



## Features

- Single 3-V Supply Voltage
- High Power-added Efficient Power Amplifier ( $P_{out}$  Typically 23 dBm)
- Ramp-controlled Output Power
- Low-noise Preamplifier (NF Typically 2.1 dB)
- Biasing for External PIN Diode T/R Switch
- Current-saving Standby Mode
- Few External Components
- Packages:
  - PSSO20
  - QFN20 with Extended Performance



## Bluetooth™/ISM 2.4-GHz Front- End IC

Electrostatic sensitive device.  
Observe precautions for handling.



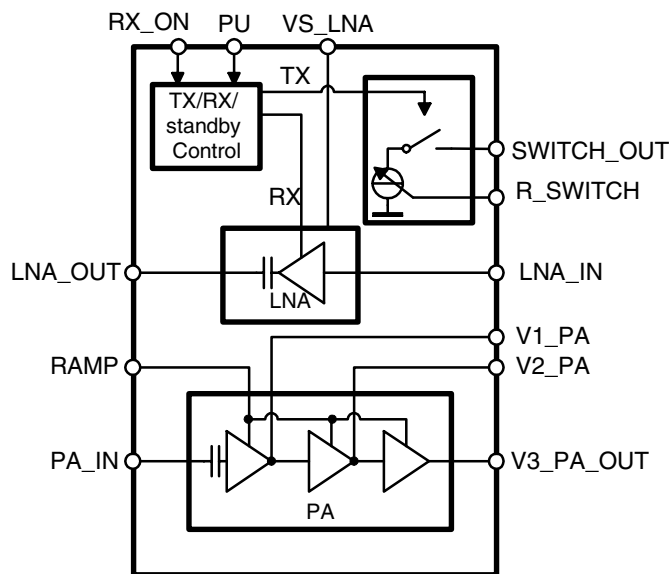
## T7024

## Description

The T7024 is a monolithic SiGe transmit/receive front-end IC with power amplifier, low-noise amplifier and T/R switch driver. It is especially designed for operation in TDMA systems like Bluetooth™ and WDC T.

Due to the ramp-control feature and a very low quiescent current, an external switch transistor for  $V_S$  is not required.

Figure 1. Block Diagram

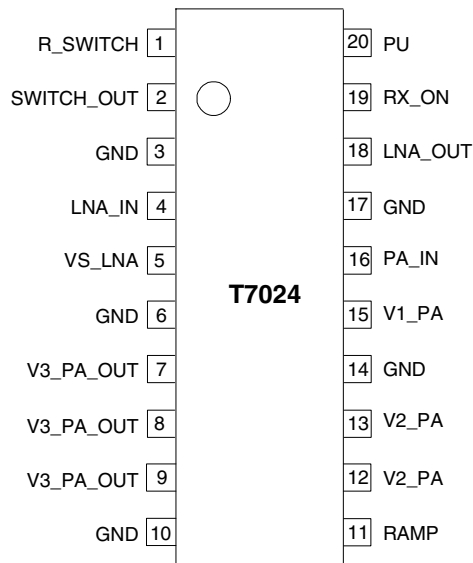


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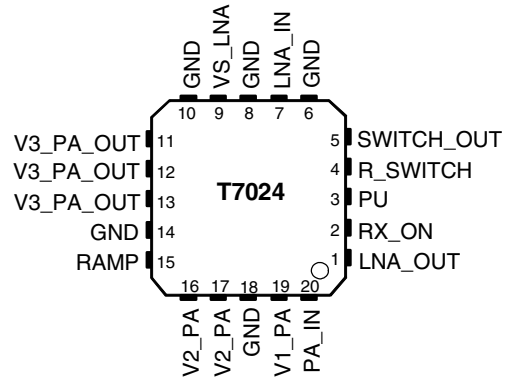


## Pin Configuration

**Figure 2.** Pinning PSSO20



**Figure 3.** Pinning QFN20



## Pin Description

Pins PSSO20	Pins QFN20	Symbol	Function
1	4	R_SWITCH	Resistor to GND sets the PIN diode current
2	5	SWITCH_OUT	Switched current output for PIN diode
3	6	GND	Ground
4	7	LNA_IN	Low-noise amplifier input
5	9	VS_LNA	Supply voltage input for low-noise amplifier
6	8	GND	Ground
7	11	V3_PA_OUT	Inductor to power supply and matching network for power amplifier output
8	12	V3_PA_OUT	Inductor to power supply and matching network for power amplifier output
9	13	V3_PA_OUT	Inductor to power supply and matching network for power amplifier output
10	10	GND	Ground
11	15	RAMP	Power ramping control input
12	16	V2_PA	Inductor to power supply for power amplifier
13	17	V2_PA	Inductor to power supply for power amplifier
14	14	GND	Ground
15	19	V1_PA	Supply voltage for power amplifier
16	20	PA_IN	Power amplifier input
17	18	GND	Ground
18	1	LNA_OUT	Low-noise amplifier output
19	2	RX_ON	RX active high
20	3	PU	Power-up active high
Slug	Slug	GND	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 Pins VS_LNA, V1_PA, V2_PA, V3_PA_OUT	$V_S$	6	V
Junction temperature	$T_j$	150	°C
Storage temperature	$T_{stg}$	-40 to +125	°C
RF input power LNA	$P_{inLNA}$	5	dBm
RF input power PA	$P_{inPA}$	10	dBm

## Thermal Resistance

Parameters	Symbol	Value	Unit
Junction ambient PSSOP20, slug soldered on PCB	$R_{thJA}$	19	K/W
Junction ambient QFN20, slug soldered on PCB	$R_{thJA}$	27	K/W

## Handling

Do not operate this part near strong electrostatic fields. This IC meets class 1 ESD test requirement (HBM in accordance to EIA/JESD22-A114-A (October 97) and class A ESD test requirement (MM) in accordance to EIA/JESD22-A115A.

## Operating Range

All voltages are referred to ground (pins GND and slug). Power supply points are VS\_LNA, V1\_PA, V2\_PA, V3\_PA\_OUT. The table represents the sum of all supply currents depending on the TX/RX mode.

