TFF1003HN

Low phase noise LO generator for VSAT applications

Rev. 2 — 1 May 2012 **Product data sheet**

1. General description

The TFF1003HN is a K_u band frequency generator intended for low phase noise Local Oscillator (LO) circuits for K_u band VSAT transmitters and transceivers. The specified phase noise complies with IESS-308 from Intelsat.

CAUTION

This device is sensitive to ElectroStatic Discharge (ESD). Therefore care should be taken during transport and handling.

2. Features and benefits

- Phase noise compliant with IESS-308 (Intelsat) in combination with appropriate source
- LO generator with VCO range from 12.8 GHz to 13.05 GHz
- Input signal 50 MHz to 816 MHz
- Divider settings 16, 32, 64, 128 or 256
- Output level –5 dBm; stability ±2 dB
- Third or fourth order PLL
- Internally stabilized voltage references for loop filter

3. Applications

- VSAT up converters
- Local oscillator signal generation

4. Quick reference data

Table 1. Quick reference data

Operating conditions of Table 10 apply.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	supply voltage		3.0	3.3	3.6	V
I_{CC}	supply current		-	100	130	mA
$f_{o(RF)}$	RF output frequency		12.8	-	13.05	GHz
$\varphi_{n(synth)}$	synthesizer phase noise	divider value = 64; at 100 kHz offset; reference phase noise is –149 dBc/Hz at 100 kHz offset	-	–97	–92	dBc/Hz
RL_{out}	output return loss	measured at demo board and de-embedded to footprint	-	–10	-	dB
$\alpha_{sup(sp)ref}$	reference spurious suppression	measured at divider value = 256	-	-	–70	dBc

5. Ordering information

Table 2. Ordering information

Type number	Package		
	Name	Description	Version
TFF1003HN	HVQFN24	plastic thermal enhanced very thin quad flat package; no leads; 24 terminals; body 4 × 4 × 0.85 mm	SOT616-1

