input) is shown in the schematic but was missing in the previous bill of materials, which listed M2 only; the schematic is the reference.

TR0329M-EVB-B 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 input transistor 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 slightly above the 90 mA high-gain current, and make sure that the supply does not overshoot V_{DD1} or V_{DD2} 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 TR0329M is ESD sensitive (HBM class 1B); handle the board with ESD precautions and connect the ground before any other connection.

Table 3: TR0329M-EVB-B 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_{DD1} and V_{DD2} to +5 V.	2. Turn V_{DD1} and V_{DD2} off.
3. Set BP to 0 V (high gain) or +5 V (low gain).	3. Turn BP and PD off (0 V).
4. Set PD to 0 V and check the current: about 90 mA (HG) or 45 mA (LG).	4. Disconnect the ground last.
5. Apply the RF power.	

The operating mode is selected with the control inputs: PD = BP = 0 V for high-gain mode (both stages on), PD = 0 V and BP = +5 V for low-gain mode (second stage bypassed), and PD = +5 V for power-down mode (about 5 mA). A current clearly different from these values indicates a wrong supply voltage, a wrong control level or an assembly problem, and the RF power should not be applied before the cause is found. When V_{DD1} and V_{DD2} are supplied from the same 5 V source, as in the test set-up of Figure 5, 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.

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Test Set-up

The TR0329M-EVB-B is shipped fully assembled and tested. Figure 5 shows the basic test set-up for evaluating the S-parameters (gain, input and output return loss, reverse isolation) in high-gain, low-gain and power-down mode with a vector network analyzer.

1. Connect the ground test point to the ground terminal of the power supply.
2. Connect the V_{DD1} and V_{DD2} test points to the output of a 5 V supply capable of sourcing approximately 90 mA.
3. Connect BP and PD to ground for high-gain mode; for low-gain mode connect BP to +5 V and PD to ground; PD = +5 V switches the board to power-down mode.
4. Connect a calibrated network analyzer to the RF_{IN} and RF_{OUT} SMA connectors. Sweep the frequency from 10 MHz to 8.5 GHz with a source power of -25 dBm.

The TR0329M-EVB-B is expected to show a gain of about 37 dB in high-gain mode and 17 dB in low-gain mode at 2.5 GHz; see Table 5 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.

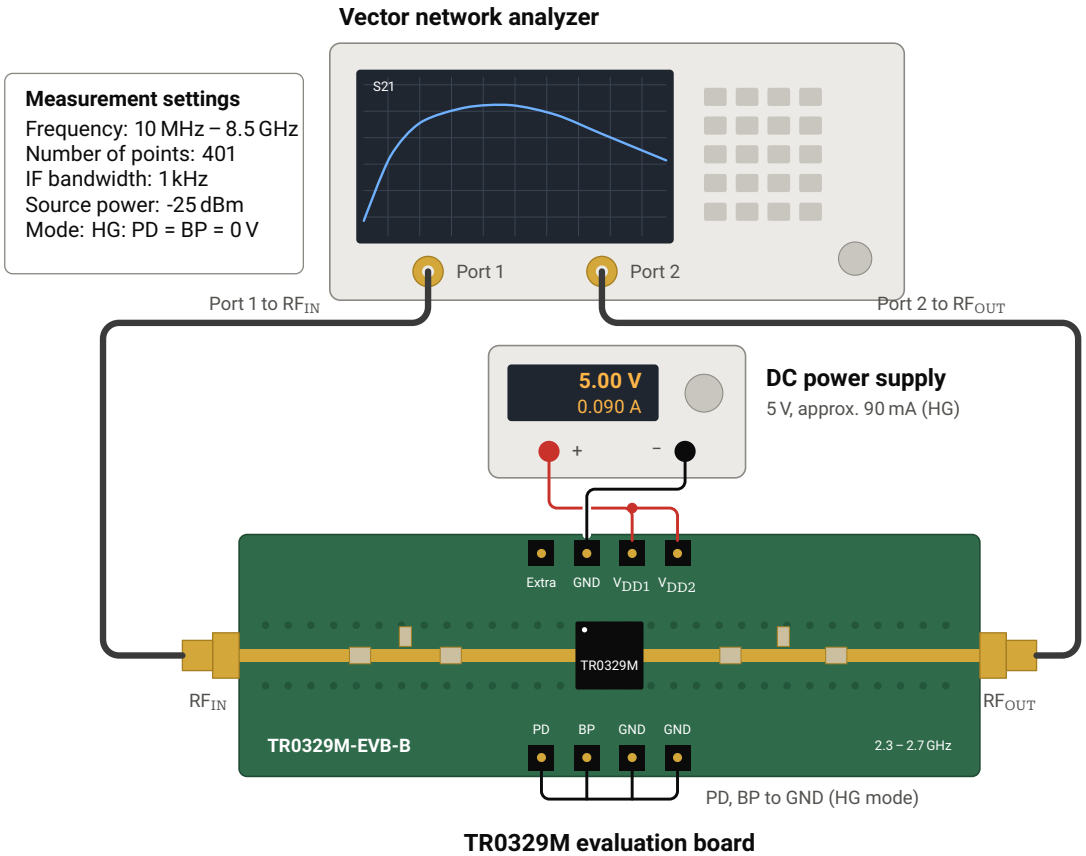

Figure 5: Test set-up for S-parameter measurements.

