

GNS7560

High-performance single-chip A-GPS solution

Rev. 2.2 — 7 May 2010

Final Datasheet

1. General description

The GNS7560 is a high-performance single-chip L1 GPS solution for cellular handset applications. The advanced GPS baseband is the result of more than 20 years investment in GPS technology and 10 generations of products. The solution offers best-in-class acquisition and tracking sensitivity, Time-To-First-Fix (TTFF) and accuracy. The device minimizes system power consumption with ultra-low energy-per-fix due to the ultra-low power consumption and a set of power management modes designed into the GPS RF and baseband architecture. The GNS7560 supports both fully-autonomous operation for use in handheld consumer navigation devices and other standalone navigation systems, and Assisted-GPS (A-GPS) operation on GSM, WCDMA and CDMA networks. The GNS7560-hosted architecture shifts the non-real-time-critical navigation software to the host system's microprocessor, minimizing system cost and PCB size. Host software drivers are available for the most popular operating systems for handsets and other portable devices. The highly integrated solution allows easy integration by providing connections for RF, clock inputs, host serial interface, and power. The GNS7560 is supported with full reference designs, demonstration systems, software development kits and other documentation.

2. Features

- ◆ Best-in-class acquisition and tracking sensitivity, TTFF and accuracy
 - ◆ -158 dBm acquisition-assisted, -160 dBm track using internal LNAs
- Optimized for cellular handsets
- Advanced proprietary multipath algorithms for robust low-dropout tracking in indoor and very low signal environments
- Hosted architecture optimized for cost and performance
- Supports GSM, WCDMA and CDMA control plane A-GPS assistance data standards
- Supports SUPL user plane A-GPS assistance data
- Exceeds 3GPP and TIA performance requirements
- Ultra-low power consumption: < 18mW in tracking mode
- Supports all cellular handset reference frequencies
 - WLCSP: 54 ball, 2.44 mm × 3.64 mm × 0.57 mm
- TFBGA option: 54 ball, for low-cost manufacturing environments
 - Ultra-low external component count to enable a PCB footprint of less than 25 mm²
- 2 UARTs and SSI host interfaces
- Temperature range -40 °C to +85 °C

3. Applications

- Cellular handset integration for navigation and location-based services
- Handheld consumer navigation and multifunction devices
- Battery-operated GPS devices

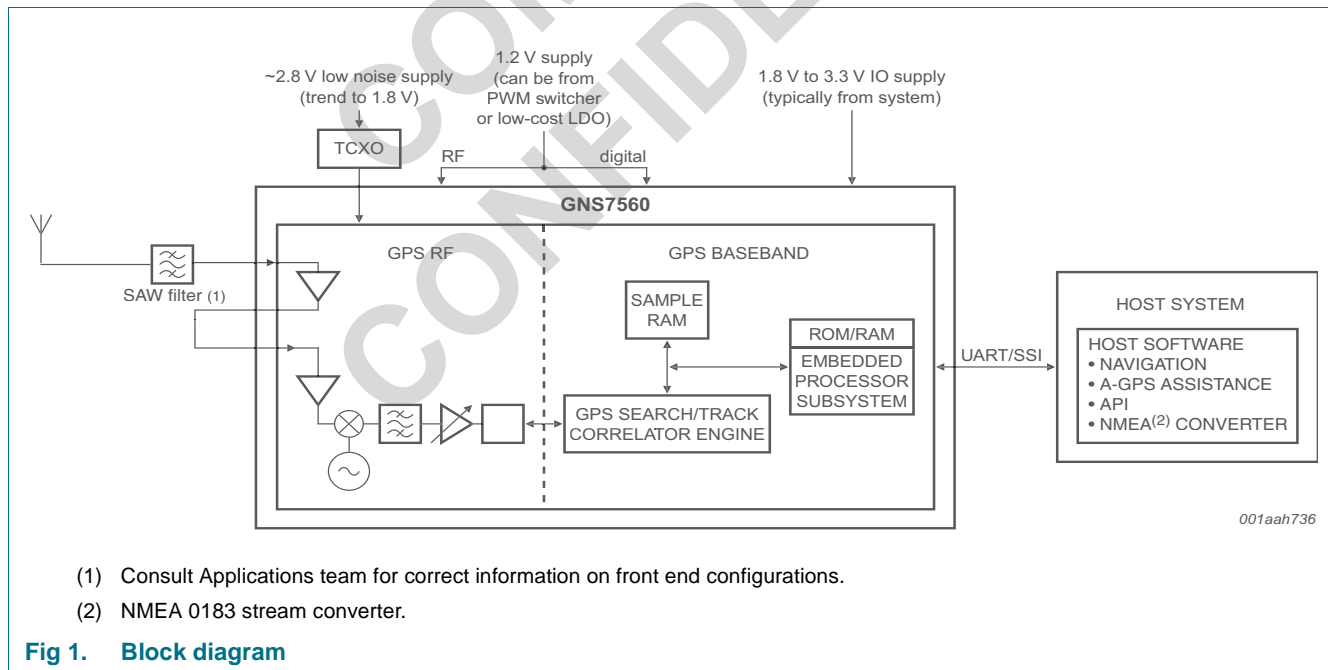
4. Ordering information

Table 1. Ordering information^[1]

Type number	Package		Version
	Name	Description	
GNS7560UK214TS	WLCSP54	wafer level chip-size package; 54 bumps; 2.44 × 3.64 × 0.57 mm	GNS7560UK/N2
GNS7560ET2GE	TFBGA54	plastic thin fine-pitch ball grid array package; 54 balls (7560/N2 is marked on IC) - Tray	SOT1065-1
GNS7560ET2UM	TFBGA54	plastic thin fine-pitch ball grid array package; 54 balls (7560/N2 is marked on IC) - Tape&Reel 13"	SOT1065-1
GNS7560ET2GA	TFBGA54	plastic thin fine-pitch ball grid array package; 54 balls (7560/N2 is marked on IC) - Single Tray	SOT1065-1
GNS7560ET2HFUM	TFBGA54	plastic thin fine-pitch ball grid array package; 54 balls (7560/N2 is marked on IC) - Halogen Free version	SOT1065-1

[1] Minimum order quantity: 5000 units for GNS7560ET2UM and 2000 units for GNS7560UK214TS.