6. Marking

Table 3. Marking codes

Type number	Marking code
TFF1003HN	1003

7. Block diagram

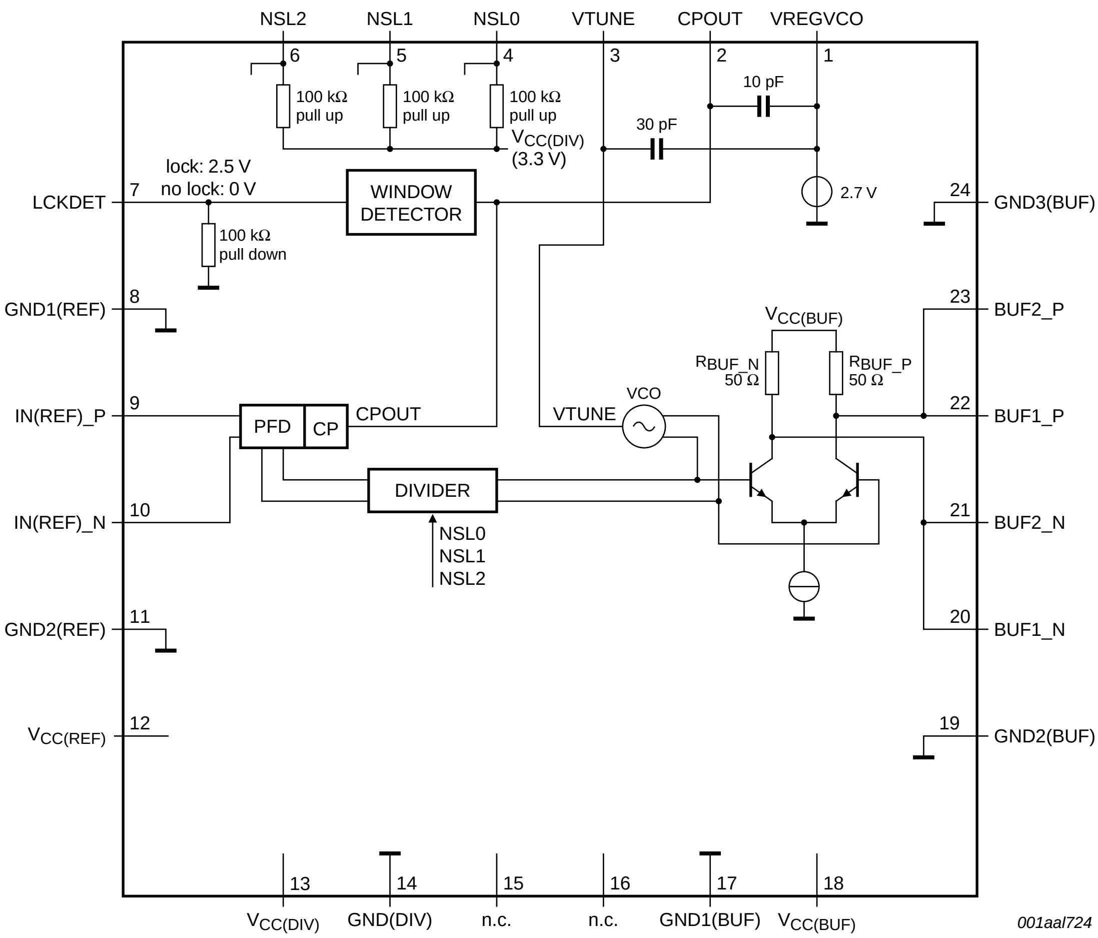


Fig 1. Block diagram

8. Functional diagram

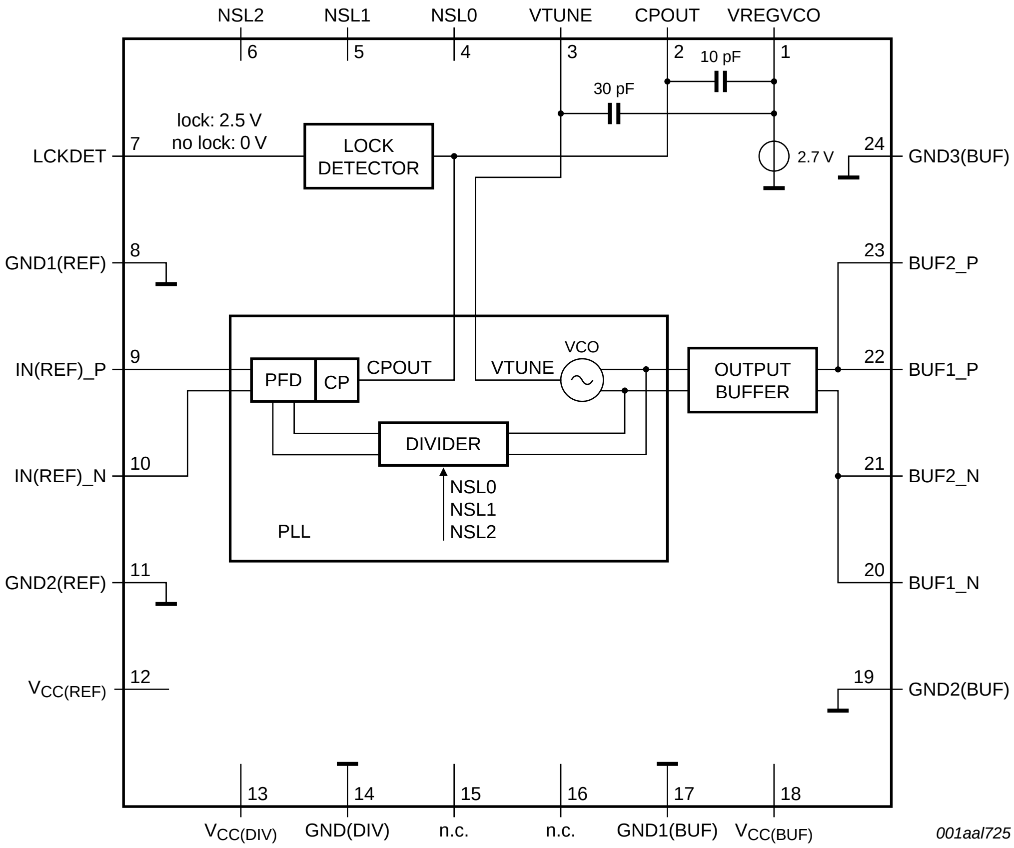


Fig 2. Functional diagram

9. Pinning information

9.1 Pinning

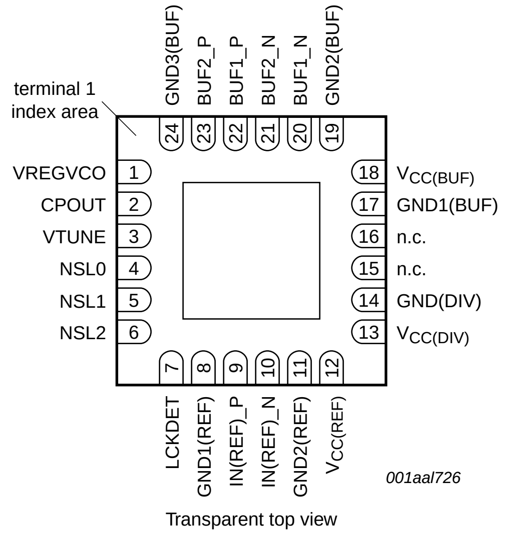


Fig 3. Pin configuration for HVQFN24

9.2 Pin description

Table 4. Pin description

Symbol	Pin	Description
VREGVCO	1	Regulated output voltage for VCO loop filter. Connect loop filter to this pin.
CPOUT	2	Charge pump output.
VTUNE	3	Tuning voltage for VCO.
NSL0	4	Divider setting, LSB. Leave open for “1”, connect to GND for “0”. See Table 8.
NSL1	5	Divider setting. Leave open for “1”, connect to GND for “0”. See Table 8.
NSL2	6	Divider setting, MSB. Leave open for “1”, connect to GND for “0”. See Table 8.
LCKDET	7	Lock detect. Lock = 2.5 V; out of lock = 0 V. See Table 6.
GND1(REF)	8	Ground for REF input. Connect this pin to the exposed diepad landing.
IN(REF)_P	9	Reference signal, non-inverting input. Couple this AC to the source.
IN(REF)_N	10	Reference signal, inverting input. Couple this AC to the source.
GND2(REF)	11	Ground for REF input. Connect this pin to the exposed diepad landing.
$V_{CC(REF)}$	12	Supply of the internal regulated voltages. Decouple this pin against GND2(REF) (pin 11).
$V_{CC(DIV)}$	13	Supply of the divider and PFD/CP. Decouple this pin against GND(DIV) (pin 14).
GND(DIV)	14	Ground of the divider. Connect this pin to the exposed diepad landing.
n.c.	15	not connected
n.c.	16	not connected
GND1(BUF)	17	Ground for RF output. Connect this pin to the exposed diepad landing.

Table 4. Pin description *...continued*

Symbol	Pin	Description
