GPS and DGPS Overview, With a Complete RF Front-End Design

This application note presents an overview of how GPS and DGPS systems work. It presents the MAX2742, MAX2744 and MAX2745 GPS receiver ICs and a complete GPS module design, using the MAX2742 and the Sony CXD2932.

Part 1: Introduction to GPS

The Global Positioning System (GPS) is a constellation of 24 satellites in six orbits. They circle the earth twice each day at an inclination angle of approximately 55 degrees to the equator. The satellites continuously transmit coded positional and timing information at high frequencies (in the 1500 MHz range).

GPS receivers on the ground pick up the signals and use the coded information to calculate a position on an earth coordinate system. A receiver determines position by calculating the time it takes for the radio signals transmitted from each satellite to reach the receiver. Multiplying the time by the speed of light determines how far the unit is from each of the satellites: Distance = Rate x Time. Time is determined using an ingenious code matching technique within the GPS receiver. The location of each satellite is encoded in its transmitted signal. With these data, the receiver can triangulate to calculate its location on Earth.

Differential GPS Enhances Accuracy

Differential GPS, or DGPS, improves GPS accuracy to within a few meters by using a high-performance GPS receiver (reference station) at a known location. Since the reference station receiver knows its exact location, it can determine errors in the satellite signals. The error data for each tracked satellite is formatted into a correction message and transmitted to GPS users. These differential corrections are then applied to the GPS calculations, removing most of the satellite signal error and improving accuracy.

GPS signals, which are available worldwide, can pinpoint your position anywhere on the globe. GPS products have been developed for many commercial applications. As the technology has continuously improved, the price and size of GPS become very important.

Part 2: Maxim IC Solutions

The MAX2742/MAX2744/MAX2745 are a family of high-performance CMOS single-chip GPS front-end down-converters. These state-of-the-art devices consume extremely low power and

eliminate the need for costly IF SAW filters or bulky discrete IF band-pass filters. Each of these devices incorporate a fully integrated low-noise amplifier (LNA), mixer, BPF, automatic-gain-control (AGC) amplifier, local oscillator synthesizer, clock buffer and digital sampler.

The MAX2742/MAX2744/MAX2745 can interface with many commercially available GPS base-band ICs for applications such as: In-Vehicle Navigation, Telematics, Automatic Security, Asset Tracking, Location Based Service (LBS), and consumer electronics. The devices require a minimum of external circuitry to provide a complete GPS RF solution. The system block diagram can be found in the sections below.

The MAX2742 works with 18.414MHz (18 x 1.023MHz, which is one-tenth of the GPS fundamental frequency 10.23MHz) crystal or TXCO and offers differential or single-ended IF output at 1.023MHz. The MAX2744 works with 16.367MHz (16 x 10.23MHz) crystal/TCXO or 32.736MHz crystal/TCXO. It offers differential or single-ended digitized IF output centered at 4.092MHz.

The MAX2745 is an improved version of the MAX2744, which offers extra features such as a voltage booster, temperature sensor, VCO trimmed capacitor, etc.

The IC selector guide can be found in Table 1 below. For more details, please refer to the MAX2742/4/5 datasheets and EVKits datasheets.

Table 1: CMOS GPS RF Front-End Receiver IC Selector Guide

	Supply Voltage	Supply Current	Reference Clock	IF Frequency	Conversion Gain	Noise Figure	IIP3	P1dB
MAX2742	2.3 to 3.6V	13.8mA	18.414MHz	1.023MHz	120dB	4.5dB	-12dBm	-50dBm
MAX2744	1.6 to 3.6V	15mA	16.367MHz /32.736MHz	4.092MHz	120dB	4.5dB	-15dBm	-50dBm
MAX2745	1.6 to 3.6V	17mA	16.367MHz /32.736MHz	4.092MHz	120dB	4.5dB	-15dBm	-50dBm

Complete GPS RF Front-End Solution

The following block diagram shows the important building blocks and features of Maxim's complete GPS RF solution. Description of the building blocks can be found in Table 2, cascaded performances are shown in Table 3.