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TR0329M-EVB-B Measurement Summary

All measurements are carried out at room temperature, $V_{DD1} = V_{DD2} = 5$ V, with the reference planes at the SMA connectors; HG: PD = BP = 0 V, LG: PD = 0 V, BP = 5 V. The S-parameters are shown as network-analyzer screenshots in high-gain and low-gain mode, with markers in the 2300 – 2700 MHz band; the lower trace is the stability factor μ_1 (load side, $\mu_1 > 1$ indicates unconditional stability). The noise figure is de-embedded to the device reference plane. Gain and gain compression are measured with a single tone, the output third-order intercept point with two tones 1 MHz apart.

Table 4: TR0329M-EVB-B electrical characteristics summary, $V_{DD1} = V_{DD2} = 5$ V, $T_A = +25$°C

Parameter	Test Condition	Minimum	Typical	Maximum	Unit
Gain	HG, across the band		36.8 – 37		dB
	LG, across the band		16.7 – 18		dB
Noise figure	HG, across the band		0.5 – 0.6		dB
	LG, across the band		0.5 – 0.6		dB
EVB noise figure	HG, across the band		0.6 – 0.7		dB
	LG, across the band		0.6 – 0.7		dB
Input return loss	HG, across the band		< -11		dB
	LG, across the band		< -11		dB
Output return loss	HG, across the band		< -11		dB
	LG, across the band		< -5.5		dB
OP_{1dB}	HG, across the band		17 – 18.5		dBm
	LG, across the band		10 – 12		dBm
OIP3	HG, 0 dBm per tone, tone spacing 1 MHz		30 – 31		dBm
	LG, -2 dBm per tone, tone spacing 1 MHz		21 – 23		dBm
Supply current, I_{DD}	HG		90		mA
	LG		45		mA
	PD		5		mA
Isolation RF_{IN} to RF_{OUT}	PD, bypass on (BP = 5 V), 2.5 GHz		55		dB
	PD, bypass off (BP = 0 V), 2.5 GHz		50		dB

Table 5: TR0329M-EVB-B small-signal performance and noise figure vs. frequency, $T_A = +25$°C

	High-gain mode (HG)				Low-gain mode (LG)			
Frequency [MHz]	NF[1] [dB]	Gain [dB]	S_{11} [dB]	S_{22} [dB]	NF[1] [dB]	Gain [dB]	S_{11} [dB]	S_{22} [dB]
2300	0.54	37.0	-11.2	-11.0	0.56	18.0	-11.4	-5.5
2400	0.53	37.0	-12.0	-11.2	0.58	17.7	-11.9	-5.7
2500	0.53	37.1	-12.5	-11.2	0.59	17.2	-12.3	-5.8
2600	0.58	37.0	-13.7	-11.7	0.58	17.0	-12.9	-6.0
2700	0.58	36.9	-15.1	-12.3	0.62	16.7	-13.1	-6.4

[1] De-embedded: the losses of the input connector and trace are removed.
Gain and return loss are network-analyzer marker readings at the marker frequencies, see Figures 6 and 7. Reverse isolation S_{12}: -58.3 to -56.2 dB (HG), -32.7 to -31.7 dB (LG); stability factor μ_1: 3.1 – 3.3 (HG), 1.5 – 1.6 (LG).

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TR0329M-EVB-B Measurement Results