$V_{CC(BUF)}$	18	Supply voltage for the RF output buffer. Decouple this pin against GND2(BUF) (pin 19).
GND2(BUF)	19	Ground for RF output. Connect this pin to the exposed diepad landing.
BUF1_N	20	RF output.
BUF2_N	21	RF output.
BUF1_P	22	RF output.
BUF2_P	23	RF output.
GND3(BUF)	24	Ground for RF output. Connect this pin to the exposed diepad landing.

10. Functional description

The TFF1003HN consists of the following blocks:

- PLL
- Output buffer
- Lock detector
- Reference input
- Divider settings

The functionality of the blocks will be discussed below.

10.1 PLL

The PLL is formed by the VCO, DIVIDER (possible settings: 16, 32, 64, 128 and 256 (see Table 8)) and a PFD/CP. The tune voltage is referred to the band gap regulated voltage: VREGVCO (pin 1).

The loop filter can be set to type 2 or type 3. If a type 2 filter is used, the pins CPOUT (pin 2) and VTUNE (pin 3) must be interconnected. A 10 pF capacitor is placed internally between pins CPOUT (pin 2) and VREGVCO (pin 1), and a 30 pF capacitor is placed between pins VTUNE (pin 3) and VREGVCO (pin 1). See Figure 4 and Figure 5. Values for the loop filter components are given in Table 5.

The VCO input voltage range is between 0.1 and 0.9 $V_{O(reg)VCO}$.

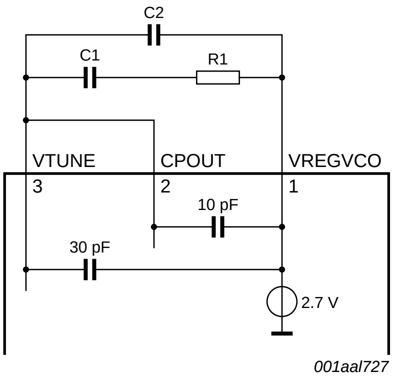


Fig 4. Type 2 loop filter

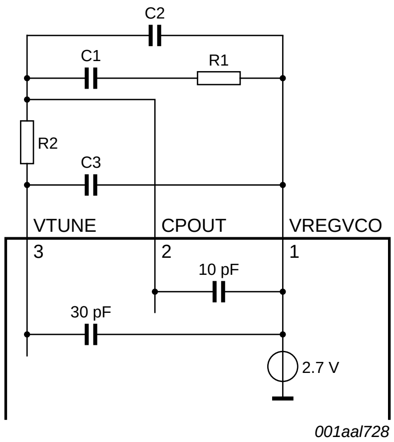


Fig 5. Type 3 loop filter

Table 5. Component values used for characterization

$f_{i(ref)}$ (MHz)	Divider value	C1 (nF)	C2 (pF)	C3 (pF)	R1 (Ω)	R2 (Ω)
50.000 to 50.977	256	27	82	33	470	560
100.000 to 101.953	128	18	82	33	330	560
200.000 to 203.906	64	18	120	33	270	560
400.000 to 407.813	32	33	270	33	120	560
800.000 to 815.625	16	68	560	33	68	560