5. Block diagram



6. Functional diagram

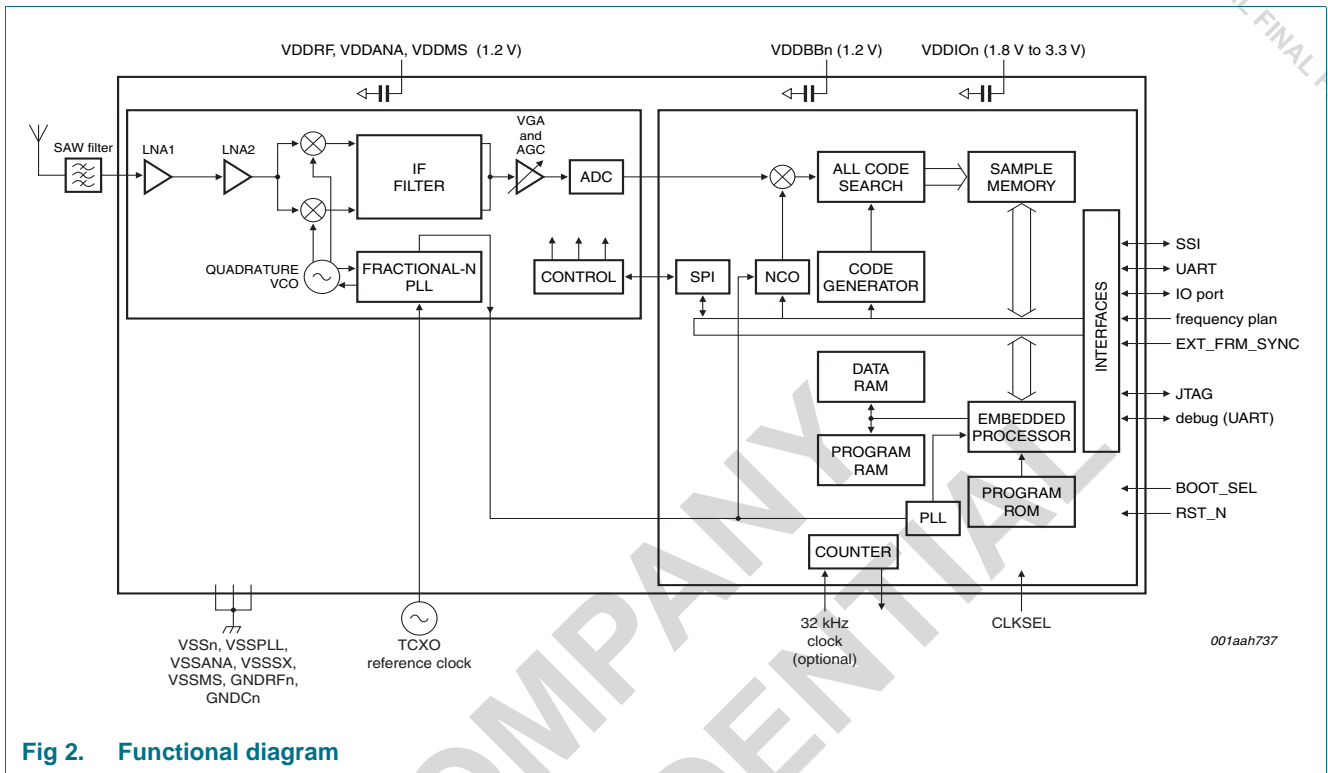


Fig 2. Functional diagram

7. Pinning information

7.1 Pinning

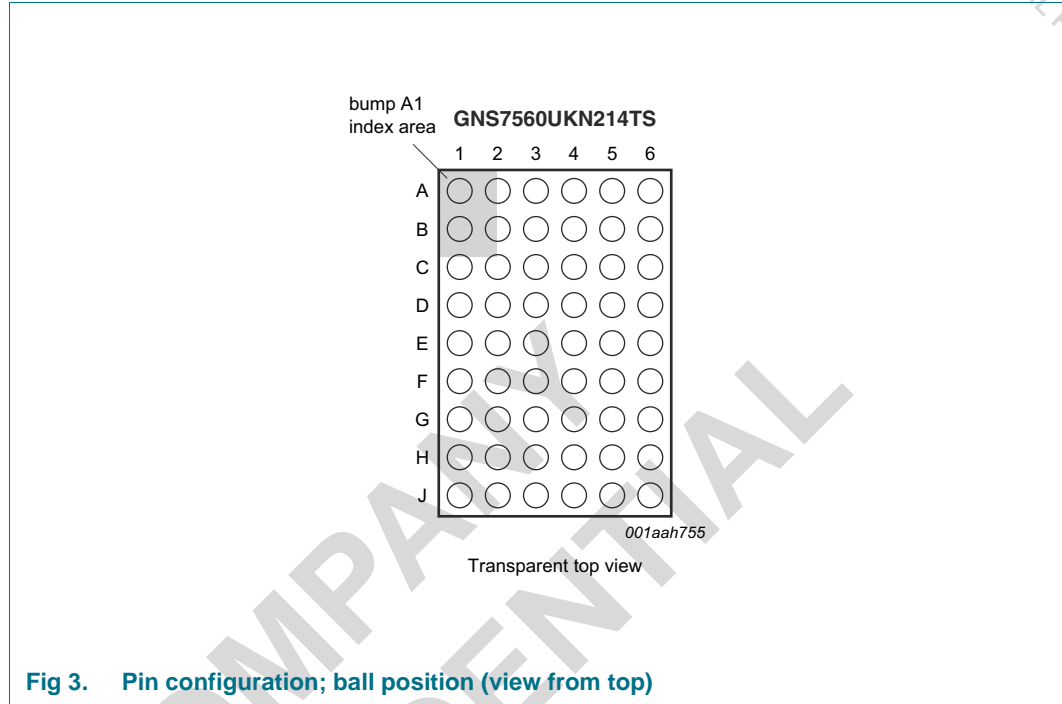


Fig 3. Pin configuration; ball position (view from top)

Table 2. Pin allocation table

Pin	Symbol	Pin	Symbol	Pin	Symbol
A1	MODE1	D1	VDDIO2	G1	GNDRF1
A2	VSS3	D2	UART2_RXD/SSI_SLV_CLKIN	G2	VDDRF
A3	VDDBB2	D3	DEBUG_BOOT	G3	TESTOUT
A4	VSS2	D4	PULSE_OUT	G4	GNDC1
A5	VDDIO1	D5	PWM_OUT	G5	GNDC2
A6	VSSPLL	D6	RST_N	G6	VSSMS
B1	VSS4	E1	GPIO[12]	H1	RFINP
B2	MODE0	E2	EXT_FRM_SYNC	H2	GNDRF2
B3	MODE3	E3	UART2_TXD/SSI_SLV_SO	H3	VDDANA
B4	GPIO[3]	E4	LNA_EN	H4	TESTIN
B5	UART2_CTS/SSI_SLV_CS	E5	VDDBB1	H5	SXTEST
B6	TCXO_EN	E6	VSS1	H6	VDDMS
C1	VDDBB3	F1	BOOT_SEL0	J1	RFINM
C2	CLKSEL	F2	BOOT_SEL1	J2	SAWIN
C3	MODE2	F3	BOOT_SEL2	J3	SAWOUT/RFIN2
C4	EXT_DUTY_CYCLE	F4	UART1_TXD	J4	VSSANA
C5	UART2_RTS/SSI_SLV_SI	F5	CLK32KIN	J5	VSSSX
C6	UART1_RXD	F6	CLK32KOUT	J6	TCXO_IN

[Table 3](#) shows the pinout of the GNS7560 device, detailing the BGA number, the pin name and a brief description of its function.

Table 3. Pin description

Symbol	Pin	Type ^[1]	Description
Power supplies			
VDDBB1	E5	P	1.2 V power supply for baseband core
VDDBB2	A3		
VDDBB3	C1		
VDDIO1	A5	P	1.8 V or 2.5 V or 3.3 V power supply for I/O cells
VDDIO2	D1		
VDDRF	G2	P	1.2 V power supply for LNA section of RF
VDDANA	H3	P	1.2 V power supply for IF analog section
VDDMS	H6	P	1.2 V power supply for mixed signal section (ADC and programmable gain amplifier)
VSS1	E6	P	ground for baseband
VSS2	A4		
VSS3	A2		
VSS4	B1		
VSSPLL	A6	P	analog ground for internal PLL block
GNDRF1	G1	P	ground for LNA1 section of RF
GNDRF2	H2	P	ground for LNA2 section of RF
GNDC1	G4	P	cold ground
GNDC2	G5		
VSSANA	J4	P	ground for IF analog section
VSSSX	J5	P	ground for analog section which includes frequency synthesizer
VSSMS	G6	P	ground for mixed signal section (ADC and programmable gain amplifier)
RF input			
RFINM	J1	I	LNA (-) RF input ^[2]
RFINP	H1	I	LNA (+) RF input ^[2]
SAWIN	J2	O	LNA1 output; in normal configuration this is connected to the input of the SAW filter
SAWOUT/RFIN2	J3	I	LNA2 input or RF input; in normal configuration this is connected to the output of the SAW filter when the device is used with an external LNA this is the RF input
Clock interfaces			
CLK32KIN	F5	I	32 kHz clock input for on-chip counter
CLK32KOUT	F6	O	32 kHz clock output

Table 3. Pin description ...continued

Symbol	Pin	Type ^[1]	Description
CLKSEL	C2	I	clock selection input; LOW = internal PLL clock HIGH = external 32 kHz clock When CLKSEL is set to HIGH the device will boot in low power mode with the UART baud rate set to 600baud. The Host software will download the frequency of the TCXO crystal being used. When using this mode the BOOTSEL[0:2] inputs are set to {1,1,1}
TCXO_IN	J6	I	external TCXO GPS reference clock input
Boot mode selection			
BOOT_SEL0	F1	I	boot mode selection inputs 0 to 2; see Table 19
BOOT_SEL1	F2		
BOOT_SEL2	F3		
RST_N	D6	I	asynchronous reset, active LOW
I/O port interface^[3]			
GPIO[3]	B4	I/O	GPIO input or output: not used output with 4 mA drive current When using UART host interface this I/O should be left unconnected. When using SPI mode this pin should have a 1k Ohm pull down resistor.
EXT_FRM_SYNC	E2	I	external sync input to synchronize the GPS engine to an external source with sub 1 ms timing; input with pull-down resistor
PULSE_OUT	D4	I/O	1 pulse-per-second input; used for timing applications output with 4 mA drive current
UART2_RXD/SSI_SLV_CLKIN	D2	I	UART2 receive data input (host interface) or SSI receive serial clock input
UART2_TXD/SSI_SLV_SO	E3	O	UART2 transmit data output (host interface) or SSI transmit serial data output to host (serial output); output with 2 mA drive current
UART1_RXD	C6	I	UART1 receive data input (test interface); input with pull-up resistor
EXT_DUTY_CYCLE	C4	I/O	external duty cycle control input; GPIO input or output with 4 mA drive current and pull-down resistor
PWM_OUT	D5	I/O	input or output with 2 mA drive current
UART1_TXD	F4	O	UART1 transmit data output (test interface); output with 2 mA drive current
LNA_EN	E4	I/O	external LNA enable output; see Table 7 input or output with 2 mA drive current and pull-down resistor
TCXO_EN	B6	I/O	external TCXO enable output; see Table 7 input or output with 4 mA drive current and pull-up resistor

Table 3. Pin description ...continued

Symbol	Pin	Type ^[1]	Description
UART2_CTS/SSI_SLV_CS	B5	I/O	UART2 clear-to-send (host interface) or SSI to host chip select input or output with 2 mA drive current, pull-up resistor and Schmitt trigger input
UART2_RTS/SSI_SLV_SI	C5	I/O	UART2 ready-to-send (host interface) or SSI to host serial input input or output with 2 mA drive current and pull-up resistor
GPIO[12]	E1	I/O	GPIO input or output with 2 mA drive current: not used
Test and debug interfaces			
TESTOUT	G3	O	IF test output
TESTIN	H4	I	test input
SXTEST	H5	I/O	test input or output (frequency synthesizer)
DEBUG_BOOT	D3	I	debug mode, trigger emulation boot, download monitor program
MODE0	B2	I	host interface selection outputs for selecting either both UARTs or the slave SSI; see Table 21
MODE1	A1		
MODE2	C3		
MODE3	B3		

[1] P = power supply, I = input, O = output, I/O = input/output.

[2] The device uses a differential front end to enable the lowest cost solution. If a single-ended antenna is used, a balun is used to match the input to the antenna.

[3] The I/O port interface pins can carry information for either the UARTs or the slave SSI depending on the setting of MODE[3:0] pins; see [Table 21](#).

8. Functional description

8.1 System overview

The GNS7560 provides a complete GPS solution designed for ease of integration into host platforms. The key components are described below.

