Now, what's tomorrow's challenge?

APN-009 Rev 1 June 19, 1997

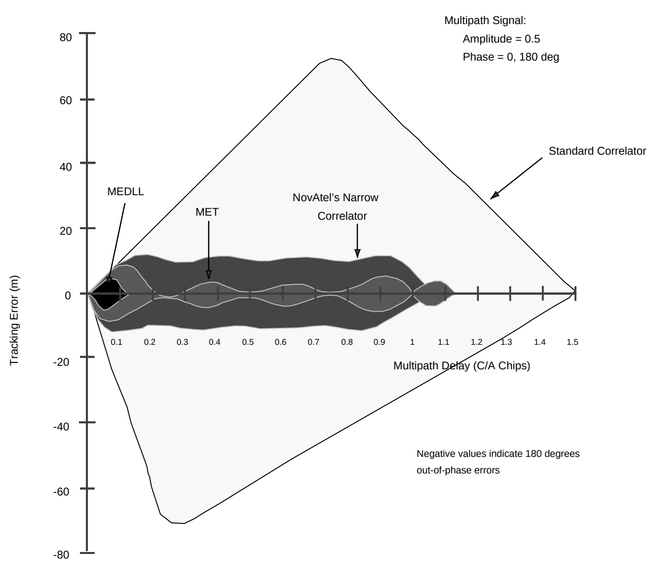
Functional Overview – WAAS Receiver Subsystem

The WAAS receiver module is based on the NovAtel L1 GPSCard and the L1/L2 GPSCard. To accomplish its high level of performance, the GPSCards are implemented in a multicard format. The L1/L2 modules are capable of receiving and tracking the L1 C/A-code, L1 and L2 carrier phase, L2 P-code, and the encrypted L2 P-code of up to 12 satellites. NovAtel has developed a multipath estimation technology that approaches the theoretical limits of GPS signal reception. This patented technology, called "Multipath Estimating Delay-Lock-Loop" (MEDLL), utilizes a combination of hardware and software techniques that are capable of reducing the combined effects of multipath errors by as much as 90% compared to a system using the Narrow Correlator™.

MEDLL can effectively remove all multipath signals that have a propagation delay of greater than 0.1 chip relative to the direct path signal. The remaining multipath effect on the C/A code pseudorange measurements is now in the same order of magnitude as a "P" code GPS receiver.

The performance gains provided by MEDLL versus other types of PRN code signal tracking techniques are illustrated below.

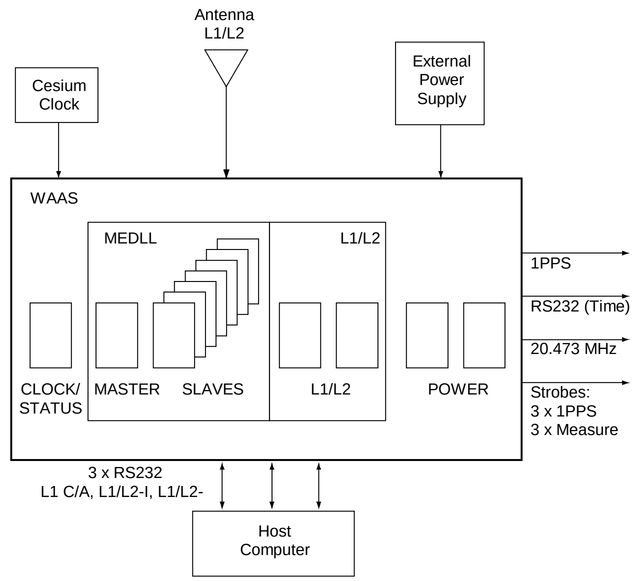
Figure 1 ***Multipath Error Envelopes for Narrow Correlator vs. MET vs. MEDLL***



Functional Overview – WAAS Receiver

The main building blocks of the WAAS receiver can be seen in the following figure.

