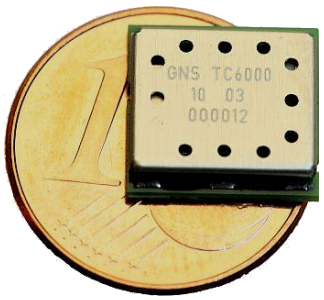
GPS Module TC6000G

confidential information ***preliminary*** *specification*

1. INTRODUCTION

GNS, developer and manufacturer of module solutions for 10 years, presents the new **TC6000G** series GPS module which incorporates a complete Global Positioning System receiver (RF, Baseband plus GPS processing) with superior performance of -162dBm tracking sensitivity.

Features



- GPS tracking sensitivity of -162dBm
- A-GPS
- Dedicated GPS processing
- GPS SAW filter and TCXO included
- PPS output for timing application
- low load on host CPU
- host computer (PDA / Notebook / embedded /phone) drivers available
- suitable for many Operating Systems
- low power consumption (70 mW at tracking, 100mW at acquisition, down to 17mW at open sky condition)
- only one single power supply (1.8V) needed
- UART interface
- Miniature 36 pin module (10x9.3x2.3) mm
- Evaluation Boards:
    - TC6000G StarterKit for testing on different host platforms
    - Plug-in for Texas Instruments OMAP 3530 EVM board

Applications

- Navigation
    - in-vehicle Navigation equipment, supports localization
    - dynamic Navigation
    - portable (“nomadic”) devices
    - Netbooks, tablet PCs and mobile phones
- Timing
    - precision timing via GPS
- Location based applications
    - GPS Logger
    - GPS Tracker
    - Security devices
    - Camera equipment

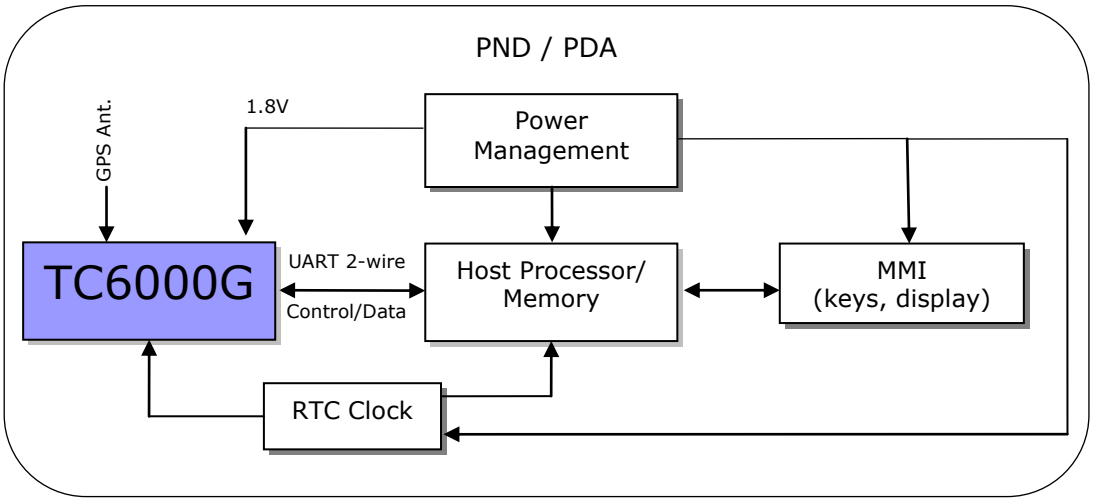
2. INDEX

3. DETAILED FEATURES

1.1. GPS Features

- Significantly improved TTFF at low signal power levels provides the consumer with a compelling GPS experience
- Improved acquisition performance down to –147dBm to process position fixes in deep indoor conditions
- Reduced power consumption through improvements to RF architecture, software techniques, receiver core, and RF noise figure partitioning
- Improved tracking performance and minimized error in multi-path environments through increased IF bandwidth and higher sampling rates in tracking channels
- Integrated APM (advanced power management) performs automatic dynamic power saving dependent on the signal conditions. Up to 70% power savings at 1 update per second.

