TFF1024HN

Integrated mixer oscillator PLL for satellite LNB

Rev. 1 — 13 January 2015 **Product data sheet**

1. General description

The TFF1024HN is an integrated downconverter for use in Low Noise Block (LNB) convertors in a 10.70 GHz to 12.85 GHz K_u band satellite receiver system.

2. Features and benefits

- Low current consumption integrated pre-amplifier, mixer, buffer amplifier and PLL synthesizer
- Flat gain over frequency
- Single 5 V supply pin
- Low cost 25 MHz crystal
- Crystal controlled LO frequency generation
- Switched LO frequency (selectable to 9.75 GHz, 10.00 GHz, 10.25 GHz, 10.55 GHz, 10.60 GHz, 10.75 GHz, 11.25 GHz or 11.30 GHz) with a 25 MHz crystal as reference
- Other LO frequencies within the 9.75 GHz to 11.30 GHz range can be realized by using an alternative reference frequency
- Low phase noise
- Low spurious
- Low external component count
- Alignment-free concept
- ESD protection on all pins

3. Applications

- K_u band LNB converters for VSAT and digital satellite reception (DVB-S / DVB-S2)

4. Quick reference data

Table 1. Quick reference data

9.75 GHz ≤ f_{LO} ≤ 11.30 GHz; operating conditions of Table 6 apply.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	supply voltage	RF input and IF output AC coupled [1]	4.5	5	5.5	V
I_{CC}	supply current	RF input and IF output AC coupled [1]	-	56	70	mA
NF_{SSB}	single sideband noise figure	f_{IF} = 1450 MHz; T_{amb} = 25 °C; 10.55 GHz ≤ f_{LO} ≤ 10.60 GHz	-	9.0	11.0	dB
f_{RF}	RF frequency	[2]	10.70	-	12.85	GHz

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

9.75 GHz ≤ f_{LO} ≤ 11.30 GHz; operating conditions of Table 6 apply.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
G_{conv}	conversion gain	f_{IF} = 1450 MHz				
		f_{LO} = 10.55 GHz	29.8	34.3	38.8	dB
		f_{LO} = 10.60 GHz	29.8	34.3	38.8	dB
s_{11}	input reflection coefficient	10.70 GHz ≤ f_{RF} ≤ 12.85 GHz	-	–10	-	dB
s_{22}	output reflection coefficient	950 MHz ≤ f_{IF} ≤ 2150 MHz; Z_0 = 75 Ω	-	–10	-	dB
$IP3_o$	output third-order intercept point	carrier power = –10 dBm (measured at output)				
		f_{IF} = 1450 MHz; 9.75 GHz ≤ f_{LO} ≤ 10.75 GHz	14	18	-	dBm
		f_{IF} = 1250 MHz; 11.25 GHz ≤ f_{LO} ≤ 11.30 GHz	14	18	-	dBm

[1] DC values.

[2] See Table 4 for specific values at certain settings of pins HB0, HB1 and HB2.

5. Ordering information

Table 2. Ordering information

Type number	Package		
	Name	Description	Version
TFF1024HN	DHVQFN16	plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads;16 terminals; body 2.5 × 3.5 × 0.85 mm	SOT763-1

