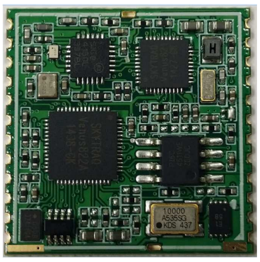
S2525DC

GPS Disciplined Clock Module

Data Sheet



10MHz, 19.2MHz, or 38.4MHz output

FEATURES

- 167 Acquisition/Tracking Channels
- Support GPS, QZSS, SBAS
- Disciplined low phase-noise VCTCXO
- Automatic hold-over
- 16 million time-frequency hypothesis testing per sec
- -148dBm cold start sensitivity
- -165dBm tracking sensitivity
- 29 second cold start TTFF
- 3.5 second TTFF with AGPS
- 1 second hot start
- 2.5m accuracy
- Multipath detection and suppression
- Jamming detection and mitigation
- 6nsec (1-sigma) timing accuracy
- Position hold mode for timing operation
- 1PPS generation with 1 satellite in view
- Complete receiver in 25mm x 25mm size
- RoHS compliant

S2525DC is a high performance GPS module targeting precision time and frequency reference applications. It includes a low-noise VCTCXO and provides 100 ppb autonomous hold-over. S2525DC offers low power consumption, high sensitivity, and best in class signal acquisition and time to first fix performance. It is designed to work in the most demanding weak signal environments, including in-home devices, femto-cells, and in-building systems.

S2525DC contains all the necessary components of a complete GPS receiver, includes RF front-end, GPS baseband signal processor, 0.5ppm TCXO, 32.768kHz RTC crystal, RTC LDO regulator, and passive components. It requires very low external component count and takes up only 25mm x 25mm PCB footprint.

Dedicated massive-correlator signal parameter search engine within the baseband enables rapid search of all the available satellites and acquisition of very weak signal. An advanced track engine allows weak signal tracking and positioning in harsh environments such as urban canyons and under deep foliage.

The self-contained architecture keeps GPS processing off the host and allows integration into applications with very little resource.

S2525DC is very easy to use, minimizes RF layout design issues and offers very fast time to market.

TECHNICAL SPECIFICATIONS

Receiver Type	L1 C/A code GPS QZSS SBAS 167 channel Venus 8 engine	
Accuracy	Position Velocity Time	2.5m CEP 0.1m/sec 6nsec (1-sigma) < 12nsec (99%)
System Clock	Frequency Lock Accuracy Holdover Stability Phase Noise	10MHz, 19.2MHz, or 38.4MHz depend on model 0.5E-11 averaging over 24hr 100ppb over 24hr -115dBc/Hz @ 100Hz -135dBc/Hz @ 1kHz -150dBc/Hz @ 10kHz
Open Sky TTFF	Hot start 1 second Cold start 29 seconds average	
Reacquisition	< 1s	
Sensitivity	Tracking -165dBm	
Update Rate	1Hz standard	
Dynamics	4G	
Operational Limits	Altitude < 18,000m[*1] or Velocity < 515m/s[*1]	
Datum	Default WGS-84	
Interface	UART LVTTL level	
Baud Rate	4800 / 9600 / 38400 / 115200 software configurable (115200 as default)	
Protocol	NMEA-0183 V3.01, SkyTraq binary, UART 8,N,1	
Input Voltage	3.3V DC +/-10%	
Backup Voltage	2.5V ~ 3.6V	
Current Consumption	63mA acquisition, 55mA tracking	
Operating Temperature	-40 ~ +85 deg-C	
Storage Temperature	-40 ~ +125 deg-C	
Dimension	25mm L x 25mm W	
Weight:	3g	

