

## Features

- Frequency Range 2.4 GHz to 2.5 GHz
- Supply Voltage 2.7 V to 3.6 V
- 21 dBm Linear Output Power for IEEE 802.11b Mode
- 3.5% EVM at 15.5 dBm Output Power for IEEE 802.11g Mode
- On-chip Power Detector with 20 dB Dynamic Range
- Power-down Mode and Biasing Control
- No External Components for Input Matching
- Low Profile Plastic Package QFN16 (4 × 4 × 0.9 mm)

## Benefits

- IEEE 802.11b WLAN
- IEEE 802.11g OFDM WLAN
- PC Cards, PCMCIA
- 2.4 GHz ISM Band Application

Electrostatic sensitive device.  
Observe precautions for handling.



## Description

### Circuitry

The PA's is designed for low current-consumption 802.11b and 802.11g multi-mode applications such as Mini-PCI and PCMCIA for portable devices. The low profile plastic package with internal input matching to 50  $\Omega$  minimizes the PCB board-space and allows simplified integration with very few passive components. The on-chip power-detector provides a voltage linear to the output power while the standby/bias control logic provides power saving and shutdown as well as a linear adjustment of output power. The PA is realized as a two stage PA with internal interstage-matching and an open-collector output structure.

### Process

The power amplifier is designed in Atmel's Silicon-Germanium (SiGe) process and provides excellent linearity and noise performance, high gain as well as good power-added efficiency.



## 2.4-GHz SiGe Power Amplifier for 802.11b/g WLAN Systems

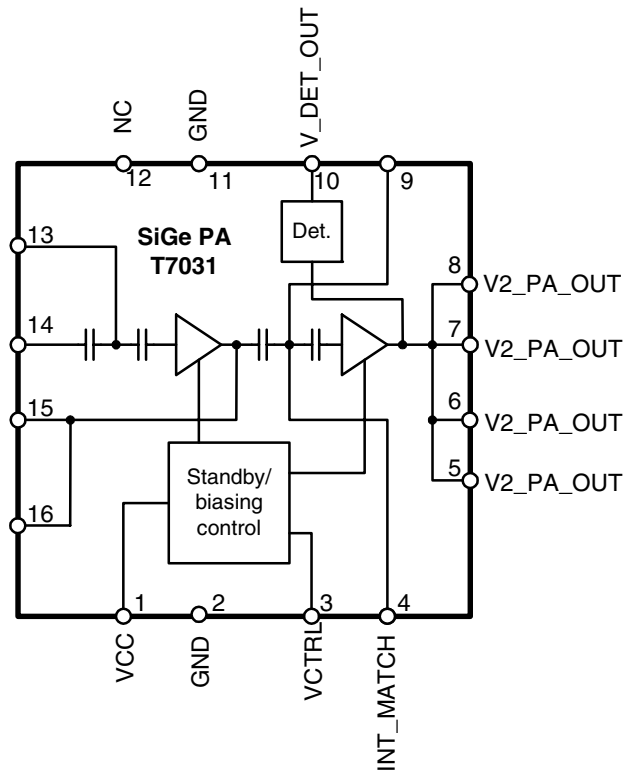
T7031

Preliminary

Rev. 4564F-WLAN-07/04

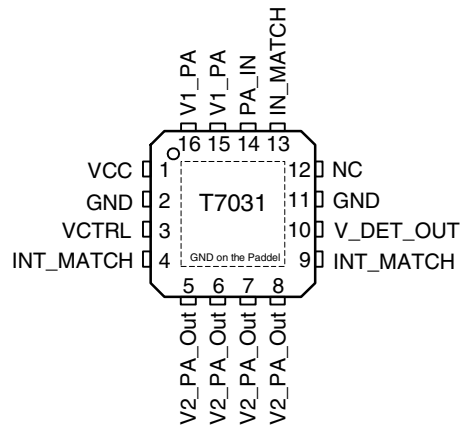


Figure 1. Block Diagram



## Pin Configuration

Figure 2. Pinning QFN16



## Pin Description

Pin	Symbol	Function
1	VCC	Supply voltage
2	GND	Ground
3	VCTRL	Power-up/biasing control voltage
4	INT_MATCH	Interstage matching (must not be connected)
5	V2_PA_Out	Power amplifier output and supply voltage for 2 <sup>nd</sup> power amplifier stage
6	V2_PA_Out	Power amplifier output and supply voltage for 2 <sup>nd</sup> power amplifier stage
7	V2_PA_Out	Power amplifier output and supply voltage for 2 <sup>nd</sup> power amplifier stage
8	V2_PA_Out	Power amplifier output and supply voltage for 2 <sup>nd</sup> power amplifier stage
9	INT_MATCH	Interstage matching (must not be connected)
10	V_DET_OUT	Power detector output
11	GND	Ground
12	NC	Not connected
13	IN_MATCH	Input matching (must not be connected)
14	PA_IN	Power amplifier input
15	V1_PA	Supply voltage for 1 <sup>st</sup> power amplifier stage
16	V1_PA	Supply voltage for 1 <sup>st</sup> power amplifier stage
Slug	–	Ground

## Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameters	Symbol	Value	Unit
Supply voltage, no RF voltage applied	$V_{CC}$	6	V
Supply current	$I_{CC}$	200	mA
Junction temperature	$T_j$	150	°C
Storage temperature	$T_{Stg}$	-40 to +125	°C
Input RF power	$P_{IN}$	12	dBm
Control voltage power up/down and biasing	$V_{CTRL}$	0 to 3	V

Note: The part may not survive all maximums applied simultaneously.