6. Functional diagram

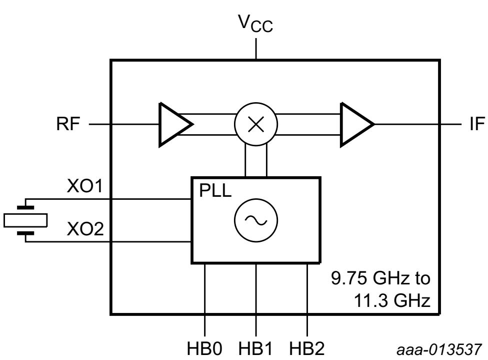

Fig 1. Functional diagram

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7. Pinning information

7.1 Pinning

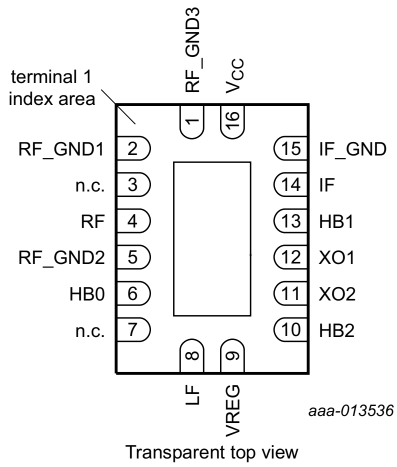

Fig 2. Pin configuration

7.2 Pin description

Table 3. Pin description

Symbol	Pin	Description
GND	0	ground (exposed die pad)
RF_GND3	1	RF ground. Connect this pin to the exposed die pad landing.
RF_GND1	2	RF ground. Connect this pin to the exposed die pad landing and the RF input CPW line.
n.c.	3	not connected. Connect to RF on PCB. [1]
RF	4	RF input.
RF_GND2	5	RF ground. Connect this pin to the exposed die pad landing and the RF input CPW line.
HB0	6	LO frequency selection, LSB. Connect this pin to GND for "0", leave open for "1". Also see Table 4.
n.c.	7	not connected. Use this pin to route the ground layer on top of the PCB to the exposed die pad.
LF	8	Loop filter PLL. Connect loop filter between this pin and VREG (pin 9).
VREG	9	Regulated output voltage for PLL loop filter. Connect loop filter to this pin. Decouple against die pad via pin 7.
HB2	10	LO frequency selection, MSB. Connect this pin to GND for "0", leave open for "1". Also see Table 4.
XO2	11	Crystal connection 2. Connect crystal between this pin and XO1 (pin 12).
XO1	12	Crystal connection 1. Connect crystal between this pin and XO2 (pin 11).
HB1	13	LO frequency selection. Connect this pin to GND for "0", leave open for "1". Also see Table 4.
IF	14	IF output
IF_GND	15	IF output ground. Connect this pin to the exposed die pad landing and the output transmission line ground.
V_{CC}	16	Supply voltage

[1] The distance between the outer edges of pin 2 and pin 3 is 740 μm. This gives an optimum transition from a 1.1 mm wide, $Z_0 = 50\ \Omega$ line to the TFF1024HN on a Rogers RO4223 Printed-Circuit Board (PCB) material of 0.5 mm height.

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8. Functional description

8.1 LO frequency selection

Table 4. LO frequency selection table

See Figure 1 for the functional diagram.

f_{LO} (GHz)	f_{xtal} (MHz)	HB2 (pin 10)	HB1 (pin 13)	HB0 (pin 6)	f_{RF} (GHz) Min	f_{RF} (GHz) Max	f_{IF} (MHz) Min	f_{IF} (MHz) Max
9.75	25	0	0	0	10.70	11.90	950	2150
10.00	25	0	0	1	10.95	12.15	950	2150
10.25	25	0	1	0	11.20	12.40	950	2150
10.45 [1]	24.76	0	1	1	11.40	12.60	950	2150
10.55	25	0	1	1	11.50	12.70	950	2150
10.60	25	1	0	0	11.55	12.75	950	2150
10.75	25	1	0	1	11.70	12.85	950	2100
11.25	25	1	1	0	12.20	12.85	950	1600
11.30	25	1	1	1	12.25	12.85	950	1550

[1] For frequencies that cannot be achieved using the 25 MHz crystal choose the closest frequency and adapt the crystal frequency. Example: 10.45 GHz. This can be achieved by choosing 10.55 GHz. The divider ratio is 422. 10.45 GHz will be achieved with a crystal frequency of 10.45 GHz / 422 = 24.76303 MHz.

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}	supply voltage		–0.5	+6	V
V_i	input voltage	on pin HB0	–0.5	+6	V
		on pin HB1	–0.5	+6	V
		on pin HB2	–0.5	+6	V
T_{stg}	storage temperature		–40	+125	°C

10. Recommended operating conditions

Table 6. Operating conditions

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	supply voltage	RF input and IF output AC coupled [1]	4.5	5	5.5	V
V_i	input voltage	on pin HB0	0	-	2.7	V
		on pin HB1	0	-	2.7	V
		on pin HB2	0	-	2.7	V
$I_{CC(startup)}$	start-up supply current	during 30 ms only at supply power-on	300	-	-	mA
T_{amb}	ambient temperature		–40	+25	+85	°C
Z_0	characteristic impedance		-	50	-	Ω
f_{RF}	RF frequency	[2]	10.70	-	12.85	GHz

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Table 6. Operating conditions *…continued*

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
f_{LO}	LO frequency	HB2 = 0; HB1 = 0; HB0 = 0	[3]	-	9.75	-	GHz
		HB2 = 1; HB1 = 1; HB0 = 1	[4]	-	11.30	-	GHz
f_{IF}	IF frequency		[2]	950	-	2150	MHz
$C_{L(xtal)}$	crystal load capacitance			-	10	-	pF
ESR	equivalent series resistance			-	-	40	Ω
f_{xtal}	crystal frequency			-	25	-	MHz

[1] DC values.