10.2 Output buffer

The output consists of a differential pair with 50 Ω collector resistors R_{BUF_P} and R_{BUF_N}. If only one output is used, terminate the non used output with the same impedance as the load (see Figure 8)

10.3 Lock detector

The lock detector is the output of a window detector. The window detector compares the output voltage over the charge pump. This voltage is identical to VTUNE when a type 2 loop filter is used (see Figure 4). In case of a type 3 loop filter this voltage is filtered by R2/C3 (see Figure 5). Due to this filtering the attack and decay time will decrease.

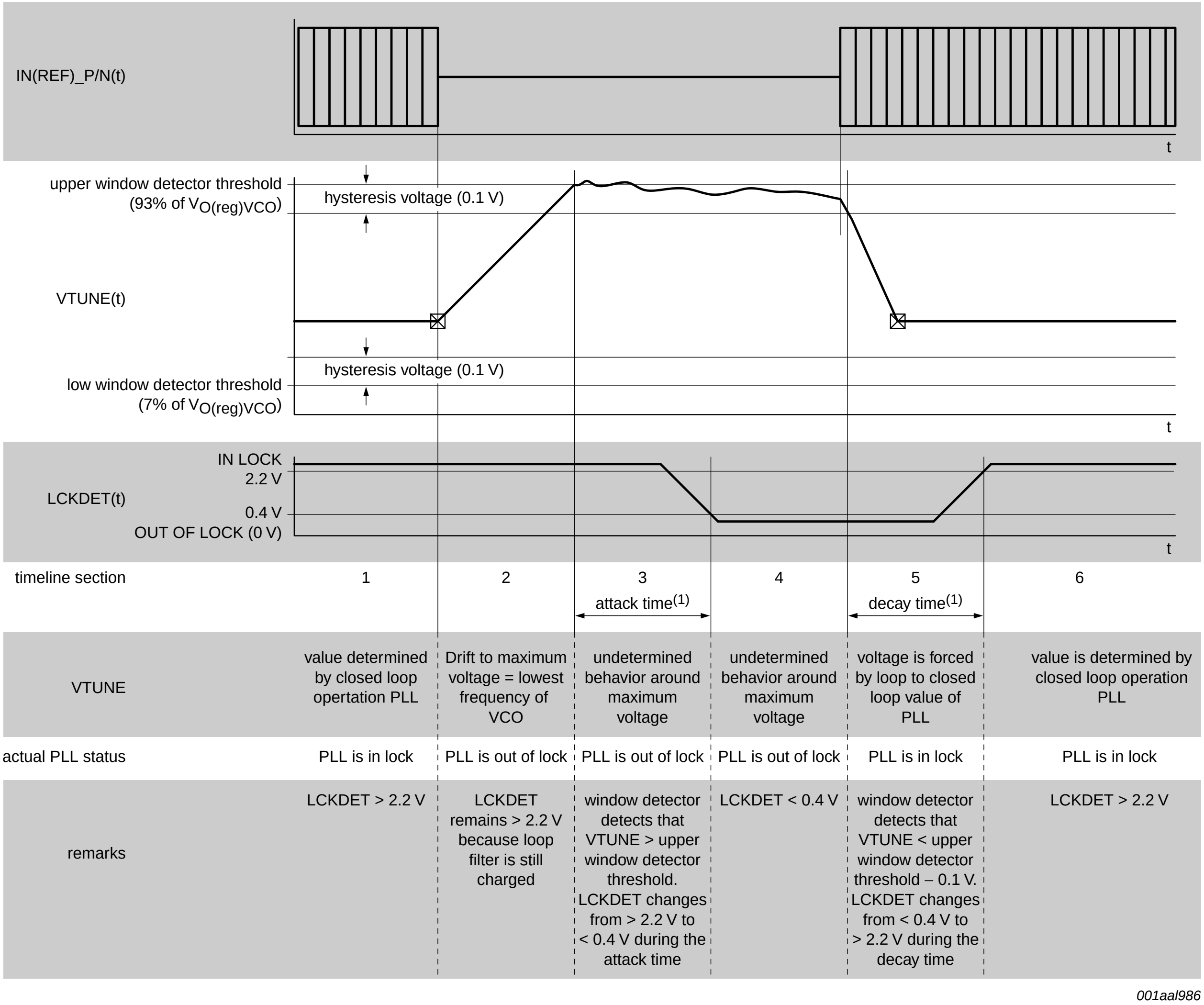
The lower window detector threshold voltage is 7 % of the output voltage on VREGVCO (pin 1), the upper window detector threshold voltage is 93 % of the output voltage on VREGVCO (pin 1). The hysteresis is 0.1 V. The output is 2.5 V CMOS compliant. The values are shown in Table 6. The timing diagram is shown in Figure 6.

