TFF1004HN/N1

Integrated mixer oscillator PLL for satellite LNB

Rev. 01 — 25 August 2008 | Product data sheet

1. General description

The TFF1004HN/N1 is an integrated downconverter for use in Low Noise Block (LNB) convertors in a 10.7 GHz to 12.75 GHz K_u band satellite receiver system.

CAUTION

This device is sensitive to ElectroStatic Discharge (ESD). Observe precautions for handling electrostatic sensitive devices.

Such precautions are described in the *ANSI/ESD S20.20*, *IEC/ST 61340-5*, *JESD625-A* or equivalent standards.

2. Features

- Pre-amplifier, mixer, buffer amplifier and PLL synthesizer in one IC
- Alignment-free concept
- Crystal controlled LO frequency generation
- Low phase noise
- Switched LO frequency (9.75 GHz and 10.6 GHz)
- Low spurious

3. Applications

- K_u band LNB converters for digital satellite reception (DVB-S)

4. Quick reference data

Table 1. Quick reference data

V_{CC} = 3.3 V; T_{amb} = 25 °C; f_{LO} = 9.75 GHz or 10.6 GHz; f_{xtal} = 50 MHz; Z_0 = 50 Ω unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{CC}	supply voltage	RF input and IF output AC coupled	[1]	3.0	3.3	3.6	V
I_{CC}	supply current	RF input and IF output AC coupled	[1][2]	-	102	125	mA
NF_{SSB}	single sideband noise figure	low band	[2][3][4][5]	-	9	10	dB
		high band	[2][4][5][6]	-	9	10	dB
G_{conv}	conversion gain	low band	[2][3][5]	26	32	35	dB
		high band	[2][5][6]	26	32	35	dB

Table 1. Quick reference data *...continued*

V_{CC} = 3.3 V; T_{amb} = 25 °C; f_{LO} = 9.75 GHz or 10.6 GHz; f_{xtal} = 50 MHz; Z_0 = 50 Ω unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$IP3_O$	output third-order intercept point	carrier power = –10 dBm (measured at output); worst case is given.					
		low band	[2][3][7][8]	10	-	-	dBm
		high band	[2][6][7][8]	10	-	-	dBm

[1] DC values.

[2] See corresponding graph in Section 13.1.2 “Parameters as function of temperature”.

[3] Low band conditions: P_{RF_IN} = –50 dBm; f_{LO} = 9.75 GHz; f_{RF_IN} = 10.70 GHz to 11.70 GHz; f_{IF_OUT} = 950 MHz to 1950 MHz.

[4] Measured with band-pass filter according to Figure 4 and Figure 5.

[5] See corresponding graph in Section 13.1.1 “Parameters as function of frequency”.

[6] High band conditions: P_{RF_IN} = –50 dBm; f_{LO} = 10.6 GHz; f_{RF_IN} = 11.70 GHz to 12.75 GHz; f_{IF_OUT} = 1100 MHz to 2150 MHz.

[7] measured in 50 Ω environment and calculated back towards a 75 Ω environment.

[8] measured with carriers depicted in Table 10.

5. Ordering information

Table 2. Ordering information

Type number	Package		
	Name	Description	Version
TFF1004HN/N1	HVQFN24	plastic, heatsink very thin quad flat package; no leads; 24 terminals; body 4 × 4 × 0.85 mm	SOT616-1