[2] See Table 4 for specific values at certain settings of pins HB0, HB1 and HB2.

[3] The minimum LO frequency is specified. See Table 4 for other specific values at certain settings of pins HB0, HB1 and HB2.

[4] The maximum LO frequency is specified. See Table 4 for other specific values at certain settings of pins HB0, HB1 and HB2.

11. Thermal characteristics

Table 7. Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-c)}$	thermal resistance from junction to case		35	K/W

12. Characteristics

Table 8. Characteristics

9.75 GHz $\leq f_{LO} \leq$ 11.30 GHz; operating conditions of Table 6 apply.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
I_{CC}	supply current	RF input and IF output AC coupled	[1]	-	56	70	mA
$\varphi_{n\lambda(itg)RMS}$	RMS integrated phase noise density	loop bandwidth = crossover bandwidth; low ESR crystal used (ESR < 20 Ω)					
		integration offset frequency = 1 kHz to 1 MHz		-	1.2	2.2	deg
		integration offset frequency = 10 kHz to 13 MHz		-	1.2	2.2	deg
NF_{SSB}	single sideband noise figure	f_{IF} = 1450 MHz; T_{amb} = 25 °C					
		f_{LO} = 9.75 GHz		-	8.8	10.8	dB
		10.55 GHz $\leq f_{LO} \leq$ 10.60 GHz		-	9.0	11.0	dB
		f_{IF} = 1250 MHz; T_{amb} = 25 °C					
		11.25 GHz $\leq f_{LO} \leq$ 11.30 GHz		-	9.5	11.5	dB
G_{conv}	conversion gain	f_{IF} = 1450 MHz					
		f_{LO} = 9.75 GHz		29.6	34.1	38.6	dB
		f_{LO} = 10.00 GHz		29.5	34.0	38.5	dB
		f_{LO} = 10.25 GHz		29.5	34.0	38.5	dB
		f_{LO} = 10.55 GHz		29.8	34.3	38.8	dB
		f_{LO} = 10.60 GHz		29.8	34.3	38.8	dB
		f_{LO} = 10.75 GHz		30.2	34.7	39.2	dB
		f_{IF} = 1250 MHz					
		f_{LO} = 11.25 GHz		30.2	34.7	39.2	dB
		f_{LO} = 11.30 GHz		30.1	34.6	39.1	dB

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Table 8. Characteristics *...continued*