Parameters	Symbol	Min.	Typ.	Max.	Unit
Supply voltage Pins V1_PA, V2_PA and V3_PA_OUT	$V_S$	2.7	3.0	4.6	V
Supply voltage, pin VS_LNA	$V_S$	2.7	3.0	5.5	V
Supply current TX, PSSO20	$I_S$		190		mA
QFN20	$I_S$		165		mA
Supply current RX	$I_S$		8		mA
Standby current, PU = 0	$I_{S\_standby}$		10		μA
Ambient temperature	$T_{amb}$	-25	+25	+85	°C

## Electrical Characteristics

Test conditions (unless otherwise specified):  $V_S = 3.0\text{ V}$ ,  $T_{amb} = 25^\circ\text{C}$

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit
<b>Power Amplifier<sup>(1)</sup></b>						
Supply voltage	Pins V1_PA, V2_PA, V3_PA_OUT	$V_S$	2.7	3.0	4.6	V
Supply current	TX PSSO20	$I_{S\_TX}$		190		mA
	TX QFN20	$I_{S\_TX}$		165		mA
	RX (PA off), $V_{RAMP} \leq 0.1\text{ V}$	$I_{S\_RX}$			10	$\mu\text{A}$
Standby current	Standby	$I_{S\_standby}$			10	$\mu\text{A}$
Frequency range	TX	f	2.4		2.5	GHz
Gain-control range	TX	$\Delta\text{Gp}$	60	42		dB
Power gain maximum	TX, pin PA_IN to V3_PA_OUT	Gp	28	30	33	dB
Power gain minimum	TX, pin PA_IN to V3_PA_OUT	Gp	-40		-17	dB
Ramping voltage maximum	TX, power gain (maximum) Pin RAMP	$V_{RAMP\ max}$	1.7	1.75	1.83	V
Ramping voltage minimum	TX, power gain (minimum) Pin RAMP	$V_{RAMP\ min}$		0.1		V
Ramping current maximum	TX, $V_{RAMP} = 1.75\text{ V}$ , pin RAMP	$I_{RAMP\ max}$			0.5	mA
Power-added efficiency	TX PSSO20	PAE	30	35		%
	TX QFN20	PAE	35	40		%
Saturated output power	TX, input power = 0 dBm referred to pins V3_PA_OUT	$P_{sat}$	22	23	24	dBm
Input matching <sup>(2)</sup>	TX, pin PA_IN	Load VSWR		< 1.5:1		
Output matching <sup>(2)</sup>	TX, pins V3_PA_OUT	Load VSWR		< 1.5:1		
Harmonics at $P_{sat} = 23\text{ dBm}$	TX, pins V3_PA_OUT	2 fo			-30	dBc
	TX, pins V3_PA_OUT	3 fo			-30	dBc
<b>T/R Switch Driver (Current Programming by External Resistor from R_SWITCH to GND)</b>						
Switch-out current output	Standby, pin SWITCH_OUT	$I_{S\_O\_standby}$			1	$\mu\text{A}$
	RX	$I_{S\_O\_RX}$			1	$\mu\text{A}$
	TX at 100 $\Omega$	$I_{S\_O\_100}$		1.7		mA
	TX at 1.2 k $\Omega$	$I_{S\_O\_1k2}$		7		mA
	TX at 33 k $\Omega$	$I_{S\_O\_33k}$		17		mA
	TX at $\infty$	$I_{S\_O\_R}$		19		mA
<b>Low-noise Amplifier<sup>(3)</sup></b>						
Supply voltage	All, pin VS_LNA	$V_S$	2.7	3.0	5.5	V
Supply current	RX	$I_S$		8	9	mA

- Notes:
- Power amplifier shall be unconditionally stable, maximum duty cycle 100%, true CW operation, maximum load mismatch and duration: load VSWR = 10:1 (all phases) 10 s,  $Z_G = 50\ \Omega$
  - With external matching network, load impedance 50  $\Omega$ .
  - Low-noise amplifier shall be unconditionally stable.
  - With external matching components.
  - LNA gain can be adjusted with RX\_ON voltage according to Figure 19 on page 11. Please note, that for RX\_ON below 1.4 V the T/R switch driver switches to TX mode.

## Electrical Characteristics (Continued)

Test conditions (unless otherwise specified):  $V_S = 3.0\text{ V}$ ,  $T_{amb} = 25^\circ\text{C}$

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit
Supply current (LNA and control logic)	TX (control logic active) Pin VS_LNA	$I_S$			0.5	mA
Standby current	Standby, pin VS_LNA	$I_{S\_standby}$		1	10	$\mu\text{A}$
Frequency range	RX	f	2.4		2.5	GHz
Power gain <sup>(5)</sup>	RX, pin LNA_IN to LNA_OUT	Gp	15	16	19	dB
Noise figure	RX PSSO20	NF		2.5	2.8	dB
	RX QFN20	NF		2.1	2.3	dB
Gain compression	RX, referred to pin LNA_OUT	O1dB	-9	-7	-6	dBm
3 <sup>rd</sup> -order input interception point	RX	IIP3	-16	-14	-13	dBm
Input matching <sup>(4)</sup>	RX, pin LNA_IN	VSWRin			2:1	
Output matching <sup>(4)</sup>	RX, pin LNA_OUT	VSWRout			2:1	
<b>Logic Input Levels (RX_ON, PU)<sup>(5)</sup></b>						
High input level	= '1' pins RX_ON and PU	$V_{iH}$	2.4		$V_{S\_LNA}$	V
Low input level	= '0'	$V_{iL}$	0		0.5	V
High input current	= '1' $V_{iH} = 2.4\text{ V}$	$I_{iH}$		40	60	$\mu\text{A}$
Low input current	= '0'	$I_{iL}$			0.2	$\mu\text{A}$

- Notes:
- Power amplifier shall be unconditionally stable, maximum duty cycle 100%, true CW operation, maximum load mismatch and duration: load VSWR = 10:1 (all phases) 10 s,  $Z_G = 50\ \Omega$
  - With external matching network, load impedance  $50\ \Omega$
  - Low-noise amplifier shall be unconditionally stable.
  - With external matching components.
  - LNA gain can be adjusted with RX\_ON voltage according to Figure 19 on page 11. Please note, that for RX\_ON below 1.4 V the T/R switch driver switches to TX mode.