S-parameters

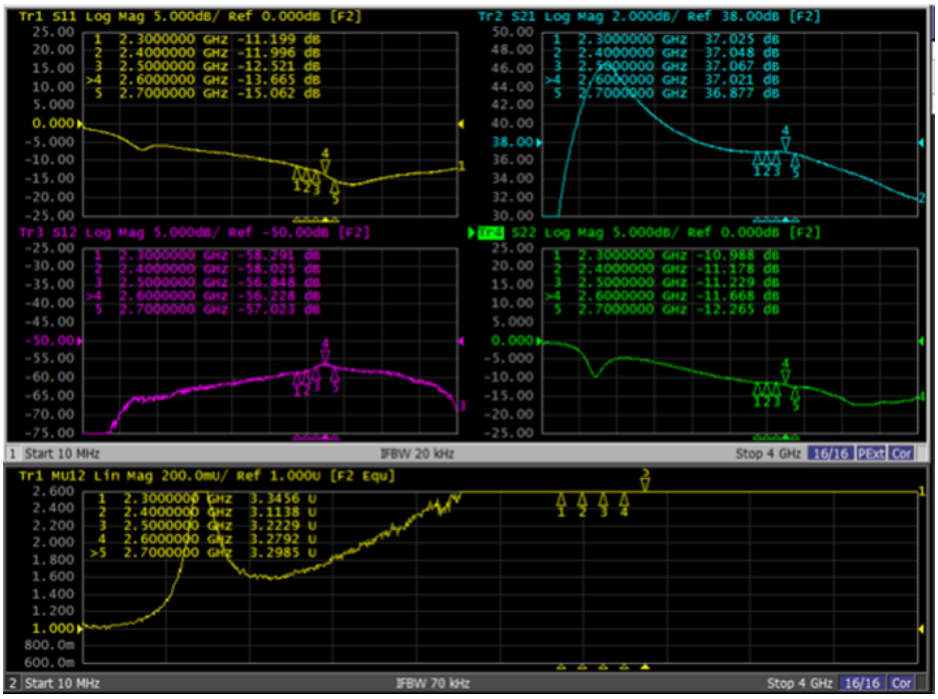

Figure 6: TR0329M-EVB-B S-parameters in high-gain mode, 10 MHz to 8.5 GHz: S_{11}, S_{21}, S_{12}, S_{22} and stability factor μ_1 (bottom), +25°C, 5 V.

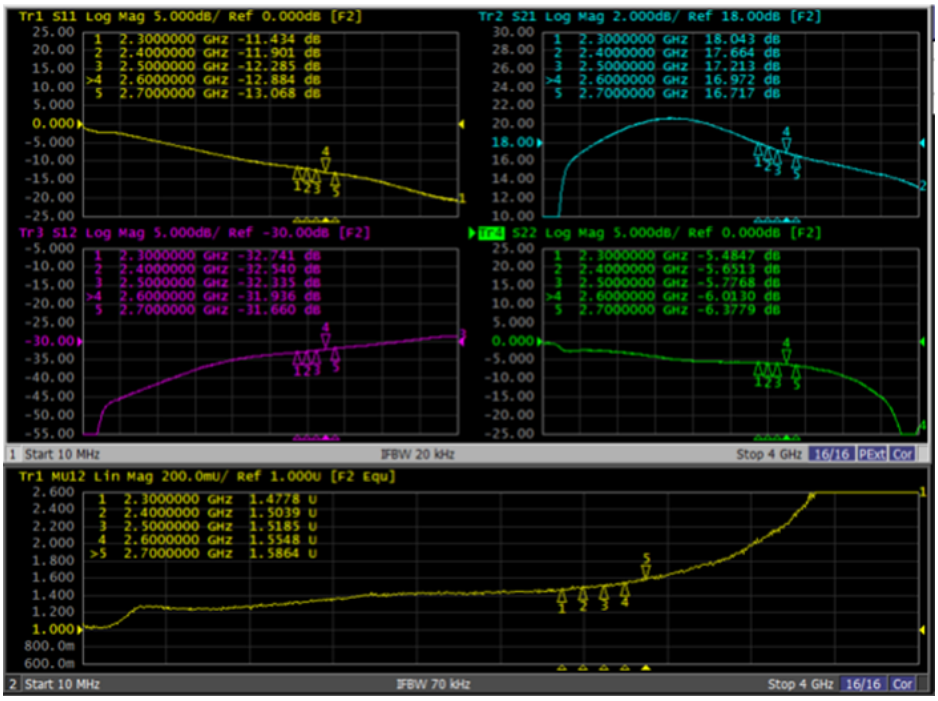

Figure 7: TR0329M-EVB-B S-parameters in low-gain mode, 10 MHz to 4 GHz: S_{11}, S_{21}, S_{12}, S_{22} and stability factor μ_1 (bottom), +25°C, 5 V.