- Baseband channel block
 - Flexible architecture readily adaptable to specific market, air interface and silicon cost requirements
- GPS software
 - Indoor acquisition and tracking
 - Network-assistance ready (mobile-based, mobile-assisted, CDMA, W-CDMA, GSM, control plane and user plane)
 - Stand-alone GPS operation
 - Support of different location-based service protocols
 - Instant fixes
- Host-based navigation software (See also [Section 8.6](#))
 - Well-defined API for control and reporting to host applications
 - ‘OS wrapper’ enabling simple porting to customer-preferred operating system

8.1.1 Receiver section

The GNS7560 includes a low-power, single-conversion low-IF GPS receiver for the 1.575 GHz, L1 signal. The device contains a fully-integrated GPS receive path, including LNAs, that down-convert the GPS L1 signal of 1575.42 MHz, to an IF signal quantized to 4 bits and delivered to the integrated GPS baseband device. The device also contains a fully-integrated frequency synthesizer that generates the correct LO frequency to down-convert the GPS signal starting from any reference frequency input, including all cellular handset reference frequencies.

8.2 GPS performance

The GNS7560 is a DSP-centric, highly-integrated design with reduced silicon, and cost-optimized for all current and next-generation air interfaces (CDMA, GSM/GPRS/EDGE, WCDMA/UMTS).

The baseband section has the following key features:

- Optimized for asynchronous networks
- Measurement engine with a search capacity of 42 channels
- Maximum acquisition sensitivity -158 dBm

The indoor and outdoor mixed-mode acquisition and tracking sensitivity performance characteristics are given in [Table 4](#).

Table 4. Acquisition and tracking performance

Acquisition/tracking mode	LNA	Signal level	TTFF ^[1]
CDMA acquisition ^[1]		-152 dBm	10 s
GSM/WCDMA/3GPP acquisition ^[2]	internal	-152 dBm	<20 s
	external	-152 dBm	<15 s
Hot start (open sky)		-130 dBm	1 s
Cold start (open sky)		-130 dBm	<38 s
Lowest sensitivity: ephemeris decode (application-specific software-build dependent)		-142 dBm to -145 dBm	
Minimum tracking signal level (deep indoors)	internal	-160 dBm	
	external	-160 dBm	

[1] CDMA aiding: time known to < 100 μ s, location known to < 3 km, oscillator known to 0.05 ppm, known ephemeris for available satellites (RMS).

[2] GSM (coarse) and WCDMA/3GPP aiding: time known to < 2 s, location known to < 3 km, oscillator known to 0.05 ppm, known ephemeris for available satellites (RMS).

8.2.1 Positional accuracy

Optimized for Location-Based Services (LBS) and better than FCC E911 mandate requirements and 3GPP 34.171 requirement; see [Table 5](#).

Table 5. Positional accuracy

Accuracy (RMS value)	Signal level
<5 m	-135 dBm (outdoor)
<20 m	-148 dBm (indoor)
<50 m	-152 dBm (indoor)

8.2.2 Additional GPS-related features

- Channels: dynamic channel and dynamically configurable architecture management
- Positioning modes: autonomous/standalone, mobile-assisted, mobile-based, simultaneous or mixed modes, navigation (Kalman filter)
- Update rate: user selectable - event, position, command/request, periodic (2 per second to once per hour)
- Host software protocol support: NMEA 0183 STEricsson API air interface
- Application microprocessor requirements: no real-time processing requirements, only requirement is C-compiler and floating-point libraries

8.3 Additional features

- Embedded DSP
- UART and SSI host interfaces
- Configurable GPIO
- 1 pulse-per-second output (PULSE_OUT)

8.4 RF front end

The RF Front End (RFFE) includes two low-noise amplifiers with a fully-integrated 50 Ω matching network on the second LNA, IF band-pass filter, VCO and high-performance fractional-N PLL.

8.5 GPS baseband

8.5.1 Overview

The GPS baseband provides the baseband signal processing for the GPS receiver (IF down-conversion, correlation and integration). The GPS baseband includes an embedded DSP whose firmware controls the baseband's GPS acquisition and tracking. The DSP firmware is a ROM within the GNS7560, that does not require support from any external device. Higher-level software running on a separate host calculates navigation solutions (the host-based navigation software).

The GPS baseband has the following features:

- Embedded DSP
- Correlation engine
- GPS code generation
- Coherent and incoherent summation block
- Doppler wipe off
- Magnitude calculation
- Compare-and-threshold signal detection
- Timing and control
- Power saving
- Clocking architectures

- Two universal asynchronous receiver/transmitter interfaces:
 - UART1: development tool for the embedded DSP firmware
 - UART2: host interface to communicate with the host-based navigation software
- Slave Synchronous Serial Interface (SSI) for optional interface to an external host microprocessor

8.5.2 Embedded DSP firmware

The embedded DSP firmware performs the following functions:

- Interfaces to GPS baseband hardware
- Searches for satellites either autonomously or commanded using acquisition data from host
- When a satellite has been acquired, transitions to track the satellite
- Where possible, demodulates the satellite navigation message data
- During satellite tracking, monitors the signals for validity and multipath
- At the required update rate (typically 1 Hz) sends the latest raw satellite measurements to the host-based navigation software

All real-time, critical or high-interrupt rate functions are performed within the embedded DSP firmware.

8.5.3 Interface between GNS7560 and host-based navigation software

This interface is a two-way link, normally using a UART interface (UART 2), but can use the slave SSI interface. The max data rate that can be supported is 400kbps, however the physical layer can run at 3Mbps. The UART interface uses a 115.2 kBd data rate, transferring about 4 kB of data per update.

The host-based navigation software sends requests for when the next raw satellite measurements are required, and also provides satellite acquisition aiding data and channel/satellite reset commands.

The host-based navigation software also sends GNS7560 mode set commands for Sleep, Coma or Deep coma. The Sleep mode command also specifies a time-out for the automatic transition from Sleep to Coma mode. A wake-up command is also provided.

The GNS7560 responds by sending raw satellite measurements to the host-based navigation software at the requested time, and also provides the parity-checked raw subframes of the satellite navigation messages (when available).

8.6 Host-based navigation software

The host-based navigation software will run on a range of processors, notably ARM, and a variety of high-level and real-time operating systems. The purpose of this software is to provide the user application with GPS position information. To do this the GPS navigation software interfaces with the host microprocessor software, the operating system and the GNS7560.

The host-based navigation software performs the following functions:

- Interface to the GNS7560

- API interface to host software
- Satellite navigation message data decode and state table generation
- Satellite measurement generation (pseudorange, Doppler, etc.)
- Navigation Kalman filter task: calculates position, velocity, time, frequency
- Satellite pre-positioning: predicts where to search for a satellite
- Navigation output generation, including NMEA 0183 stream

The typical system requirements of the host software are:

- Memory requirement:
 - ROM or flash 100 kB to 300 kB, OS dependent
 - RAM - up to 100 kB - OS dependent
- Microprocessor requirement:
 - Acquisition or tracking mode requires 5 MIPS (32-bit ARM MIPS) on the host microprocessor
- Basic OS functions required:
 - Memory allocation/de-allocation
 - Basic input/output
 - System timers
 - Thread management
- Floating-point libraries available for:
 - IEEE 8-byte double precision
 - IEEE 4-byte float single precision

Other system features which need to be considered are:

- Availability of optional external 32 kHz clock to OS
- Availability of NVRAM or file system to OS
- Type of serial interface to GNS7560
- Microprocessor type and clock speed
- Interface to location application, such as mapping:
 - Virtual serial port
 - Memory buffer
 - NMEA messages required

8.7 Clocks

8.7.1 TCXO clock input

The GNS7560 can accept a variety of different GPS clock input frequencies. Sensitivity performance may vary depending on the reference frequency used at the TCXO input; in particular reference frequencies whose harmonics fall within about 1 MHz of the GPS RF signal center frequency (1575.42 MHz) band are more likely to cause performance degradation.

8.7.2 Low-power clock counter

The GNS7560 device has a low-power mode input which can be used in standalone operation to keep time using the 32 kHz counter. The counter block needs a 32.768 kHz clock input with 20 ppm accuracy.

8.8 Operating modes

The GNS7560 has four main operating modes which require and provide different levels of power and performance. These modes are controlled by the high-level software.

Normal mode: the GNS7560 is active as a GPS receiver. The GNS7560 will automatically acquire and track GPS satellites. When required, the GNS7560 will automatically enable or disable clocks to minimize the power consumption depending on the operating environment, for example, based on satellite signal strength, user dynamics, ephemeris validity. These sub-modes can provide power saving of up to 75 % of baseband RF power.

Sleep mode: the GNS7560 is switched to a sleep state, and most baseband clocks are disabled. The RFFE clock chain is active, but the rest of the RFFE chain is placed in a low-power mode. The GNS7560 enters Sleep mode by a command from the host-based navigation software, and is woken from this state either by communications from the host-based navigation software or from an internal wake-up function. Sleep mode is supported for a maximum time of 60 s, and after this, the GNS7560 will automatically enter Coma mode. In Sleep mode, local time is maintained using the 32 kHz clock. On exit from Sleep mode, tracking of GPS satellites that were tracked prior to entering Sleep mode will continue.

Coma mode: the GNS7560 is switched to a coma state, and all baseband clocks are disabled except for a 32 kHz clock and counter. The RF is placed in a low-power mode. The GNS7560 is placed into Coma mode by a command from the host-based navigation software, and woken from this state by either communications from the host-based navigation software or from an internal wake-up function. Coma mode is supported for a maximum time of 49 days. In Coma mode, local time is maintained using the 32 kHz clock. If a 32 kHz clock input is not available, the GNS7560 enters Deep coma mode instead of Coma mode. On exit from Coma mode, GPS satellites previously being tracked will be re-acquired rapidly where the satellite ephemeris is still valid.

Deep coma mode: the GNS7560 has all clocks disabled, and the RFFE is turned off. The GNS7560 is placed into Deep coma mode by a command from the host-based navigation software. The GNS7560 can only wake up from this mode via a power-on reset. This would be used where the system does not require any GPS functionality enabled.