## Control Logic PA and LNA/Antenna Switch Driver

PU	RX_ON	Ramp <sup>(1)</sup>	PA	LNA	Antenna Switch Driver	Operation Mode
0	0	0	off	off	off	standby
0	0	1	on	off	off	(2)
0	1	0	off	on	off	(3)
0	1	1	on	on	off	(4)
1	0	0	off	off	on	(4)
1	0	1	on	off	on	TX
1	1	0	off	on	off	RX
1	1	1	on	on	off	(5)

- Notes:
- "0" =  $V_{RAMP} \leq 0.1\text{ V}$ , "1" =  $V_{RAMP}$  typically 1.75 V,  $1.3\text{ V} < V_{RAMP} < 1.83\text{ V}$  controls gain and output power, compare Figure 9 on page 7 and Figure 13 on page 9
  - Only for special operation, e.g. only PA operation, no LNA/switch driver operation
  - Only for special operation, e.g. no switch driver operation
  - Only for special operation
  - Only for special operation, e.g. separate TX/RX antennas, TX and RX operation at the same time

# Typical Operating Characteristics

Figure 4. LNA (PSSO20): Gain and Noise Figure versus Frequency

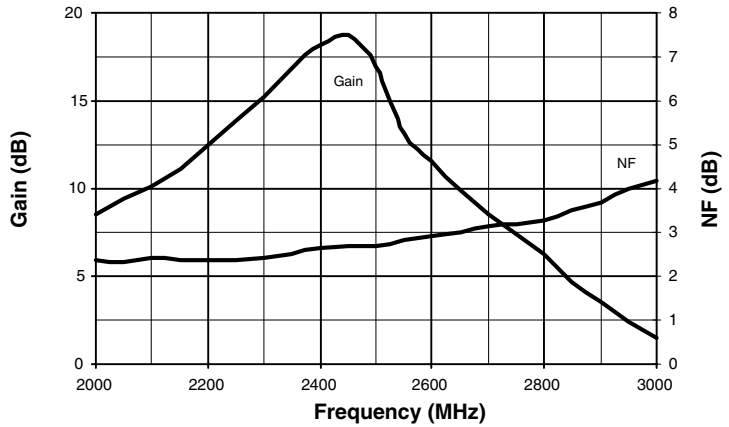


Figure 5. LNA (N20): Gain and Noise Figure versus Frequency

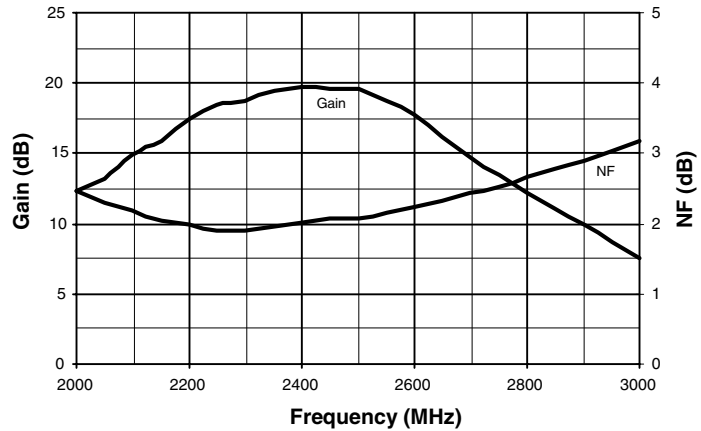


Figure 6. LNA: NF and Gain versus Temperature

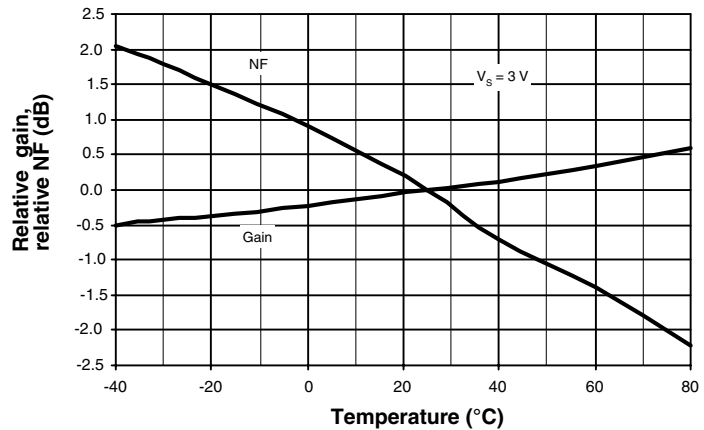


Figure 7. LNA: Typical Switch-out Current versus  $R_{switch}$

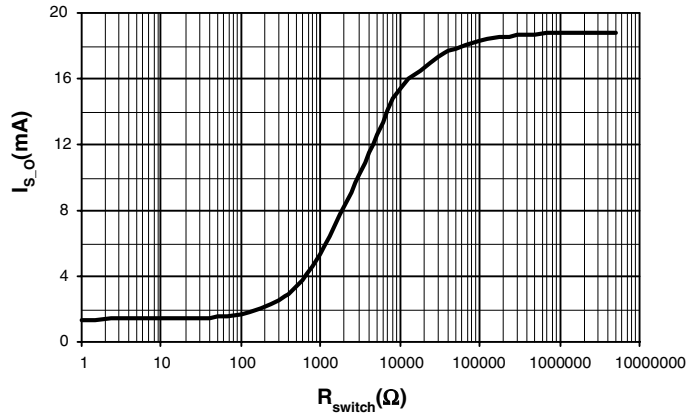


Figure 8. PA (PSSO20): Output Power and PAE versus Supply

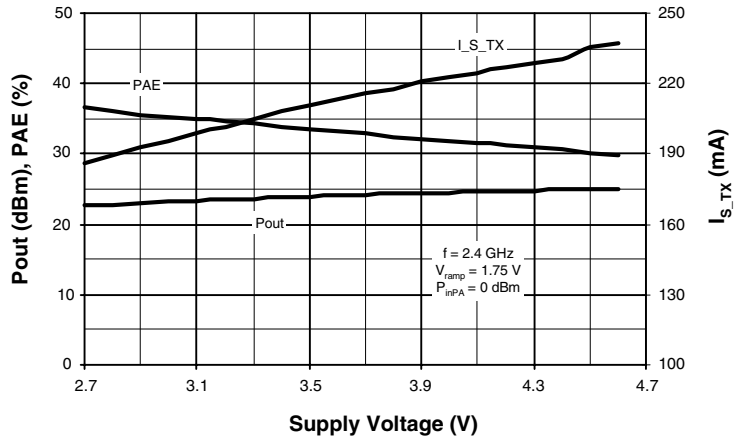
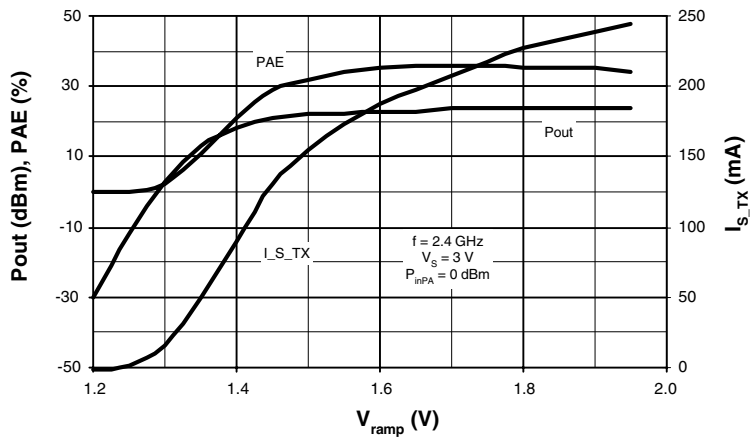
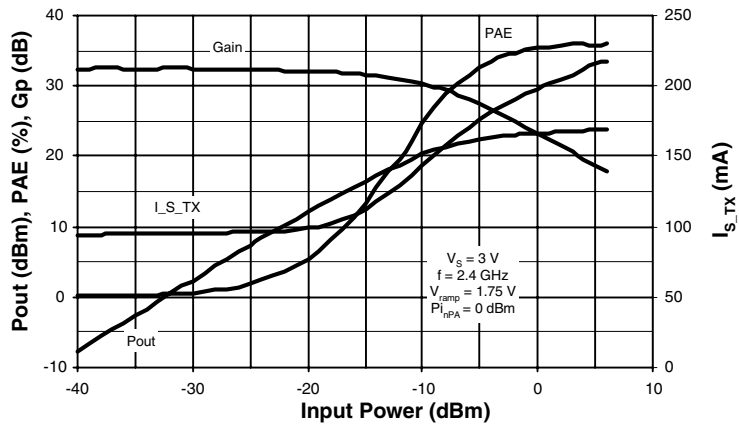


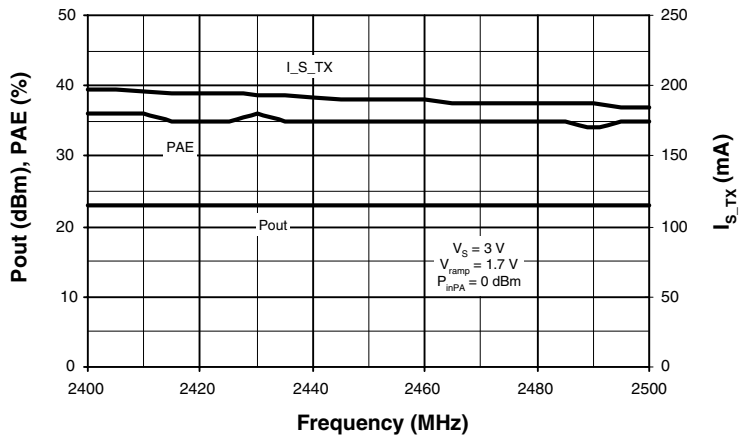
Figure 9. PA (PSSO20): Output Power and PAE versus Ramp Voltage