6. Block diagram

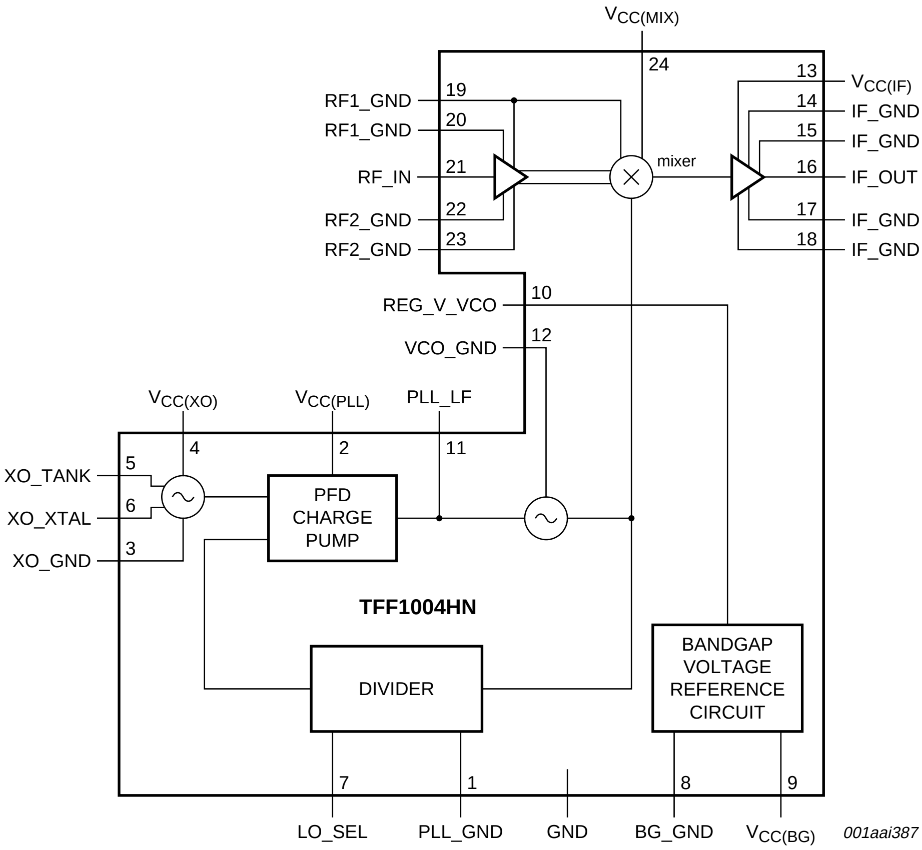


Fig 1. TFF1004HN/N1 block diagram

7. Functional diagram

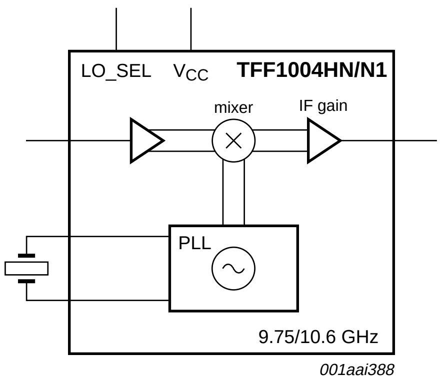


Fig 2. Functional diagram

8. Pinning information

8.1 Pinning

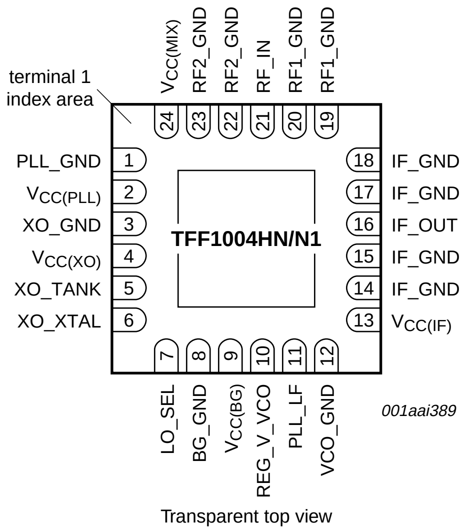


Fig 3. Pin configuration

8.2 Pin description

Table 3. Pin description

Symbol	Pin	Description
GND	0	ground (exposed die pad)
PLL_GND	1	ground [1]
$V_{CC(PLL)}$	2	PLL supply voltage. Decouple against pin 1.
XO_GND	3	ground [1]
$V_{CC(XO)}$	4	crystal oscillator supply voltage. Decouple against pin 3.
XO_TANK	5	crystal oscillator tank
XO_XTAL	6	50 MHz. Crystal connection. Connect other crystal terminal to GND.
LO_SEL	7	select high or low band [2]
BG_GND	8	ground [1]
$V_{CC(BG)}$	9	internal regulator supply. Decouple against pin 8.
REG_V_VCO	10	decoupling of the internal VCO supply
PLL_LF	11	loop filter PLL. Connect loop filter between this pin and pin 10.
VCO_GND	12	ground [1]
$V_{CC(IF)}$	13	IF-buffer supply voltage. Decouple against pin 14.
IF_GND	14, 15, 17, 18	ground [1]
IF_OUT	16	IF-buffer output. Connect RF choke coil between this pin and pin 13.
RF1_GND	19, 20	ground [1]

Table 3. Pin description *...continued*

Symbol	Pin	Description
RF_IN	21	RF input. AC coupling required.
RF2_GND	22, 23	ground [1]
$V_{CC(MIX)}$	24	mixer supply voltage. Decouple against pin 23.

[1] Connect this to the exposed die pad.

[2] See Table 4.

Table 4. LO_SEL

LO_SEL (pin 7) (V)	local oscillator frequency (GHz)
0	9.75
V_{CC}	10.60
open	10.60

9. Limiting values

Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{CC(BG)}$	band gap supply voltage		–0.5	+3.6	V
$V_{CC(IF)}$	IF supply voltage		–0.5	+3.6	V
$V_{CC(PLL)}$	PLL supply voltage		–0.5	+3.6	V
$V_{CC(XO)}$	XO supply voltage		–0.5	+3.6	V
T_j	junction temperature		-	125	°C
T_{stg}	storage temperature		-	125	°C

10. Recommended operating conditions

Table 6. Operating conditions

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
T_{amb}	ambient temperature		–40	+25	+85	°C
Z_0	characteristic impedance		-	50	-	Ω

Table 7. Selection of crystal

Mode	Frequency (MHz)	Load capacitor (pF)	Frequency stability (ppm)	Quartz cut	Maximum drive level (μW)	Tank circuit
fundamental	50	0 [1]	± 50 [2]	AT-cut	100	not used
overtone	50	0 [1]	± 50 [2]	AT-cut	100	used [3]

[1] Series resonant.

[2] The LO will have the same frequency stability.

[3] The components of the tank circuit are selected to form a parallel resonance at 50 MHz. The input capacitance at XO_TANK (pin 5) is 3 pF.

The tank circuit should have no DC path between $V_{CC(XO)}$ (pin 4) and XO_TANK (pin 5), therefore the inductive branch should contain a DC block.

11. Thermal characteristics

Table 8. Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-sp)}$	thermal resistance from junction to solder point		24	K/W

12. Characteristics

Table 9. Characteristics

V_{CC} = 3.3 V; T_{amb} = 25 °C; f_{LO} = 9.75 GHz or 10.6 GHz; f_{xtal} = 50 MHz; Z_0 = 50 Ω unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{CC}	supply voltage	RF input and IF output AC coupled	[1]	3.0	3.3	3.6	V
I_{CC}	supply current	RF input and IF output AC coupled	[1][2]	-	102	125	mA
$\varphi_{n\lambda(itg)}$	integrated phase noise density	integration offset frequency = 10 kHz to 13 MHz; loop bandwidth = crossover bandwidth					
		low band	[2][3]	-	-	2.5	°RMS
		high band	[2][4]	-	-	2.5	°RMS
NF_{SSB}	single sideband noise figure	low band	[2][3][5][6]	-	9	10	dB
		high band	[2][4][5][6]	-	9	10	dB
G_{conv}	conversion gain	low band	[2][3][6]	26	32	35	dB
		high band	[2][4][6]	26	32	35	dB
ΔG_{conv}	conversion gain variation	low band	[2][3]	-	-	5	dB
		high band	[2][4]	-	-	5	dB
		in every 36 MHz band; high band and low band	[6]	-	-	1.5	dB
s_{11}	input reflection coefficient	with optimum matching structure	[6]	-	-	–10	dB
s_{22}	output reflection coefficient	f_{IF_OUT} = 950 MHz to 2150 MHz; Z_0 = 75 Ω	[7]	-	-	–10	dB
$IP3_O$	output third-order intercept point	carrier power = –10 dBm (measured at output); worst case is given.					
		low band	[2][3][7][8]	10	-	-	dBm
		high band	[2][4][7][8]	10	-	-	dBm
$\alpha_{L(RF)lo}$	local oscillator RF leakage	center frequency = local oscillator frequency; span = 100 MHz; RBW = 50 kHz; VBW = 200 kHz					
		low band	[2][3][9]	-	-	–35	dBm
		high band	[2][4][9]	-	-	–35	dBm
$\alpha_{L(IF)lo}$	local oscillator IF leakage	center frequency = local oscillator frequency; span = 100 MHz; RBW = 50 kHz; VBW = 200 kHz					
		low band	[2][3][10]	-	-	–15	dBm
		high band	[2][4][10]	-	-	–15	dBm
$\alpha_{resp(sp)IF\_OUT}$	spurious response on pin IF_OUT	center frequency = 1.6 GHz; span frequency = 1.2 GHz; RBW = 30 kHz; VBW = 100 kHz	[10]	-	-	–60	dBm

[1] DC values.

