Precision Geodesy after Y-Code

For high-accuracy, high-productivity GPS survey applications, today's advanced receiver system must collect and measure **all observables** as well as optimize signal processing, enhance jam immunity, multipath rejection and signal to noise.

Ashtech's unique P-W Tracking tracks P-Code signals under AS ("anti-spoofing") conditions by breaking the encrypted Y-Code into two components, the original P-Code and the W-Code used to encrypt the P-Code.

With P-W Tracking, satellite signals are correlated with locally generated versions of the P-Code (without the limiting and obsoleted cross-correlation technique) and integrated over the W-Code chip intervals.

All observables remain pure GPS (direct code and full-wavelength carrier on both frequencies) as if the Y-Code had not been invoked. It also provides a 13dB signal-to-noise improvement over the so-called "Sixth Observable."

P-W Tracking is an upgrade option for all Ashtech GPS receivers equipped for dual-frequency operation. Call for details.

ASHTECH P-W TRACKING GPS

When AS is on, don't be limited to cross-correlation or fictitious observables!

Only Ashtech has state-of-the-art P-W Tracking.

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Don't get caught with your signals crossed!

A critical look at P-Code squaring, code-correlation plus squaring and the so-called "6th Observable."

Accurate and efficient GPS surveys require complete information from both L1 and L2 frequencies; today's advanced systems must :

- Collect all available observables
- Accurately measure all observables
- Optimize signal processing to enhance jam immunity, multipath rejection and signal-to-noise improvement

When available, correlation of P-Code on L1 and L2 along with range and phase data used in conjunction with C/A code processing produces the best results. No codeless technique can recover GPS signal information as well as one which makes use of the modulating code.

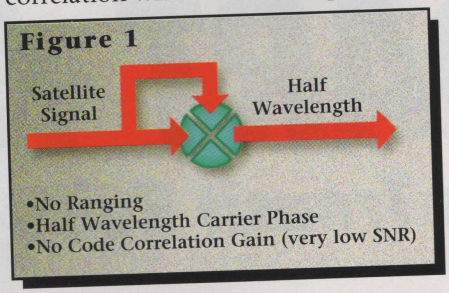
However, when AS (Anti-Spoofing) is activated, the P-Code is replaced with Y-Code on L1 and L2 carriers, precluding the use of traditional P-Code correlation techniques. Under these circumstances, GPS receiver manufacturers use different techniques to recover L2 carrier and code phases in the presence of AS:

- Squaring
- Code-correlation plus squaring
- Cross-correlation
- Tracking underlying P-Code and W-Code components of Y-Code

Squaring

Squaring, or auto-correlating L2, produces a half-wavelength carrier signal at twice the center frequency (Figure 1), resulting in a very low signal -to-noise ratio, approximately 30dB lower than that obtained by correlation with the code. Squaring

Figure 1

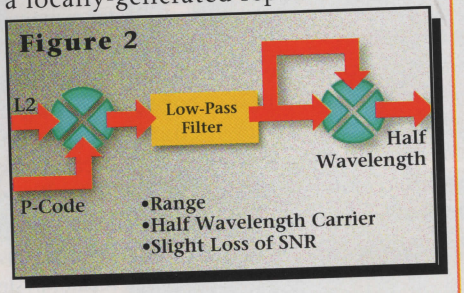


rules out the use of the 86cm L2 - L1 widelane observable since it halves the L2 carrier wavelength.

Code Correlation Squaring

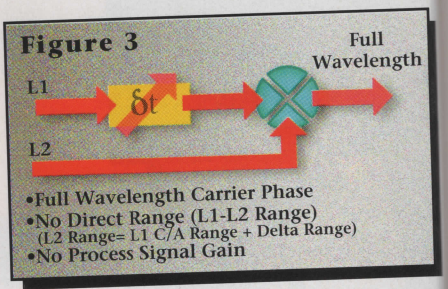
This method (Figure 2) involves correlating the L2 Y-Code signal with a locally-generated replica of the

Figure 2



underlying P-Code, narrowing the bandwidth and subsequently squaring. This results in a half-wavelength carrier-phase observable and a signal-to-noise 17dB lower than that obtained by correlating with the P-Code.

Figure 3



Cross-Correlation

Figure 3 illustrates cross-correlation in which a variable delay is introduced in L1. Two observables result from this process; the range difference between L1 and L2 and a beat frequency carrier (L2 - L1). Since there is no direct measurement of L1 and L2, the pseudorange differences between L2 and L1 codes plus the beat-frequency carriers are used, along with the C/A code, to create the so-called "Sixth Observable."