**Figure 10. PA (PSSO20): Output Power and PAE versus Input Power**



**Figure 11. PA (PSSO20): Output Power and PAE versus Frequency**



**Figure 12. PA (QFN20): Output Power and PAE versus Supply Voltage**

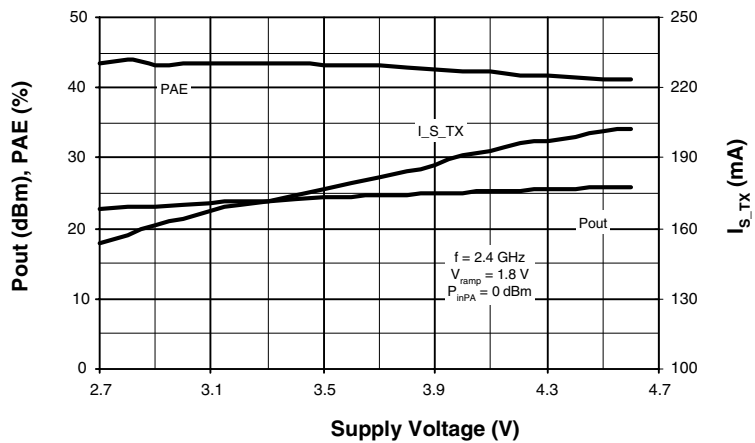




Figure 13. PA (QFN20) Output Power and PAE versus Ramp Voltage

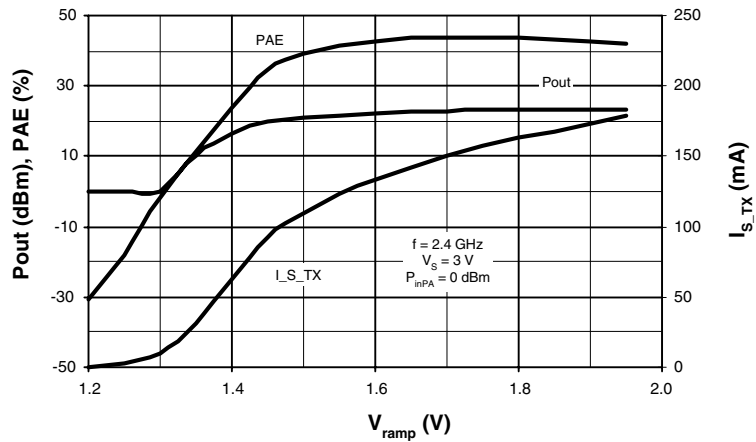


Figure 14. PA (QFN20): Output Power and PAE versus Input Power

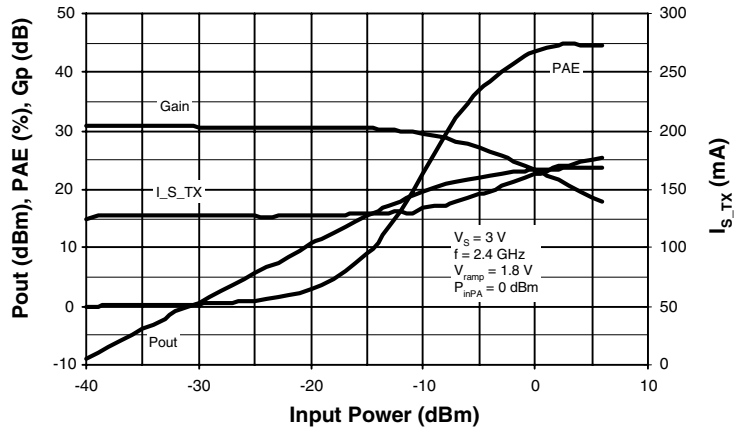
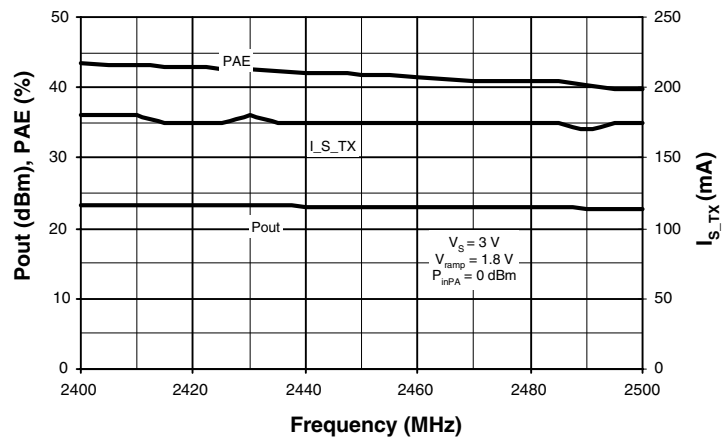
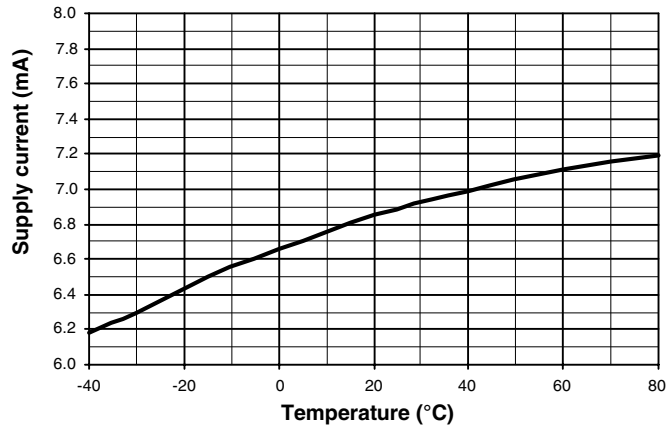


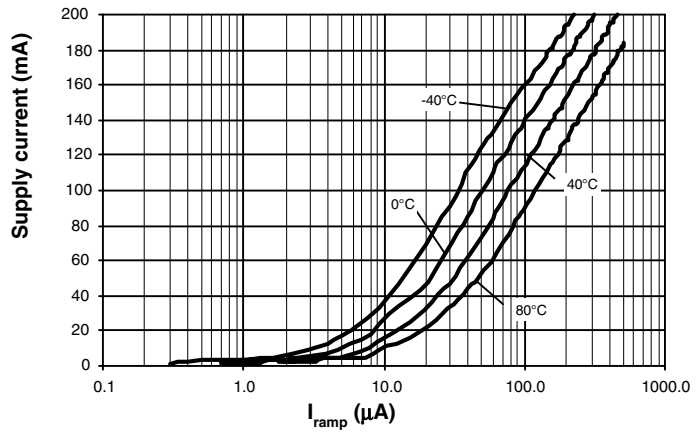