The typical power consumption of the GNS7560 in each mode is given in [Table 6](#).

Table 6. GNS7560 typical power consumption

Operating mode	Typical total power consumption
Normal mode: acquisition	55 mW
Normal mode: tracking 5 SVs at signal strength of -130 dBm (no power saving)	42 mW
Normal mode: power saving enabled	18mW to 42 mW depending on the sub-mode automatically enabled within Normal mode

Table 6. GNS7560 typical power consumption ...continued

Operating mode	Typical total power consumption
Sleep mode	15 mW
Coma mode	100 μ W
Deep coma mode	90 μ W

Table 7. External LNA enable (LNA_EN) and TCXO enable (TCXO_EN)

GNS7560 mode	Pin LNA_EN	External LNA state	Pin TCXO_EN	TCXO state
Reset	LOW	Off	HIGH	On
Normal	HIGH	On	HIGH	On
Sleep	LOW	Off	HIGH	On
Coma and Deep Coma	LOW	Off	LOW	Off

8.9 UART interfaces

The GNS7560 provides two identical, full-duplex, universal asynchronous receiver/transmitter interfaces:

- UART1 for development and test purposes
- UART2 for communication with the host-based navigation software

These interfaces are fully-compliant with the latest UART specifications and have a baud rate of 115200. The UARTs are based on the 16550 industry standard. If the UART host interface is required, then the GNS7560 UART2 should be connected to a dedicated UART port from the host, and not shared with any other functions.

It is not necessary that flow control be implemented (see detailed application notes)

9. Limiting values

Table 8. Limiting values

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

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{DD(C)bb}$	baseband core supply voltage		-	1.32	V
$V_{DD(I/O)}$	I/O supply voltage		-	3.6	V
$V_{DD(C)RF}$	RF core supply voltage		-	1.32	V
V_n	voltage on any other pin	I/O pins	-	$V_{DD(I/O)} + 0.2$	V
T_{stg}	storage temperature		-55	+125	$^{\circ}$ C

10. Recommended operating conditions

Power supply sequencing. To avoid the possibility of latch-up it is highly recommended to turn on the higher supply voltage $V_{DD(I/O)}$ first and then the lower supply voltage $V_{DD(C)bb}$.

Table 9. Operating conditions

Symbol	Parameter	Conditions	Min	Typ	Max
$V_{DD(C)bb}$	baseband core supply voltage	pins VDDBB1, VDDBB2, VDDBB3	1.08	1.2	1.32
$V_{DD(IO)}$	I/O supply voltage	pins VDDIO1, VDDIO2 [1]			
		1.8 V supply	1.62	1.8	1.98
		2.5 V supply	2.25	2.5	2.75
		3.3 V supply	3.0	3.3	3.6
$V_{DD(C)RF}$	RF core supply voltage	pins VDDRF, VDDANA, VDDMS [2]	1.08	1.2	1.32
V_n	voltage on any other pin	I/O pins			
		1.8 V supply	-	1.8	2.1
		2.5 V supply	-	2.5	2.8
		3.3 V supply	-	3.3	3.63
T_{amb}	ambient temperature		-40	+25	+85

[1]The VDDIO supply can be between 1.8v and 3.3v however they are only characterized at 1.8v, 2.5v and 3.3v

[2]Must be supplied from low-noise LDO linear regulator. The maximum noise floor is 30µV RMS

11. Characteristics

Table 10. Power supplies

$T_{amb} = -40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$ unless otherwise specified.

Symbol	Parameter	Condition	Min	Typ	Max	Unit
Baseband core supply; pins VDDBB1, VDDBB2, VDDBB3 = 1.2 V ± 10%						
I_{DD}	supply current	Normal mode	[1]	-	23	40 mA
		Sleep mode	[2]	-	2.4	- mA
		Coma mode	[3]	10	20	90 µA
		Deep coma mode	[4]	10	20	90 µA
I_{LI}	input leakage current	$V_{IN} = V_{DD}$ or GND	-	2	-	µA
I/O supply						
Pins VDDIO1, VDDIO2 = 3.3 V ± 10%						
I_{DD}	supply current	Normal mode	[1]	-	0.9	5 mA
		Sleep mode	[2]	-	0.14	- mA
		Coma mode	[3]	-	60	- µA
		Deep coma mode	[4]	-	60	- µA
I_{LI}	input leakage current	$V_{IN} = V_{DD}$ or GND	-	2	-	µA
Pins VDDIO1, VDDIO2 = 2.5 V ± 10%						

Table 10. Power supplies ...continued
T_{amb} = -40 °C to +85 °C unless otherwise specified.

Symbol	Parameter	Condition	Min	Typ	Max	Unit
I _{DD}	supply current	Normal mode	[1] -	0.9	5	mA
		Sleep mode	[2] -	0.11	-	mA
		Coma mode	[3] -	40	-	µA
		Deep coma mode	[4] -	40	-	µA
I _{LI}	input leakage current	V _{IN} = V _{DD} or GND	-	2	-	µA
Pins VDDIO1, VDDIO2 = 1.8 V ± 10%						
I _{DD}	supply current	Normal mode	[1] -	0.11	5	mA
		Sleep mode	[2] -	0.11	-	mA
		Coma mode	[3] -	30	-	µA
		Deep coma mode	[4] -	30	-	µA
I _{LI}	input leakage current	V _{IN} = V _{DD} or GND	-	2	-	µA
RF core supply; pins VDDRF, VDDANA, VDDMS = 1.2 V ± 10%						
I _{DD}	supply current	Normal mode	[1] -	20	30	mA
		Sleep mode	[2] -	10.3	-	mA
		Coma mode	[3] -	20	-	µA
		Deep coma mode	[4] -	20	-	µA
I _{LI}	input leakage current	V _{IN} = V _{DD} or GND	-	2	-	µA

[1] All systems active, running typical program.

[2] Embedded DSP static, PLL on and TCXO GPS reference clock running.

[3] 32 kHz oscillator running, all other I/O static. The TCXO will be off assuming the TCXO_EN is connected to the TCXO enable, current drain is mainly through the up resistor in the TCXO_EN I/O. Current also be higher depending on other I/O Connections.

[4] Deep coma mode is entered via a software command on the Host interface. When this command is received the device will power down the RF sections of the device and turn off the clocks. To exit this mode the RST_N is applied. Note however that on initial power up of the device and before RST_N is applied the power consumption can be as high as 20mA.

Table 11. Digital input/output characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
3.3 V supply						
V _{IL}	LOW-level input voltage		-0.3	-	+0.8	V
V _{IH}	HIGH-level input voltage		2.0	-	3.63	V
V _{th}	threshold voltage	all I/O pins	1.33	1.44	1.52	V
V _{th(LH)}	LOW to HIGH threshold voltage		1.54	1.64	1.71	V
V _{th(HL)}	HIGH to LOW threshold voltage		-1.08	-1.18	-1.25	V
I _{LI}	input leakage current	V _i = 3.0 V or 0 V	-	-	±10	µA
I _{OZ}	OFF-state output current	V _O = 3.0 V or 0 V	-	-	±10	µA
C _i	input capacitance		-	1.54	-	pF
R _{pu}	pull-up resistance		30	43	65	kΩ
R _{pd}	pull-down resistance		32	52	91	kΩ
V _{OL}	LOW-level output voltage	I _{OL} = 2.4 mA	-	-	0.4	V
V _{OH}	HIGH-level output voltage	I _{OH} = 2.4 mA	2.4	-	-	V

Table 11. Digital input/output characteristics ...continued

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I _{OL}	LOW-level output current	V _{OL} = 0.4 V				
		I _{OL} = 2 mA drive	3.2	-	-	mA
		I _{OL} = 4 mA	6.4	-	-	mA
I _{OH}	HIGH-level output current	V _{OH} = 2.4 V				
		I _{OH} = 2 mA	4.1	-	-	mA
		I _{OH} = 4 mA	9.4	-	-	mA
2.5 V supply						
V _{IL}	LOW-level input voltage		-0.3	-	+0.7	V
V _{IH}	HIGH-level input voltage		1.7	-	2.8	V
V _{th}	threshold voltage	all I/O pins	1.03	1.11	1.2	V
V _{th(LH)}	LOW to HIGH threshold voltage		1.23	1.32	1.4	V
V _{th(HL)}	HIGH to LOW threshold voltage		-0.82	-0.90	-0.98	V
I _{LI}	input leakage current	V _I = 2.5 V or 0 V	-	-	±10	µA
I _{OZ}	OFF-state output current	V _O = 2.5 V or 0 V	-	-	±10	µA
R _{pu}	pull-up resistance		40	60	98	kΩ
R _{pd}	pull-down resistance		43	73	134	kΩ
V _{OL}	LOW-level output voltage	I _{OL} = 2.4 mA	-	-	0.7	V
V _{OH}	HIGH-level output voltage	I _{OH} = 2.4 mA	1.7	-	-	V
I _{OL}	LOW-level output current	V _{OL} = 0.7 V				
		I _{OL} = 2 mA drive	3.5	-	-	mA
		I _{OL} = 4 mA	7.1	-	-	mA
I _{OH}	HIGH-level output current	V _{OH} = 1.7 V				
		I _{OH} = 2 mA	2.7	-	-	mA
		I _{OH} = 4 mA	6.3	-	-	mA
1.8 V supply						
V _{IL}	LOW-level input voltage		-0.3	-	+0.63	V
V _{IH}	HIGH-level input voltage		1.17	-	2.10	V
V _{th}	threshold voltage	all I/O pins	0.78	0.84	0.91	V
V _{th(LH)}	LOW to HIGH threshold voltage		0.94	1.03	1.10	V
V _{th(HL)}	HIGH to LOW threshold voltage		-0.58	-0.64	-0.70	V
I _{LI}	input leakage current	V _I = 1.8 V or 0 V	-	-	±10	µA
I _{OZ}	OFF-state output current	V _O = 1.8 V or 0 V	-	-	±10	µA
R _{pu}	pull-up resistance		62	102	179	kΩ
R _{pd}	pull-down resistance		66	120	231	kΩ
V _{OL}	LOW-level output voltage	I _{OL} = 2.4 mA	-	-	0.45	V
V _{OH}	HIGH-level output voltage	I _{OH} = 2.4 mA	1.35	-	-	V
I _{OL}	LOW-level output current	V _{OL} = 0.45 V	1.6	-	-	mA
		I _{OL} = 2 mA drive	1.6	-	-	mA
		I _{OL} = 4 mA	3.2	-	-	mA