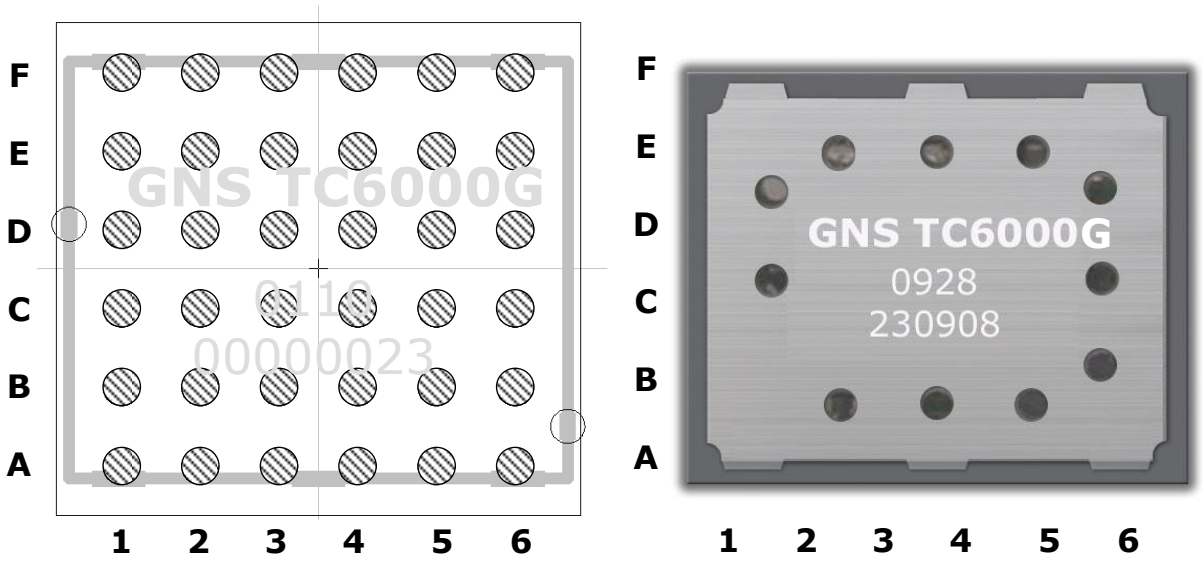
4. TYPICAL APPLICATION DIAGRAM



5. DEVICE PINOUT DIAGRAM

1.2. Pin locations

TOP VIEW



F	VDD_IO	GND	N.U.	N.U.	GND	N.U.
E	VDD	GND	N.U.	N.U.	N.U.	GND
D	N.U.	N.U.	N.U.	N.U.	N.U.	N.U.
C	GPS_PPS	TCXO_CLK	GPS_TX	GPS_ENABLE	RTC_CLK	N.U.
B	GPS_RF	GPS_GND	GPS_RX	N.U.	N.U.	N.U.
A	GPS_GND	GPS_GND	N.U.	N.U.	N.U.	N.U.
	1	**2**	**3**	**4**	**5**	**6**

Note: Do **NOT** connect **N.U.** pins to anywhere! These pins must be left open!

1.3. Pin description

NO	NAME	Type[1]	description
Power-Management Signals			
E1	VDD	P	1.8V Power supply voltage
F1	VDD_IO	P	1.8V I/O power supply voltage
C4	GPS_ENABLE	I	Shutdown control for the GPS core
F2	GND	P	Common Ground
E2	GND	P	Common Ground
E6	GND	P	Common Ground
F5	GND	P	Common Ground
Clocks Signals			
C2	TCXO_CLK	O	TCXO clock output.
C5	RTC_CLK	I	Sleep clock input: 32.768 kHz. Fail-safe.
GPS Signals			
B1	GPS_RF	Ana	GPS RF input to the device
C3	GPS_TX	O	GPS UART TX
B3	GPS_RX	I	GPS UART RX
C1	GPS_PPS	O	GPS Pulse per second
A1	GPS_GND	Ana	GPS Ground
A2	GPS_GND	Ana	GPS Ground
B2	GPS_GND	Ana	GPS Ground

(1) I = INPUT; O = OUTPUT; I/O = BIDIRECTIONAL; P = POWER PIN; ANA = ANALOG PIN.

6. ELECTRICAL SPECIFICATION

Absolute Maximum Ratings		
Parameter	**Value**	**Unit**
Supply voltage range: VDD	–0.5 to 2.1	V
Supply voltage range: VDD_IO	–0.5 to 2.1	V
Input voltage to analog pins[1]	–0.5 to 2.1	V
Input voltage to all other pins	–0.5 to (VDD_I/O + 0.5)	V
Operating ambient temperature range	–40 to +85	°C
Storage temperature range	–55 to +125	°C

(1) GPS_RF

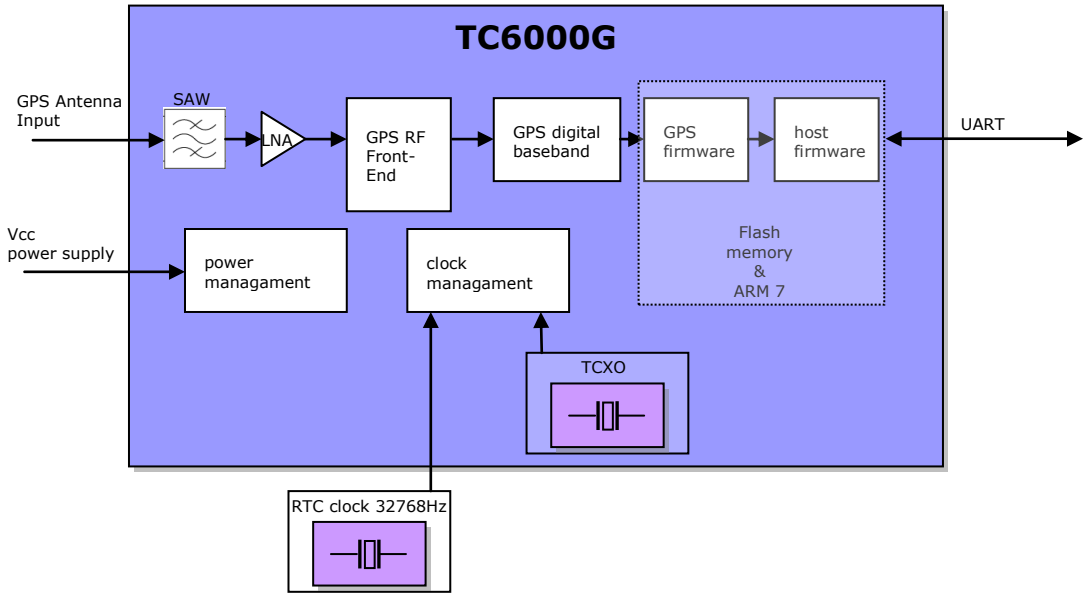
Recommended Operating Conditions					
Parameter	**Min**	**Typ**	**Max**	**Unit**	**Note**
VDD	1.7		1.95	V	Power-supply voltage
VDD_IO	1.65		1.92	V	I/O power-supply voltage
V_{IH}	0.65x VDD_IO		VDD_IO	V	High-level input voltage
V_{IL}	0		0.35x VDD_IO	V	Low-level input voltage
Maximum ripple on VDD			60	mVpp	0 MHz to 0.1 MHz
			50	mVpp	0.1 MHz to 0.5 MHz
			30	mVpp	0.5 MHz to 1.7 MHz
			25	mVpp	1.7 MHz to 2.5 MHz
			15	mVpp	2.5 MHz to 3.3 MHz
			5	mVpp	Greater than 3.3 MHz