*1: COCOM limit, either may be exceeded but not both

BLOCK DIAGRAM

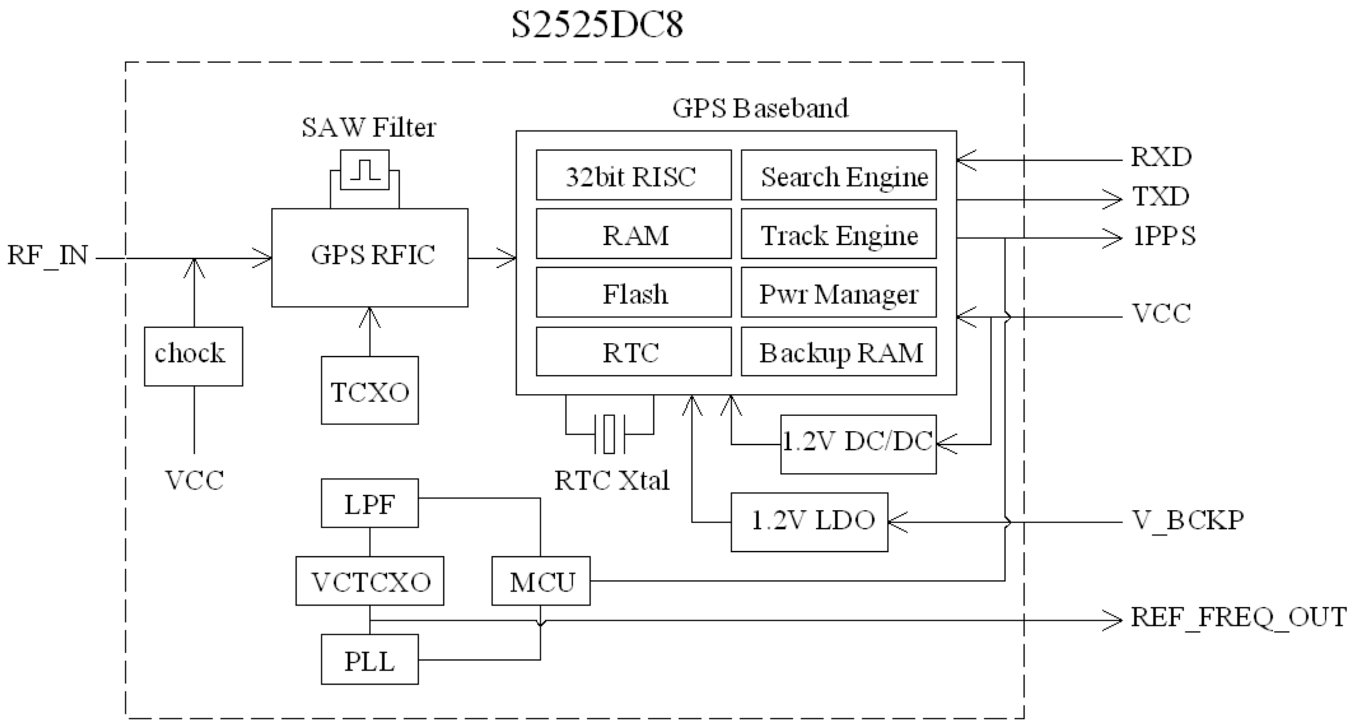


Figure-1 GPS receiver block diagram

OPERATION

When S2525DC is turned on, it automatically begin to acquire and track GPS signals. After valid ephemeris data is collected for each tracked satellite signal and ready for position fix, it performs self-survey of its location in Survey Mode. After 2000 position fixes (configurable) the S2525DC automatically enters Static Mode, a clock over-determined time-only mode.

Satellites above elevation mask and signal level above CNR mask are used for position fix. Default elevation mask is 5 degrees and CNR mask is 0.

During normal operation, the frequency of the internal VCTCXO oscillator is corrected or disciplined continuously to account for changes in temperature. During hold-over the most recent setting is held, the frequency stability is then determined by the VCTCXO oscillator characteristics.

S2525DC operates Survey Mode, Static Mode, or PVT Mode.

Upon power on, the S2525DC performs 2000 point position fix self-survey. The number of points used for self-survey may be changed using binary command 0x43. After self-survey is completed, the receiver enters Static Mode.

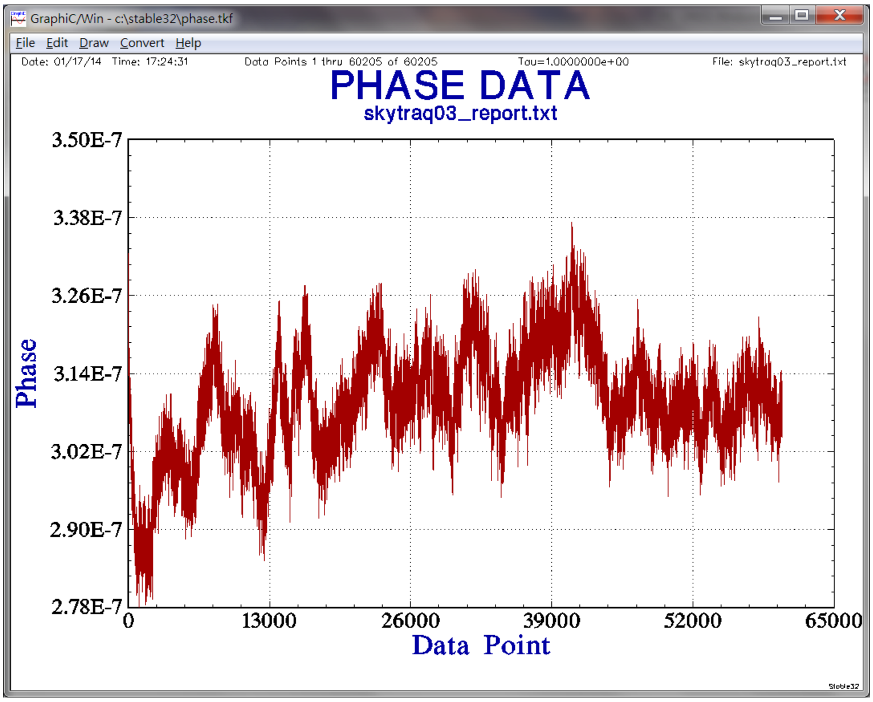
Static Mode is used in static timing application. It is entered after the receiver self-surveyed its static reference position, or by user input. The over-determined clock solution is checked against TRAIM algorithm to remove faulty satellites from the solution. In this mode the receiver will no longer update its position or velocity, only solving for receiver clock bias and bias rate to maintain the 1PPS output.

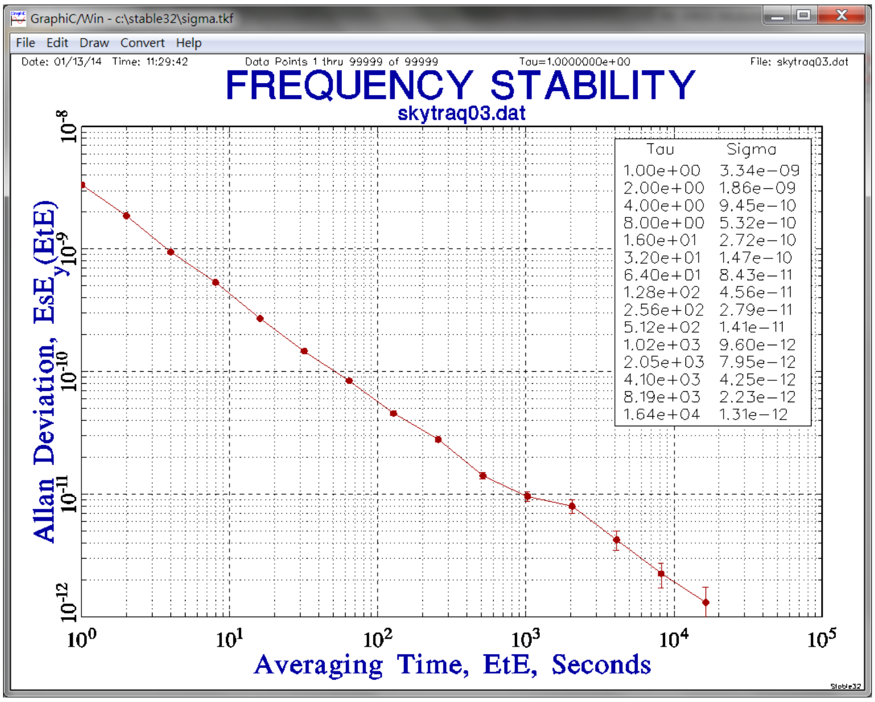
The PVT mode is for navigation type of application, less used with timing application. In this mode, TRAIM and single-satellite 1PPS generation is not supported.