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Noise figure and large-signal performance

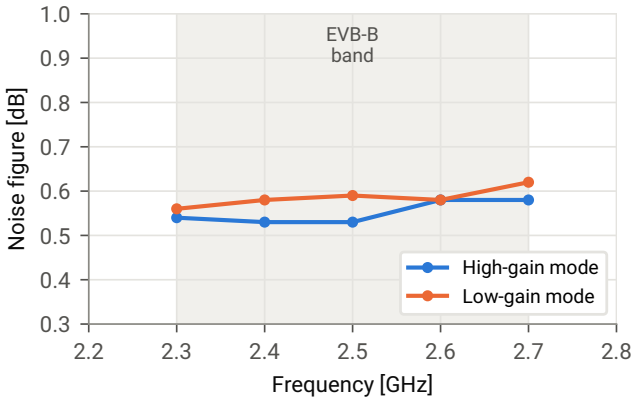
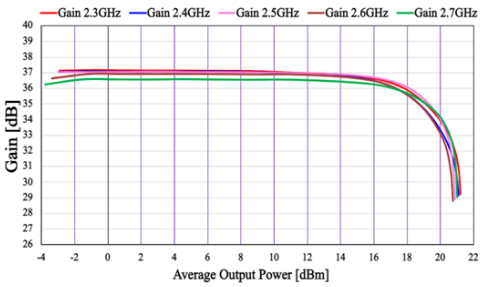
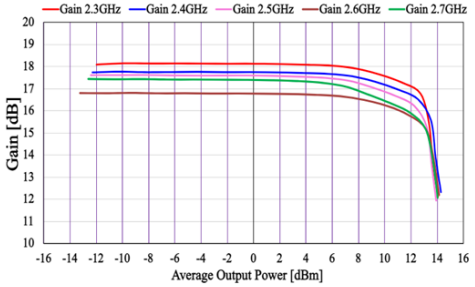


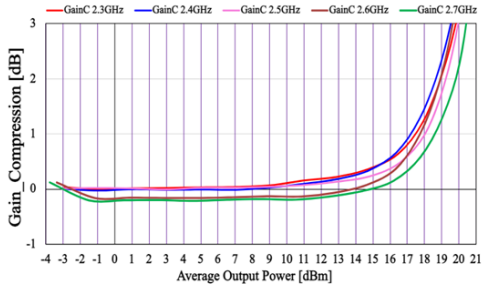
Figure 8: TR0329M-EVB-B de-embedded noise figure vs. frequency, high-gain (HG) and low-gain (LG) mode, +25°C, 5 V.



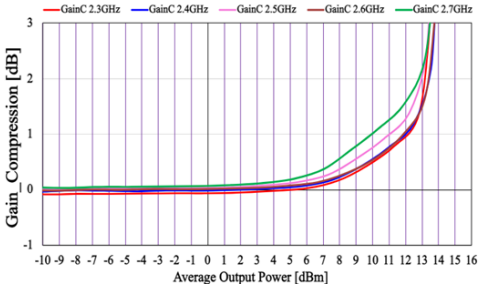
(a) Gain vs. output power, high-gain mode.



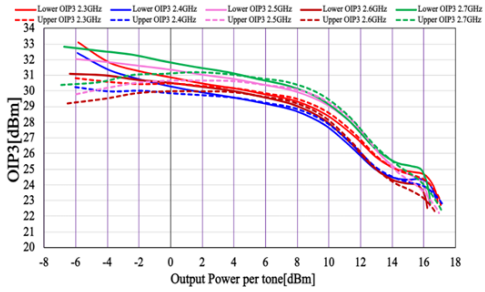
(b) Gain vs. output power, low-gain mode.



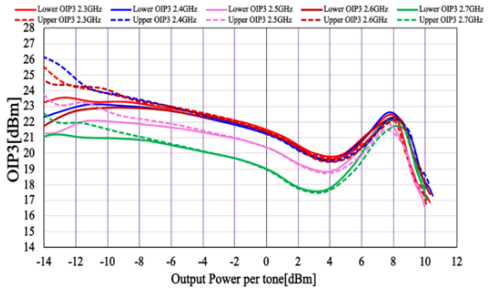
(c) Gain compression vs. output power, high-gain mode.



(d) Gain compression vs. output power, low-gain mode.



(e) OIP3 vs. output power per tone, high-gain mode.



(f) OIP3 vs. output power per tone, low-gain mode.

Figure 9: TR0329M-EVB-B large-signal performance in the 2300 – 2700 MHz band, +25°C, 5 V. OIP3 with two tones 1 MHz apart.

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Changelog

Table 6: Changelog

Date	Revision	Notes
07/30/2024	2.1	Application note in the previous format.
10/16/2026	3.0	Application note converted to the common TagoreTech document template: schematic redrawn with the not-assembled position M3 marked DNP, bill of materials corrected to match the schematic (M1), biasing sequence and test set-up redrawn, measurement summary per frequency added from the network-analyzer markers and the noise figure data, de-embedded noise figure redrawn as vector graphics from the measured data, links to the TR0329M datasheet and application notes TN-001/TN-002, QR code link to the latest version.

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