Low speed GPS UART settings					
Parameter	**Min**	**Typ**	**Max**	**Unit**	**Note**
Baud rate		115.2		kbps	Start value after reset
Baud Rate	9.6		400	kbps	
Data format		8 N 1			8-Bit no parity 1 stopbit
t5 and t7			-2,0% to +1,5%		Baud rate accuracy
tr / tf			25	ns	Rise and Fall times (10%-90%)

7. GPS CORE

1.4. GPS core description

The TC6000G GPS core is a high performance, low power GPS receiver with integrated RF Front End.
Due to high input sensitivity it can work directly with a passive antenna.
The very short TTFF (Time To First Fix) and improved acquisition performance at low signal power levels is achieved through an enhanced receiver core architecture.
The improved RF architecture and software techniques reduce the average power consumption.
Minimized error in multi-path environments is achieved through increased IF bandwidth and higher sampling rates in tracking channels.
TC6000G supports APM (adapted power management) schemes to lower the average power of the GPS core to below 20mW.
Supply of aiding information like ephemeris, almanac, rough last position and time and satellite status will reduce time to first fix significantly and improve the acquisition sensitivity.



GPS characteristics					
Parameter	**Min**	**Typ**	**Max**	**Unit**	**Note**
general					
frequency		GPS L1 C/A code			
Output data frequency	1	1	2	1/sec	configurable data rate
Tracking sensitivity		-162	-163	dBm	
Acquisition sensitivity		-146	-147	dBm	autonomous
			-155	dBm	assisted tbc
TTFF hotstart			1	sec	@-130dBm
TTFF hotstart			10	sec	@-155dBm
TTFF coarse time assisted			18	sec	@-155dBm
TTFF autonomous cold start		34		sec	@-130dBm
TTFF autonomous cold start		45		sec	@-142dBm
Number of channels tracking		16			
Number of acquisition channels		40			
Current consumption GPS IDLE		5.64		mA	
Current consumption GPS DEEP SLEEP		100	391	uA	
Current consumption GPS ACTIVE (acquisition)		63	76	mA	NMEA frequency = 1/sec
Current consumption GPS ACTIVE (tracking)		40	50	mA	NMEA frequency = 1/sec
Current consumption GPS ACTIVE (tracking)			9.5	mA	NMEA frequency=1/sec, -130dBm,APM feature active
1PPS pulse duration		1		msec	
1PPS time jitter			100	nsec	Pulse rising edge deviation from expected pulse time, measured in a 300 seconds interval with full 3D fix
1PPS rise and fall time			10	nsec	10%..90%
TCXO output frequency		38.400		MHz	±5ppm
TCXO output impedance		1MΩ//5pF		-	tbc

accuracy					
Static position error CEP68	-	2	-	m	**Normal open sky in Field** Horizontal position accuracy using open sky roof-top antenna
Static position error CEP95	-	3	-	m	**Normal open sky in Field** Horizontal position accuracy using open sky roof-top antenna
Static position error CEP68	-	-	2	m	**Simulator feed ,** IONO and TROPO errors oN at -130 dBm power level
Static position error CEP95	-	-	3	m	**Simulator feed ,** IONO and TROPO errors oN at -130 dBm power level
dynamic position error CEP68	-	-	3	m	**Simulator feed ,** IONO and TROPO errors oN at -130 dBm power level

dynamic position error CEP95	-	-	4	m	**Simulator feed ,** IONO and TROPO errors oN at -130 dBm power level
velocity error CEP68	-	-	0.1	m/s	**Simulator feed ,** IONO and TROPO errors oN at -130 dBm power level
velocity error CEP95	-	-	0.7	m/s	**Simulator feed ,** IONO and TROPO errors oN at -130 dBm power level
other					
1PPS pulse duration	-	1	-	msec	
1PPS time jitter	-	-	100	nsec	Pulse rising edge deviation from expected pulse time, measured in a 300 seconds interval with full 3D fix
1PPS rise and fall time			10	nsec	10%..90%
1PPS output impedance	-	10kΩ//20pF	-		

ITAR limits					
Operation altitude	-5,000	-	18,288	m	
Operation velocity	-	-	514	m/s	
Operation acceleration	-	-	-	m/s^2	No limit set

1.5. GPS power management features

Power management schemes implemented for any GPS/A-GPS system requires an optimally tuned performance for both accuracy of the position fixes and the average power consumed for best user experience. TC6000G architecture achieves both these aspects, by providing flexibility and design choices for the system integration based on wide range of use cases and leveraging on the proven silicon methodologies. Also TC6000G can provide position, velocity and time (PVT) measurements without any host loading. This coupled with the built-in power management option reduces the overall system power budget.
Power management features