## Thermal Resistance

Parameters	Symbol	Value	Unit
Junction ambient	$R_{thJA}$	45	K/W

## Operating Range

Parameters	Symbol	Value	Unit
Supply voltage range	$V_{CC}$	2.7 to 3.6	V
Ambient temperature range	$T_{amb}$	-30 to +80	°C

## Electrical Characteristics

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
1.0	Supply voltage			$V_{CC}$	2.7	3.3	3.6	V	A
1.1	Frequency Range			f	2400		2500	MHz	A
1.2	Control voltage range	PA operating mode		$V_{CTRL}$	1		2	V	A
1.3		Power-down Mode		$V_{CTRL}$			0.2	V	A
1.4	Current Consumption	Quiescent		$I_{CQ}$		75		mA	A
1.5		Power-down mode		$I_{PD}$			10	μA	A

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

## Electrical Characteristics - Unmodulated Carrier

Test conditions (unless otherwise stated):  $V_{CC} = 3.3\text{ V}$ , Frequency = 2.45 GHz,  $T_{amb} = 25^\circ\text{C}$

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
2.0	Saturated output power	For reference		$P_{SAT}$		24		dBm	A
2.1	P1dB output Power			P1dB		23		dBm	A
2.2	2 <sup>nd</sup> harmonic rejection	$P_{OUT} = 18\text{ dBm}$ , with external matching		$2f_{OUT}$		30		dB	A
2.3	Small signal gain	$I_{CQ}$ , small signal condition		GL		22		dB	A
2.4	Reverse isolation	$I_{CQ}$ , small signal condition		ISOr		40		dB	A
2.5	Input 50 $\Omega$ VSWR	$I_{CQ}$ , small signal condition		VSWRin			2:1		C
2.6	Output 50 $\Omega$ VSWR	$I_{CQ}$ , small signal condition, with external matching		VSWRout			2:1		C

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

## Electrical Characteristics - 11 Mbps CCK Modulation

Test conditions (unless otherwise stated):  $V_{CC} = 3.3\text{ V}$ , Frequency = 2.45 GHz,  $T_{amb} = 25^\circ\text{C}$ , IEEE 802.11b conform 11 Mbps CCK modulation with gaussian transmit filtering

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
3.0	Maximum linear output power	ACPR1 $\geq 33\text{ dBc}$ ACPR2 $\geq 55\text{ dBc}$		$P_{LIN}$		21		dBm	A
3.1	Linear power gain	$P_{OUT} = P_{LIN}$ ACPR1 $\geq 33\text{ dBc}$ ACPR2 $\geq 55\text{ dBc}$		GL		22		dB	A
3.2	Current Consumption	$P_{OUT} = P_{LIN}$ ACPR1 $\geq 33\text{ dBc}$ ACPR2 $\geq 55\text{ dBc}$		$I_{CC}$		130		mA	A

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

## Electrical Characteristics - 54 Mbps OFDM Modulation

Test conditions (unless otherwise stated):  $V_{CC} = 3.3\text{ V}$ , Frequency = 2.45 GHz,  $T_{amb} = 25^\circ\text{C}$ , IEEE 802.11g conform 54 Mbps OFDM modulation, 0.7% EVM measurement equipment noise floor included in EVM measurement result.

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
4.0	Error vector magnitude	$P_{OUT} = 15.5\text{ dBm}$		EVM		3.5		%	C
4.1	Linear power gain	$P_{OUT} = 15.5\text{ dBm}$		GL		22		dB	A
4.2	Current consumption	$P_{OUT} = 15.5\text{ dBm}$		$I_{CC}$		85		mA	A

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

## Power Detector

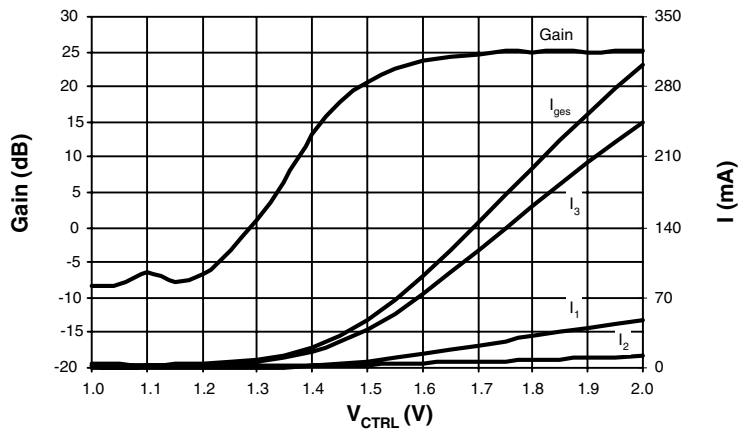
Test conditions (unless otherwise stated):  $V_{CC} = 3.3\text{ V}$ , Frequency = 2.45 GHz,  $T_{amb} = 25^\circ\text{ C}$