Table 2: System Block Diagram

Block	Description	Note

GPS Antenna	Active GPS antenna, commonly has ~1.5dB NF and ~20dB gain	
LNA	MAX2641/MAX2654/MAX2655 LNA	External LNA is required when Active GPS Antenna is be present.
RF SAW	RF Band-Pass Filter centered at 1575.42MHz	RF BPF is required for jammer immunity
Power Management	MAX8510 Low Noise LDO	
RF Downconverter	MAX2742/MAX2744/MAX2745	
Reference Clock	18.414MHz (MAX2742) or 16.367MHz (MAX2744/MAX2745) crystal/TCXO	
DSP	Base-Band Processor	

Table 3: System Cascaded Performance

Spec	Cascaded Performance	Note
Gain	131dB	Without Active Antenna, assuming 15dB external LNA gain, 3dB BPF loss and 1dB matching network loss
Noise Figure	1.9dB	Without Active Antenna, assuming 1.5dB external LNA NF
Power Consumption	20mA	MAX2744+MAX2654 as example

Part 3: Maxim GPS Receiver Module

Maxim offers a cost-effective, high-performance GPS receiver module. The module, shown below, uses the MAX2742 RF downconverter and the Sony CXD2932 base-band IC. This 2-chip configuration system can measure its position anywhere on the globe, and it represents a small, lightweight solution.

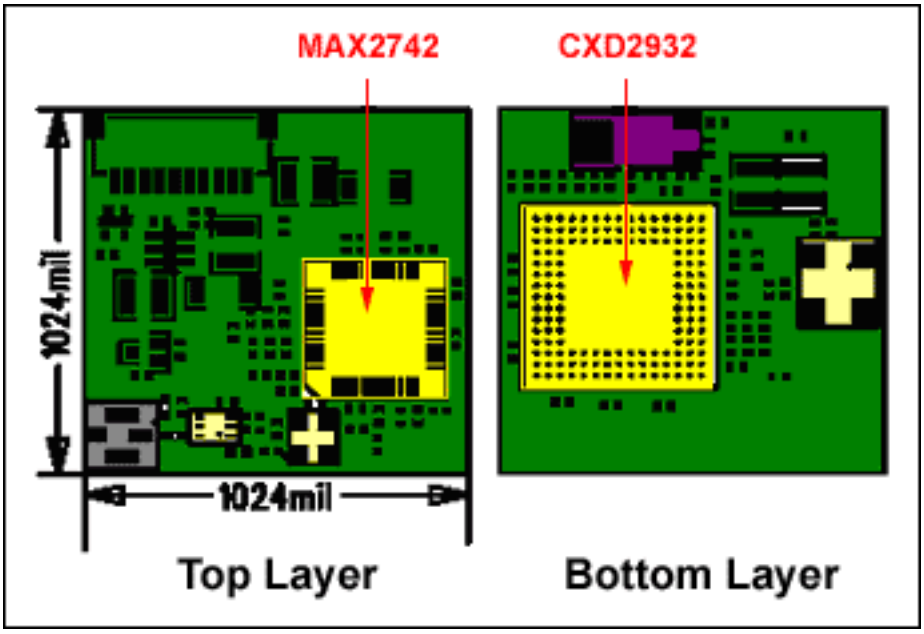

Figure 1.

The MAX2742 complete single-chip global positioning system (GPS) RF front-end uses many innovative RF CMOS design techniques. This high performance, state-of-the-art device consumes extremely low power and eliminates the need for costly SAW and bulky discrete IF filters. The MAX2742 incorporates a fully integrated low-noise amplifier (LNA), IF section, digital sampler, and local oscillator synthesizer. The intended input signal for the MAX2742 is the L1 GPS signal 1.57542GHz. This device supports high accuracy output quantization, which delivers the best performance obtainable for the GPS receiver.

Table 4. MAXIM GPS Receiver Module Performance

PARAMETER	SYMBOL	TEST CONDITIONS	TYPE	UNITS
Power Supply	Vcc			V
Current Consumption	Icc		110	mA
Sensitivity	Sens	Acquisition	-138	dBm
		Tracking	-145	
TTFF	TFC	Cold Start	58	s
	TFW	Warm Start	45	
	TFH	Hot Start	17	
Position Drift range	PR	95% possibility	100	ft

This MAXIM GPS receiver module has the following advantages:

- 16-channel GPS receiver, which is capable of simultaneously receiving 16 satellite signals.
- All-in-view measurement or 2-satellite measurement

- DGPS (Differential GPS): Supports
  - RTCM SC104 version 2.1
  - DARC BTA R-003
- Power management function
- Small and light package type: 1024mil X 1024mil

Reference

1) Description of GPS and DGPS from Starlink, Inc.

More Information

MAX2742: QuickView -- Full (PDF) Data Sheet -- Free Samples