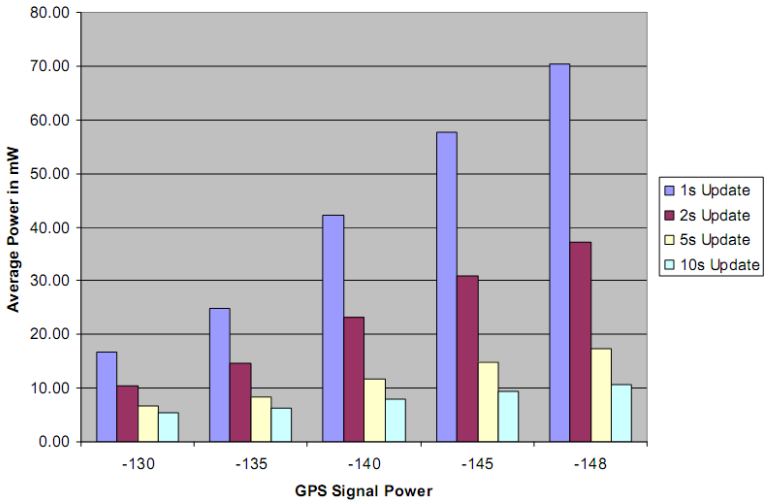
- APM feature provides overall GPS system power consumption of 17mW in tracking mode under open sky conditions
- Power management options that allows operation in typical signal conditions and deep sensitivity modes
- Inbuilt adaptive algorithm to provide best position accuracy and best power savings based on the user environment (urban canyon, open sky, semi urban etc)
- Can provide PVT solution without any load on the host. This reduces the overall system power further.
- Programmable position update rates. Max of 2 Hz update rate.

1.5.1. Power states for single location fix solutions

Applications involving the single fix (E-911, accessing catalog data like restaurants, tourist attraction etc, or for personalized services like buddy finder, query the asset being tracked, map browsing based on current location) require single fix with varied quality of service (accuracy and time to first fix). For single fix solutions, the GPS core can be set to very low power state DEEP SLEEP.
Single fixes can either be assisted or autonomous depending on the network service provider. ACTIVE, IDLE and DEEP SLEEP are host software driven states. The host can command the receiver to enter different SW driven states using NMEA command messages.

1.5.2. Power states for continuous location fix

For navigation or other tracking scenarios like asset tracking, geo fencing, child tracking, fleet management etc., a continuous position update is required. Based on the update rate "APM tracking" mode or "APM rapid reacquisition" mode schemes can be used. The APM modes will be activated via an NMEA command.
APM mode is based on temporarily deactivating parts of the GPS engine when signal conditions are good. (open sky conditions).
The graph shows typical power consumptions with *APM Tracking Mode* activated. The current consumption is as low as 9.5 mA even for a 1-second update rate. *APM Tracking Mode* will automatically adapt it's power requirements to the signal conditions. When entering a more difficult signal environment, the GPS engine will automatically switch to a higher or full power mode.



APM mode will be activated through a NMEA command message.

1.6. GPS almanac and ephemeris data

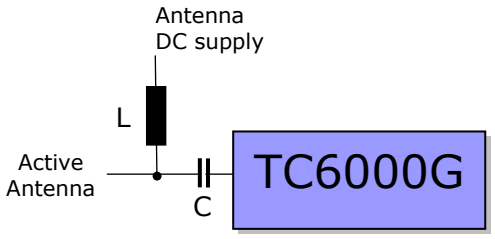
For quick re-acquisition of the GPS after off-times, the GPS engine should have access to almanac and ephemeris data. For TC6000G, these data have to be held in the host non-volatile memory. GNS drivers will automatically store this data whenever there's an update. When the GPS is powered-up again, the data will be transferred to TC6000G to allow a quick re-acquisition.

1.6.1. Assisted GPS (A-GPS)

Assisted GPS functionality allows quick GPS position fixes, even if the receiver has been off for longer time periods or if the receiver has changed it's geographical location in power off state (>100km). Assisted GPS will perform quick fixes by using almanac and ephemeris data that come from an external source and will be fed into the almanac and ephemeris memory described above.

1.7. GPS antenna

TC6000G contains all input circuitry needed to connect directly a passive GPS antenna. Dependent of the application patch- or chip antennas or combo antennas (combination of GPS and Bluetooth) can be used. However, if there is a long wire between TC6000G GPS RFinput and antenna, there should be an LNA (on the antenna side) to compensate cable losses ("active" antenna). For active antenna configuration, the antenna supply DC must be blocked from the antenna signal line with a coil (L = 120nH) and a capacitor (C = 100pF).



More information about connecting and implementing a GPS antenna to an application PCB, refer to [2] **GPS Antenna Connection Design Guide.**

8. POWER MANAGEMENT

The TC6000G module requires a single 1.8V power supply. The 1.8V at the VDD pin supplies the GPS core. The 1.8V at VDD_IO pin supplies the digital I/Os with voltage. **No signals are allowed on the device I/Os in the absence of VDD_IO voltage** because the most I/Os are **not** fail-safe. Not fail-safe means that the pins will draw undefined current from an external voltage applied to the pin, when no I/O power is supplied to the device. Only exception is RTC_CLK .

1.8. Power-Up/Power-Down Sequence

The TC6000G power-up procedure is triggered by setting the Enable GPS_EN pin to high.