Figure 2 WAAS Receiver Subsystem Functional Block Diagram



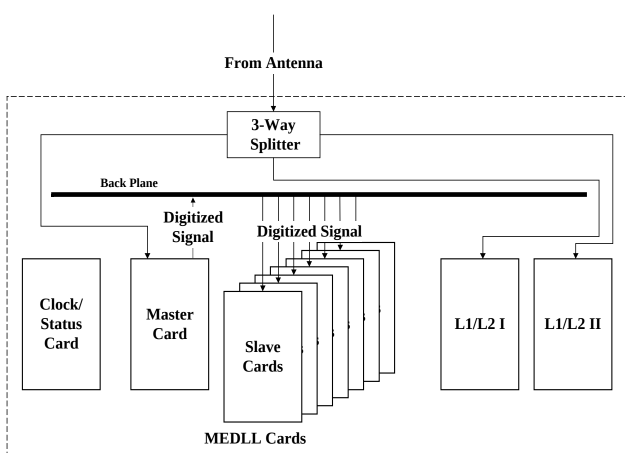
All I/O interconnections to the WAAS receiver are accessed via the unit's rear panel. These include system power, optional external reference clock input, antenna input, 20.473MHz output, timing strobes, and four RS232 ports: L1-C/A, L1/L2-I, L1/L2-II, and Time communications. All connectors are available from the mounted 9-pin D and coaxial connectors.

<u>WAAS Receiver Architecture</u>

The WAAS receiver consists of three separate subreceivers, MEDLL, L1/L2-I, and L1/L2-II, so the incoming RF antenna signal must be split for each receiver unit.

The Slave Cards of the MEDLL receiver receive their GPS/GEO signals in a digitized format generated on the MEDLL Master Card. The figure below illustrates how the satellite signals are distributed from the MEDLL Master Card to the Slave Cards. It can also be seen how the signals are split from the antenna input to the MEDLL Master Card and to the L1/L2 cards simultaneously.

Figure 3 RF Signal Distribution



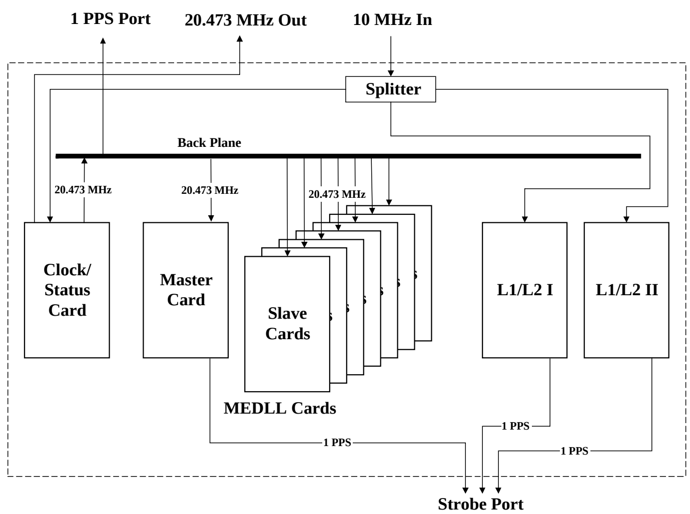
Although the subreceivers (MEDLL, L1/L2-I, and L1/L2-II) can operate independently, their oscillators are locked together since they receive their clock signals from the same external clock source. The GPSCards of the MEDLL unit (Master Card and Slave Cards), however, must operate synchronously as a single unit. They receive the GPS/GEO signals in a digitized format in order to eliminate interchannel biases. Also, the pseudorange and carrier phase measurements on all MEDLL cards must happen at the same time.

The pseudorange and carrier phase measurement synchronization and digital signal distribution is performed by an additional “clock/status” EuroCard that has been added to the multi-card system. The clock/status card has a number of bi-colour LEDs that are used to indicate go/no-go health status for the individual GPS cards. Red indicates a faulty module, whereas Green indicates a good module. If any of the LEDs are red, the system should be considered unreliable.