Table 11. Digital input/output characteristics ...continued

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I _{OH}	HIGH-level output current	V _{OH} = 1.35 V				
		I _{OL} = 2 mA	1.0	-	-	mA
		I _{OL} = 4 mA	2.2	-	-	mA

Table 12. Clock inputs

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Counter input clock: pin CLK32KIN						
f _{i(clk)}	clock input frequency		-	32.768	-	kHz
V _i	input voltage	[3]	0.3	-	V _{DD(C)bb}	V _{pp}
SSI clock input: pin SSI_SLV_CLKIN						
f _{i(clk)}	clock input frequency		-	5	-	MHz
V _i	input voltage		V _{IH(min)}	-	V _{IH(max)}	V
Reference clock: pin TCXO_IN						
f _{i(clk)}	clock input frequency		[1] 10	[2]	28	MHz
V _i	input voltage		[1] 0.2	-	V _{DD(C)RF}	V _{pp}
φ _n	phase noise	100 Hz offset	[1] -	-	-110	dBc/Hz

[1] For detailed information on the TCXO (e.g. phase noise requirements) and other supporting component requirements, please contact ST-Ericsson. Example specification for the TCXO is shown in [Table 14](#). This input has a DC bias of 0.6V and must be AC coupled, use a 10nF DC blocking capacitor

[2] Standard clock frequencies: 13 MHz, 16.368 MHz, 16.8 MHz, 19.2 MHz, 19.68 MHz, 20 MHz, 26 MHz Contact ST Ericsson for use of other frequencies.

[3] DC bias typical 0.9V, AC couple to this pin.

Table 13. 32kHz crystal oscillator characteristics

V_{DD(I/O)} = 1.8 V, 2.5 V and 3.3 V; V_{DD(C)bb} = 1.2 V; V_{DD(C)RF} = 1.2 V; input drive levels = 0.0 V to V_{IH}; input t_r and t_f = 1 ns; I/O timing reference levels = V_{DD(I/O)} / 2.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f _{xtal}	crystal frequency	-	32.768	-	kHz	f _{xtal}
Δf _{xtal}	crystal frequency accuracy	-	±20 × 10 ⁻⁶	-	Hz	Δf _{xtal}
Δf _{xtal} /f _{xtal}	relative crystal frequency variation	aging per year	-	±3	10 ⁻⁶	Δf _{xtal} /f _{xtal}
P _{drive}	drive power	-	-	0.5	μW	P _{drive}

Table 14. Example specification characteristics for TCXO

Parameters based on Rakon IT3205CE 26 MHz TCXO.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V _{dd(xtal)}	crystal input voltage		2.56	-	2.84	V
V _{o(xtal)}	crystal output voltage	[4]	0.8	-	-	V
ΔV _{TCXO} /V _{TCXO}	relative TCXO voltage variation		-	-	±0.1	10 ⁻⁶
I _{clk(TCXO)}	TCXO clock current		-	-	1.5	mA

Table 14. Example specification characteristics for TCXO

Parameters based on Rakon IT3205CE 26 MHz TCXO.

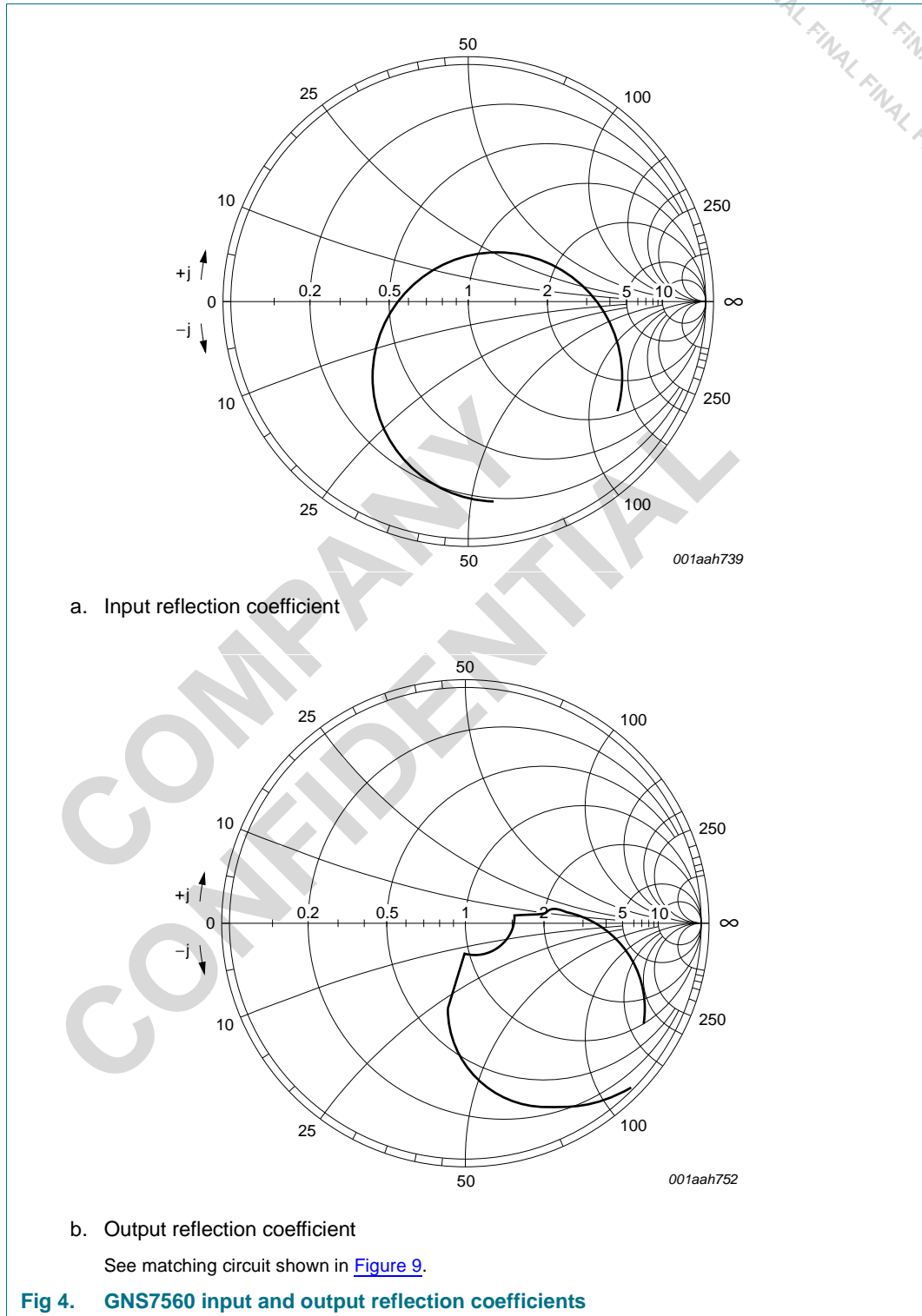
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$\phi_{n(SSB)}$	single sideband phase noise	100 Hz offset	-	-	-110	dBc/Hz
		10 kHz offset	-	-	-140	dBc/Hz
f_{nom}	nominal frequency		-	26	-	MHz
$\Delta f_{nom(T)}$	nominal frequency deviation with temperature	per °C	-	-	$\pm 0.5 \times 10^{-6}$	Hz
$\Delta f_{xtal}/f_{xtal}$	relative crystal frequency variation	load sensitivity	[2]	-	0.2	10^{-6}
		long-term stability	[3]	-	1	10^{-6}
		frequency slope per °C	[4]	-	0.1	10^{-6}
		instantaneous frequency jump (micro-jump)	[5]	-	0.02	10^{-6}
$C_{o(L)}$	output load capacitance		9	-	11	pF
$R_{L(o)}$	output load resistance		9	-	11	k Ω
T_{amb}	ambient temperature		-30	-	+85	°C