Power-up Requirements:

1. I/O voltage (VDD_IO) and supply voltage (VDD) should be available before pulling the GPS_EN pin high. Internal pull-downs are provided on the Enable pins to avoid false start-ups.
2. The RTC_CLK must be available before Enable pin is pulled high.

Power-down Requirements:

1. The requirement for device power-down is that the GPS_EN pin should be pulled low before the I/O supply (VDD_IO) is removed.

1.9. Shutdown and Reset

The low GPS_EN signal puts the TC6000G into an ultra–low power (shutdown) mode and also performs an internal reset to the device. The Enable signal rise time must not exceed 20us and must be driven low for a period of 5 ms (min.) in order to reset the device.

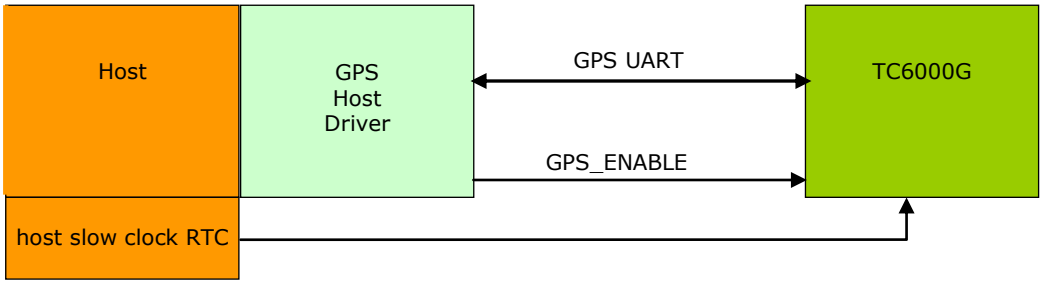
9. RTC CONNECTION

The RTC_CLK or slow clock is a free-running clock that is supplied from an external clock source. It is connected to the RTC_CLK pin on the TC6000G, and is a digital square wave signal in the range of 0 V to 1.8 V (nominal). The slow clock frequency is 32.768 kHz.

Digital RTC Requirements					
Parameter	**Min**	**Typ**	**Max**	**Unit**	**Note**
Input slow clock frequency		32.768		Hz	
Input slow clock accuracy			±200	ppm	Initial + temperature + aging
Input transition time			100	ns	t_R/t_F: 10% to 90%
Frequency input duty cycle	20%	50%	80%		
Phase noise			–125	dBC/Hz	At 1 kHz offset
Frequency jitter			1	Hz	Integrated over 300 Hz to 15 kHz
V_{IH}	0.65x VDD_IO		VDD_IO	V	Slow clock input voltage limits
V_{IL}	0		0.35x VDD_IO	V	Slow clock input voltage limits
Load capacitance			10	pF	Capacitance on RTC_CLK pin
Load resistance			1	MΩ	Resistance on RTC_CLK pin

10. HARDWARE HOST INTERFACE

GPS uses a two-wire interface with no flow control (null modem connection). The UART for GPS supports speed up to 400kbps.



The UART is used to send/receive control information and data to the host.
The default baud rate after power-up the device is 115.2 kBaud, regardless of the clock frequency supplied to the device. The maximum baud rate deviation supported is ±2%.

11. HOST INTERFACE PROTOCOL

Data transport layer is realized through a proprietary low level protocol.
To gain access to the NMEA data, a driver is needed to translate the proprietary protocol to standard protocol.

Drivers for various operating systems are already available or in preparation:
Desktop Windows (Demo for XP, Vista, 7), Windows CE, Linux (& Android), RTOS

12. NMEA DATA

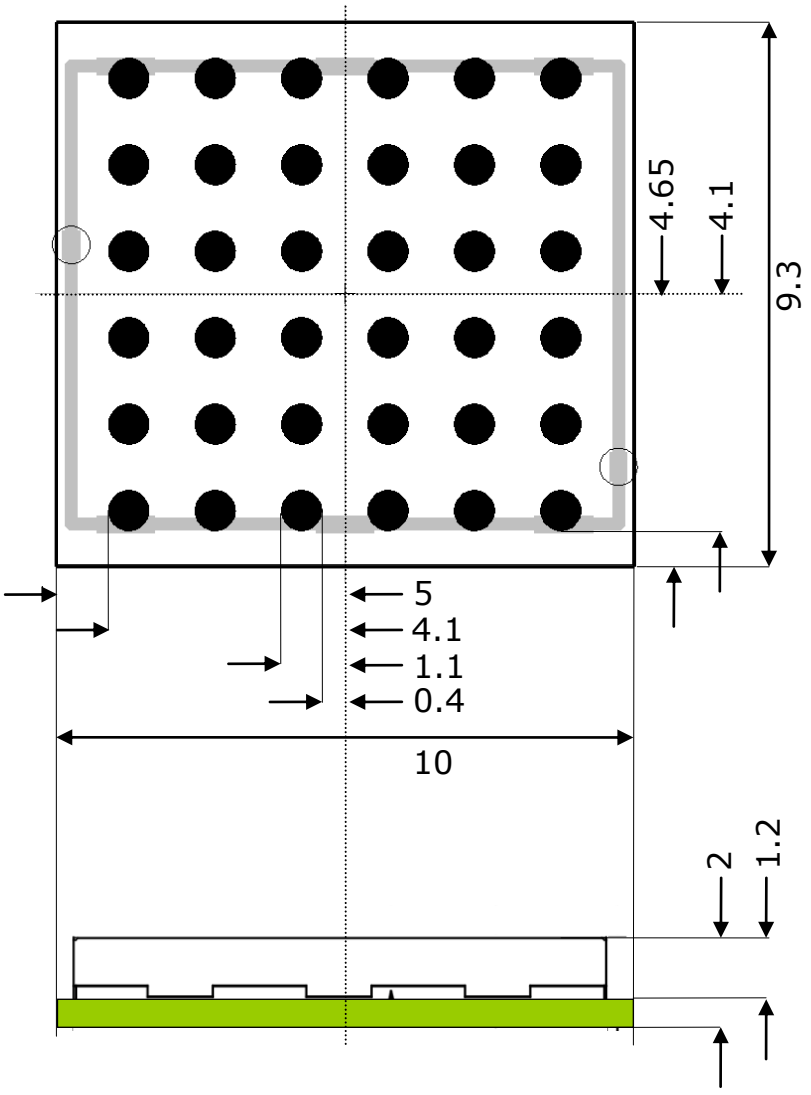
TC6000G drivers provide NMEA (National Marine Electronics Association) 0183 compatible data.
The following table shows the available NMEA sentences