The clock/status card also has an OCXO to provide good quality clock signal for the L1 GPSCards (MEDLL Master and Slave Cards), and circuitry to accept the high stability external reference clock signal. The green stage of the external oscillator LED (11th: bottom) indicates the system has locked to the external reference. If no external reference signal is present, the LED remains dark. Red indicates the system is under the locking process, and may not have a stabilized clock. Note that the warm-up process may take several minutes, depending on ambient temperature.

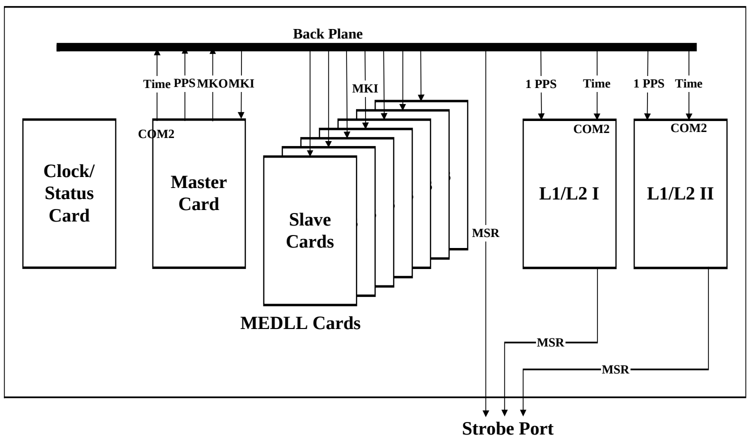
The clock/status card also provides a buffered 20.473 MHz clock signal for the external GSV unit. The following diagram illustrates the clock signal input, frequency conversion, and distribution from the Clock/Status Card to the MEDLL receiver cards. In this graphic, we can also trace the 1PPS output signal from the three receiver systems, through the Strobes port as well as the 1PPS output connector on the rear panel.

Figure 4 Clock Tree Distribution



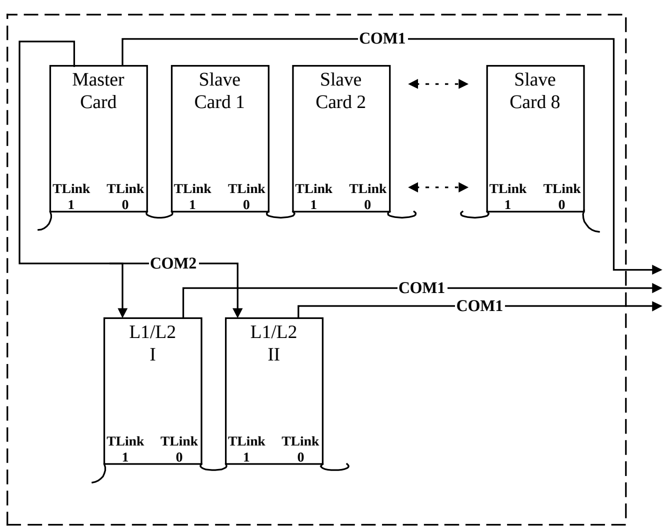
As mentioned, all the MEDLL cards must take the pseudorange and carrier phase measurements at the same time. The synchronization is implemented through MKI (Mark Input) and MKO (Mark Output) signals. MKO is generated on the MEDLL Master Card and is distributed on the backplane as a MKI signal after inversion and buffering. The time synchronization is implemented using the 1PPS (1 Pulse Per Second) and Time signals. Time is a simplex RS232 channel between the MEDLL Master Card and the L1/L2 modules. Both the Time and 1PPS output signals are accessible through the rear panel connectors. The following illustration displays the flow of the measurement strobes and timing signals.

Figure 5 Measurement Strobes and Timing



The MEDLL cards as well as the L1/L2 modules communicate with each other through the Tlink (Transputer link) interface. Since the MEDLL and the L1/L2 modules operate at a different clock frequency, there is no Tlink connection between the MEDLL and the L1/L2 modules, although they can communicate using COM2 which is implemented as a simplex Time connection. The Tlink and Time (COM2) distribution network is illustrated in the figure below.

