# SGS-Thomson Crams GPS Into Two Chips

## *ST20GP6 Includes DSP, CPU, Memory; Analog Companion Completes the Set*

*by Jim Turley*

A new ST20-based integrated processor from SGS-Thomson (ST) reduces the size and complexity of a GPS (global positioning system) receiver to just two ICs and a handful of passive analog components. For about $30 in parts and three square inches of real estate, OEMs can produce a capable GPS receiver suitable for automobile or marine applications, container tracking, or navigation aids.

Compared with existing products that use several chips or that don't include a microprocessor or memory, the ST20GP6 reduces board space, power consumption, and development time. The lower chip count also means that fewer signals traverse the PC board, reducing the opportunities for RF leakage and the necessity for shielding.

### Software Replaces Sensitive Analog Parts

SGS-Thomson's two-chip set consists of the ST20GP6 microprocessor and an analog companion, the STB5600. The 'GP6 is based on the company's ST20 processor core (see MPR 7/31/95, p. 13). The ST20 core is integrated with all the digital interfaces a generic GPS receiver might need, including dual UARTs, 16 programmable I/O pins, and a 32-bit external interface, as Figure 1 shows. The external bus can be used to connect the GPS subsystem to a larger embedded system or to access additional memory if desired.

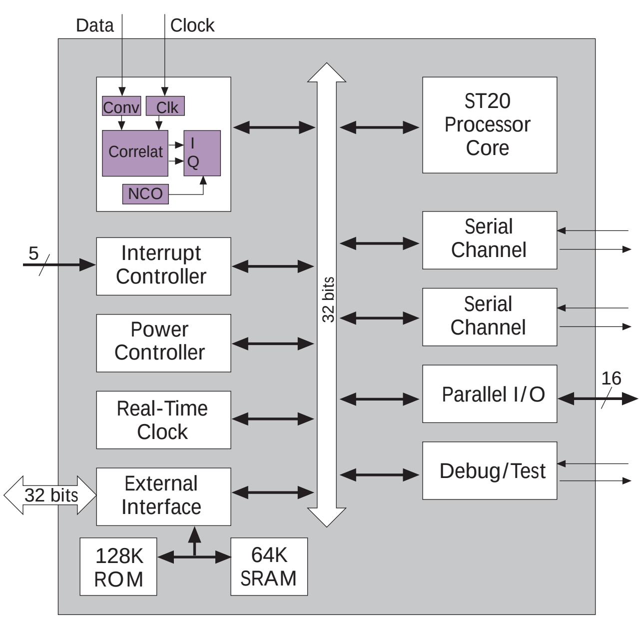


**Figure 1.** SGS-Thomson's ST20GP6 processor takes a conditioned GPS input signal and produces parallel or serial output data.

The ST20GP6 also includes a whopping 64K of SRAM and 128K of mask-programmed ROM. It is these latter features, in fact, that make the two-chip system possible, for the 'GP6 comes with built-in firmware to handle all internal GPS receiver functions. This software allows ST to use a fairly unsophisticated analog front end and compensate with real-time control loops.

### Radio Waves In, ASCII Out

A typical GPS receiver might use the ST20GP6 and STB5600 as Figure 2 shows. In this arrangement, only an active antenna (i.e., one with built-in amplification), 15–20 passive components, and a power supply are required. Specifically, the setup requires no programming or external memory. In this arrangement, the current position can be output from the serial port as an ASCII string with no additional user code or components required. As an alternative, the 'GP6 could communicate with a larger embedded system through its external bus interface or I/O pins.

### Closed-Loop Code Zeroes In On Position

Conventional GPS receivers rely on carefully tuned RF front-ends and fairly exotic (and often temperature-controlled) signal filtering and separation circuits to extract minute timing differences from orbiting GPS transmitters. ST's approach is to let the ST20GP6 guess the user's current position and continually refine its estimate on the basis of feedback from the internal signal-processing path.

In the example system, the GPS signal passes through a ceramic RF filter and into the STB5600. Also feeding the STB5600 is an 81.84-MHz reference oscillator; another simple RF filter selects the 19th harmonic of this frequency to produce the 1.555-GHz reference for GPS signals. After some more filtering, the STB5600 amplifies and drives a 4-MHz sample signal and a 16-MHz clock to the 'GP6.

The 'GP6 generates phase and quadrature (I/Q) versions of the sampled data. These are distributed to 12 identical processing units to "de-spread" the spread-spectrum information contained in the transmission. The I/Q signals are multiplied by the outputs of a numerically controlled oscillator (NCO) in an image-rejecting mixer to remove phase errors.

Here is where the GP6's built-in firmware enters the picture. The software continually adjusts the parameters of the NCO until the signals match exactly in frequency and phase. When they do, any remaining signal is due to the data encoded in the signal stream (i.e., the time base that all GPS satellites broadcast). The current position can then be derived from the inputs to the NCO.

In short, ST20GP6 estimates the positions of the visible satellites based on time of day, adjusts its NCO until phase and frequency differences disappear, and then calculates the relative position of those satellites—and, by implication, of the receiver—from the adjustments. In a sense, the 'GP6 works backwards, deriving the positions of the satellites rather than of the receiver itself.