9.75 GHz ≤ f_{LO} ≤ 11.30 GHz; operating conditions of Table 6 apply.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$\Delta G_{conv}/\Delta f$	conversion gain variation with frequency	over IF band; –40 °C ≤ T_{amb} ≤ +85 °C; V_{CC} = 5.0 V					
		f_{LO} = 9.75 GHz	[2]	-	-	2.5	dB
		f_{LO} = 10.00 GHz	[2]	-	-	3.0	dB
		f_{LO} = 10.25 GHz	[2]	-	-	3.6	dB
		f_{LO} = 10.55 GHz	[2]	-	-	4.0	dB
		f_{LO} = 10.60 GHz	[2]	-	-	4.0	dB
		f_{LO} = 10.75 GHz	[2]	-	-	4.0	dB
		f_{LO} = 11.25 GHz	[2]	-	-	3.0	dB
		f_{LO} = 11.30 GHz	[2]	-	-	3.0	dB
		in every 36 MHz band; –40 °C ≤ T_{amb} ≤ +85 °C; V_{CC} = 5.0 V		-	-	0.6	dB
s_{11}	input reflection coefficient	10.70 GHz ≤ f_{RF} ≤ 12.85 GHz		-	–10	-	dB
s_{22}	output reflection coefficient	950 MHz ≤ f_{IF} ≤ 2150 MHz; Z_0 = 75 Ω		-	–10	-	dB
$IP3_o$	output third-order intercept point	carrier power is –10 dBm (measured at the output)					
		f_{IF} = 1450 MHz; 9.75 GHz ≤ f_{LO} ≤ 10.75 GHz		14	18	-	dBm
		f_{IF} = 1250 MHz; 11.25 GHz ≤ f_{LO} ≤ 11.30 GHz		14	18	-	dBm
$P_{L(1dB)}$	output power at 1 dB gain compression	measured at the output					
		f_{IF} = 1450 MHz; 9.75 GHz ≤ f_{LO} ≤ 10.75 GHz		2	6	-	dBm
		f_{IF} = 1250 MHz; 11.25 GHz ≤ f_{LO} ≤ 11.30 GHz		2	6	-	dBm
$\alpha_{L(RF)lo}$	local oscillator RF leakage	f_c = f_{LO}; span = 100 MHz; RBW = 50 kHz; VBW = 200 kHz		-	-	–35	dBm
V_{IL}	LOW-level input voltage	on pin HB0		-	-	0.8	V
		on pin HB1		-	-	0.8	V
		on pin HB2		-	-	0.8	V
V_{IH}	HIGH-level input voltage	on pin HB0		1.6	-	2.7	V
		on pin HB1		1.6	-	2.7	V
		on pin HB2		1.6	-	2.7	V
R_{pu}	pull-up resistance	on pin HB0		80	110	140	kΩ
		on pin HB1		80	110	140	kΩ
		on pin HB2		80	110	140	kΩ

[1] DC values.

[2] See Table 4 for the corresponding f_{IF} ranges.

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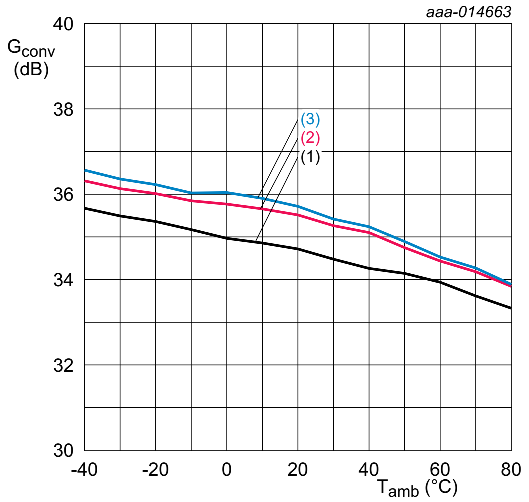
12.1 Graphs



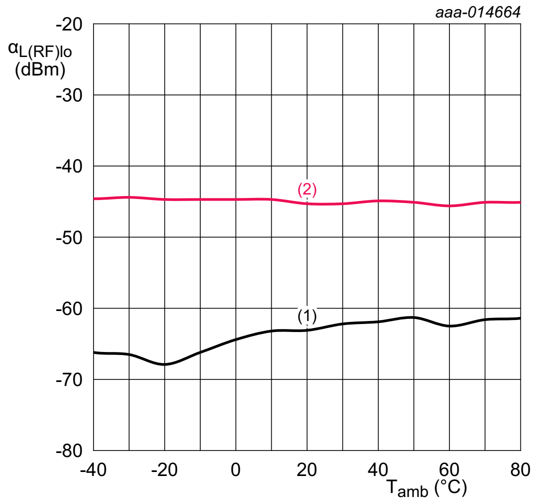
V_{CC} = 5 V; f_{IF} = 1550 MHz.

(1) f_{LO} = 9.75 GHz

(2) f_{LO} = 10.60 GHz

(3) f_{LO} = 11.30 GHz

Fig 3. Conversion gain as a function of ambient temperature; typical values

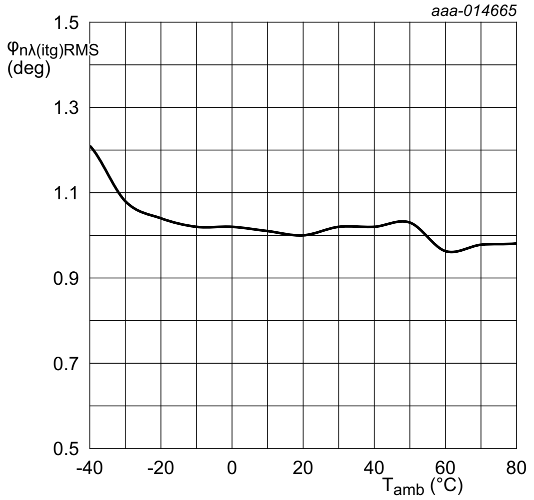


V_{CC} = 5 V.