[2] See corresponding graph in Section 13.1.2 “Parameters as function of temperature”.

[3] Low band conditions: P_{RF_IN} = –50 dBm; f_{LO} = 9.75 GHz; f_{RF_IN} = 10.70 GHz to 11.70 GHz; f_{IF_OUT} = 950 MHz to 1950 MHz.

[4] High band conditions: P_{RF_IN} = –50 dBm; f_{LO} = 10.6 GHz; f_{RF_IN} = 11.70 GHz to 12.75 GHz; f_{IF_OUT} = 1100 MHz to 2150 MHz.

[5] Measured with band-pass filter according to Figure 4 and Figure 5.

[6] See corresponding graph in Section 13.1.1 “Parameters as function of frequency”.

[7] measured in 50 Ω environment and calculated back towards a 75 Ω environment.

[8] measured with carriers depicted in Table 10.

[9] measured with spectrum analyzer at RF_IN (pin 21); IF_OUT (pin 16) terminated with 50 Ω.

[10] measured with spectrum analyzer at IF_OUT (pin 16); RF_IN (pin 21) terminated with 50 Ω via DC block.

Table 10. $IP3_O$ carriers

Band	RF frequency Carrier #1 (GHz)	RF frequency Carrier #2 (GHz)	$IP3_O$ low frequency (MHz)	IF frequency Carrier#1 (MHz)	IF frequency Carrier#2 (MHz)	$IP3_O$ high frequency (MHz)
Low	10.74	10.78	950	990	1030	1070
	11.62	11.66	1830	1870	1910	1950
High	11.74	11.78	1100	1140	1180	1220
	12.67	12.71	2030	2070	2110	2150

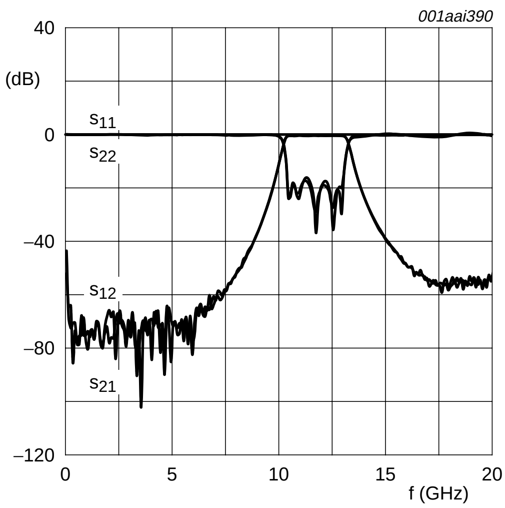


Fig 4. Filter SEI FSCM:67021

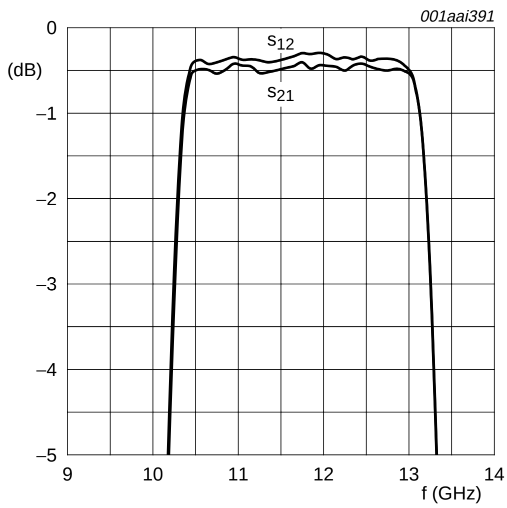
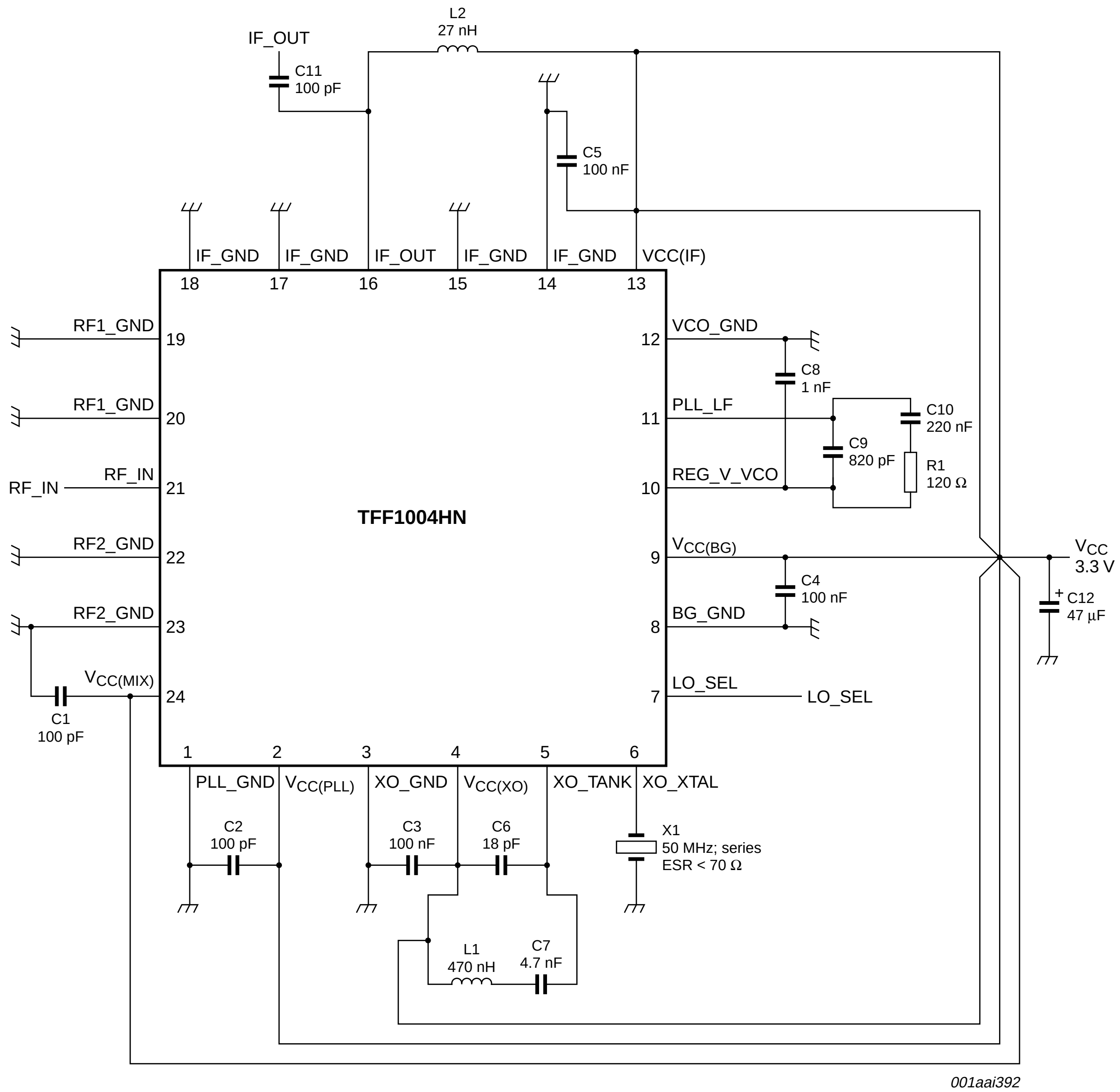