1PPS Quantization Error

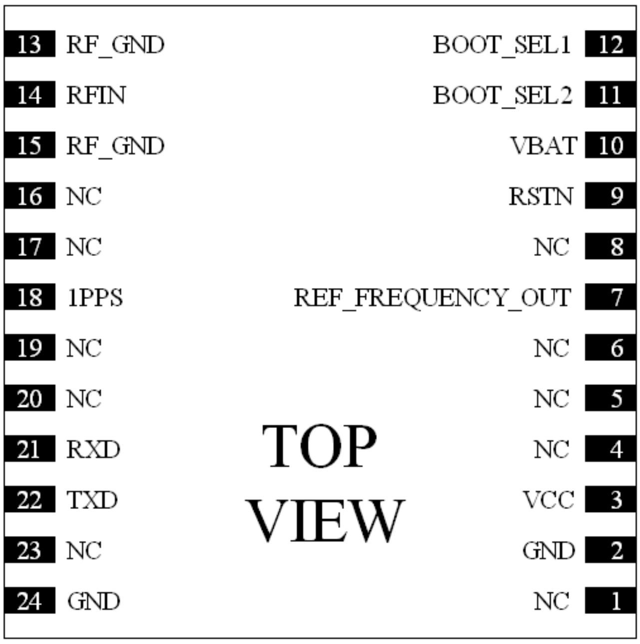
S2525DC uses 81.838335MHz clock for 1PPS generation, which has period of 12nsec. By steering 1PPS output rising edge closest to UTC second, there remains a quantization error of half clock period, +/-6nsec. The amount of quantization error is reported by the S2525DC using SkyTraq proprietary NMEA message $PSTI,00; this information can be used to reduce the effective amount of jitter on 1PPS output.

The figures below illustrate the characteristic of the 1PPS signal.