(1) f_{LO} = 9.75 GHz

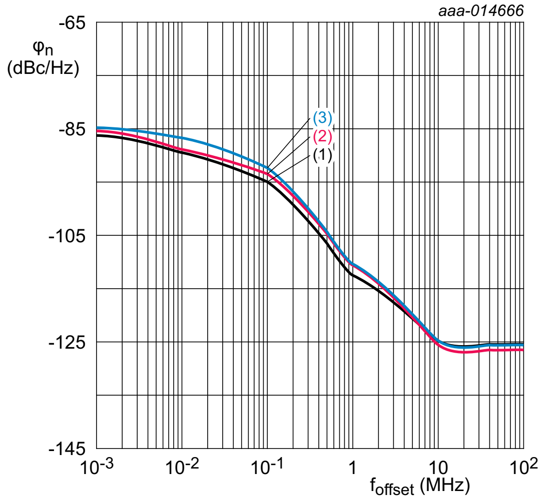
(2) f_{LO} = 11.30 GHz

Fig 4. Local oscillator RF leakage as a function of ambient temperature; typical values



V_{CC} = 5 V; f_{LO} = 10.55 GHz.

Fig 5. RMS integrated phase noise density as a function of ambient temperature; typical values



V_{CC} = 5 V; T_{amb} = 25 °C.

(1) f_{LO} = 9.75 GHz

(2) f_{LO} = 10.60 GHz

(3) f_{LO} = 11.30 GHz

Fig 6. Phase noise as a function of offset frequency; typical values

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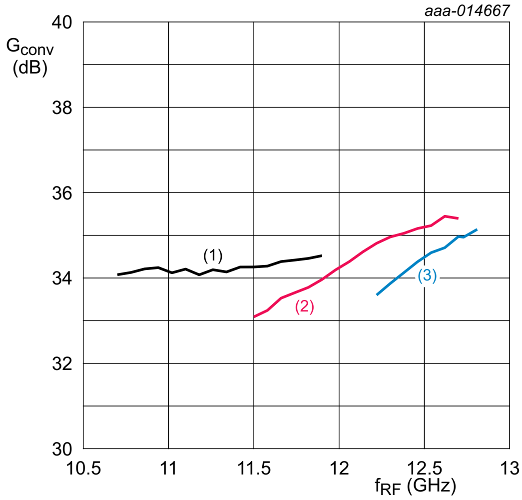


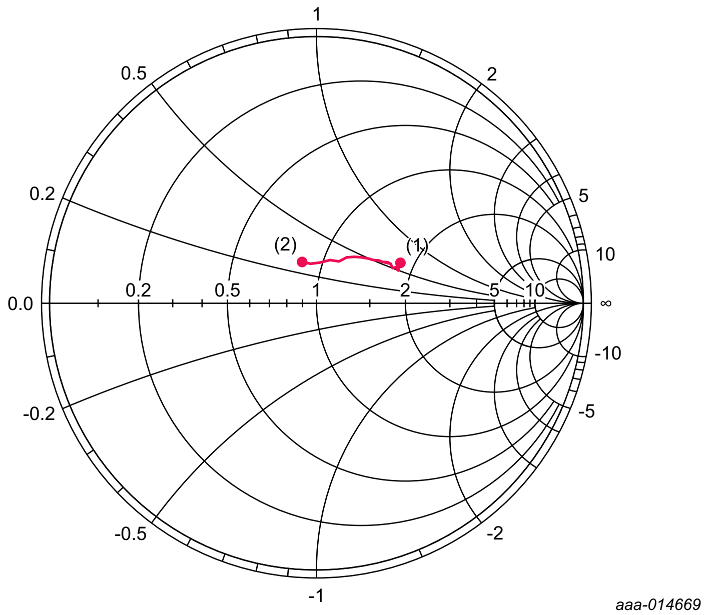
V_{CC} = 5 V.