NMEA data rate is 1/second or 2/second. All active NMEA sentences are sent at the selected rate

NMEA available sentences	
type	**content**
$GPRMC	Recommended Minimum Navigation Information
$GPGGA	Global Positioning System Fix Data, Time, Position and fix related data for a GPS receiver
$GPGSV	Satellites in view
$GPGLL	Geographic Position - Latitude/Longitude
$GPGSA	GPS DOP and active satellites
$GPVTG	Track made good and Ground speed

13. PHYSICAL DIMENSIONS

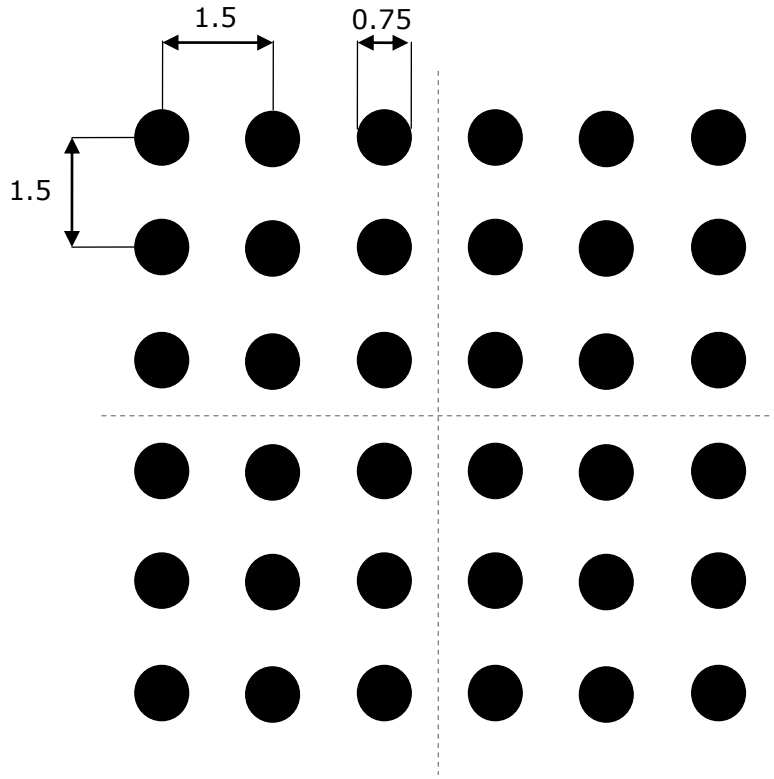
TOP VIEW



all units in mm

14. RECOMMENDED PAD LAYOUT

TOP VIEW



all units in mm

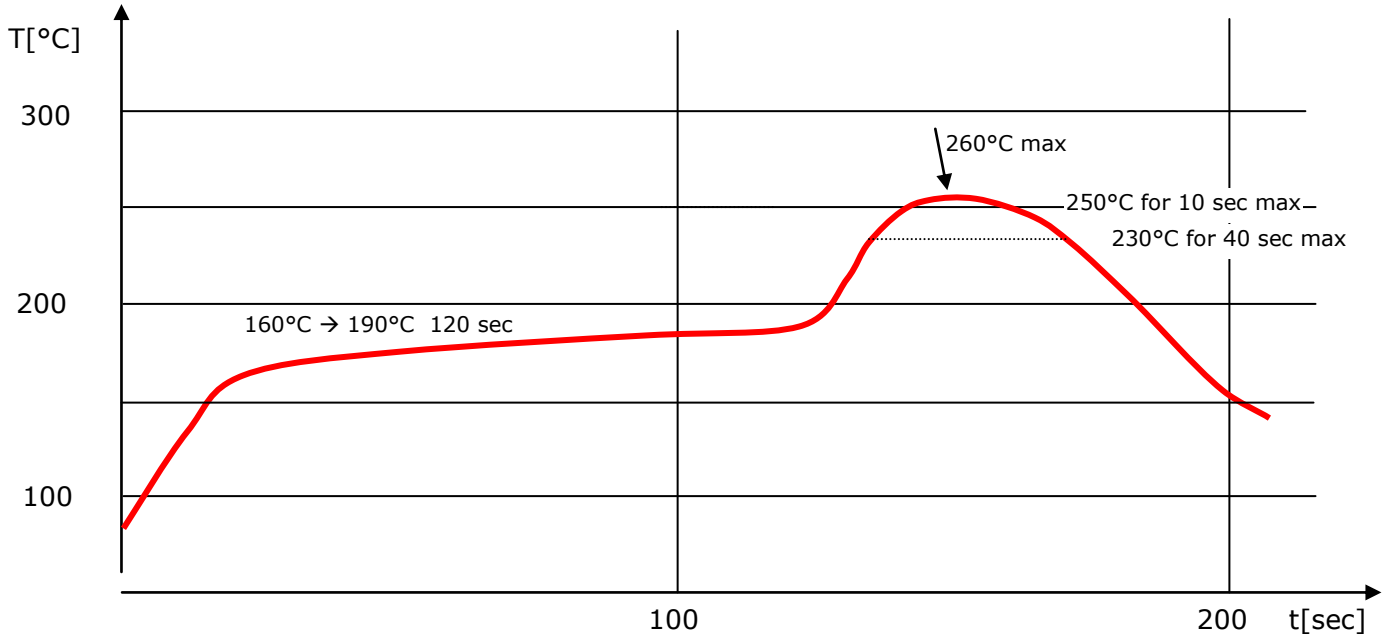
15. MATERIAL INFORMATION

complies to ROHS standard