At start-up the LCKDET (pin 7) will be LOW until the circuit has acquired lock.

Table 6. Logical value and physical value for lock detect (LCKDET)

Logical value	Physical value	Lock detect state
0	0 V	out of lock
1	2.5 V	lock

LCKDET (pin 7) has a pull-down resistor of 100 kΩ to GND1(REF) (pin 8).



(1) The attack time and decay time are typically 10 μs and are mainly depending on the drift of the VCO tuning voltage.

Fig 6. Timing diagram lock detector

10.4 Reference input (IN(REF)_P, IN(REF)_N)

The reference input is a differential pair and is internally biased. The input is high ohmic. The input signal must be AC coupled. If used in a single ended mode, the not used input must be terminated with the same impedance as the driving source.

An example of the differential source and two single ended loads are shown in Figure 7. An example of a single ended application is shown in Figure 8.

Note that the phase noise of the output signal is also determined by the phase noise of the reference signal. The reference frequency range is equal to the output frequency / division value. Note that the output frequency is guaranteed from 12.8 GHz to 13.05 GHz.

10.5 Divider settings (NSL2, NSL1, NSL0)

The divider can be set to 16, 32, 64, 128 and 256 (See Table 8). The logic levels for NSL0 (pin 4), NSL1 (pin 5) and NSL2 (pin 6) are given in Table 7.

The pins have a pull-up resistor of 100 kΩ to $V_{CC(DIV)}$ (pin 13).

The device is only guaranteed when NSL2, NSL1 and NSL0 are predefined at start-up (no change of divider value is allowed during operation).

Table 7. Logical and physical value for divider setting (NSL2, NSL1, NSL0)

Logical value	Physical value
0	GND
1	open or V_{CC}

The truth table is shown in Table 8.

Table 8. Divider setting as function of NSL2, NSL1 and NSL0

Setting number	NSL2	NSL1	NSL0	Divider value
0	0	0	0	16
1	0	0	1	32
2	0	1	0	64
3	0	1	1	128
4	1	0	0	256
5	1	0	1	[1]
6	1	1	0	[1]
7	1	1	1	[1]

[1] Test mode, divider output will be disabled.

11. Limiting values

Table 9. Limiting values

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

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{CC(REF)}$	reference supply voltage		–0.5	+3.6	V
$V_{CC(DIV)}$	divider supply voltage		–0.5	+3.6	V
$V_{CC(BUF)}$	buffer supply voltage		–0.5	+3.6	V
T_j	junction temperature		–40	+125	°C
T_{stg}	storage temperature		–40	+125	°C

12. Recommended operating conditions

Table 10. Operating conditions

NSL0 (pin 4), NSL1 (pin 5) and NSL2 (Pin 6) not changed during operation.
Loop filter component values as depicted in Table 5 are used.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
T_{amb}	ambient temperature			–40	+25	+85	°C
Z_0	characteristic impedance			-	50	-	Ω
$\varphi_{n(ref)}$	reference phase noise	divider value = 16	[1]	-	-	–134	dBc/Hz
		divider value = 32	[1]	-	-	–143	dBc/Hz
		divider value = 64	[1]	-	-	–149	dBc/Hz
		divider value = 128	[1]	-	-	–150	dBc/Hz
		divider value = 256	[1]	-	-	–151	dBc/Hz
$f_{i(ref)}$	reference input frequency	$f_{i(ref)} = f_{o(RF)}$ / divider value		50	-	816	MHz
$P_{i(ref)}$	reference input power			–10	-	0	dBm

[1] Required reference phase noise is set 10 dB below equivalent input phase noise.

13. Thermal characteristics

Table 11. Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-sp)}$	thermal resistance from junction to solder point		25	K/W

14. Characteristics

Table 12. Characteristics

Operating conditions of Table 10 apply.