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
5.0	Detector voltage range	$P_{OUT} = 2\text{ to }22\text{ dBm}$		$V_{DET}$	0		2	V	A
5.1	Settling time			$t_{SET}$		0.5		$\mu\text{s}$	C

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

## Typical Operating Characteristics

**Figure 3.** Typical Gain and Current versus Control Voltage  
Frequency = 2450 MHz,  $P_{IN} = -40\text{ dBm}$ ,  $V_{CC} = 3.3\text{ V}$



**Figure 4.** S-parameter, Magnitude

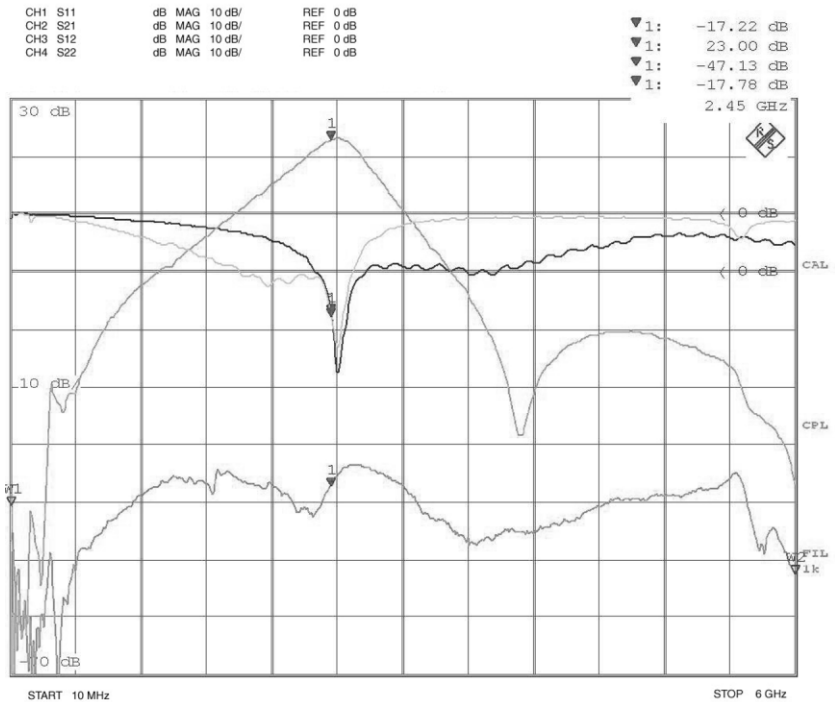