Figure 6 Communication – TLink and RS-232

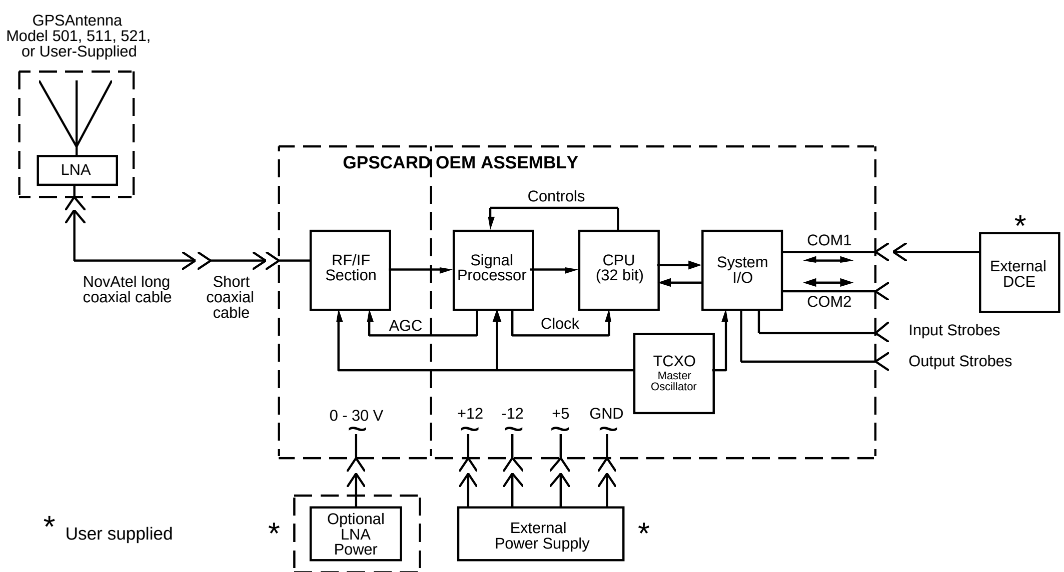


As the NovAtel GPSCards are the primary building blocks for the WAAS receiver, the following section is provided to give the user some insight into the functionality of the GPSCard and is directly applicable to the WAAS receiver.

Functional Overview – L1 GPSCard

The GPSCard modules are composed of two major sections: an RF section (MEDLL Master Card only) and a Digital section (all L1 GPSCards). In order for the GPSCard module to function as a complete system, you must also connect an external antenna, external power supply, and external DCE. A brief description of each section follows.

Figure 7 L1 GPSCard System Functional Block Diagram



GPSCard RF/IF Section

The GPSCard receives the filtered and amplified RF signal from the GPS antenna via the external interconnecting coaxial cable. The RF section of the GPSCard serves the following primary functions:

- Filters the RF signal to reduce noise and interference.
- Down-converts the RF signal to an IF (intermediate frequency) range that is suitable for the A/D converter.
- Amplifies the GPS signal to a level suitable to drive the A/D converter in the digital section.
- Accepts automatic gain control (AGC) input from the Digital Signal Processor (DSP) to maintain the IF signal at a constant level.
- Converts the IF signal to a digital format (A/D conversion).

Digital Section

The GPSCard digital section consists of three major subsections: Signal Processor, CPU, and System I/O.

The **Signal Processor** contains two NovAtel custom ASIC correlator chips, and performs the following primary functions:

- Independent satellite channel tracking
- C/A code and carrier phase tracking

The **CPU** is the heart of the GPSCard. All of the system control, processing, and positioning intelligence is in the CPU. It consists of both hardware and software components. The CPU is summarized below:

- A 32-bit microprocessor
- Custom Real Time Operating System (RTOS)
- Database management
- I/O control
- Position filtering
- Channel/loop control

The **I/O** section allows two-way communications and timing strobes between outside devices and the GPSCard. All interfacing and connections to the GPSCard (with the exception of RF input and external oscillator input) are provided through the on-card 64 (or 96) pin DIN 4162 type B (or C) male connector. A summary of I/O functions is listed below:

- Provides two serial communication ports for interfacing with outside DCE – EIA RS232 configurable.
- Selectable baud rates up to 115.2 KBaud (defaults to 9600 baud)
- Provides input and output timing strobe lines.
- Allows user command input.
- Provides a means of output logging of various data types.