Figure 15. PA (QFN20): Output Power and PAE versus Frequency



**Figure 16. LNA: Supply Current versus Temperature**



**Figure 17. PA (PSSO20): Supply Current versus  $I_{ramp}$  and Temperature**



**Figure 18. PA (PSSO20, QFN20):  $P_{out}$  versus  $V_{RAMP}$  and Temperature**

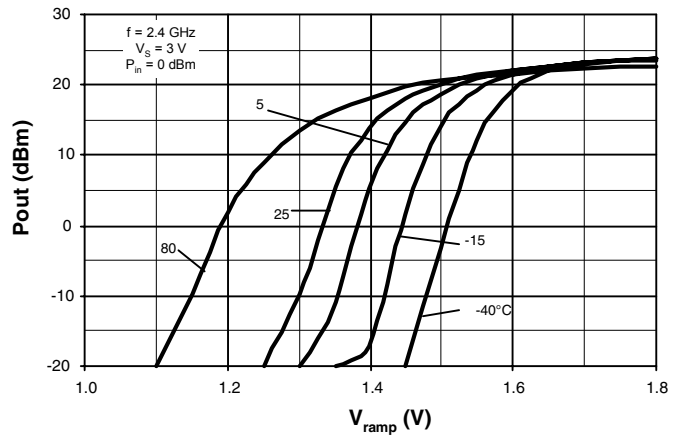
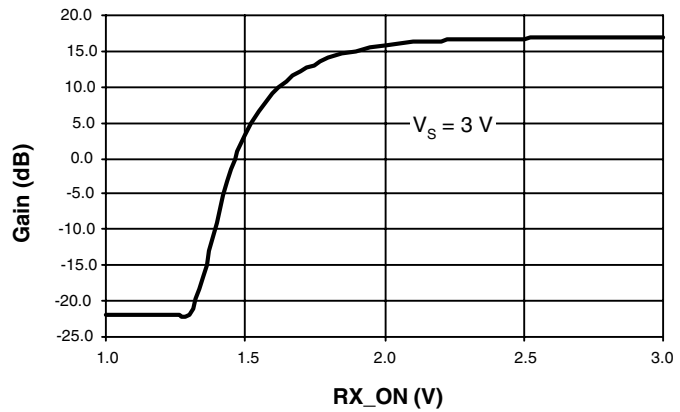


Figure 19. (PSSO20, QFN20): LNA Gain (dB) versus RX\_ON (V)



## Input/Output Circuits

Figure 20. Input Circuit PA\_IN/V1\_PA

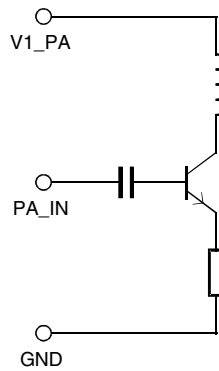
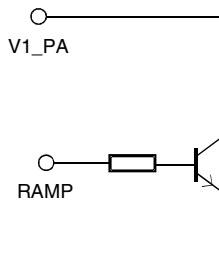
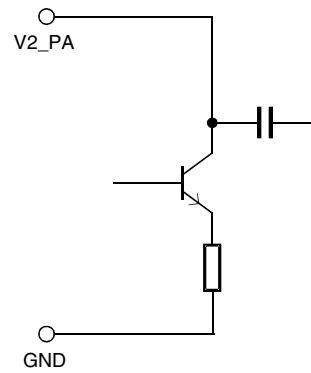