INTERFACE

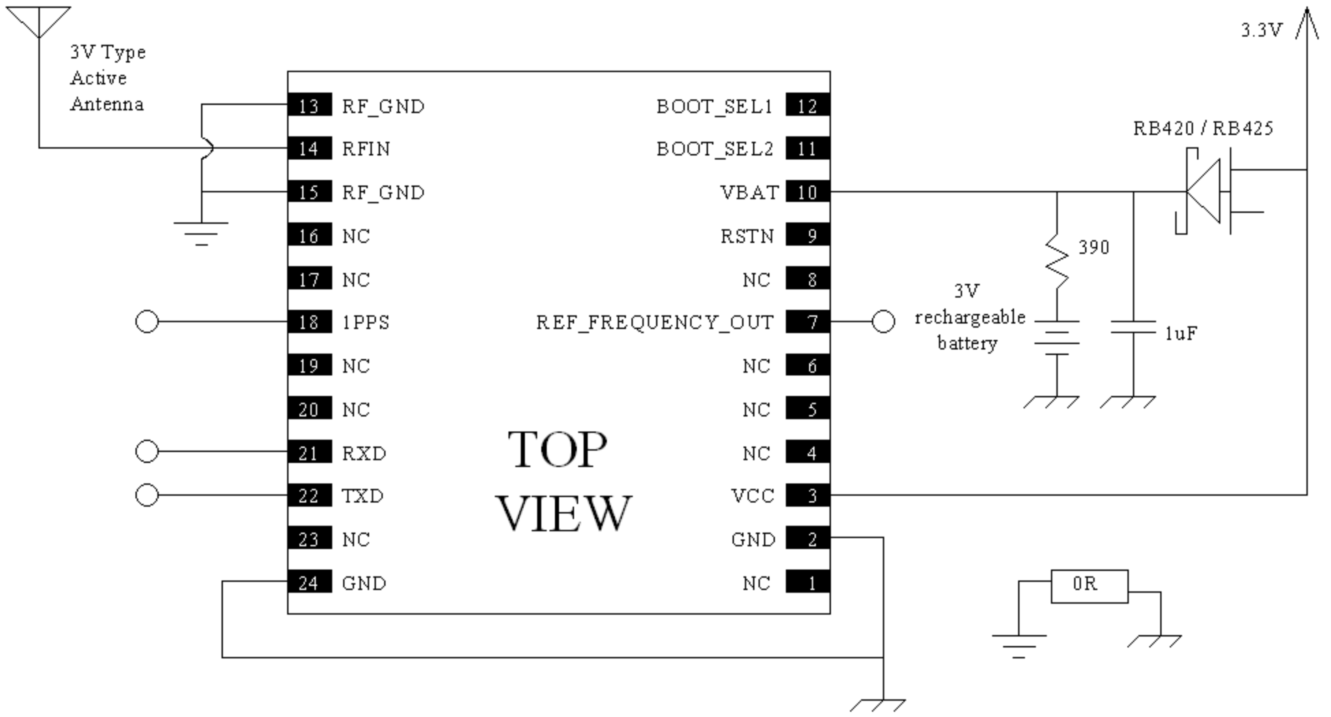


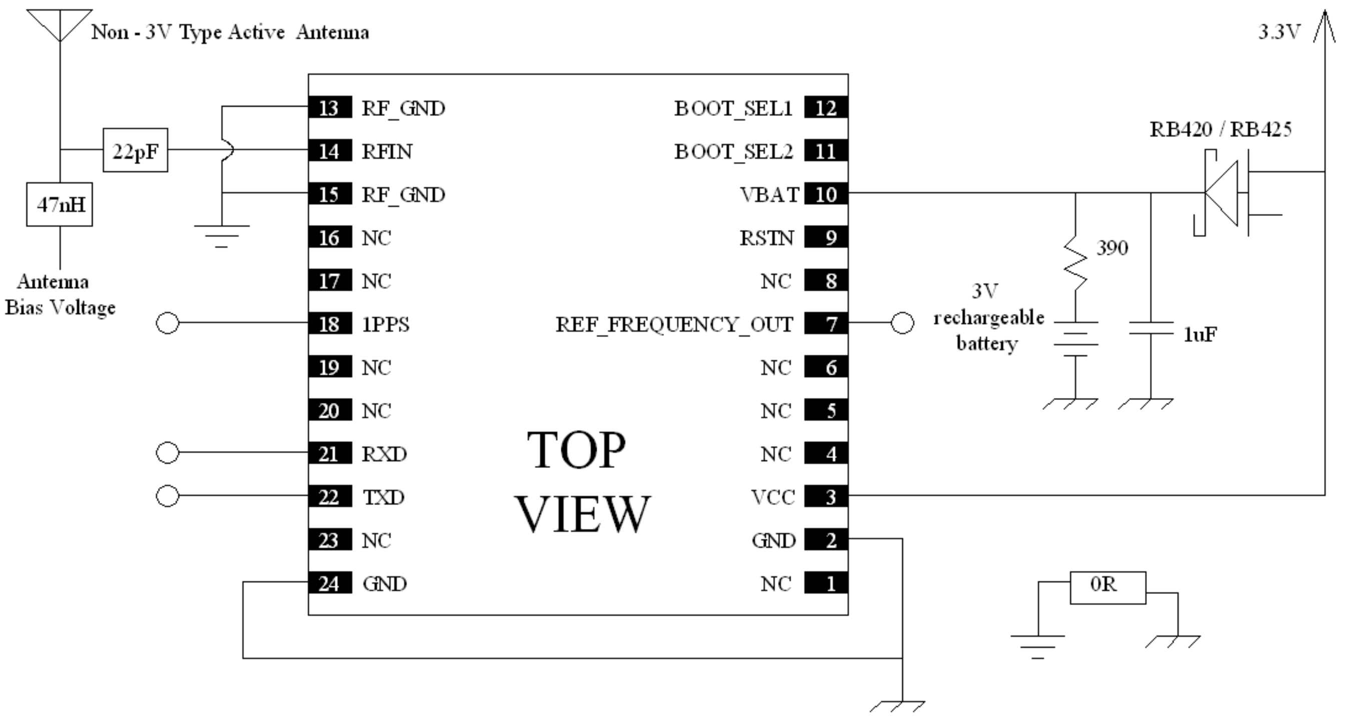
PINOUT DESCRIPTION

Pin No.	Name	Description
1	NC	No connection
2	GND	Ground
3	VCC	Main power supply, 3.0V ~ 3.6V DC
4,5,6	NC	No connection
7	REF_FREQUENCY_OUT	Reference frequency output. 10MHz, 19.2MHz, or 38.4MHz depending on model type. CMOS output
8	NC	No connection
9	RSTN	External active-low reset input. Only needed when power supply rise time is very slow or software controlled reset is desired.
10	VBAT	Backup supply voltage for internal RTC and backup SRAM, 2.5V ~ 3.6V. VBAT must be applied whenever VCC is applied. This pin should be powered continuously to minimize the startup time. If VCC and VBAT are both removed, all user configuration set is lost. For applications the does not care cold starting every time, this pin can be connect to VCC.
11	BOOT_SEL1	No connection for normal use. Pull-low for loading firmware into empty or corrupted Flash memory of GPS baseband from ROM mode by the module maker.
12	BOOT_SEL2	No connection for normal use. Pull-low for loading firmware into empty or corrupted Flash memory of MCU from ROM mode by the module maker.
13, 15	RF_GND	RF ground
14	RFIN	RF input, connects to antenna. There is 3.3V DC bias output for powering active antenna.
16,17	NC	No connection

18	1PPS	One-pulse-per-second (1PPS) time mark output, 3V LVTTL. The rising edge synchronized to UTC second when getting 3D position fix. The pulse duration is about 800usec at rate of 1 Hz.
19, 20	NC	No connection
21	RXD	UART serial data input, 3V LVTTL. One full-duplex asynchronous serial UART port is implemented. This UART input is normally for sending commands or information to the receiver in SkyTraq binary protocol. In the idle condition, this pin should be driven HIGH. If the driving circuitry is powered independently of S2525DC, ensure that this pin is not driven to HIGH when primary power to S2525DC is removed, or a 10K-ohm series resistor can be added to minimize leakage current from application to the powered off module.
22	TXD	UART serial data output, 3V LVTTL. One full-duplex asynchronous serial UART port is implemented. This UART output is normally used for sending position, time and velocity information from the receiver in NMEA-0183 format. When idle, this pin output HIGH.
23	NC	No connection
24	GND	Ground