Because the power of the L1 ranging signal is twice that of L2, cross-correlating results in a 3dB SNR improvement over squaring, however, the L2 observables suffer severe SNR degradation (up to 27dB) when cross-correlation is used instead of direct correlation with the P-Code.

P-W Tracking

Ashtech's unique P-W Tracking methodology (U.S. Patent No. 5134407) tracks the P-Code signal when encrypted (Anti-Spoofing on), by breaking the encrypted Y-Code into two components; the original P-Code and the W-Code used to encrypt the P-Code.

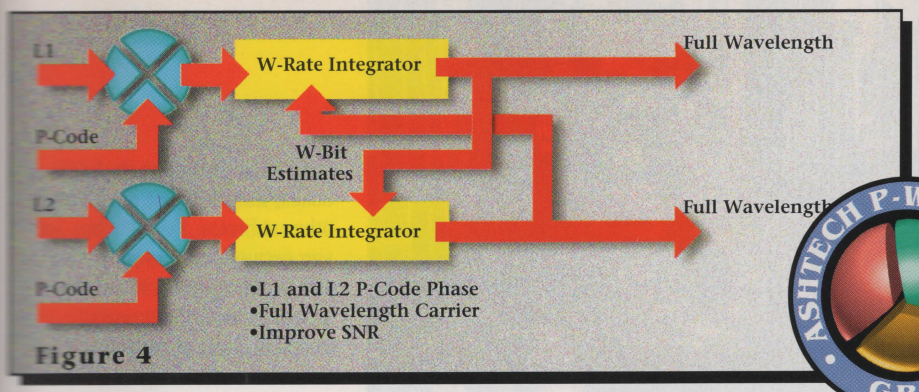


Figure 4

With this technique, satellite signals are correlated with locally generated versions of the P-Code (no cross-correlation) and integrated over W-Code chip intervals.

This technique produces "pure" GPS observables (direct code and full wavelength carrier on both frequencies) independently, as if the Y-Code had not been envoked. It should not be confused with inferior cross-correlation (so called "Sixth Observable") technique that provides much lower signal strength and no direct Y-Code measurements.

P-W Tracking makes use of the fact that the Y-Code is the modulo two sum of the P-Code and a substantially lower rate encrypting code W. L1 and L2 signals are first correlated with locally generated replicas of the underlying P-Code, then the bandwidth is reduced to that of the encrypting code and, finally, they are applied to the opposite frequency signal processing (see Figure 4).

System Comparison Chart Figure 5 shows that Ashtech P-W Tracking offers substantial advantages:

- The L1 and L2 Y-Code ranges a re available (the same observables obtained by correlation with the P-Code) as are full-wavelength L1 and L2 carrier phases from direct tracking.
- Signal-to-noise is improved by 13dB over cross-correlation and 3db over code correlation.

Figure 5. System Comparison

Parameters	*Squaring*	*Code Correlation Squaring*	*Cross Correlation*	*Ashtech P-W Tracking*
C/A Code	**No**	**Yes**	**Yes**	**Yes**
Y Code	**No Y**	**Y2**	**(Y2-Y1)**	**Y1 & Y2**
Wavelength	**Half**	**Half**	**Full**	**Full**
SNR	**-16 dB**	**-3 dB**	**-13 dB**	**0 dB**

Commercial Considerations of GPS Y-Code Encryption

The Defense Department's need for exclusive access to real-time, 10-meter level GPS accuracy (SA) plus protection against fake signals (AS) collides with many civilian needs which also require real-time, sub-meter and even centimeter-level accuracy. Differential GPS is a technical solution to SA, but encryption of P-code to Y-code (under AS) forces commercial GPS users to investigate alternate techniques for high-accuracy, high-productivity applications.

Ashtech's unique P-W Tracking technique breaks the Y-Code into its P-Code and W-Code components which are tracked separately, correlated with locally-generated P-Codes and integrated over the W-Code chip intervals. This method, different from any existing or reported technique, requires no code "cross correlation" or even "squaring." The observables are all pure GPS observables (direct code and full-wavelength carrier on both frequencies) as if the Y-Code had not been envoked.

Ashtech's P-W Tracking satisfies civilian needs, but it does not conflict with the DoD's AS objectives, indeed, it affords the best geodetic surveying and precision navigation system performance in the presence of AS.

P-W Tracking is an upgrade option, available for installation in all Ashtech M-Series GPS receivers equipped for dual-frequency operation, beginning in the first quarter of 1993.