Figure 5. S-parameters, Magnitude and Phase

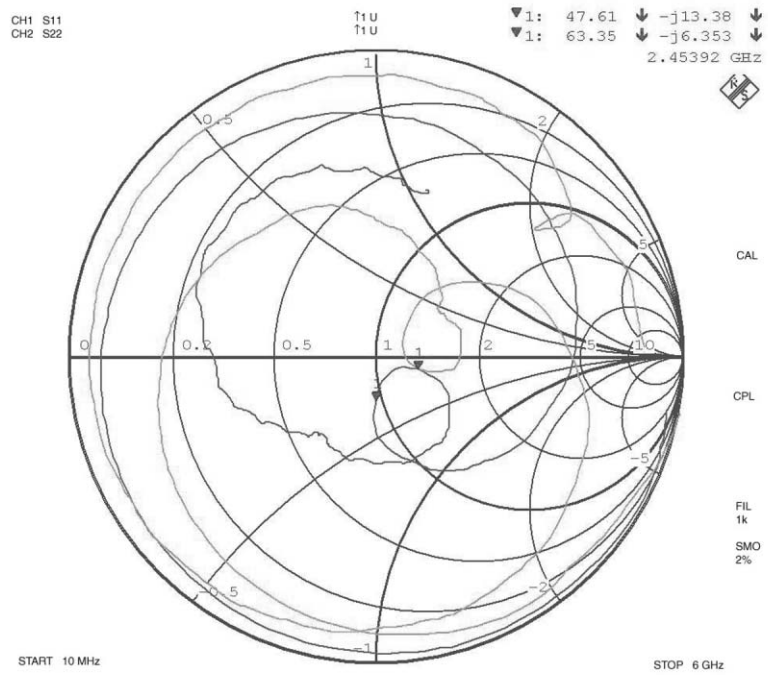
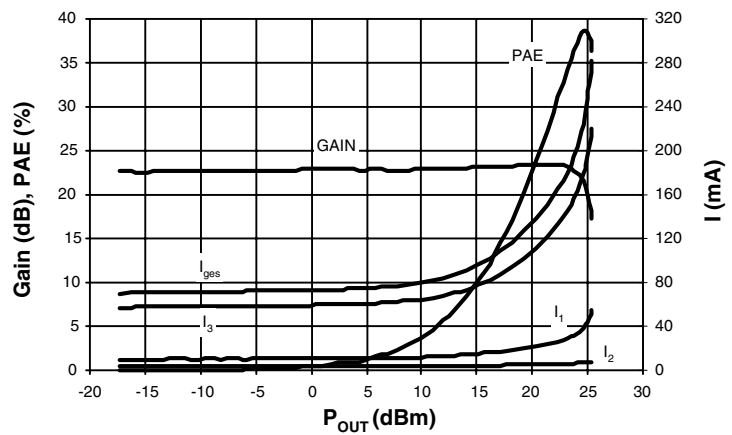
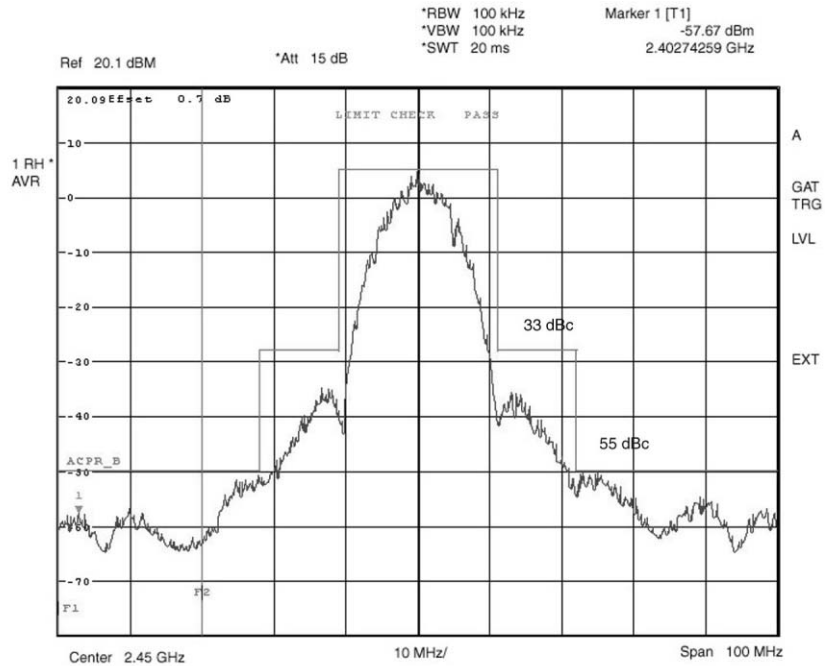


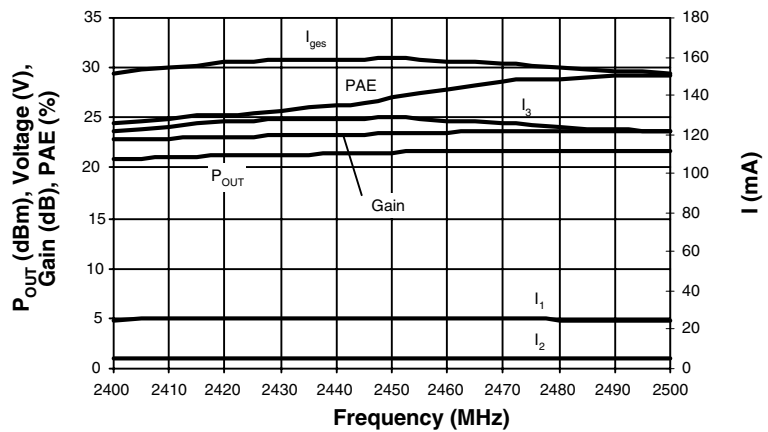
Figure 6. Power-sweep, CW-mode  
Frequency = 2450 MHz,  $V_{CC} = 3.3$  V,  $V_{CTRL} = 1.56$  V



**Figure 7.** CCK-modulation Spectrum Conforming Compliance to 802.11b Spectral Mask (3/5 db Additional Margin at ACPR 1/2 Compared to Limit Given by IEEE802.11b Standard) at  $P_{OUT} = 21$  dBm,  $V_{CC} = 3.3$  V,  $V_{CTRL} = 1.56$  V