APPLICATION CIRCUIT





ELECTRICAL SPECIFICATIONS

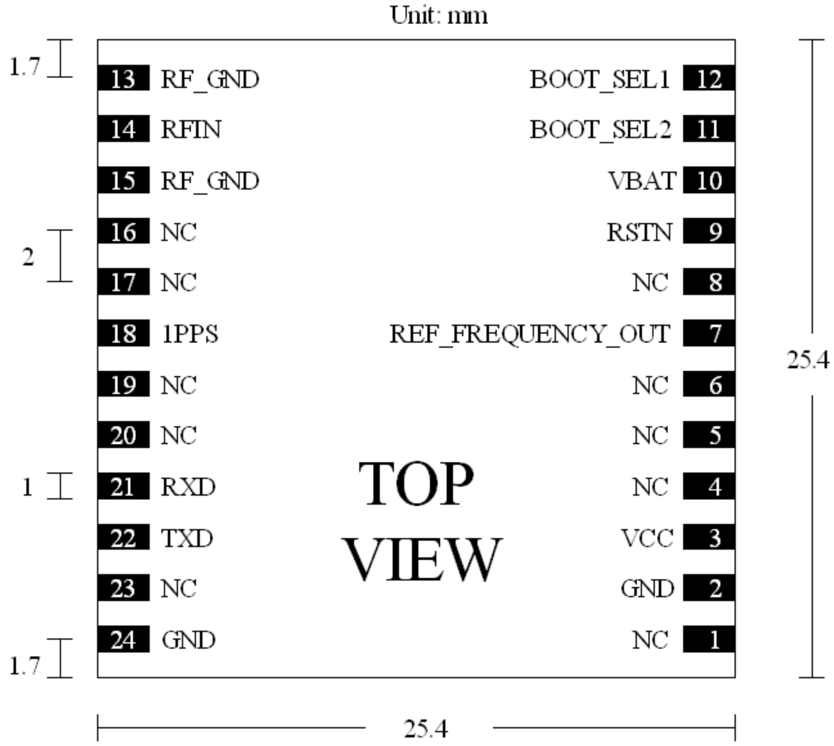
ABSOLUTE MAXIMUM RATINGS

Parameter	Minimum	Maximum	Condition
Supply Voltage (VCC)	-0.5	3.6	Volt
Backup Battery Voltage (V_BCKP)	-0.5	3.6	Volt
Input Pin Voltage	-0.5	VCC+0.5	Volt
Input Power at RF_IN		+5	dBm
Storage Temperature	-55	+100	degC

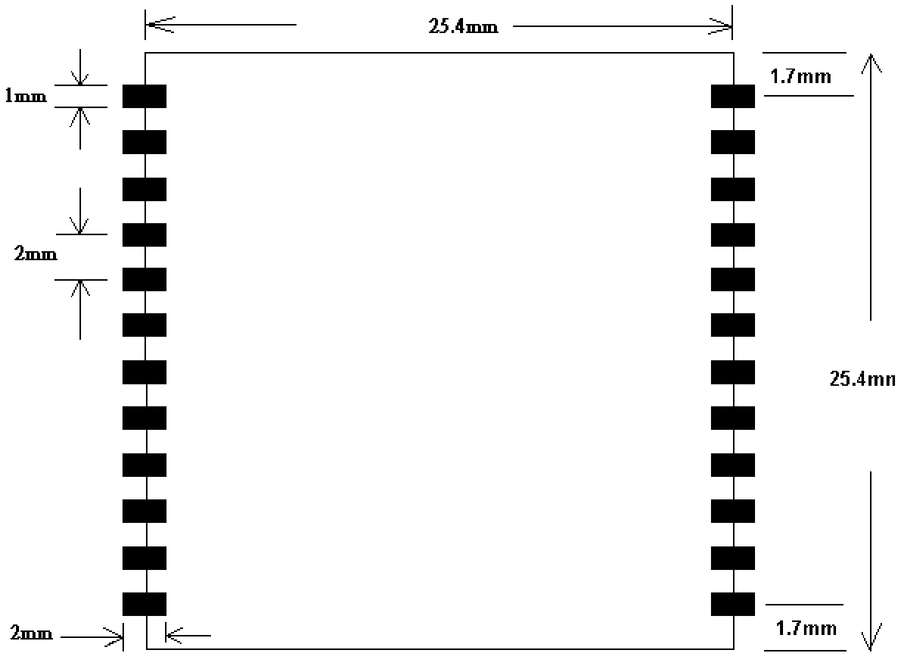
OPERATING CONDITIONS

Parameter	Min	Typ	Max	Unit
Supply Voltage (VCC)	3	3.3	3.6	Volt
Acquisition Current (exclude active antenna current)		63		mA
Tracking Current (exclude active antenna current)		55		mA
Backup Voltage (VBAT)	2.5		3.6	Volt
Backup Current (VCC voltage applied)			0.5	mA
Backup Current (VCC voltage off)			35	uA
Output Low Voltage			0.4	Volt
Output HIGH Voltage	2.4			Volt
Input LOW Voltage			0.8	Volt
Input HIGH Voltage	2			Volt
Input LOW Current	-10		10	uA
Input HIGH Current	-10		10	uA
RF Input Impedance (RFIN)		50		Ohm