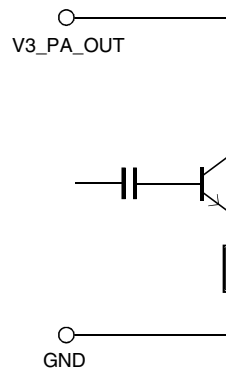
Figure 21. Input Circuit RAMP/V1\_PA



**Figure 22.** Input Circuit V2\_PA



**Figure 23.** Input/Output Circuit V3\_PA\_OUT



**Figure 24.** Input Circuit SWITCH\_OUT/R\_SWITCH

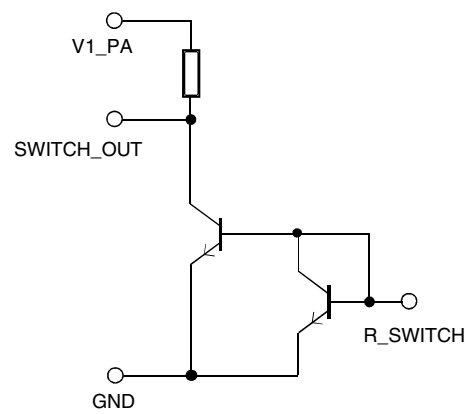


Figure 25. Input Circuit LNA\_IN/VS\_LNA

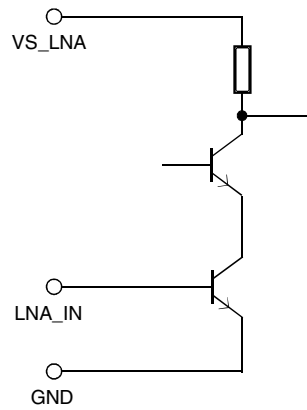


Figure 26. Input Circuit PU/RX\_ON

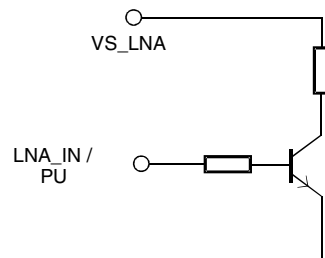
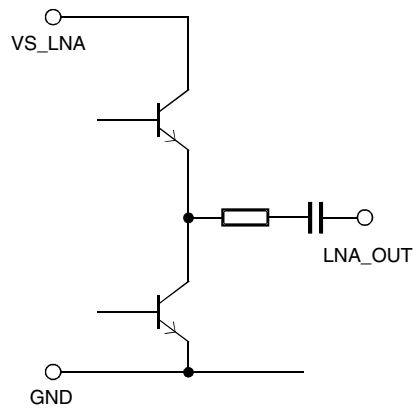


Figure 27. Output Circuit LNA\_OUT



**Figure 28.** Typical Application T7024 (PSSO20 Package)

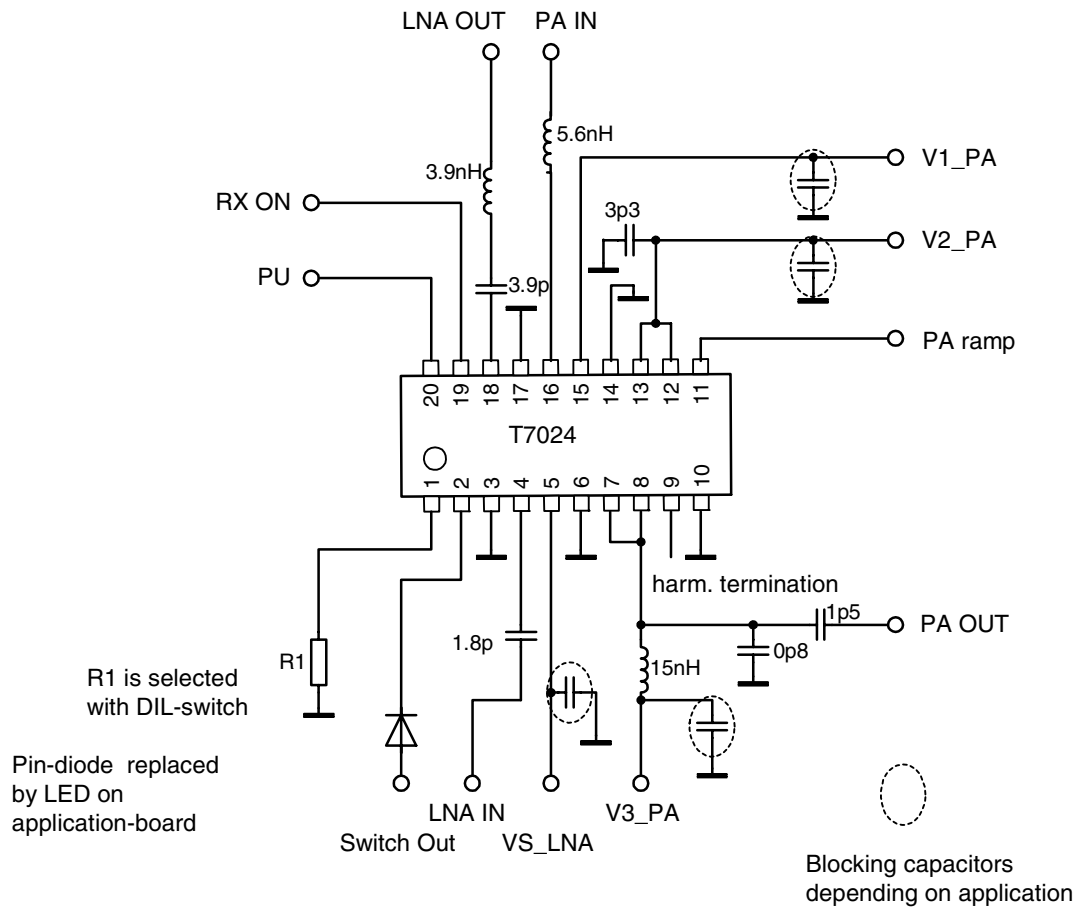
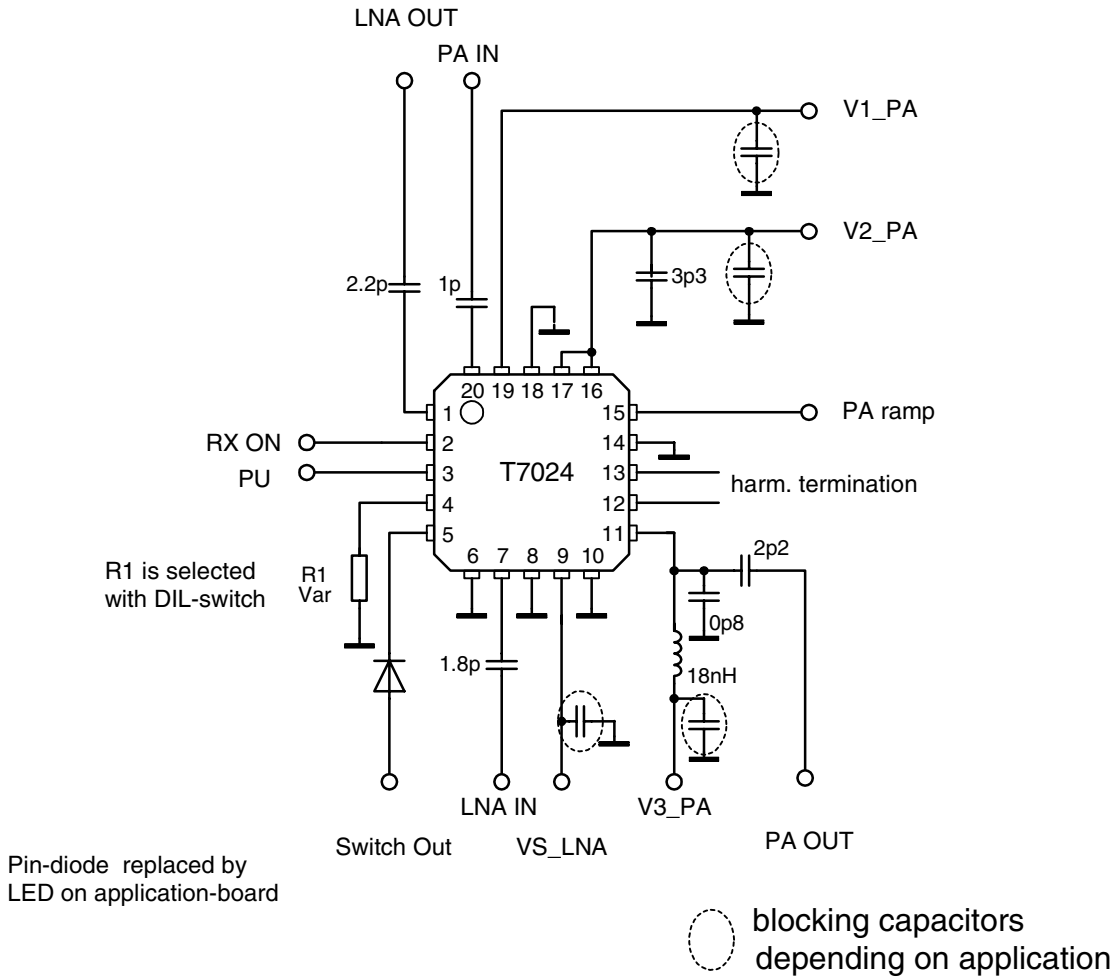