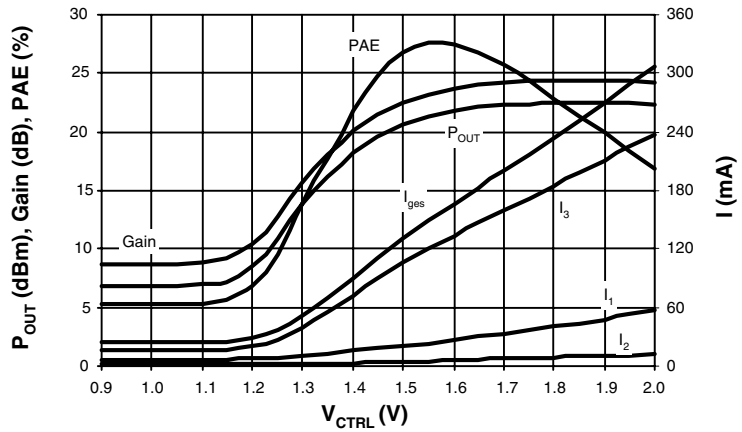


**Figure 8.** Frequency-sweep at  $P_{IN} = -1.9$  dBm,  $V_{CC} = 3.3$  V,  $V_{CTRL} = 1.56$  V (ACPR Limit), CW-mode

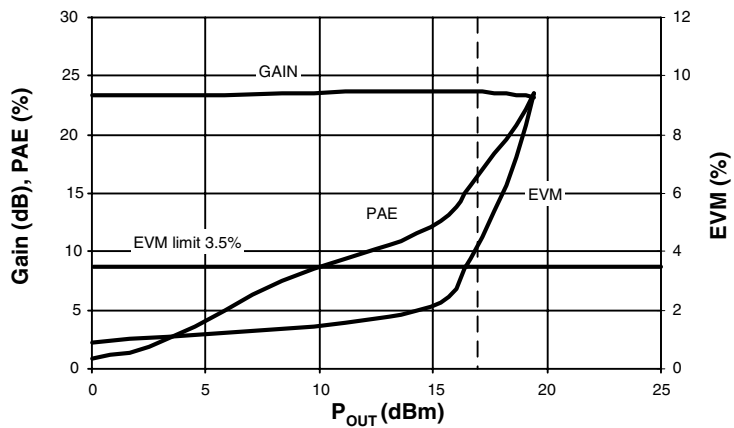




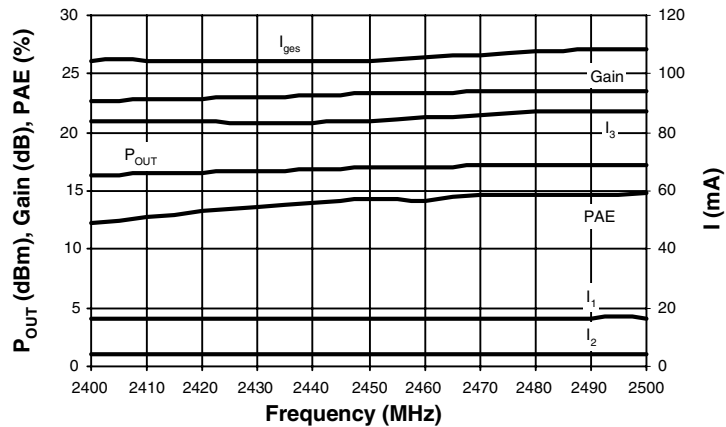
**Figure 9.**  $V_{CTRL}$ -sweep at Maximum Linear  $P_{OUT}$  (ACPR Limit), CW-mode, Frequency = 2450 MHz,  $P_{IN} = -1.9$  dBm,  $V_{CC} = 3.3$  V



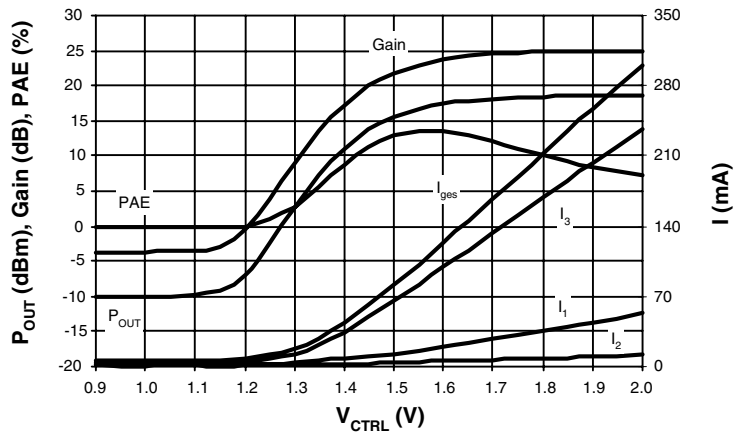
**Figure 10.** Error Vector Magnitude (EVM) for 54 MBit OFDM-modulation, Power Added Efficiency (PAE), Gain versus  $P_{OUT}$



**Figure 11.** Frequency-sweep at EVM = 3.5% (EVM limit), CW-mode  $P_{IN} = -6.3$  dBm,  $V_{CC} = 3.3$  V,  $V_{CTRL} = 1.56$  V



**Figure 12.**  $V_{CTRL}$ -sweep at EVM = 3.5% (EVM limit), CW-mode  
 Frequency = 2450 MHz,  $P_{IN}$  = -6.3 dBm,  $V_{CC}$  = 3.3 V



**Figure 13.** Power Detector Voltage versus  $P_{OUT}$  (Unmodulated Carrier), CW-Mode  
 Frequency = 2450 MHz,  $V_{CC}$  = 3.3 V,  $V_{CTRL}$  = 1.56 V