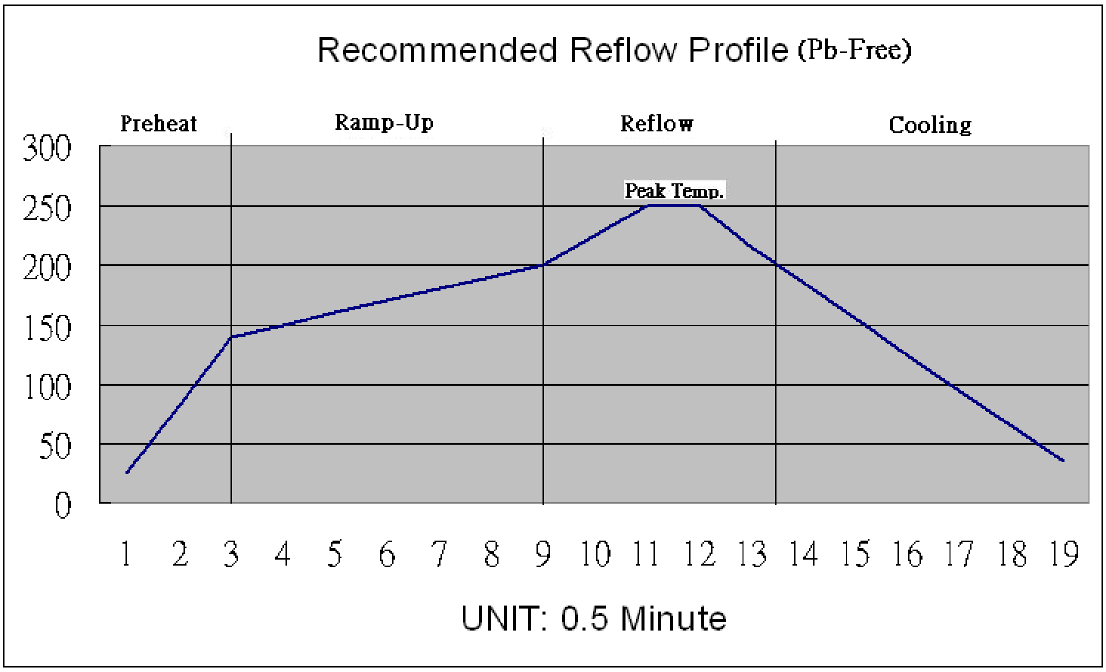
MECHANICAL CHARACTERISTICS



RECOMMENDED PAD LAYOUT



RECOMMENDED REFLOW PROFILE



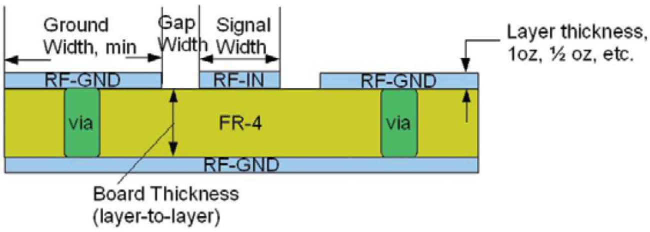
Temperature (℃)	25	82.5	140	150	160	170	180	190	200	225	250	250	215	185	155	125	95	65	35
Time(minute)	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9

Profile Description	**SnPb Eutectic Process**	**Lead Free Process**
Preheat		
Maximum Temperature	100+/-10 ℃	140+/-10 ℃
Time(∆T)	40~60s	50~70s
Ramp-Up		
Ramp-Up Rate	1 ℃/s Max.	1 ℃/s Max.
Time(∆T)	120~150s	160~200s
Reflow		
Maximum Temperature	Peak Temp.	Peak Temp.
Minimum Temperature	180+/-5℃	200+/-10℃
Peak Temperature	220+/-2℃	250+/-2℃
Time(∆T) during Peak Temp.+/-2℃	10~30s	20~40s
Reflow Time(∆T)	120~150s	120~150s
Cooling		
Cooling Rate	1.5 ℃/s Max	1.5 ℃/s Max
Time(∆T)	60~120s	150~180s

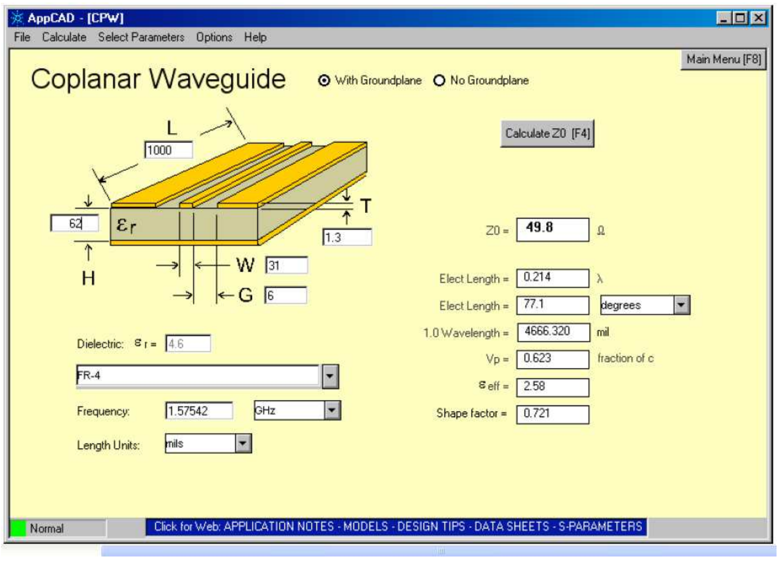
ANTENNA CONSIDERATIONS

The S2525DC is designed to use with active antennas. Active antenna with gain up to 30dB and noise figure less than 1.5dB can be used with S2525DC.

The signal path from antenna to RF input of S2525DC is the most critical part of application design. The goal is to provide optimal 50-ohm match between a 50Ω antenna and the module 50-ohm RF input for maximum power transfer. The 50-ohm grounded coplanar wave guide, consisting of the RF input signal with RF ground on either sides and a RF ground underneath, is a good choice for efficiency.



For a two-layer FR4 PCB design with 1.6mm thickness, 4.6 dielectric constant, and 1oz copper the RF-input trace should be 31mil in width, the gap to the adjacent grounds should be 6mil, and each of the RF grounds should be at least twice the width of the input signal trace (62mil). Freeware program such as AppCAD can be used to calculate values required for other configurations.



POWER SUPPLY REQUIREMENT

S2525DC requires a stable power supply, avoid ripple on VCC pin (<50mVpp). Power supply noise can affect the receiver's sensitivity. Bypass capacitors of 10uF and 0.1uF is recommended to be placed close to the module VCC pin; the values could be adjusted according to the amount and type of noise present on the supply line.