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{CC}	supply voltage			3.0	3.3	3.6	V
I_{CC}	supply current			-	100	130	mA
PLL							
$f_{o(RF)}$	RF output frequency			12.8	-	13.05	GHz
$V_{O(reg)VCO}$	VCO regulator output voltage			2.5	2.7	2.9	V
I_{cp}	charge pump current			-	1	-	mA
K_O	VCO steepness		[1]	0.3	0.6	1.0	GHz/V
$\varphi_{n(VCO)}$	VCO phase noise	at 10 MHz offset		-	–130	-	dBc/Hz
$\varphi_{n(synth)}$	synthesizer phase noise	divider value = 64; at 100 kHz offset; reference phase noise is –149 dBc/Hz at 100 kHz offset		-	–97	–92	dBc/Hz
Output buffer							
P_o	output power	measured single ended	[2]	–7	–5	–3	dBm
RL_{out}	output return loss	measured at demo board and de-embedded to footprint		-	–10	-	dB
$\alpha_{sup(sp)ref}$	reference spurious suppression	measured at divider value = 256		-	-	–70	dBc

Table 12. Characteristics *…continued*
Operating conditions of Table 10 apply.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$\alpha_{H(LO)}$	LO harmonic rejection		-	–10	-	dBc
Lock detector						
V_{OL}	LOW-level output voltage	I_O = 1 mA	-	-	0.4	V
V_{OH}	HIGH-level output voltage	I_O = –1 mA	2.2	-	-	V
R_{pd}	pull-down resistance		70	100	130	kΩ
Divider setting (NSL0, NSL1, NSL2)						
R_{pu}	pull-up resistance		70	100	130	kΩ
V_{IL}	LOW-level input voltage		-	-	0.8	V
V_{IH}	HIGH-level input voltage		2.0	-	-	V

[1] The typical ratio of the maximum K_O in relation to the minimum K_O is 1.25.

[2] Output stage is a differential pair with 50 Ω collector impedances.
Output power is measured per output pin for the fundamental tone only.
Output is DC coupled and is AC coupled in on-board.