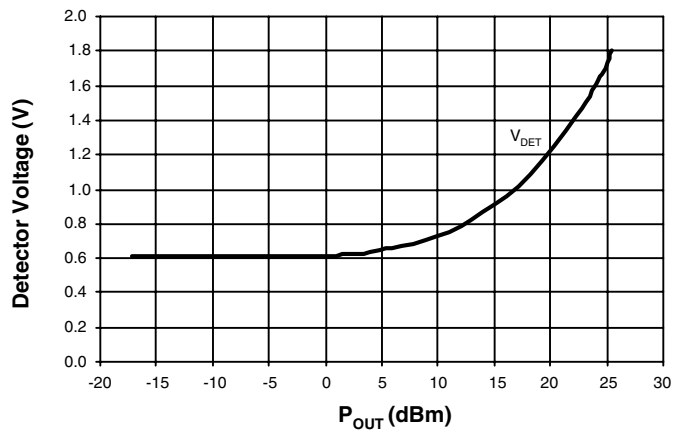


Figure 14. Power Detector Response Rising Edge

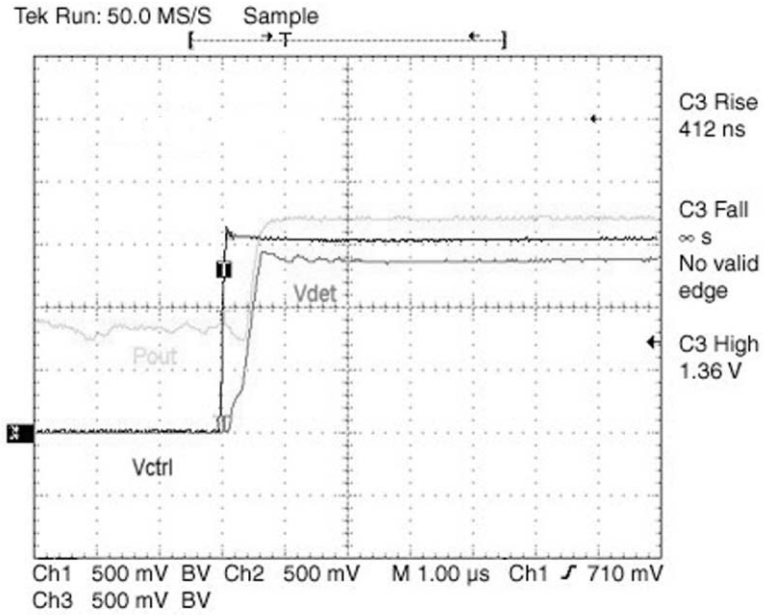
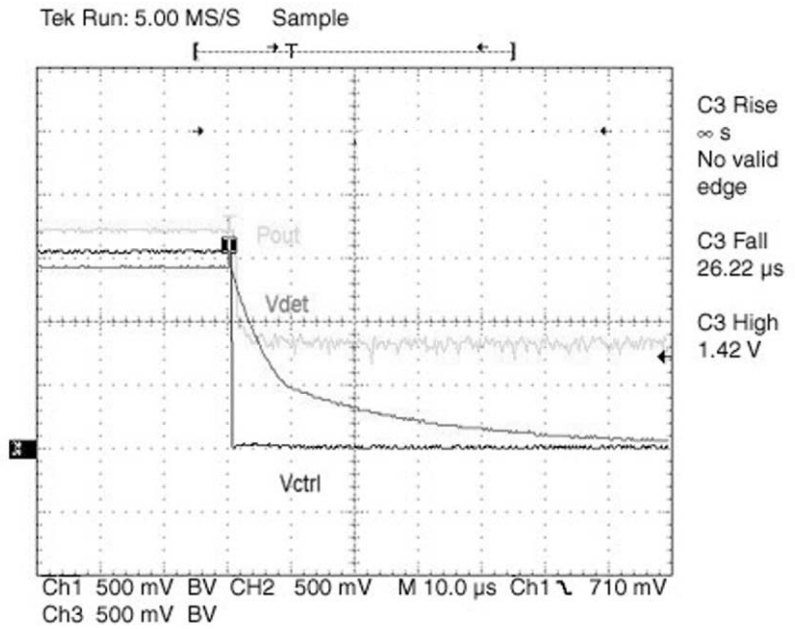
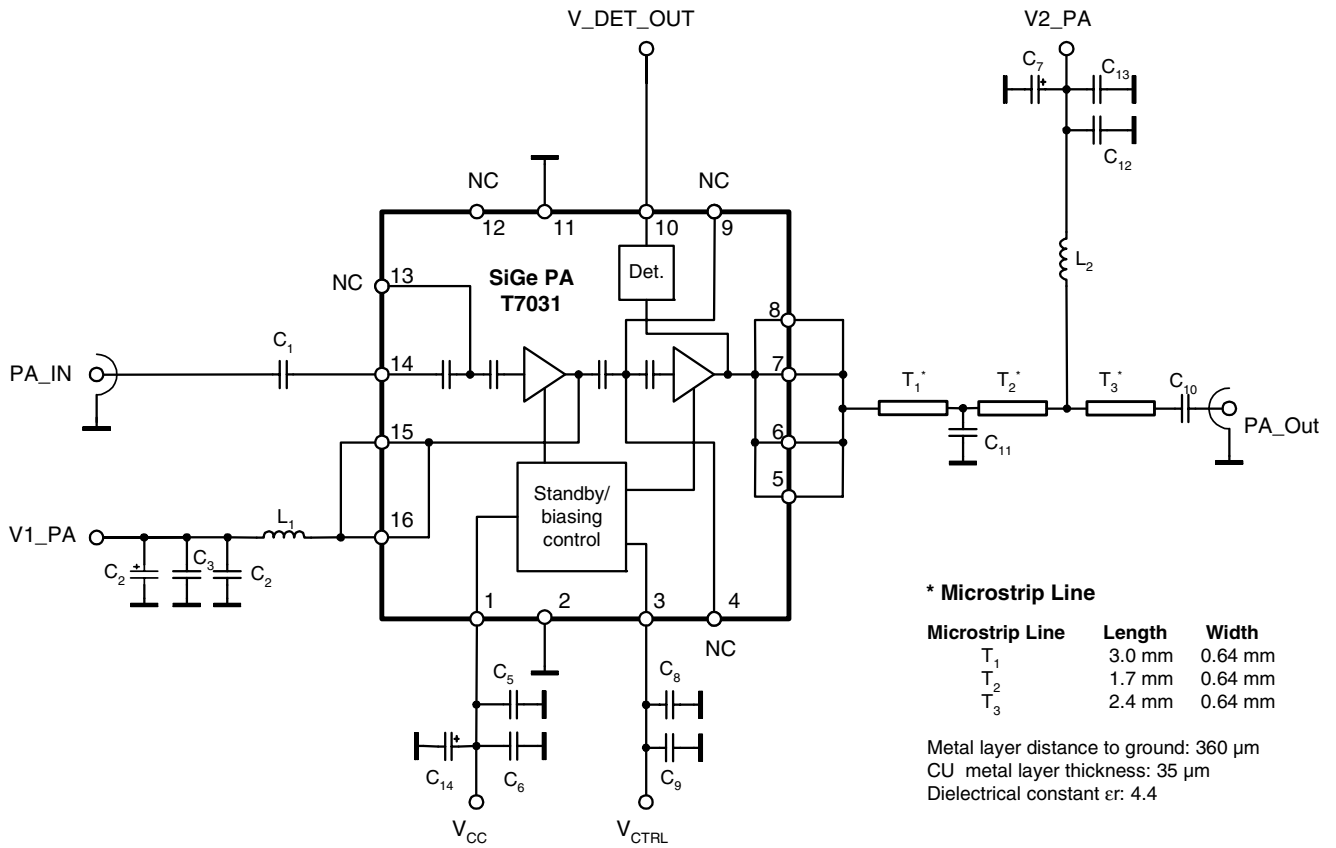