Fig 5. Filter SEI FSCM:67021

13. Application information



For list of components see Table 11.

Fig 6. Application diagram of TFF1004HN/N1

Table 11. List of components

The Printed Circuit Board (PCB) is a Rogers RO4223 (ε_r = 3.38); thickness = 0.51 mm.
For application diagram, see Figure 6.

Component	Description	Value	Remarks
C1	decoupling of RF and MIX domain	100 pF	
C2	decoupling of PLL domain	100 pF	
C3	decoupling of XO domain	100 nF	
C4	decoupling of BG domain	100 nF	

Table 11. List of components *...continued*

The Printed Circuit Board (PCB) is a Rogers RO4223 (ε_r = 3.38); thickness = 0.51 mm.
For application diagram, see Figure 6.

Component	Description	Value	Remarks
C5	decoupling of IF domain	100 nF	
C6	XO_TANK circuit (only with overtone crystal)	18 pF	[1]
C7	XO_TANK circuit, DC coupling (only with overtone crystal)	4.7 nF	[1]
C8	REG_V_VCO decoupling	1 nF	maximum value 1 nF
C9	loop filter	820 pF	
C10	loop filter	220 nF	
C11	output capacitor	100 pF	
C12	main supply decoupling and 22 kHz rejection	47 µF	
L1	XO_TANK circuit (only with overtone crystal)	470 nH	[1]
L2	RF choke at 2.15 GHz	27 nH	
R1	loop filter	120 Ω	
X1	crystal; series resonant; ESR < 70 Ω	50 MHz	[1]

[1] See Table 7.

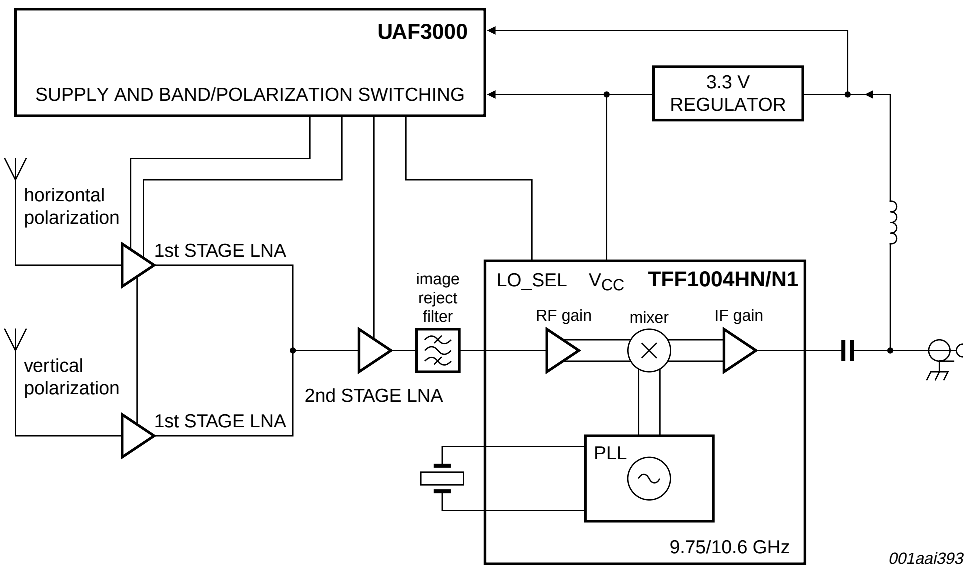


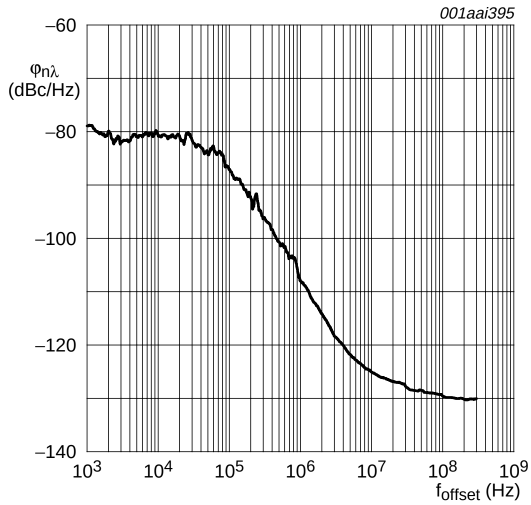
Fig 7. TFF1004HN/N1 in practice

13.1 Graphs

13.1.1 Parameters as function of frequency

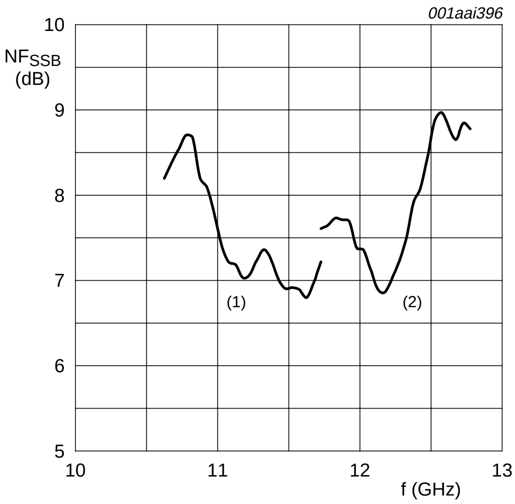
V_{CC} = 3.3 V; f_{LO} = 9.75 GHz.