Figure 29. Typical Application T7024 (QFN20 Package)



## Ordering Information

Extended Type Number	Package	Remarks	MOQ
T7024-TRS	PSSO20	Tube	830 pcs.
T7024-TRQ	PSSO20	Taped and reeled	4000 pcs.
T7024-PGP	QFN20	Taped and reeled	1500 pcs.
T7024-PGQ	QFN20	Taped and reeled	6000 pcs.
T7024-PGPM	QFN20	Taped and reeled Pb free, halogen free	1500 pcs.
T7024-PGQM	QFN20	Taped and reeled Pb free, halogen free	6000 pcs.
Demoboard-T7024-PG	QFN20	Evaluation board QFN	1
Demoboard-T7024-TR	PSSO20	Evaluation board PSSO	1

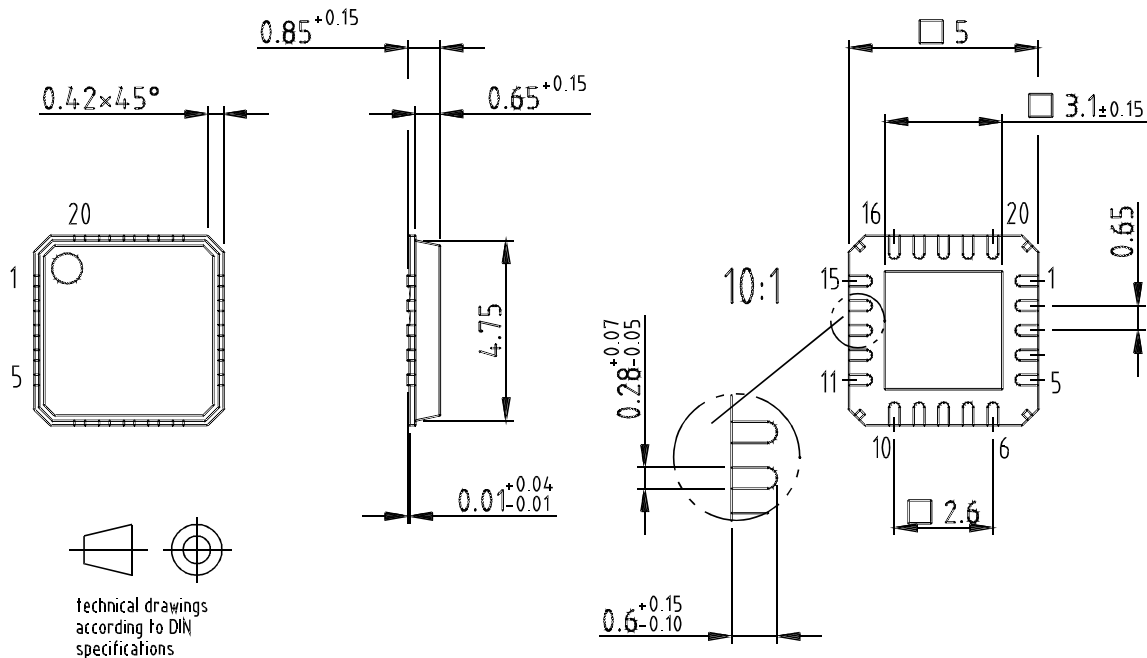
## Package Information

Package: QFN 20 - 5x5

Exposed pad 3.1x3.1

(acc. JEDEC OUTLINE No. MO-220)