Figure 15. Power Detector Response Falling Edge



# Evaluation Board Schematic

Figure 16. Schematic of the Evaluation Board



**\* Microstrip Line**

Microstrip Line	Length	Width
T <sub>1</sub>	3.0 mm	0.64 mm
T <sub>2</sub>	1.7 mm	0.64 mm
T <sub>3</sub>	2.4 mm	0.64 mm

Metal layer distance to ground: 360 μm  
 CU metal layer thickness: 35 μm  
 Dielectrical constant εr: 4.4

## Evaluation Board Bill of Materials

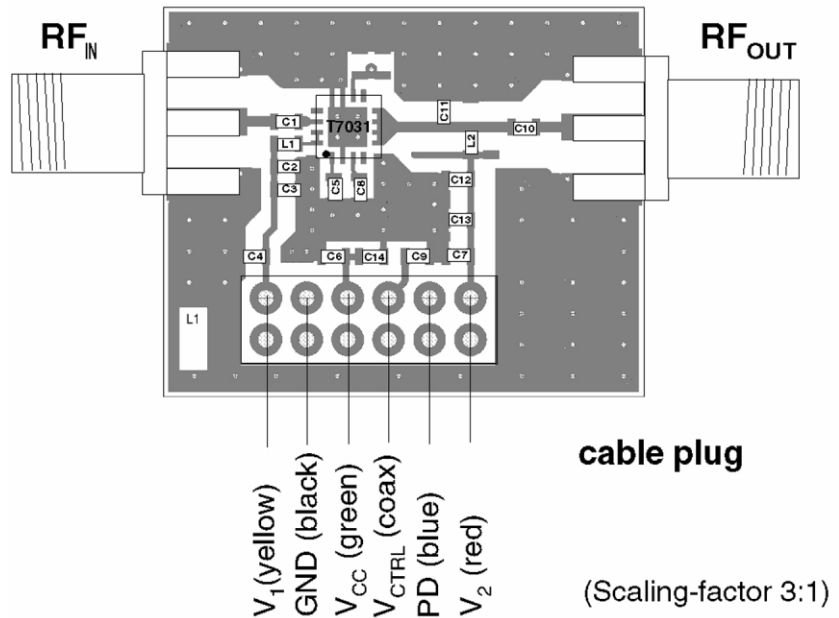
**Table 1.** Bill of Materials of the Evaluation Board