Fig 8. Phase noise density as function of offset frequency (low band); typical values



V_{CC} = 3.3 V; f_{LO} = 10.6 GHz.

Fig 9. Phase noise density as function of offset frequency (high band); typical values

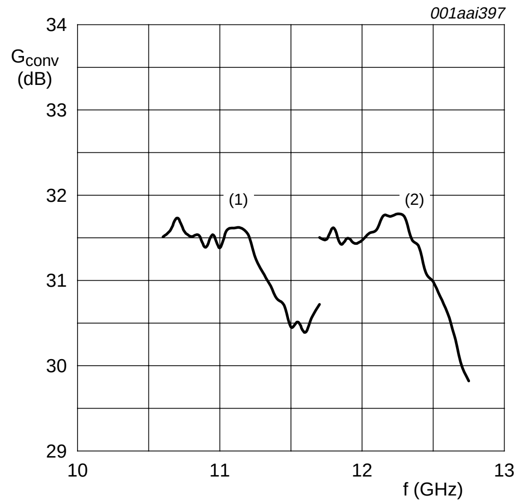


(1) low band

(2) high band

V_{CC} = 3.3 V.

Fig 10. Noise figure as function of frequency; typical values

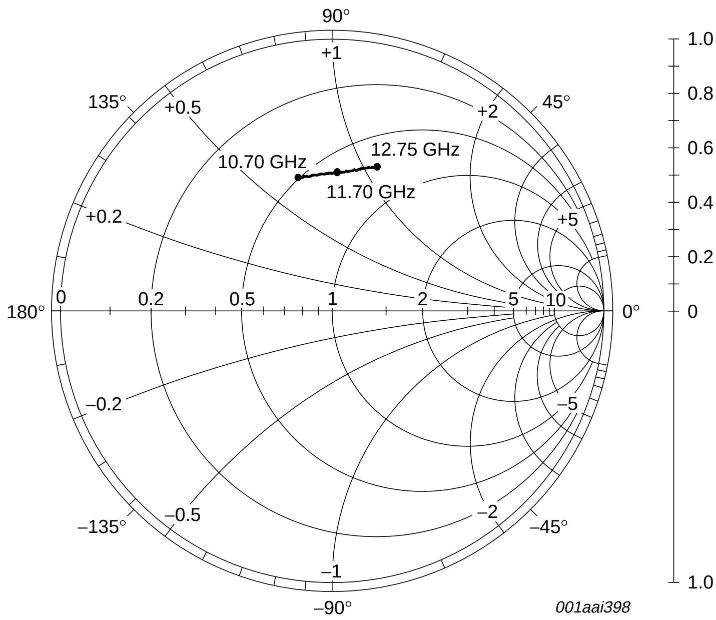


(1) low band

(2) high band

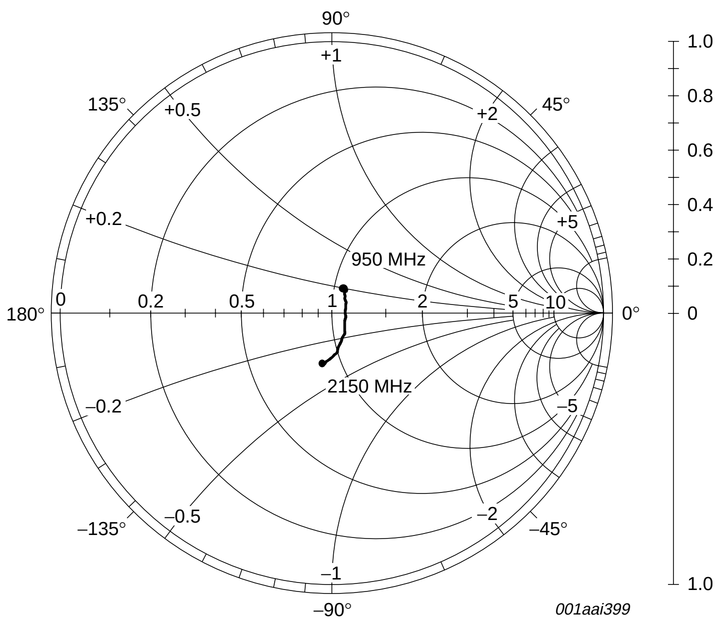
V_{CC} = 3.3 V.

Fig 11. Conversion gain as function of frequency; typical values



T_{amb} = 25 °C; I_{CC} = 102 mA; V_{CC} = 3.3 V; Z_0 = 50 Ω.

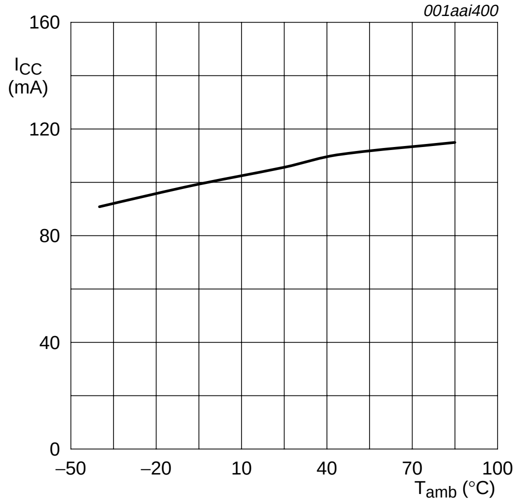
Fig 12. Input reflection coefficient (S_{11}) without matching structure; typical values



T_{amb} = 25 °C; I_{CC} = 102 mA; V_{CC} = 3.3 V; Z_0 = 50 Ω.