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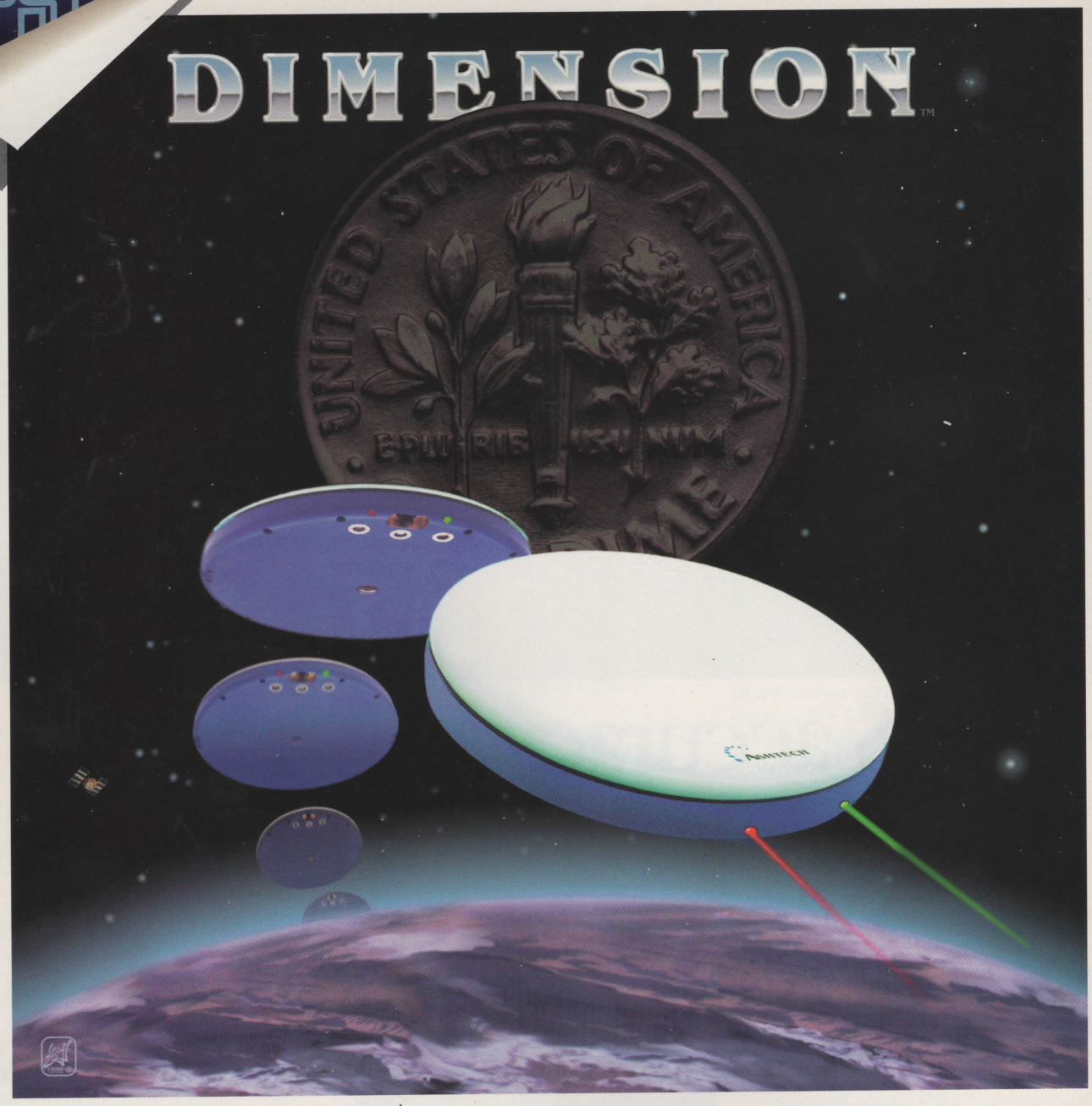

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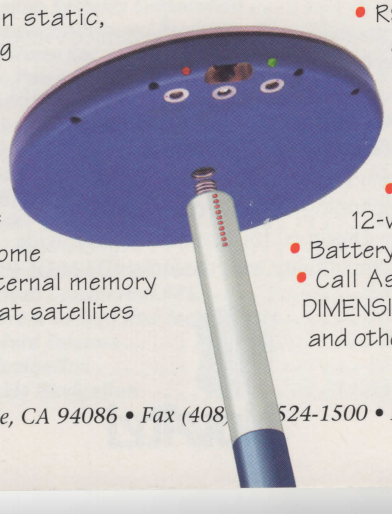

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