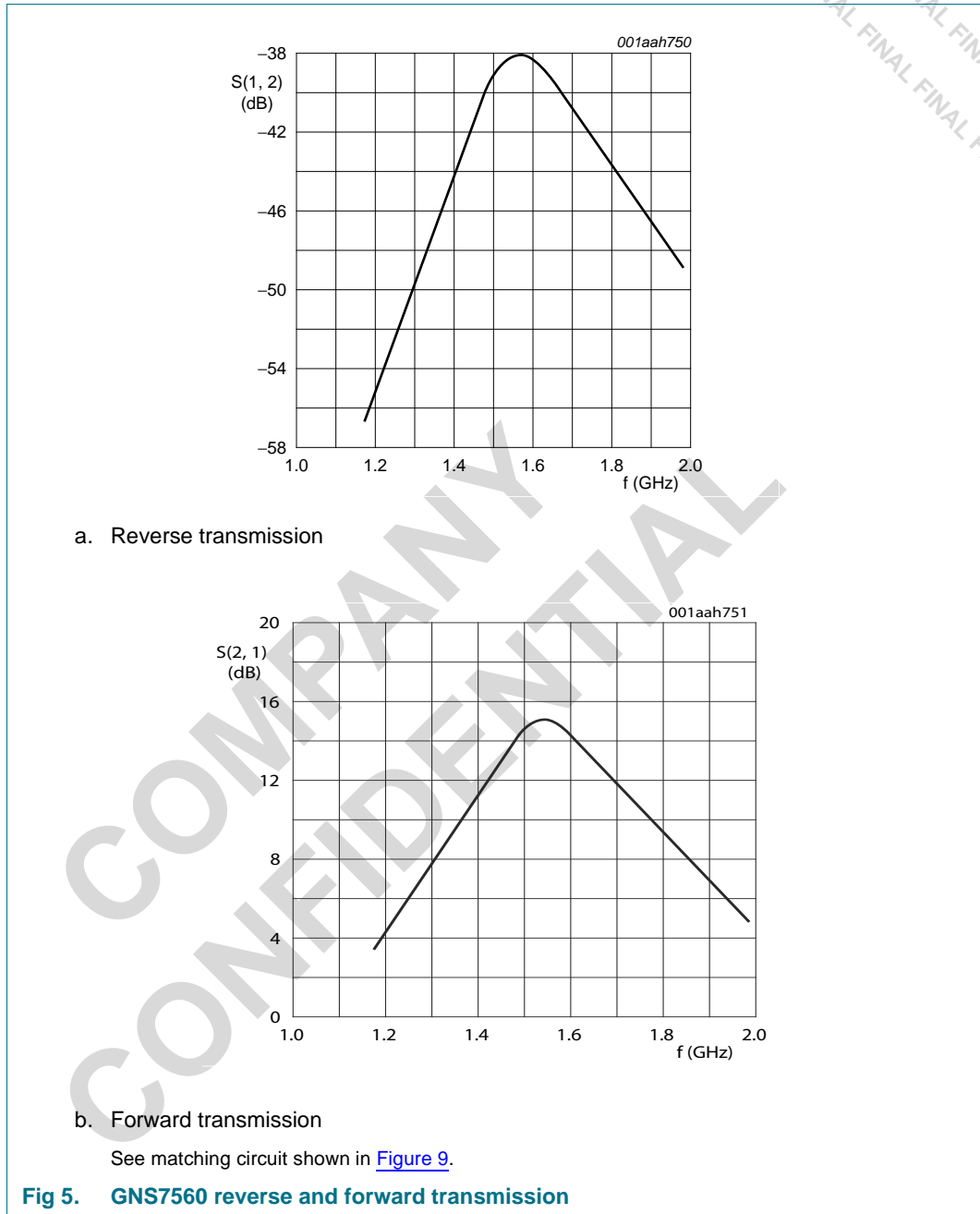
- [1] Clipped sine wave.
- [2] $\pm 10\%$ load change.
- [3] Frequency drift over 1 year.
- [4] Minimum of 1 frequency reading every 2 °C.
- [5] Refer to the *application note* for the TCXO used.

12. Dynamic characteristics

Table 15. RF input
 $V_{DD(I/O)} = 1.8\text{ V}, 2.5\text{ V and } 3.3\text{ V}; V_{DD(C)bb} = 1.2\text{ V}; V_{DD(C)RF} = 1.2\text{ V};$ input drive levels = 0.0 V to V_{IH} ; input t_r and $t_f = 1\text{ ns}$; I/O timing reference levels = $V_{DD(I/O)} / 2$.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
RF input: pins RFINP, RFINM						
NF	noise figure	cascaded, without external LNA	-	2.5	-	dB
ICP_{1dB}	1 dB input compression point	Measured at the PGA output with default gain settings (low). The 1dB loss of the SAW has been factored in.	-	-89	-	dBm
$ s_{11} ^2$	input return loss	see Figure 4 and Figure 5	-	13 - 15	-	dB





13. SSI host interface

The Slave Synchronous Serial Interface (SSI) is available as an optional interface which can be used instead of UART2 for interfacing an external host microprocessor.

Table 16. SSI slave timing

$V_{DD(I/O)} = 1.8\text{ V}, 2.5\text{ V and }3.3\text{ V}$; $V_{DD(C)bb} = 1.2\text{ V}$; $V_{DD(C)RF} = 1.2\text{ V}$; input drive levels = 0.0 V to V_{IH} ; input t_r and $t_f = 1\text{ ns}$; I/O timing reference levels = $V_{DD(I/O)} / 2$.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Clock input: pin SSI_SLV_CLKIN						
T_{clk}	clock period	[1]	200	-	-	ns
$t_{clk(H)}$	clock HIGH time		80	-	-	ns
$t_{clk(L)}$	clock LOW time		80	-	-	ns
Chip select input: pin SSI_SLV_CS						
$t_{su(CS)}$	CS set-up time		$0.5 \times T_{clk}$	-	$1 \times T_{clk}$	ns
$t_{su(clk)}$	clock set-up time		$0.5 \times T_{clk}$	-	$1 \times T_{clk}$	ns
$t_{CS(H)}$	HIGH CS time		$1 \times T_{clk}$	-	-	ns
$t_{CS(L)}$	LOW CS time		$9 \times T_{clk}$	-	-	ns
Serial data output: pin SSI_SLV_SO						
$t_{su(Q)}$	data output set-up time	10 pF load	-	-	96	ns
Serial data input: pin SSI_SLV_SI						
$t_{su(D)}$	data input set-up time		10	-	-	ns
$t_{h(D)}$	data input hold time		55	-	-	ns

[1]Valid when TCXO frequency is 13Mhz, 20Mhz or 26Mhz. If other TCXO frequencies are used these timings will change

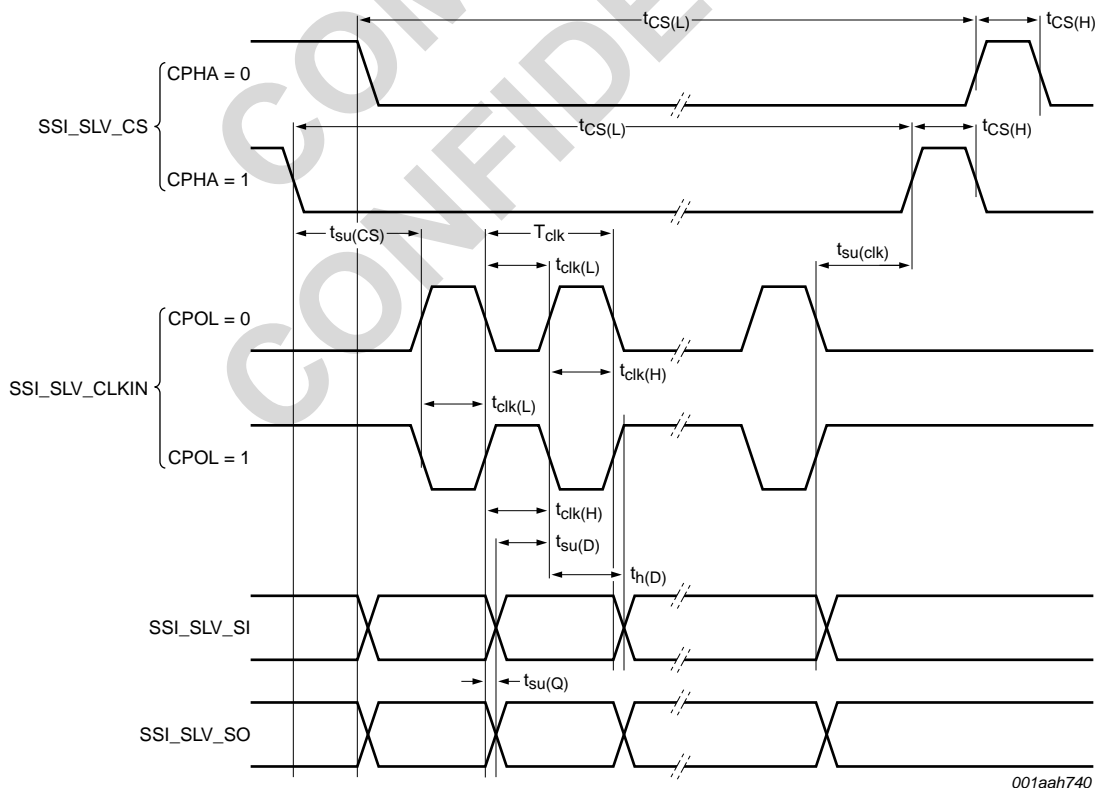


Fig 6. SSI slave setup and hold timing

14. Reset input

Table 17. Reset timing

$V_{DD(I/O)} = 1.8\text{ V}, 2.5\text{ V and }3.3\text{ V}; V_{DD(C)bb} = 1.2\text{ V}; V_{DD(C)RF} = 1.2\text{ V};$ input drive levels = 0.0 V to V_{IH} ; input t_r and $t_f = 1\text{ ns}$; I/O timing reference levels = $V_{DD(I/O)} / 2$.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t_{stab}	stabilization time	32 kHz oscillator	[1]	-	500	- ms
		TCXO_IN oscillator	-	100	-	ms
$t_{d(pu)}$	power-up delay time	power rails valid to RST_N going HIGH; see Figure 7	[2]	500	-	ms
$t_{WL(rst)}$	reset pulse width LOW	once sampled; see Figure 8	[3]	214	-	μs

[1] At $V_{DD(C)bb} = 1.08\text{ V}$ (minimum specified value).