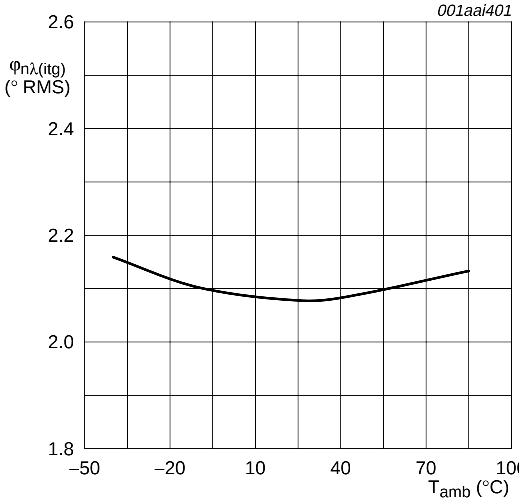
Fig 13. Output reflection coefficient (S_{22}); typical values

13.1.2 Parameters as function of temperature



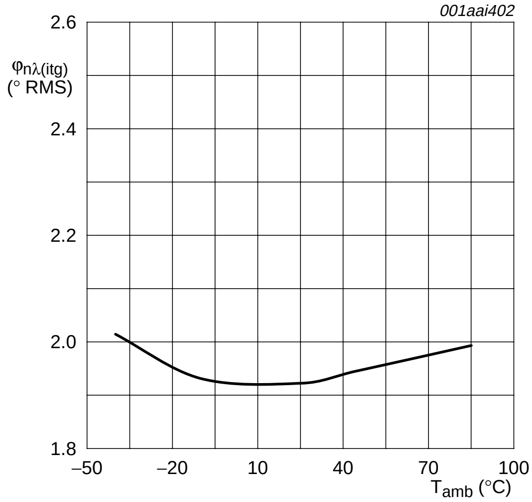
V_{CC} = 3.3 V.

Fig 14. Supply current as function of temperature; typical values



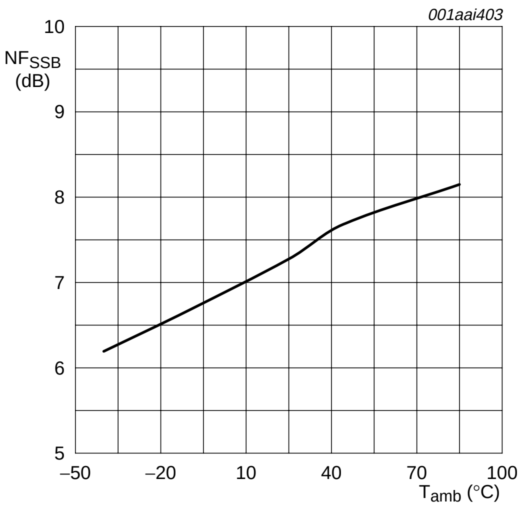
V_{CC} = 3.3 V; f_{LO} = 9.75 GHz.

Fig 15. Integrated phase noise density as function of temperature (low band); typical values



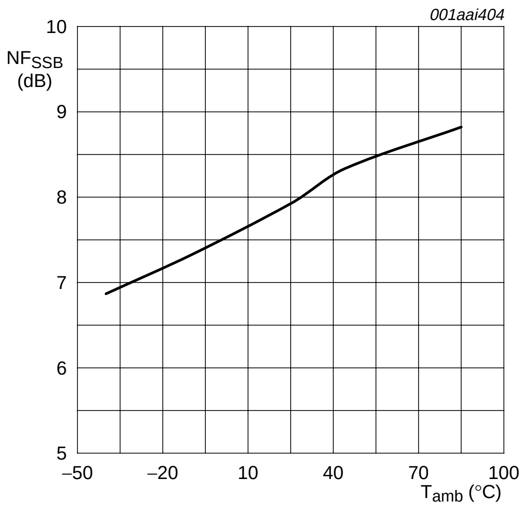
V_{CC} = 3.3 V; f_{LO} = 10.6 GHz.

Fig 16. Integrated phase noise density as function of temperature (high band); typical values



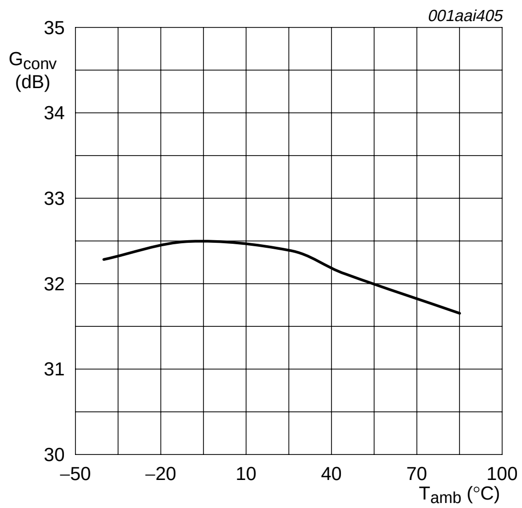
V_{CC} = 3.3 V; f_{LO} = 9.75 GHz; f_{IF} = 1525 MHz.

Fig 17. Single sideband noise figure as function of temperature (low band); typical values



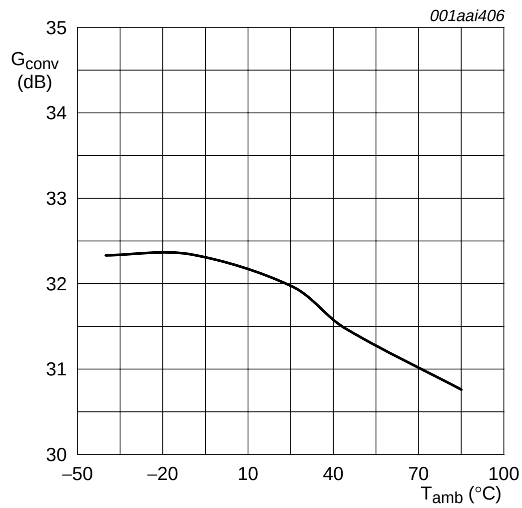
V_{CC} = 3.3 V; f_{LO} = 10.6 GHz; f_{IF} = 1525 MHz.

Fig 18. Single sideband noise figure as function of temperature (high band); typical values



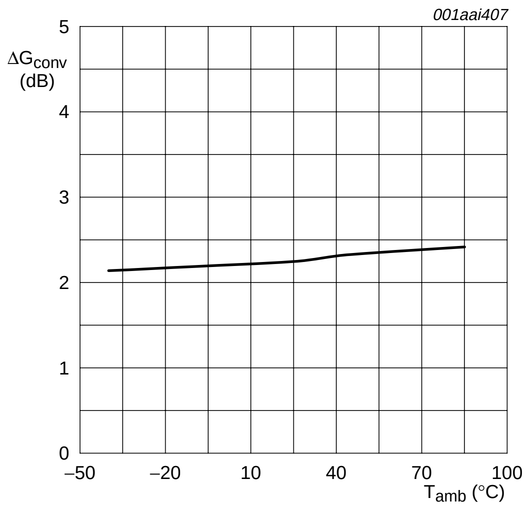
V_{CC} = 3.3 V; f_{LO} = 9.75 GHz; f_{IF} = 1525 MHz.