ROHS documentations are available on request
contact surface : gold over nickel

SHIELD MATERIAL INFORMATION

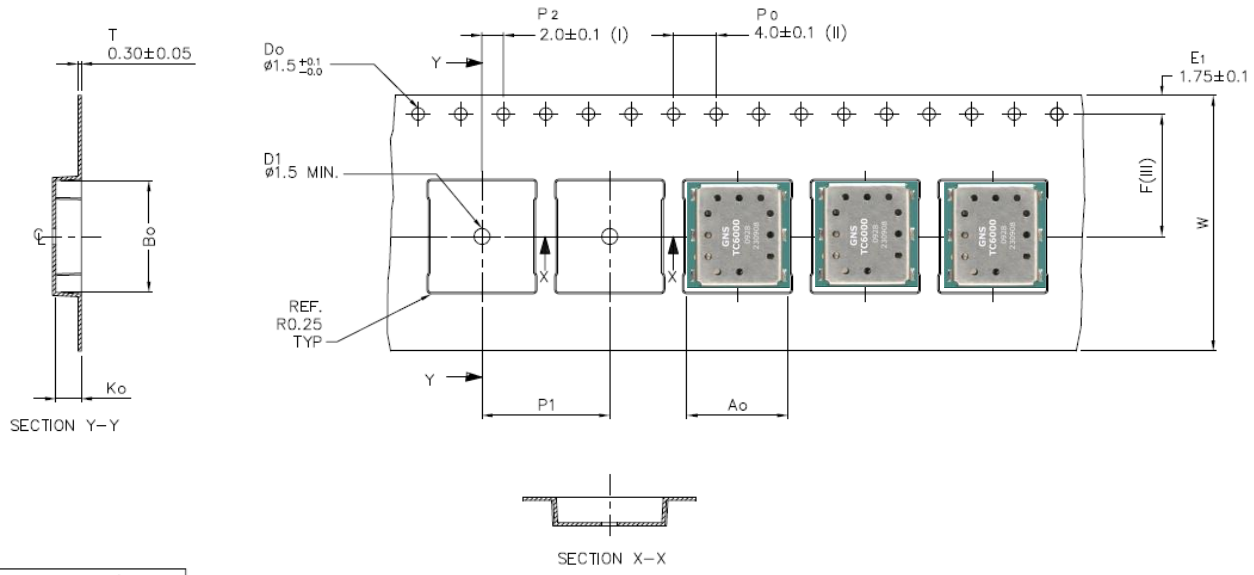
"German Silver " , CuNi18Zn27
Cu: 53.5..56.5%
Ni : 16.5..19.5%
Zn : 24..30%
thickness :0.2mm

16. RECOMMENDED SOLDERING REFLOW PROFILE



Notes:
1. TC6000 should be soldered in upright soldering position. In case of head-over soldering, please prevent shielding / TC6000-Module from falling down.
2. Do never exceed maximum peak temperature
3. Reflow cycles allowed: 1 time
4. Do not solder with Pb-Sn or other solder containing lead (Pb)
5. This device is not applicable for flow solder processing
6. This device is not applicable for solder iron process !