BACKUP SUPPLY

The purpose of backup supply voltage pin (VBAT) is to keep the SRAM memory and the RTC powered when the module is powered down. This enables the module to have a faster time-to-first-fix when the module is powered on again. The backup current drain is less than 35μA. In normal powered on state, the internal processor access the SRAM and current drain is higher in active mode

LAYOUT GUIDELINES

Separate RF and digital circuits into different PCB regions.

It is necessary to maintain 50-ohm impedance throughout the entire RF signal path. Try keeping the RF signal path as short as possible.

Do not route the RF signal line near noisy sources such as digital signals, oscillators, switching power supplies, or other RF transmitting circuit. Do not route the RF signal under or over any other components (including S2525DC), or other signal traces. Do not route the RF signal path on an inner layer of a multi-layer PCB to minimize signal loss.

Avoid sharp bends for RF signal path. Make two 45-deg bends or a circular bend instead of a single 90-degree bend if needed.

Avoid vias with RF signal path whenever possible. Every via adds inductive impedance. Vias are acceptable for connecting the RF grounds between different layers. Each of the module's ground pins should have short trace tying immediately to the ground plane below through a via.

The bypass capacitors should be low ESR ceramic types and located directly adjacent to the pin they are for.

HANDLING GUIDELINE

The S2525DC modules are rated MSL4, must be used for SMT reflow mounting within 72 hours after taken out from the vacuumed ESD-protective moisture barrier bag in factory condition < 30degC / 60% RH. If this floor life time is exceeded, or if the received ESD-protective moisture barrier bag is not in vacuumed state, then the device need to be pre-baked before SMT reflow process. Baking is to be done at 85degC for 8 to 12 hours. Once baked, floor life counting begins from 0, and has 72 hours of floor life at factory condition < 30degC / 60% RH.

S2525DC module is ESD sensitive device and should be handled with care.

NMEA Output Description

The output protocol supports NMEA-0183 standard. The implemented messages include GGA, GLL, GSA, GSV, VTG, RMC, ZDA and GNS messages. The NMEA message output has the following sentence structure:

$aaccc,c–c*hh<CR><LF>

The detail of the sentence structure is explained in Table 1.

Table 1: The NMEA sentence structure

character	HEX	Description
"$"	24	Start of sentence.
Aaccc		Address field. "aa" is the talker identifier. "ccc" identifies the sentence type.
","	2C	Field delimiter.
C–c		Data sentence block.
"*"	2A	Checksum delimiter.
Hh		Checksum field.
<CR><LF>	0D0A	Ending of sentence. (carriage return, line feed)

Table 2: Overview of SkyTraq receiver's NMEA messages

$GPGGA	Time, position, and fix related data of the receiver.
$GPGLL	Position, time and fix status.
$GPGSA	Used to represent the ID's of satellites which are used for position fix.
$GPGSV	Satellite information about elevation, azimuth and CNR
$GPRMC	Time, date, position, course and speed data.
$GPVTG	Course and speed relative to the ground.
$GPZDA	UTC, day, month and year and time zone.

The formats of the supported NMEA messages are described as follows:

GGA – Global Positioning System Fix Data

Time, position and fix related data for a GPS receiver.

Format:
$--GGA,hhmmss.sss,llll.llll,a,yyyyy.yyyy,a,x,uu,v.v,w.w,M,x.x,M,,zzzz*hh<CR><LF>

Field	**Name**	**Description**
hhmmss.sss	UTC Time	UTC of position in hhmmss.sss format, (000000.000 ~ 235959.999)
llll.llll	Latitude	Latitude in ddmm.mmmm format. Leading zeros are inserted.
A	N/S Indicator	'N' = North, 'S' = South
yyyyy.yyyy	Longitude	Longitude in dddmm.mmmm format. Leading zeros are inserted.
A	E/W Indicator	'E' = East, 'W' = West
x	GPS quality indicator	GPS quality indicator 0: position fix unavailable 1: valid position fix, SPS mode 2: valid position fix, differential GPS mode
uu	Satellites Used	Number of satellites in use, (00 ~ 24)
v.v	HDOP	Horizontal dilution of precision, (0.0 ~ 99.9)
w.w	Altitude	Mean sea level altitude (-9999.9 ~ 17999.9) in meter
x.x	Geoidal Separation	In meter
zzzz	DGPS Station ID	Differential reference station ID, 0000 ~ 1023 NULL when DGPS not used
hh	Checksum	

GLL – Geographic Position – Latitude/Longitude

Latitude and longitude of vessel position, time of position fix and status.

Format:
$--GLL,llll.llll,a,yyyyy.yyyy,b,hhmmss.sss,A,a*hh<CR><LF>

Field	**Name**	**Description**
llll.llll	Latitude	Latitude in ddmm.mmmm format. Leading zeros are inserted.
A	N/S Indicator	'N' = North, 'S' = South
yyyyy.yyyy	Longitude	Longitude in dddmm.mmmm format. Leading zeros are inserted.
B	E/W Indicator	'E' = East, 'W' = West
hhmmss.sss	UTC Time	UTC of position in hhmmss.sss format, (000000.000 ~ 235959.999)
A	Status	A= data valid, V= Data not valid
hh	Checksum	

GSA – GNSS DOP and Active Satellites

GPS receiver operating mode, satellites used in the navigation solution reported by the GGA or GNS sentence and DOP values.