### Accuracy Approaches Three Meters

In conventional GPS receivers, the RF circuits are carefully calibrated at the factory and then fixed, to provide the maximum accuracy. The ST20GP6 does just the opposite. It tweaks the RF circuits all the time, making up for lost precision with constant software supervision.

The software control loop runs in a 1-ms cycle, double-buffering its 32-bit output for retrieval by the ST20 processor core. According to SGS-Thomson, a 16-MHz ST20GP6 can maintain nominal accuracy under most conditions. The part is generally specified for 33 MHz, which frees about 50% of the ST20 CPU for application code. Maximum speed is 50 MHz; the faster clock rate provides still more headroom for OEM application code or interfacing protocols.

Accuracy is typically 100 meters, given the deliberate jamming (euphemistically called Selective Availability) by the U.S. military. Two optional software upgrades can alleviate some accuracy problems. Differential corrections are often broadcast near marine waterways, greatly improving accuracy to 3–5 meters, on average. Current plans call for the U.S. and Europe to be covered by WAAS (wide area augmentation service) and EGNOS (European geostationary navigation overlay system) corrections, respectively, within a few years, which will also improve resolution.

For occluded areas such as tunnels or densely developed metropolitan areas, the ST20GP6 can optionally handle dead reckoning with the help of an inexpensive piezoelectric gyroscope and distance measurements from, say, a wheel sensor. The chip's firmware is able to compute locations from the last GPS fix plus motion vectors from the gyro.

### Locating a New Market Niche

As the price of this once-exotic military system has come down, creative OEMs have used GPS receivers in automobiles for navigation assistance, on railroad cars and long-haul trucks for shipment tracking, and even on large shipping containers for stock management. Retail versions are sold to hikers, boaters, and autocrossers in increasing numbers. Civil engineers use them to grade roadways, and farmers to till their fields. In cars, the combination of a GPS and wireless phone is being sold as a security system; if the car is stolen, it reports its own location, speed, and direction to authorities.

SGS-Thomson's ST20GP6 competes with other OEM GPS-receiver chip sets from Philips, Motorola, Rockwell, SiRF, and others. Philips's SAA1575 and UAA1570 are similar to the 'GP6 and STB5600, but the Philips pair requires a temperature-controlled crystal, 64K of RAM, and 256K of ROM. The two-chip set sells for about the same price as ST's pair, but the additional components push the overall cost and board space significantly higher. The Rockwell, Motorola, and SiRF GPS receivers don't include a microprocessor or firmware and therefore demand more development effort.

From the designer's perspective, the ST20GP6 isn't a microprocessor at all: it's a dedicated GPS receiver. No programming is required (or desirable, in most cases), and the underlying ST20 architecture and instruction set are completely invisible. Even the fact that the chip carries 128K of software is essentially irrelevant to the OEM.

SGS-Thomson's strategy of replacing finicky hardware with embedded software suits the company well, as the company has broad mixed-signal experience and its ST20 is not among those best-supported by third-party tool chains. Keeping the ST20 processor buried within the 'GP6 allows ST to sell the part as a functional block, not as a microprocessor.

The merits of the ST20GP6 lie in its integration and in SGS-Thomson's ability to provide an entire package: a complete and tidy kit for OEMs that aren't interested in programming but in adding GPS capability with the minimum amount of fuss and planning. With its simple interface, the ST20GP6 should do well against more hardware-specific solutions in a growing number of embedded applications.

The 'GP6 is also indicative of a trend toward throwing CPUs at devices that were previously hardwired. Xionics's PowerPC-based XipChip is another example: a printer rasterizer that replaces logic with code. Controllers for high-precision motors, networks, and datacommunications (see MPR 3/30/98, p. 12) are also headed that direction. In each case, the microprocessor is embedded at a new level. M

**Price & Availability**

SGS-Thomson's ST20GP6 and STB5600 are sampling now, with production in 3Q98. In 100,000-unit quantities, the pair of chips will be priced at $25.

For more information, contact SGS-Thomson Microelectronics (Lincoln, Mass.) at 781.259.0300 or check out *www.st.com/stonline/press/news/p260p.htm*

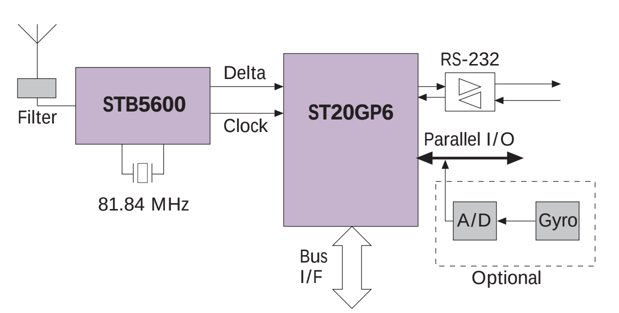


**Figure 2.** With two ICs and a handful of passive analog components, a GPS receiver can be built in about 3 $in^2$ of space.