Fig 19. Conversion gain as function of temperature (low band); typical values



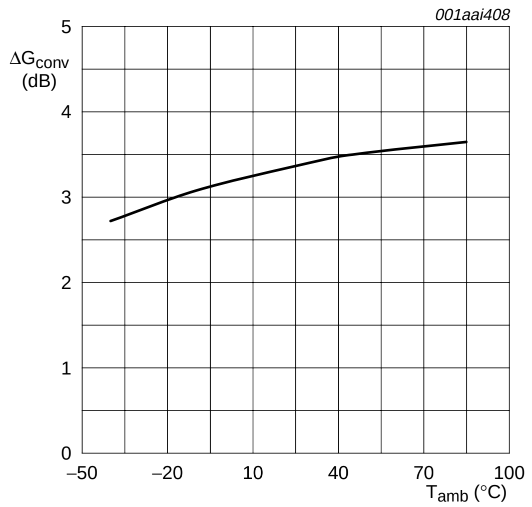
V_{CC} = 3.3 V; f_{LO} = 10.6 GHz; f_{IF} = 1385 MHz.

Fig 20. Conversion gain as function of temperature (high band); typical values



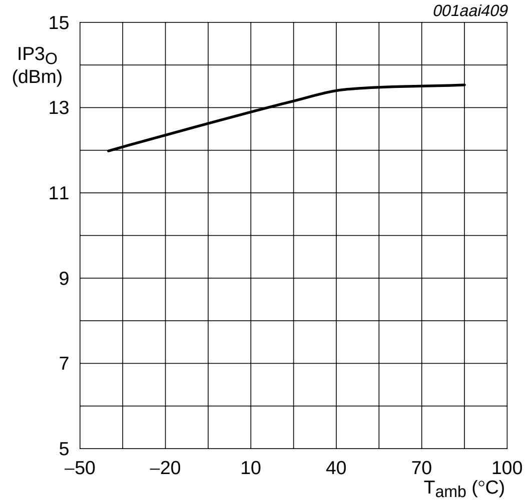
V_{CC} = 3.3 V; f_{LO} = 9.75 GHz.

Fig 21. Conversion gain variation as function of temperature (low band); typical values



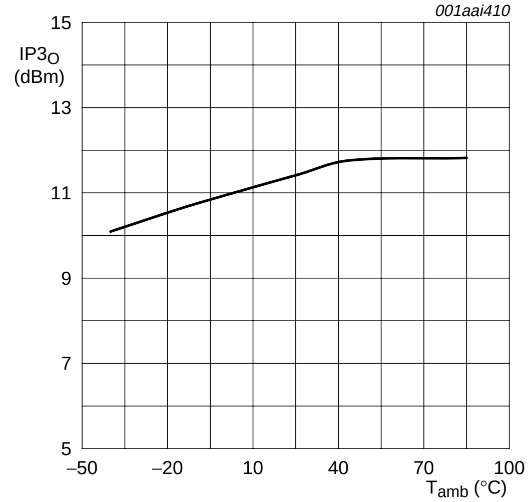
V_{CC} = 3.3 V; f_{LO} = 10.6 GHz.

Fig 22. Conversion gain variation as function of temperature (high band); typical values



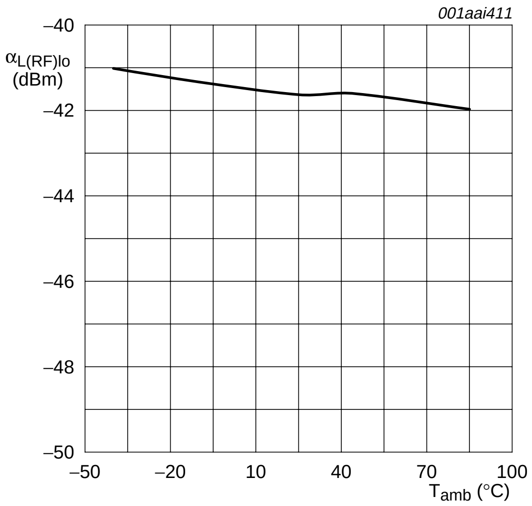
V_{CC} = 3.3 V; f_{LO} = 9.75 GHz.

Fig 23. Output third-order intercept point as function of temperature (low band); typical values



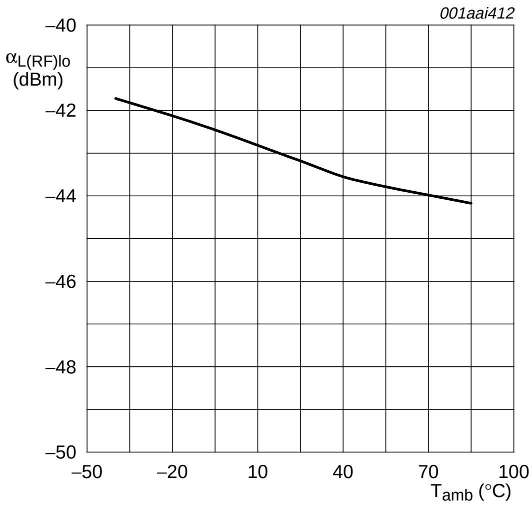
V_{CC} = 3.3 V; f_{LO} = 10.6 GHz.

Fig 24. Output third-order intercept point as function of temperature (high band); typical values



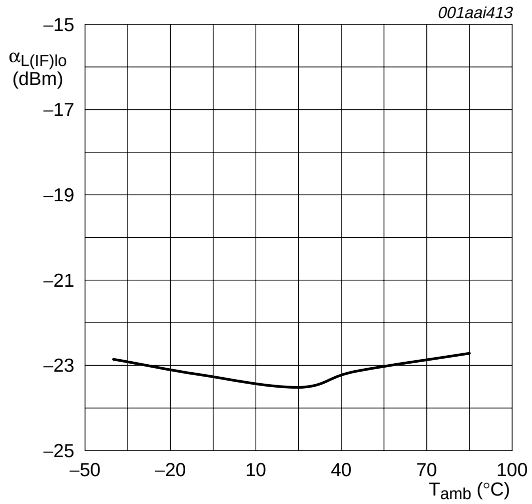
V_{CC} = 3.3 V; f_{LO} = 9.75 GHz.