Functional Overview – L1/L2 GPSCard

Each of its 24 tracking channels can independently track a code/carrier combination of a GPS satellite in view and provide a pseudorange accuracy within 10 cm RMS. It is configurable to track a variety of combinations of GPS L1 and L2 signals; for example, any combination of L1/L2 pairs up to a maximum of 12, or up to 24 L1 channels. Proprietary correlator circuits combined with a high-performance 25 MHz 32-bit CPU are capable of generating satellite code and carrier phase data as well as position solutions at a rate of up to 5 times per second.

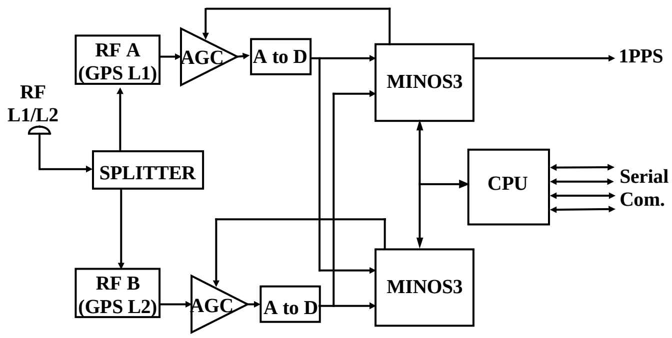
NovAtel's P-Code Delayed Correlation Technology guarantees superior performance even in the presence of P-code encryption. The L1/L2 modules extend the exceptional performance of NovAtel's patented narrow correlation process, high data update rates, multipath-resistant processing, and solid tracking loops to provide reliable centimeter-level positioning. Exceptional acquisition and re-acquisition times allow this receiver to operate in environments where very high dynamics and frequent interruption of signals can be expected.

L1/L2 GPSCard RF/IF Section

The GPS signal is fed from the antenna module, through the interconnect cable to an input connector on the L1/L2 receiver module. The signal is split into two channels and fed to an L1 channel operating at 1575.42 MHz and an L2 channel operating at 1227.6 MHz. The RF section of the GPSCard serves the following functions:

- Filters and amplifies the RF signal to reduce noise and interference.
- Down-converts the RF signal to an IF (intermediate frequency) range that is suitable for the A/D converter.
- Performs further filtering and amplifies the GPS signal to a level suitable to drive the A/D converter in the digital section.
- Accepts automatic gain control (AGC) input from the Digital Signal Processor (DSP) to maintain the IF signal at a constant level.
- Converts the IF signal to a digital format (A/D conversion).

Figure 8 L1/L2 GPSCard System Functional Block Diagram



L1/L2 GPSCARD Digital Section

The L1/L2 GPSCard digital section essentially is an upgraded version of the L1 GPSCard.

The Signal Processor contains two NovAtel custom high-density ASIC correlator chips, which are capable of tracking P-codes as well as C/A-codes.

The **CPU** operates at a higher clock frequency due to increased performance needs. As was seen for the L1 GPSCard, all of the system control, processing, and positioning intelligence is in the CPU.

From the interface point of view, the L1/L2 **I/O** section is 100% compatible with the L1 GPSCard.

For more information:

Write to: NovAtel Inc.

1120 – 68 Ave N.E.

Calgary, Alberta, Canada

T2E 8S5

Phone: 1-800-NOVATEL (in Canada or the U.S.) or +1-403-295-4900

Fax: 403-295-4901

E-mail: support@novatel.ca

Website: www.novatel.ca