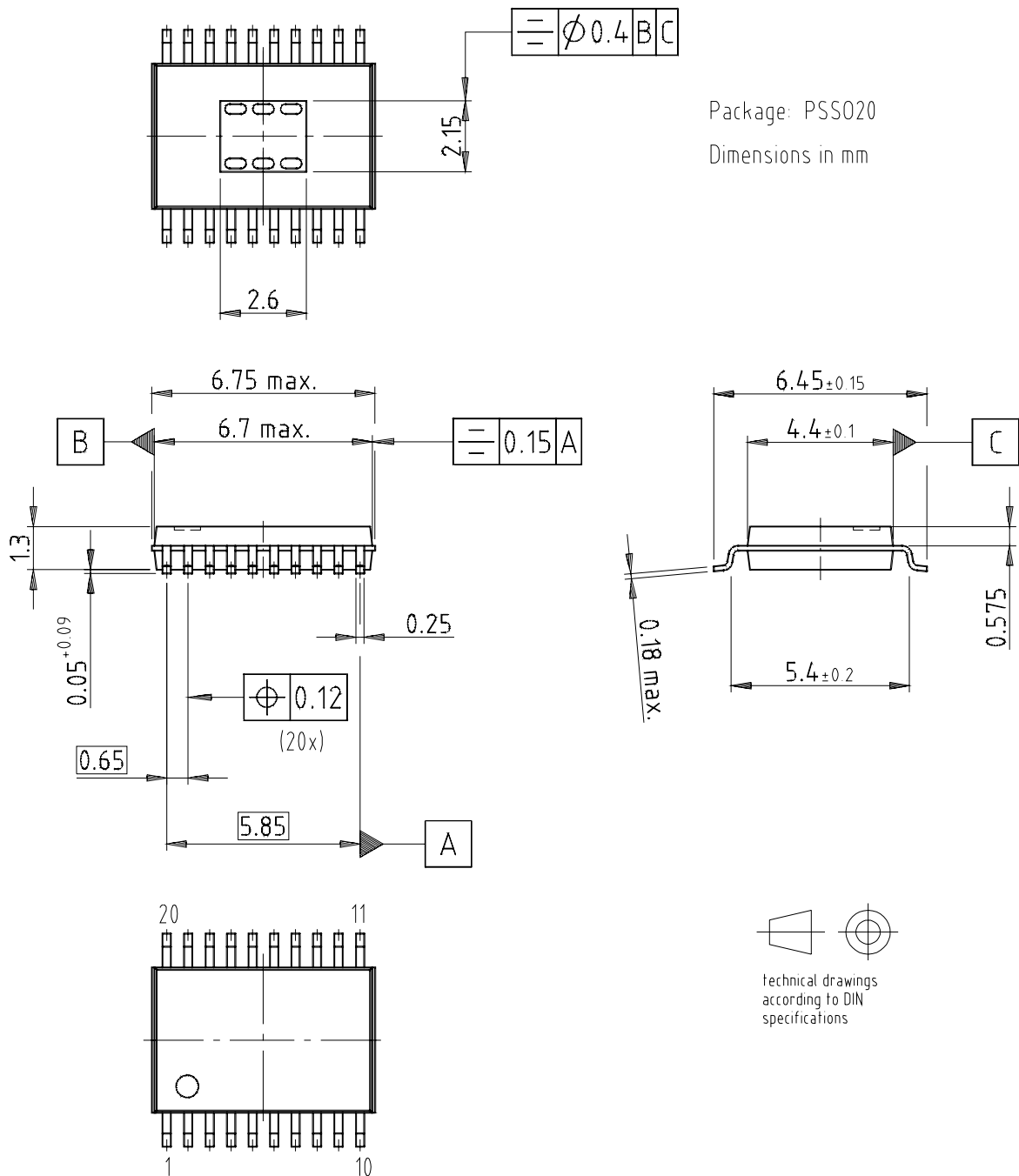
Dimensions in mm



Drawing-No.: 6.543-5069.02-4

Issue: 3; 24.01.03





Package: PSS020  
Dimensions in mm

Drawing-No.: 6.543-5078.01-4  
Issue: 1; 05.06.01



## Recommended PCB Land Pattern

Figure 30. Recommended PCB Land Pattern

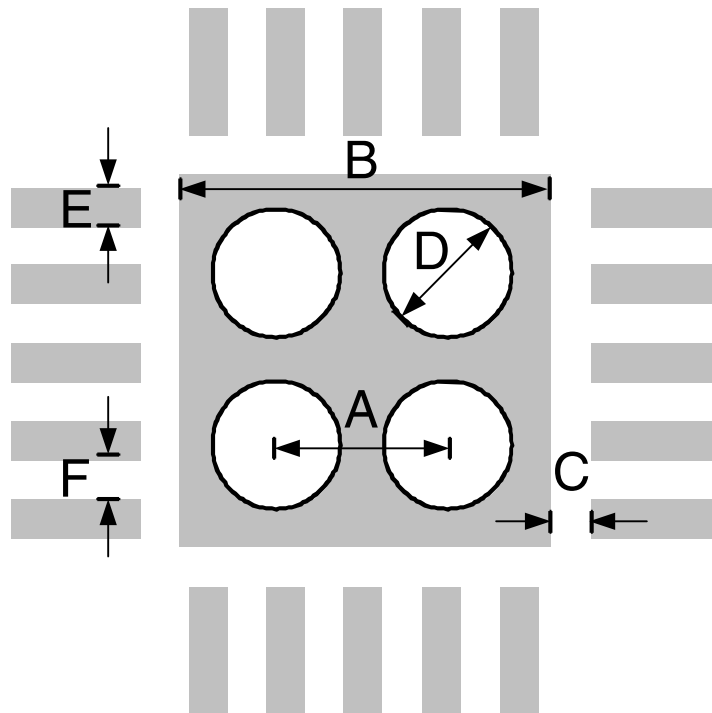


Table 1. Recommended PCB Land Pattern Signs

Sign	Description	Size
A	Distance of vias	1.6 mm
B	Size of slug pattern	3.1 mm
C	Distance slug to pins	0.33 mm
D	Diameter of vias	1 mm
E	Width of pin pattern	0.3 mm
F	Distance of pin pattern	0.33 mm



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