Component	Reference	Value	Size
Capacitor	C <sub>1</sub>	4p7	0603
Capacitor	C <sub>2</sub>	56p	0603
Capacitor	C <sub>3</sub>	1n	0603
Capacitor	C <sub>4</sub> <sup>(1)</sup>	1μ	0603
Capacitor	C <sub>5</sub>	4p7	0603
Capacitor	C <sub>6</sub> <sup>(1)</sup>	1n	0603
Capacitor	C <sub>7</sub> <sup>(1)</sup>	1μ	0603
Capacitor	C <sub>8</sub>	4p7	0603
Capacitor	C <sub>9</sub> <sup>(1)</sup>	1n	0603
Capacitor	C <sub>10</sub>	4p7	0603
Capacitor	C <sub>11</sub>	2p2	0603
Capacitor	C <sub>12</sub>	56p	0603
Capacitor	C <sub>13</sub>	1n	0603
Capacitor	C <sub>14</sub> <sup>(1)</sup>	1μ	0603
Inductor	L <sub>1</sub>	22n	0603
Inductor	L <sub>2</sub>	15n	0603

Note: 1. Can be omitted at optimum DC supply

## Evaluation Board Layout

**Figure 17.** Layout of the Evaluation Board



## Evaluation Board Set-up Institutions

After connection of all cables (RF and DC):

- $V_{CC}, V_1, V_2 = 3.3 \text{ V}$
- Increase  $V_{CTRL}$  until 75 mA quiescent current is reached ( $V_{CTRL} \sim 1.55 \text{ V}$ , at frequency = 2450 MHz,  $P_{IN} = -40 \text{ dBm}$ )
- Unmodulated measurements:
  - Measure gain,  $P_{OUT}$ , PAE, currents,  $V_{DET}$  versus  $P_{IN}$ ,  $V_{CTRL}$ ,  $V_{CC}$ , frequency
- Modulated measurements: increase input power until desired linear output power is reached; this means in case of
  - 11 Mbps CCK Modulation →APCR measurement:  $P_{OUT} \sim 21 \text{ dBm}$
  - 54 Mbps OFDM Modulation →measurement of EVM (Error Vector Magnitude):  $P_{OUT} \sim 15.5 \text{ dBm}$

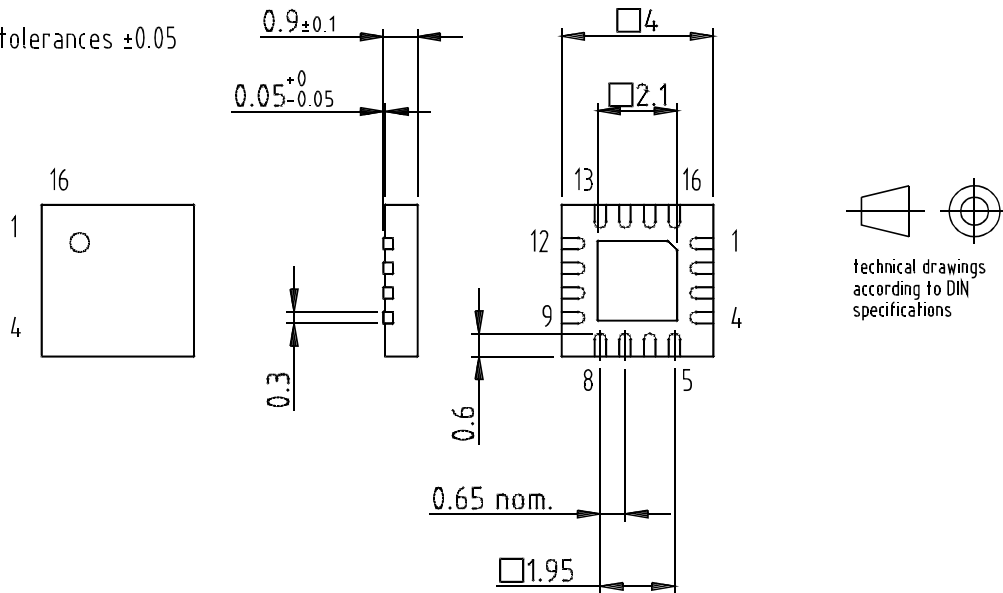
## Ordering Information

Extended Type Number	Package	Remarks	MOQ
T7031-PEP	QFN16 - 4 x 4	Taped and reeled	1500 pcs.
T7031-PEQ	QFN16 - 4 x 4	Taped and reeled	6000 pcs.
T7031-PEPM	QFN16 - 4 x 4	Taped and reeled Pb free, halogen free	1500 pcs.
T7031-PEQM	QFN16 - 4 x 4	Taped and reeled Pb free, halogen free	6000 pcs.
Demoboard-T7031	-	Evaluation board	1

## Package Information

Package: QFN 16 - 4x4  
 Exposed pad 2.1x2.1  
 (acc. JEDEC OUTLINE No. MO-220)  
 Dimensions in mm

Not indicated tolerances  $\pm 0.05$



Drawing-No.: 6.543-5090.01-4

Issue: 2; 24.01.03



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