15. Application information

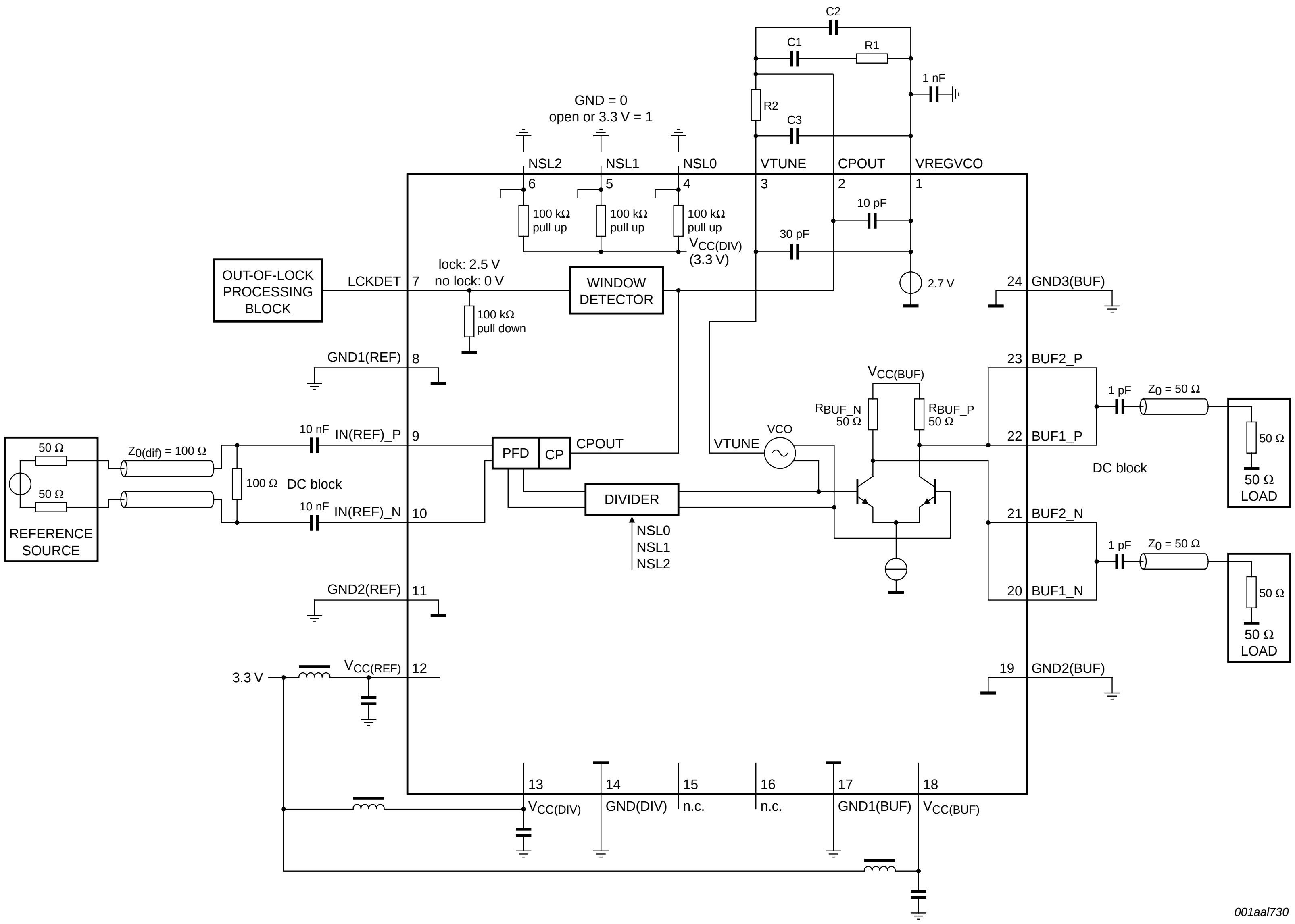


Fig 7. Application diagram with differential source for IN(REF) and both outputs driving a load, loop filter is type 3