(1) f_{LO} = 9.75 GHz

(2) f_{LO} = 10.60 GHz

(3) f_{LO} = 11.30 GHz

Fig 7. Conversion gain as a function of RF frequency; typical values



(1) f_{RF} = 10.70 GHz

(2) f_{RF} = 12.75 GHz

Fig 8. Input reflection coefficient (S_{11}); typical values

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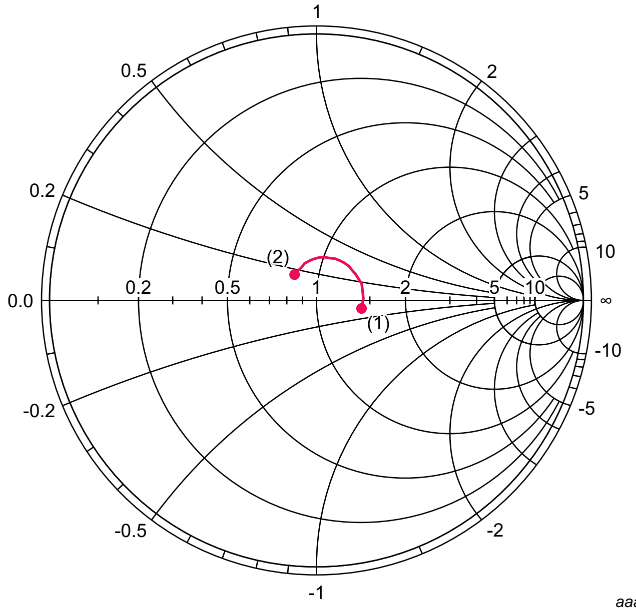
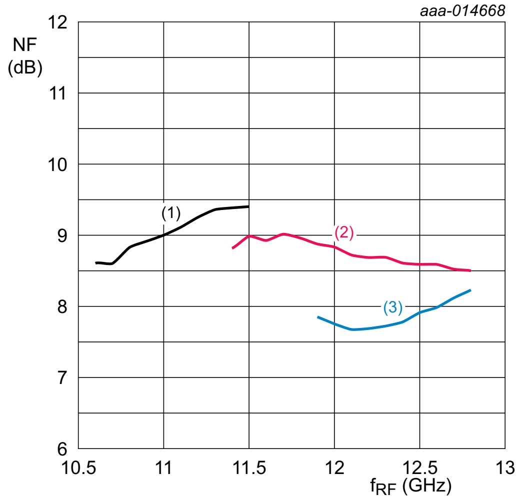


(1) f_{IF} = 250 MHz

(2) f_{IF} = 2150 MHz

Fig 9. Output reflection coefficient (S_{22}); typical values



V_{CC} = 5 V.