17. TAPE INFORMATION



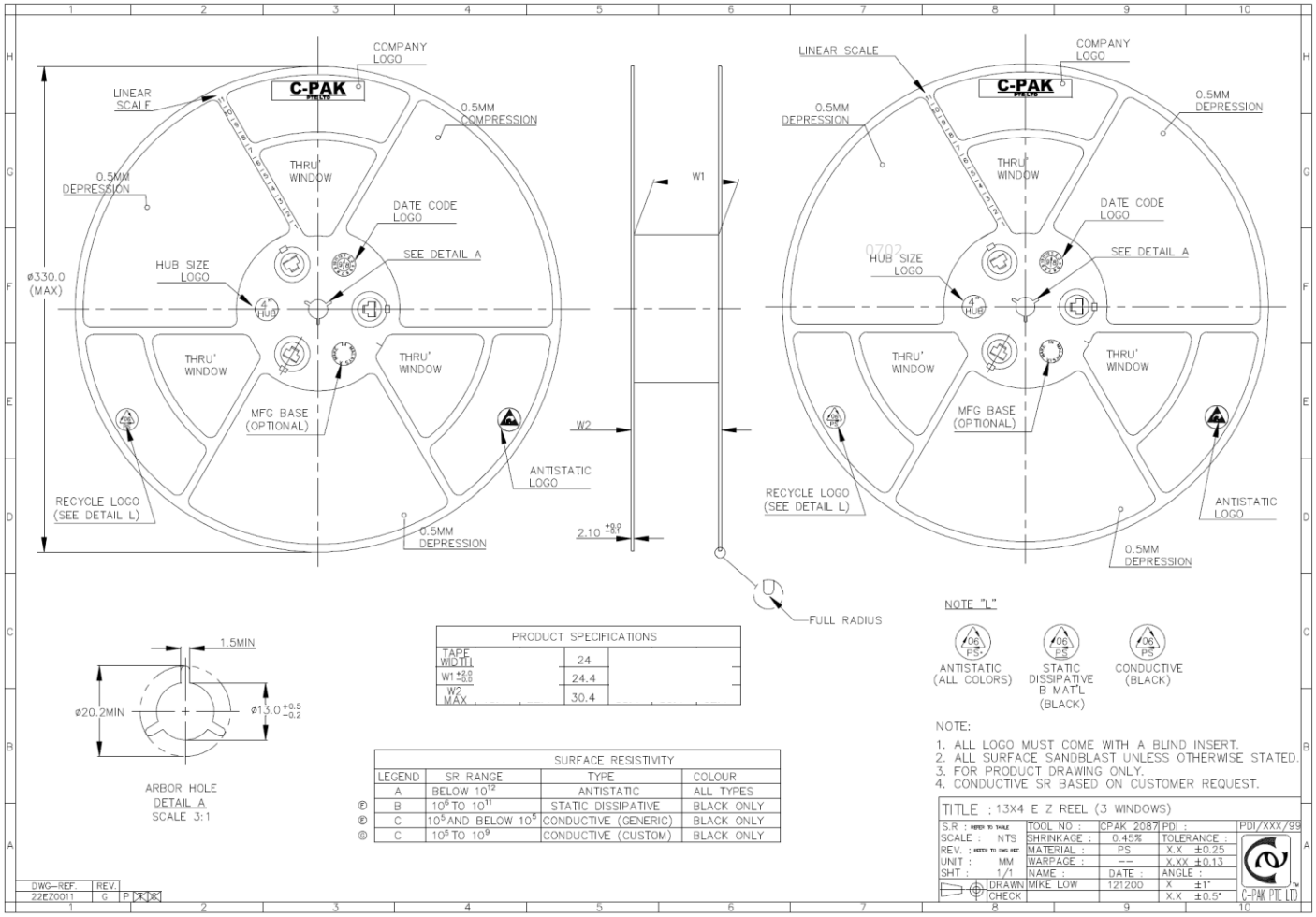
Ao	9.80	+/− 0.1
Bo	10.50	+/− 0.1
Ko	2.40	+/− 0.1
F	11.50	+/− 0.1
P1	12.00	+/− 0.1
W	24.00	+/− 0.3

Forming format : Flatbed
Estimated max. length : 60 meter/22B3 reel

(I) Measured from centreline of sprocket hole to centreline of pocket.
(II) Cumulative tolerance of 10 sprocket holes is ± 0.20 .
(III) Measured from centreline of sprocket hole to centreline of pocket.
(IV) Other material available.

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

18. REEL INFORMATION



no. of devices : 2000 pcs / reel

19. ORDERING INFORMATION

Ordering information			
Type	**Part#**	**Laser marking**	**Description**
TC6000 G	4037735104211	GNS TC6000 G <yy mm> <serial#>	GPS Module with embedded TCXO

20. ENVIRONMENTAL INFORMATION

This product is free of environmental hazardous substances and complies to 2002/95/EC. (RoHS directive).

21. MOISTURE SENSITIVITY

Shelf life	Unlimited
Storage conditions	≤30C/85%RH
Moisture Sensitivity Level (MSL)	1
Possible prebake recommendations	None

22. RELATED DOCUMENTS

Type	**description**	**Ref**	**Available from**
TC6000G_StarterKit_User manual	Hardware manual for the GNS Starter Kit	1	www.forum.gns-gmbh.com
GPS Antenna Connection Design Guide	Design Guide to implement an GPS antenna to an application PCB	2	www.forum.gns-gmbh.com

23. DOCUMENT REVISION HISTORY

V0.01	Sep 04 2009	K.Rudnizki	initial objective
V0.03	Feb 04 2010	K.Rudnizki	
V0.04	Feb 26 2010	K.Rudnizki	
V0.05	Mar 04 2010	K.Rudnizki	Uart Timing,
V0.1	Jun 11 2010	P.Skaliks	Overall revision, doc status changed to preliminary V01
V0.11	Jun 15 2010	P.Skaliks	Added MSL information
V0.12	July 16 2010	M.Reiff	Added Host Interface Combinations
V0.13	July 19 2010	P.Skaliks	Addeed host protocol, formal rework of doc
V0.14	Dec 14 2010	P.Skaliks	formal rework of doc
V0.15	Dec 23 2010	P.skaliks	Correction of TCXO definition. TCXO_CLK is Output, TCXO integrated in module.
V0.16	Apr 11 2011	K.Rudnizki	Additional information for pin description.
V0.17	Jan 4 2012	M.Reiff	Added information: GPS accuracy; ITAR limits; Related documents, Module block diagram