Format:
$--GSA,a,x,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,u.u,v.v,z.z*hh<CR><LF>

Field	Name	Description
a	Mode	Mode 'M' = Manual, forced to operate in 2D or 3D mode 'A' = Automatic, allowed to automatically switch 2D/3D
x	Mode	Fix type 1 = Fix not available 2 = 2D 3 = 3D
xx's	Satellite ID	01 ~ 32 are for GPS; 33 ~ 64 are for WAAS (PRN minus 87); 193 ~ 197 are for QZSS. Maximally 12 satellites are included in each GSA sentence.
u.u	PDOP	Position dilution of precision (0.0 to 99.9)
v.v	HDOP	Horizontal dilution of precision (0.0 to 99.9)
z.z	VDOP	Vertical dilution of precision (0.0 to 99.9)
hh	Checksum	

GSV – GNSS Satellites in View

Number of satellites (SV) in view, satellite ID numbers, elevation, azimuth, and SNR value. Four satellites maximum per transmission.

Format:
$--GSV,x,u,xx,uu,vv,zzz,ss,uu,vv,zzz,ss,…,uu,vv,zzz,ss*hh<CR><LF>

Field	**Name**	**Description**
x	Number of message	Total number of GSV messages to be transmitted (1-4)
u	Sequence number	Sequence number of current GSV message
xx	Satellites in view	Total number of satellites in view (00 ~ 16)
uu	Satellite ID	01 ~ 32 are for GPS; 33 ~ 64 are for WAAS (PRN minus 87); 193 ~ 197 are for QZSS. Maximally 4 satellites are included in each GSV sentence.
vv	Elevation	Satellite elevation in degrees, (00 ~ 90)
zzz	Azimuth	Satellite azimuth angle in degrees, (000 ~ 359)
ss	SNR	C/No in dB (00 ~ 99) Null when not tracking
hh	Checksum	

RMC – Recommended Minimum Specific GNSS Data

Time, date, position, course and speed data provided by a GNSS navigation receiver.

Format:
$--RMC,hhmmss.sss,x,llll.llll,a,yyyyy.yyyy,a,x.x,u.u,xxxxxx,,,v*hh<CR><LF>

Field	**Name**	**Description**
hhmmss.sss	UTC time	UTC time in hhmmss.sss format (000000.000 ~ 235959.999)
x	Status	Status 'V' = Navigation receiver warning 'A' = Data Valid
llll.llll	Latitude	Latitude in dddmm.mmmm format. Leading zeros are inserted.
A	N/S indicator	'N' = North; 'S' = South
yyyyy.yyyy	Longitude	Longitude in dddmm.mmmm format. Leading zeros are inserted.
A	E/W Indicator	'E' = East; 'W' = West
x.x	Speed over ground	Speed over ground in knots (000.0 ~ 999.9)
u.u	Course over ground	Course over ground in degrees (000.0 ~ 359.9)
xxxxxx	UTC Date	UTC date of position fix, ddmmyy format
v	Mode indicator	Mode indicator 'N' = Data not valid 'A' = Autonomous mode 'D' = Differential mode 'E' = Estimated (dead reckoning) mode
hh	checksum	

VTG – Course Over Ground and Ground Speed

The actual course and speed relative to the ground.

Format:
$--VTG,x.x,T,y.y,M,u.u,N,v.v,K,m*hh<CR><LF>

Field	Name	Description
x.x	Course	Course over ground, degrees True (000.0 ~ 359.9)
y.y	Course	Course over ground, degrees Magnetic (000.0 ~ 359.9)
u.u	Speed	Speed over ground in knots (000.0 ~ 999.9)
v.v	Speed	Speed over ground in kilometers per hour (0000.0 ~ 1800.0)
m	Mode	Mode indicator ‘N’ = not valid ‘A’ = Autonomous mode ‘D’ = Differential mode ‘E’ = Estimated (dead reckoning) mode
hh	Checksum	

ZDA – Time and Date

UTC, day, month, year and local time zone.

Format:
$--ZDA,hhmmss.sss,dd,mm,yyyy,xx,yy*hh<CR><LF>

Field	Name	Description
hhmmss.sss	UTC time	UTC time in hhmmss.sss format (000000.000 ~ 235959.999)
dd	UTC day	01 to 31
mm	UTC month	01 to 12
yyyy	UTC year	Four-digit year number
xx	Local zone hours	00 to +-13
yy	Local zone minutes	00 to +59
hh	Checksum	

STI,00 – 1 PPS timing report

An output message, id 0x0, contains information of 1 PPS timing mode, 1 PPS survey length and 1PPS quantization error.

Structure:

$PSTI,00,x,xx,xx,x,x *hh<CR><LF>

1 2 3 4 5 6 7

Example:

$PSTI,00,1,1985,-12.4,30,5*28<CR><LF>

Field	Name	Example	Description
1	00	00	Proprietary NMEA message identifier
2	1PPS Timing Mode	1	0 = PVT Mode 1 = Survey Mode 2 = Static Mode
3	1PPS Survey Length	1985	Survey length for Survey Mode values 60 ~ 1209600
4	1PPS Quantization Error	-12.4	Quantization error of 1PPS timing values -31 ~ +31
5	Position Standard Deviation Threshold	30	Position standard deviation threshold for comparing self-surveyed position result. At end of self-survey period, if position standard deviation from averaged center point is less than this threshold, static mode is entered; otherwise survey mode is restarted again. Default threshold is 30m. Output null field when not in survey mode.
6	Calculated Position Standard Deviation After Self-Survey	5	When still in survey mode, this field output 0. At end of self-survey period, if position standard deviation from averaged center point is less than the Position Standard Deviation Threshold, static mode is entered; otherwise survey mode is restarted and computed position standard deviation value is output. Null field when not in survey mode.
7	Checksum	28	

ORDERING INFORMATION

Part Number	Description
S2525DC-100	GPS Precision Timing Mode Receiver Module, 10MHz version
S2525DC-192	GPS Precision Timing Mode Receiver Module, 19.2MHz version
S2525DC-384	GPS Precision Timing Mode Receiver Module, 38.4MHz version

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Change Log

Version 0.2, November 27, 2014

1. Updated frequency accuracy on page-3

Version 0.1, November 19, 2014

1. Initial release