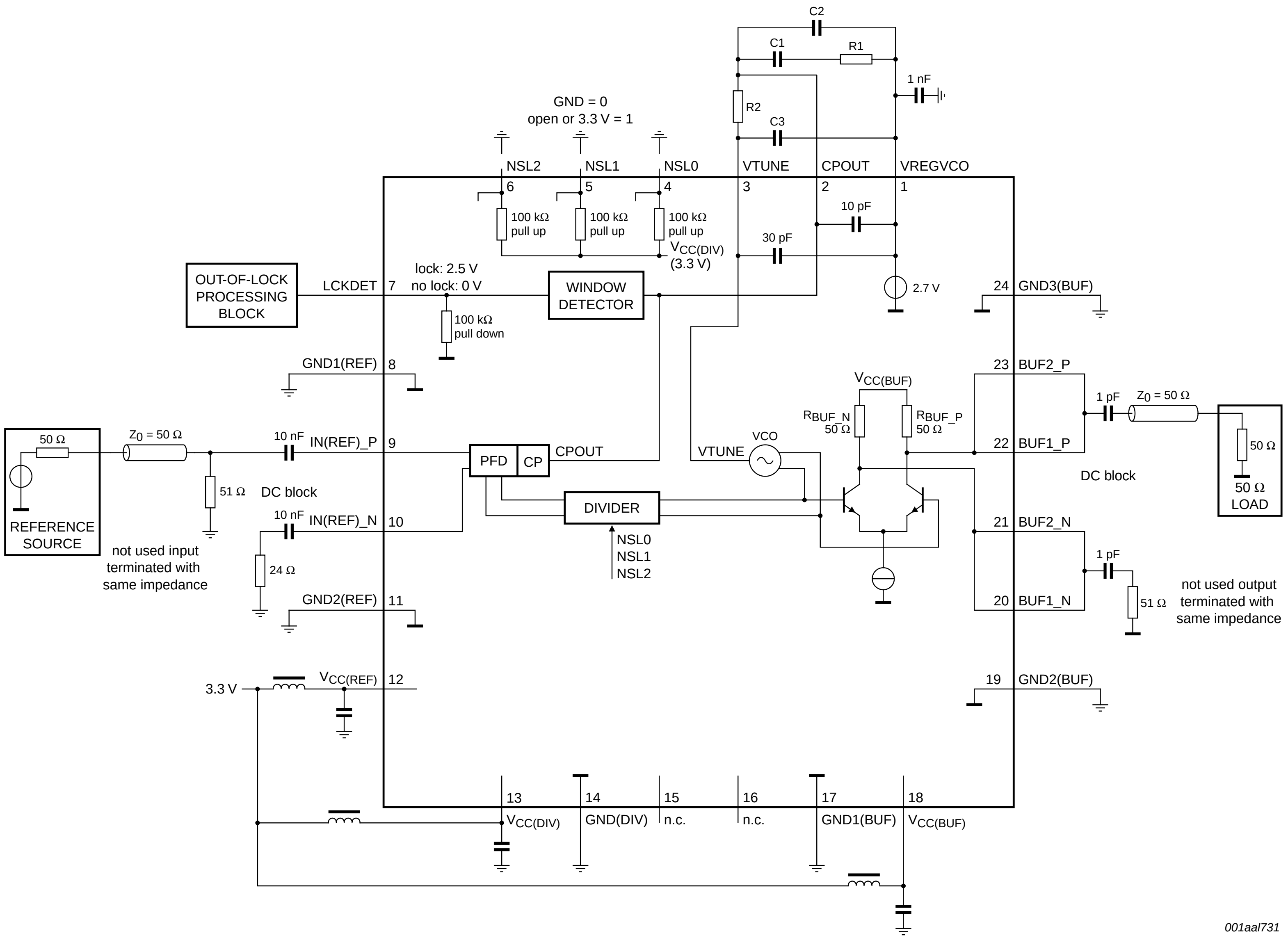
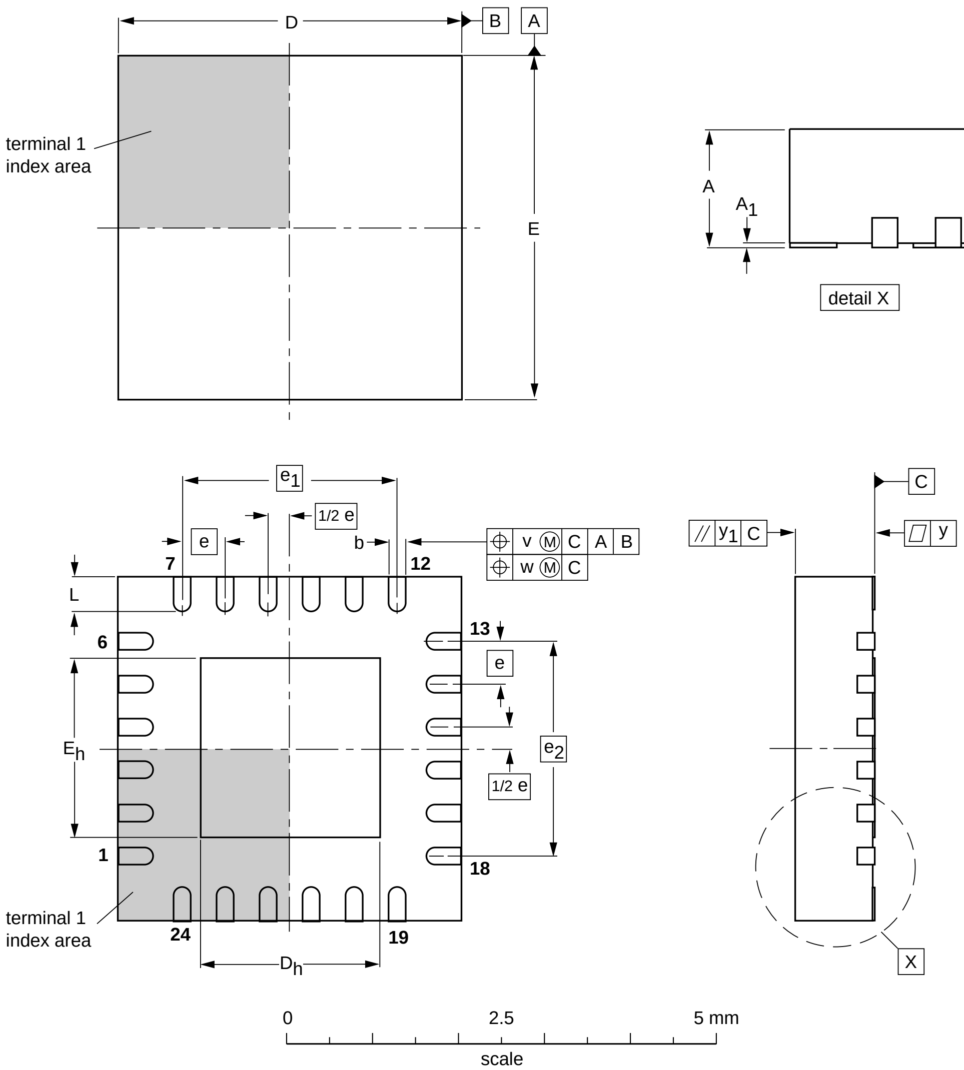


Fig 8. Application diagram with single ended source for IN(REF) and single ended load, loop filter is type 3

16. 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 9. Package outline SOT616-1 (HVQFN24)

17. Abbreviations

Table 13. Abbreviations

Acronym	Description
CMOS	Complementary Metal Oxide Semiconductor
CP	Charge Pump
K_u band	K-under band
LSB	Least Significant Bit
MSB	Most Significant Bit
PFD	Phase Frequency Detector
PLL	Phase-Locked Loop
VCO	Voltage Controlled Oscillator
VSAT	Very Small Aperture Terminal

18. Revision history

Table 14. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
TFF1003HN v.2	20120501	Product data sheet	-	TFF1003HN v.1
Modifications:	• Table 3 on page 2: marking has been corrected.			
TFF1003HN v.1	20100519	Product data sheet	-	-

19. Legal information

19.1 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.
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[2] The term 'short data sheet' is explained in section "Definitions".

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