[2] Reset delay must be matched to the start-up delays of the TCXO and optional external 32 kHz clock source, dependent on the components used. If the TCXO (PLLREFCLK is used then the power-up delay can be 7 cycles of the PLLREFCLK. In the case of a 26Mhz TCXO this time delay would be

[3] Based on seven 32 kHz clock periods,

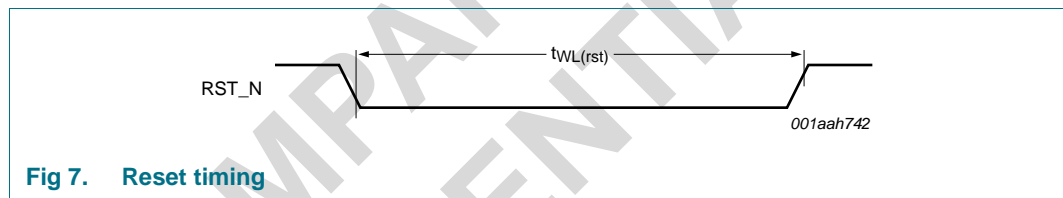
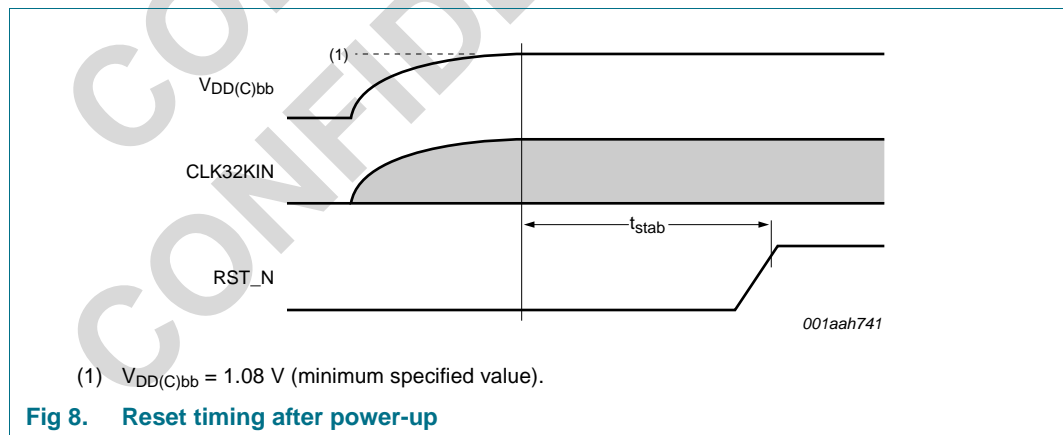


Fig 7. Reset timing



(1) $V_{DD(C)bb} = 1.08\text{ V}$ (minimum specified value).

Fig 8. Reset timing after power-up

15. I/O Port timing

Table 18. I/O port timing

Measured across the flat part of the waveform only; rise and fall parts not included.

$V_{DD(I/O)} = 1.8\text{ V}, 2.5\text{ V}$ and 3.3 V ; $V_{DD(C)bb} = 1.2\text{ V}$; $V_{DD(C)RF} = 1.2\text{ V}$; input drive levels = 0.0 V to V_{IH} ; input t_r and $t_f = 1\text{ ns}$; I/O timing reference levels = $V_{DD(I/O)} / 2$.

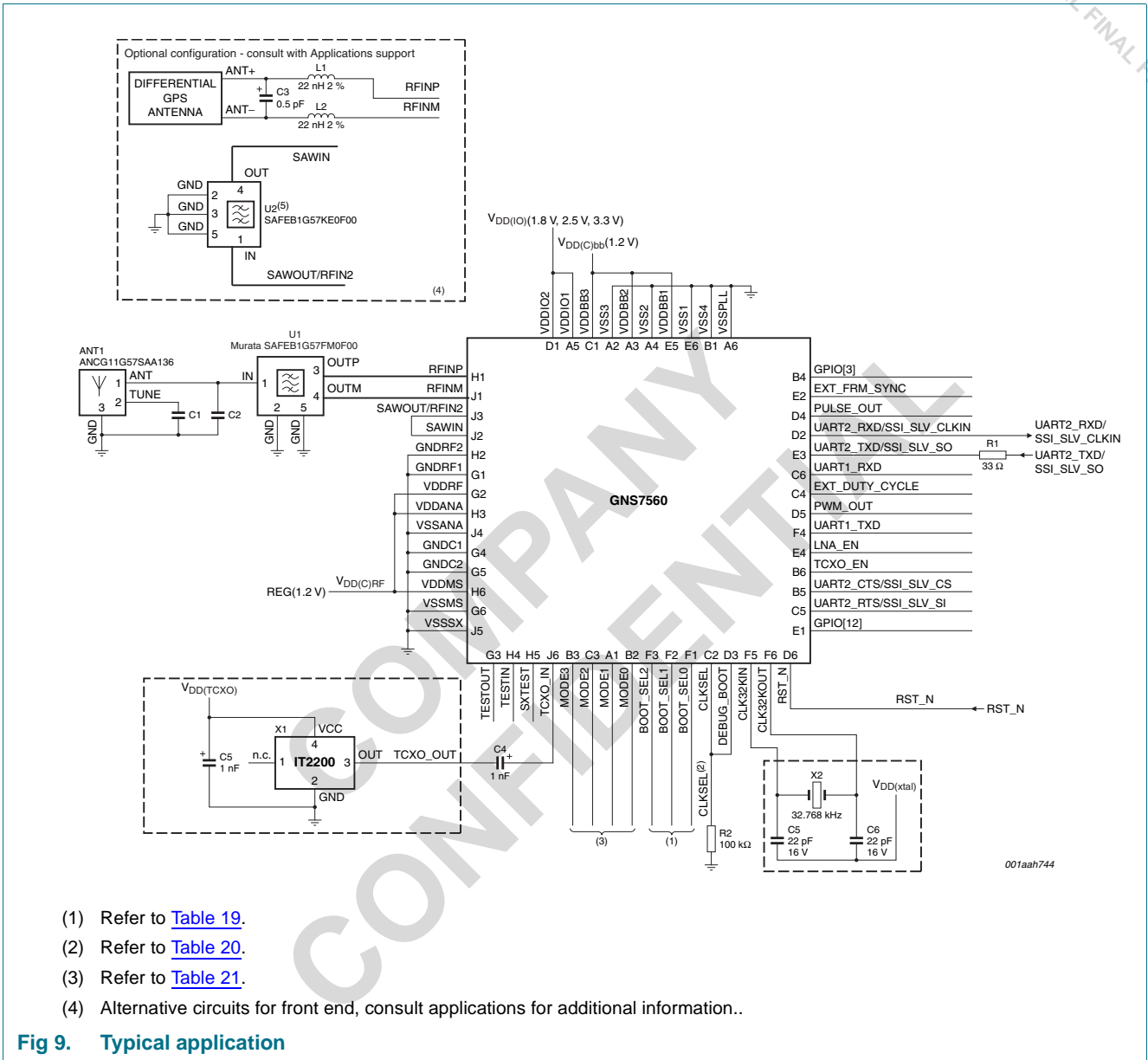
Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
t_w	pulse width	pin EXT_FRM_SYNC	[1]	77	-	-	ns
		pin EXT_DUTY_CYCLE	[2]	23	-	-	ns
		pin PULSE_OUT	[2]	23	-	-	ns

[1] 2 TCXO clock periods.

[2] 2 data clock periods.

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16. Application information



- (1) Refer to [Table 19](#).
- (2) Refer to [Table 20](#).
- (3) Refer to [Table 21](#).
- (4) Alternative circuits for front end, consult applications for additional information..

Fig 9. Typical application

Table 19. BOOT_SEL[2:0] settings

Frequency (MHz)	Pin		
	BOOT_SEL2	BOOT_SEL1	BOOT_SEL0
13	LOW	LOW	LOW
16.368	LOW	LOW	HIGH
16.8	LOW	HIGH	LOW
19.2	LOW	HIGH	HIGH
19.68	HIGH	LOW	LOW
20	HIGH	LOW	HIGH
26	HIGH	HIGH	LOW
[1]	HIGH	HIGH	HIGH

[1] Patch code.

Table 20. CLKSEL settings

Clock source	Pin CLKSEL
Internal PLL clock	LOW
External 32 kHz clock	HIGH

Table 21. MODE[3:0] settings

Host interface	Pin			
	MODE3	MODE2	MODE1	MODE0
UART1 and UART2	HIGH	LOW	LOW	LOW
Slave SSI	HIGH	LOW	LOW	HIGH