(1) f_{LO} = 9.75 GHz

(2) f_{LO} = 10.60 GHz

(3) f_{LO} = 11.30 GHz

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

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13. Application information

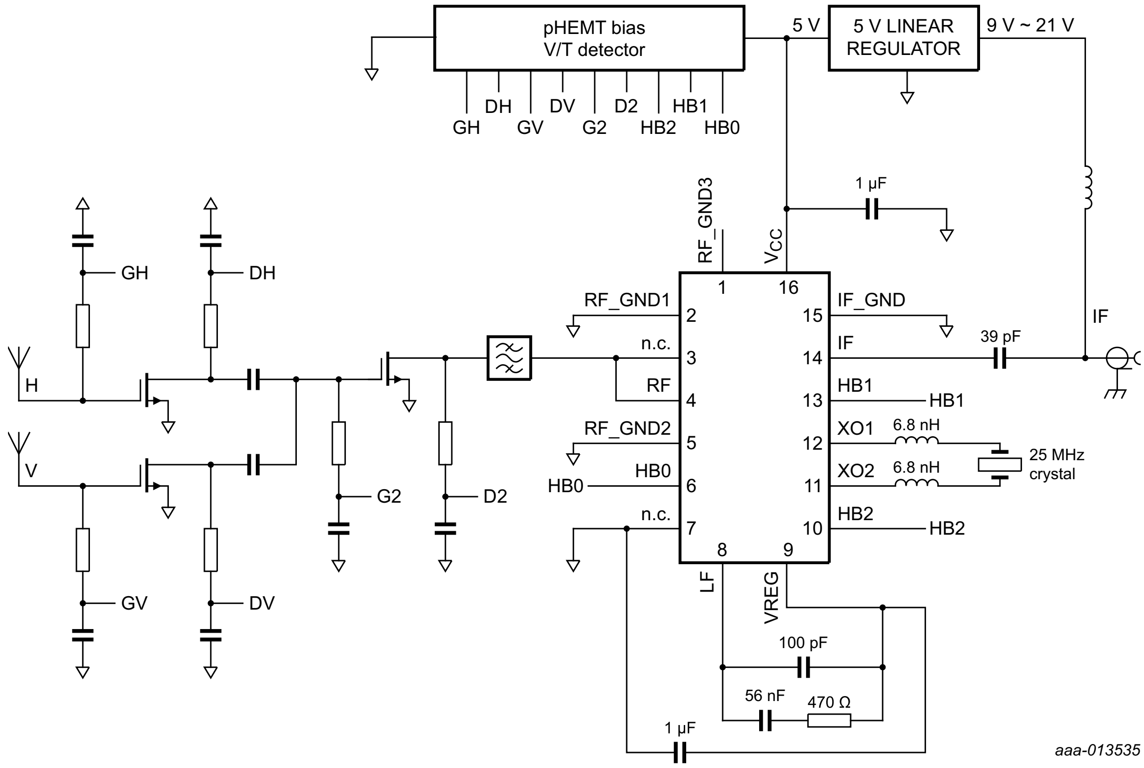

Fig 11. Application diagram of TFF1024HN

Table 9. List of netnames

See Figure 11.

Netname	Description
GH	Gate voltage of 1st stage LNA. Horizontal polarization
DH	Drain voltage of 1st stage LNA. Horizontal polarization
GV	Gate voltage of 1st stage LNA. Vertical polarization
DV	Drain voltage of 1st stage LNA. Vertical polarization
G2	Gate voltage of 2nd stage LNA
D2	Drain voltage of 2nd stage LNA
HB0	LO frequency selection, LSB
HB1	LO frequency selection
HB2	LO frequency selection, MSB

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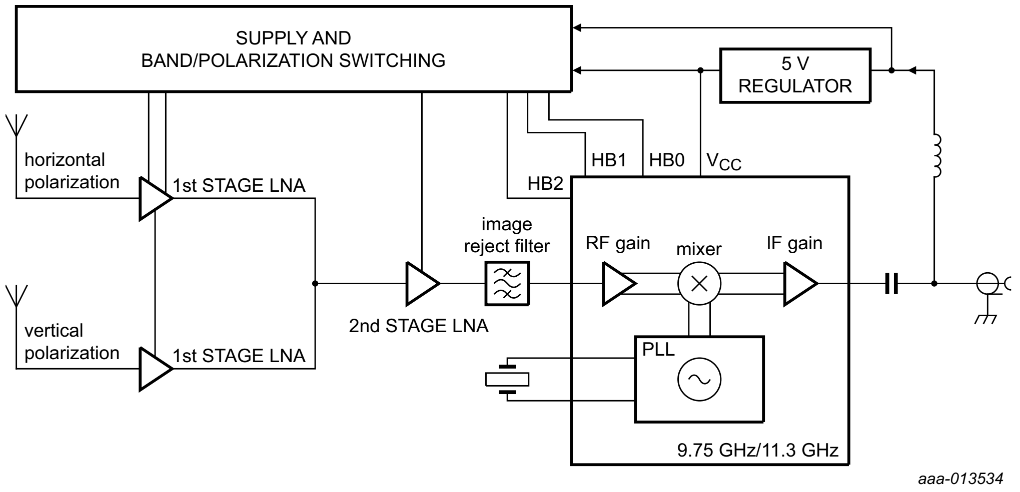