Fig 25. Local oscillator RF leakage as function of temperature (low band); typical values



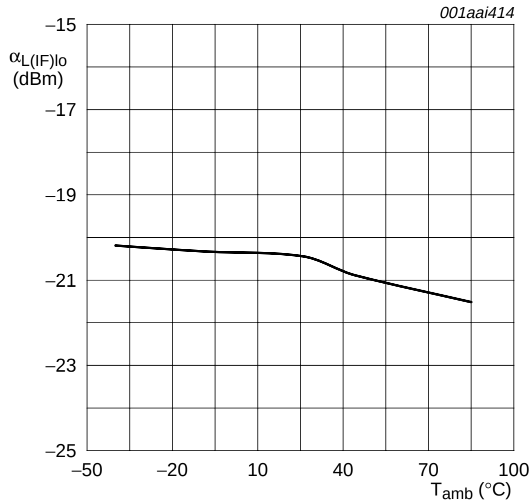
V_{CC} = 3.3 V; f_{LO} = 10.6 GHz.

Fig 26. Local oscillator RF leakage as function of temperature (high band); typical values



V_{CC} = 3.3 V; f_{LO} = 9.75 GHz.

Fig 27. Local oscillator IF leakage as function of temperature (low band); typical values



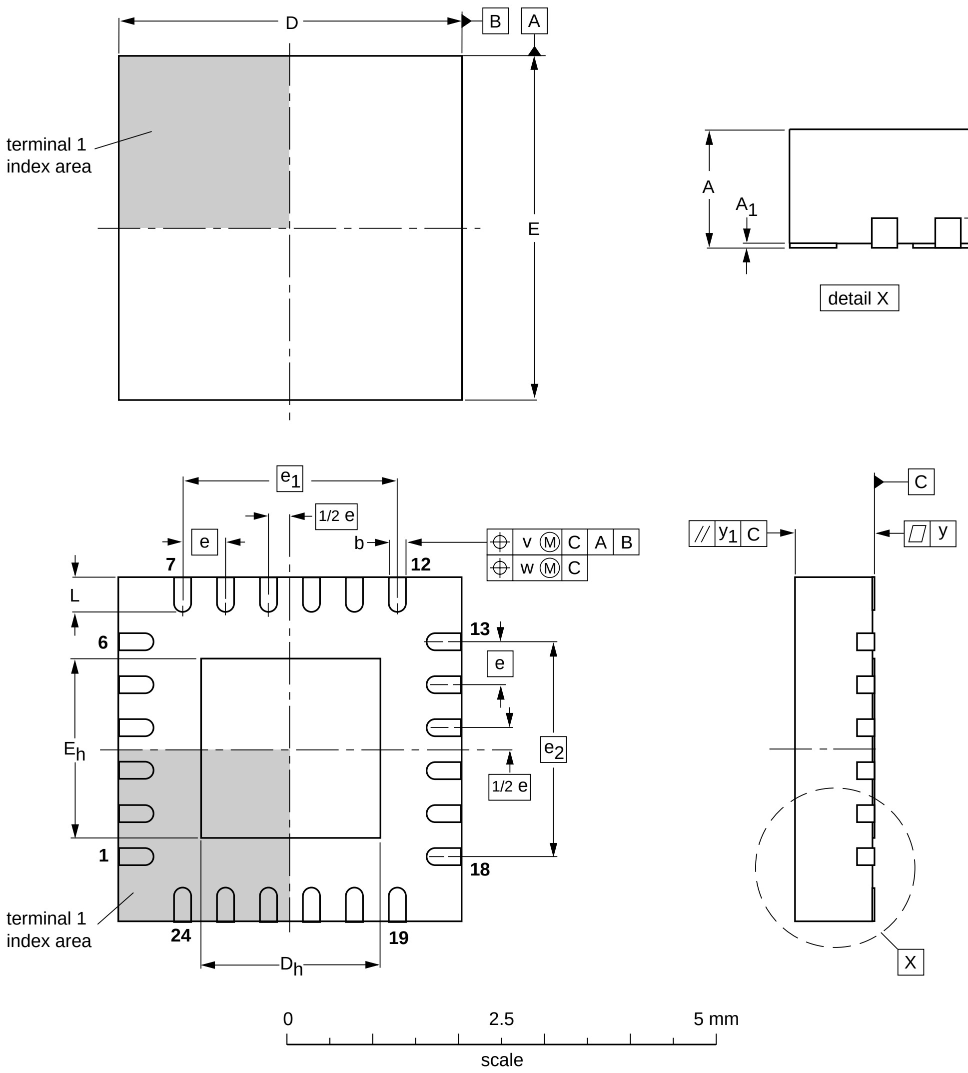
V_{CC} = 3.3 V; f_{LO} = 10.6 GHz.

Fig 28. Local oscillator IF leakage as function of temperature (high band); typical values

14. Package outline

HVQFN24: plastic thermal enhanced very thin quad flat package; no leads; 24 terminals; body 4 x 4 x 0.85 mm

SOT616-1



DIMENSIONS (mm are the original dimensions)

UNIT	A(1) max.	A_1	b	c	D(1)	D_h	E(1)	E_h	e	e_1	e_2	L	v	w	y	y_1
mm	1	0.05 0.00	0.30 0.18	0.2	4.1 3.9	2.25 1.95	4.1 3.9	2.25 1.95	0.5	2.5	2.5	0.5 0.3	0.1	0.05	0.05	0.1

Note

1. Plastic or metal protrusions of 0.075 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT616-1	- - -	MO-220	- - -			~~01-08-08~~ 02-10-22

Fig 29. Package outline SOT616-1

15. Abbreviations

Table 12. Abbreviations

Acronym	Description
BG	Band Gap
DVB-S	Digital Video Broadcasting by Satellite
ESR	Equivalent Series Resistance
IC	Integrated Circuit
IF	Intermediate Frequency
K_u band	K-under band
LO	Local Oscillator
PFD	Phase Frequency Detector
PLL	Phase-Locked Loop
RBW	Resolution BandWidth
RF	Radio Frequency
VBW	Video BandWidth
VCO	Voltage-Controlled Oscillator
XO	Crystal Oscillator

16. Revision history

Table 13. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
TFF1004HN_N1_1	20080825	Product data sheet	-	-

17. Legal information

17.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

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18. Contact information

For more information, please visit: **http://www.nxp.com**

For sales office addresses, please send an email to: **salesaddresses@nxp.com**

19. Contents

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