17. Package outline

TFBGA54: plastic thin fine-pitch ball grid array package; 54 balls

SOT1065-1

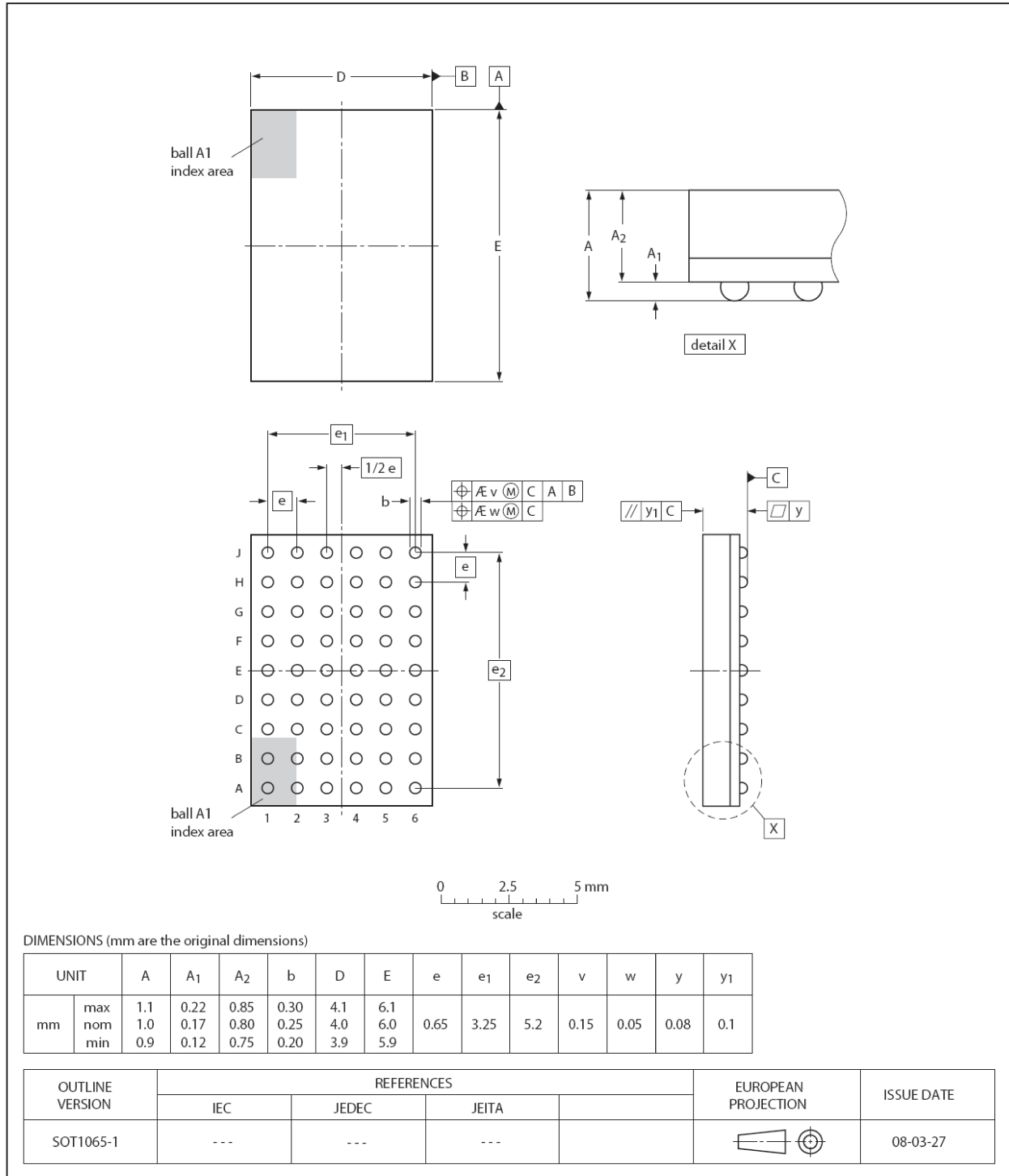


Fig 10. GNS7560ET2UM Package Outline

WLCSP54: wafer level chip-size package; 54 bumps; 2.44 x 3.64 x 0.57 mm

GNS7560UK/N2

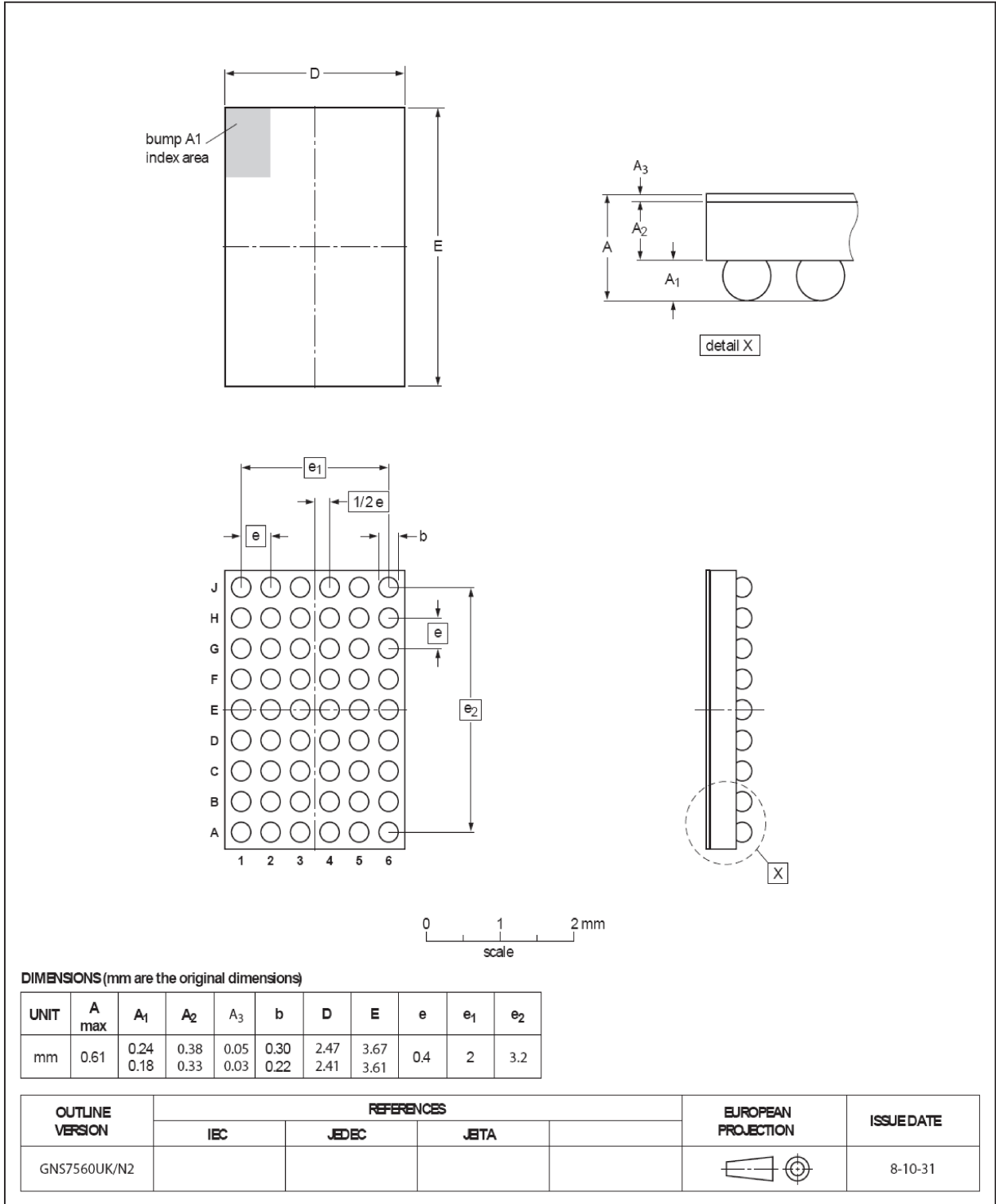


Fig 11. GNS7560UK214TS WLCSP package

18. Package Marking Information

18.1 BGA Marking information

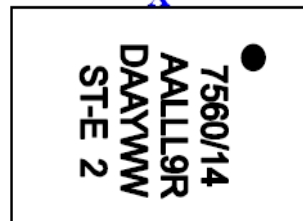


Marking Content

Line A : 7560/N2
 Line B: PLLLLWX
 Line C: LFTFYWW

Where; PP is Assembly plant (7B for ATP)
 LLL is to be replaced by trace code
 WX is wafer fab code (9R for TSMC14)
 LF is the RoHS code ,
 "G" for Halogenated substrate
 "D" for Halogen Free (HF) substrate
 TF is the Testing and Finishing Production Area Code
 (78 for STC)
 YWW is to be replaced by actual date code.

18.2 WLCSP Marking information



Marking Content

Line A : 7560/14
 Line B: PLLLLWX
 Line C: LFTFYWW
 Line D: ST-E 2

Where; PP indicates Assembly plant (AA for ASE)
 LLL is to be replaced by traceability code
 WX is wafer fab code (9R for TSMC14)
 LF is the RoHS code ("D" for Halogen Free)
 TF is the Testing and Finishing Production Area Code
 (AA for ASE, AX for APK)
 YWW is to be replaced by actual date code.

19. Abbreviations

Table 22. Abbreviations

Acronym	Description
ADC	Analog-to-Digital Converter
API	Application Programming Interface
BGA	Ball Grid Array
CDMA	Code Division Multiple Access

Table 22. Abbreviations ...continued

Acronym	Description
CS	Chip Select
DSP	Digital Signal Processor
EDGE	Enhanced Data rates for GSM Evolution
GPIO	General Purpose Input Output
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communications
IF	Intermediate Frequency
L1	L-band frequency 1 (centred at 1575 MHz)
LDO	Low DropOut
LNA	Low-Noise Amplifier
LO	Local Oscillator
NCO	Numerical-Controlled Oscillator
NVRAM	Non-Volatile Random Access Memory
OS	Operating System
PCB	Printed-Circuit Board
PLL	Phase-Locked Loop
PWM	Pulse-Width Modulator
RFFE	Radio Frequency Front-End
RMS	Root-Mean-Square
SAW	Surface Acoustic Wave
SMD	Surface-Mount Device
SPI	Serial Peripheral Interface
SSI	Serial Synchronous Interface
SUPL	Secure User Plane Location
SV	Satellite Vehicle
TCXO	Temperature-Controlled Crystal Oscillator
UART	Universal Asynchronous Receiver Transmitter
UMTS	Universal Mobile Telecommunications System
VCO	Voltage-Controlled Oscillator
WCDMA	Wideband Code Division Multiple Access
WLCSP	Wafer-Level Chip Scale Package

20. Revision history

Table 23. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
GNS7560_1	20080507	Objective data sheet	-	-
GNS7560_2	20081104	Preliminary data sheet		
GNS7560_5	20081222	Minor updates to Table 10		
GNS7560_8	20090519	Converted to STE format		

Table 23. Revision history ...continued

Document ID	Release date	Data sheet status	Change notice	Supersedes
GNS7560_20	20090701	Order numbers and order quantity updated		
GNS7560_21	20100303	CLK32 & TCXO section improvements		
GNS7560_22	20100403	Additional order codes added & die marking section added		

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