Fig 12. LNB system block diagram with TFF1024HN

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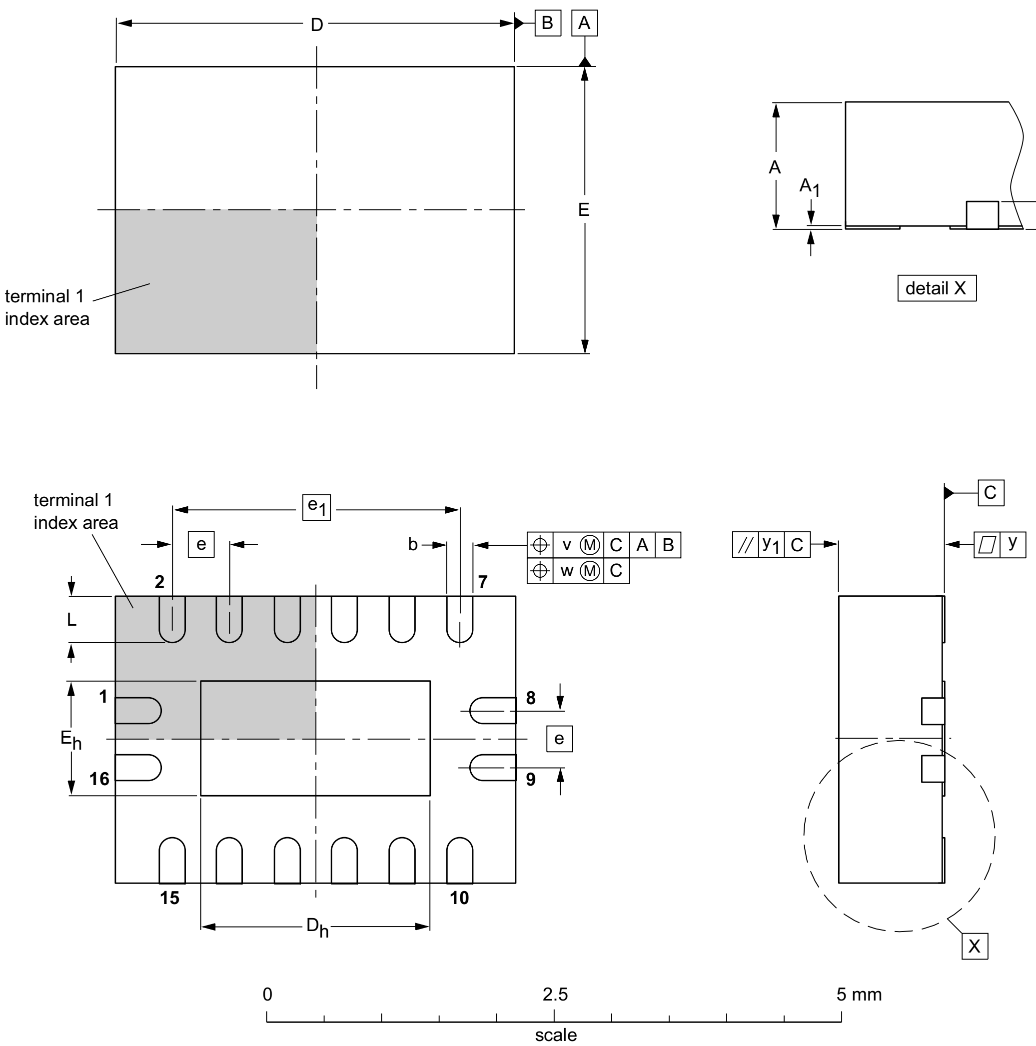
14. Package outline

DHVQFN16: plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 16 terminals; body 2.5 x 3.5 x 0.85 mm **SOT763-1**



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	L	v	w	y	y_1
mm	1	0.05 0.00	0.30 0.18	0.2	3.6 3.4	2.15 1.85	2.6 2.4	1.15 0.85	0.5	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			
SOT763-1	- - -	MO-241	- - -			~~02-10-17~~ 03-01-27

Fig 13. Package outline SOT763-1

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15. Abbreviations

Table 10. Abbreviations

Acronym	Description
CPW	CoPlanar Waveguide
DVB-S	Digital Video Broadcasting by Satellite
DVB-S2	Digital Video Broadcasting - Satellite - Second generation
ESD	ElectroStatic Discharge
IF	Intermediate Frequency
K_u band	K-under band
LNA	Low-Noise Amplifier
LNB	Low-Noise Block
LO	Local Oscillator
LSB	Least Significant Bit
MSB	Most Significant Bit
pHEMT	Pseudomorphic High Electron Mobility Transistor
PLL	Phase-Locked Loop
RBW	Resolution BandWidth
VSAT	Very Small Aperture Terminal
V/T	Voltage / Tone
VBW	Video BandWidth

16. Revision history

Table 11. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
TFF1024HN v.1	20150113	Product data sheet	-	-

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

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19. Contents

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Date of release: 13 January 2015
Document identifier: TFF1024HN