Faculty of Engineering,
Electronics and Communications Engineering,
Communications Systems,
Lab2, Section 5.
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Ghaidaa Samir Mohamed 180
Omar Mohamed Mounir 163
Omar Nabil Fathy 165
Omar Nasr Mohamed Younis 166

Communication Systems

Lab 2

Part1: GPS Report:

1. Introduction and History:

In 1960, the Air Force proposed a radio-navigation system called MOSAIC (MObile System for Accurate ICBM Control). A follow-on study was worked in 1963 and it was "in this study that the GPS concept was born". That same year, the concept was pursued, which had "many of the attributes that are now seen in GPS” and promised increased accuracy for Air Force bombers as well as ICBMs.

Another important predecessor to GPS came from a different branch of the United States military. In 1964, the United States Army orbited its first Sequential Collation of Range (SECOR) satellite used for geodetic surveying. The SECOR system included three ground-based transmitters at known locations that would send signals to the satellite transponder in orbit. A fourth ground-based station, at an undetermined position, could then use those signals to fix its location precisely. The last SECOR satellite was launched in 1969.

With these parallel developments in the 1960s, it was realized that a superior system could be developed by synthesizing the best technologies from the previous iterations in a multi-service program. Satellite orbital position errors had to be resolved. A team led by Harold L Jury of Pan Am Aerospace Division in Florida from 1970–1973 reduced systematic and residual errors to a manageable level to permit accurate navigation.

Ten prototype satellites were launched between 1978 and 1985 (an additional unit was destroyed in a launch failure).

In 1983 President Ronald Reagan issued a directive making GPS freely available for civilian use, once it was sufficiently developed. The first Block II satellite was launched on February 14, 1989, and the 24th satellite was launched in 1994. The GPS program cost at this point, not including the cost of the user equipment but including the costs of the satellite launches, has been estimated at US$5 billion.

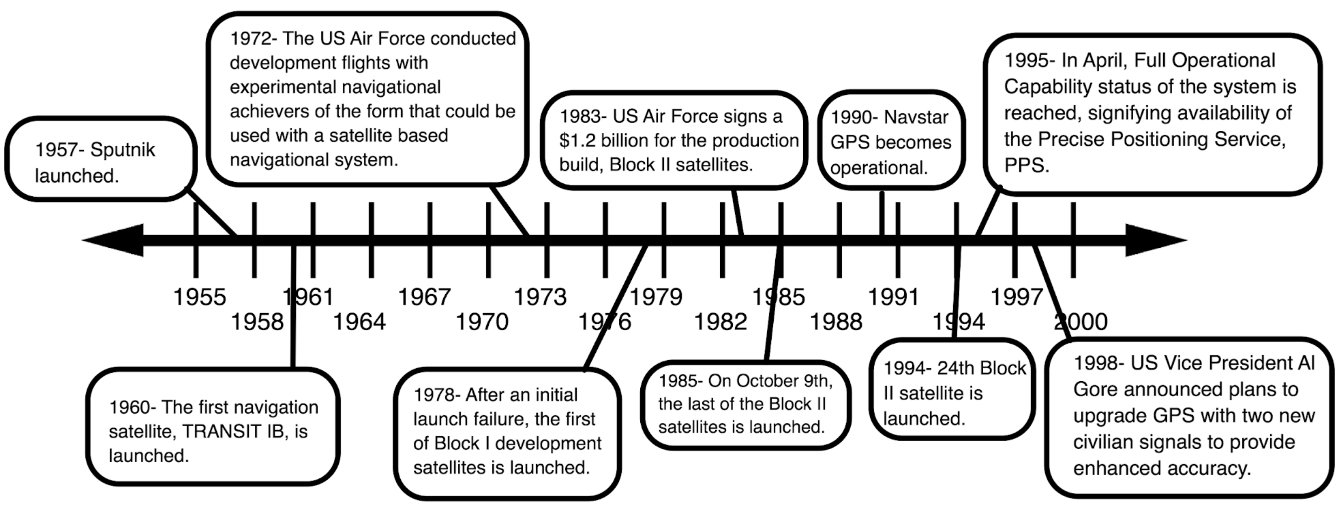
Initially, the highest-quality signal was reserved for military use, and the signal available for civilian use was intentionally degraded, in a policy known as Selective Availability. This changed in 2000, a policy directive to turn off Selective Availability to provide the same accuracy to civilians that was afforded to the military.

Since its deployment, the U.S. has implemented several improvements to the GPS service, including new signals for civil use and increased accuracy and integrity for all users, all the while maintaining compatibility with existing GPS equipment. Modernization of the satellite system has been an ongoing initiative by the U.S. Department of Defense through a series of satellite acquisitions to meet the growing needs of the military, civilians, and the commercial market.

As of early 2015, high-quality, FAA grade, Standard Positioning Service (SPS) GPS receivers provided horizontal accuracy of better than 3.5 meters (11 ft), although many factors such as receiver quality and atmospheric issues can affect this accuracy.

GPS is owned and operated by the United States government as a national resource. The Department of Defense is the steward of GPS. The Interagency GPS Executive Board (IGEB) oversaw GPS policy matters from 1996 to 2004. After that, the National Space-Based Positioning, Navigation and Timing Executive Committee were established by presidential directive in 2004 to advise and coordinate federal departments and agencies on matters concerning the GPS and related systems.

GPS MILESTONE TIMELINE



Timeline from- http://www.radio-electronics.com/info/satellite/gps/history-dates.php

2. Applications:

2.1. Military Applications:

a. Navigation.
b. Target tracking.
c. Missile and projectile guidance.
d. Search and rescue.
e. Patrol movement management.
f. Nuclear detonation detectors.

2.2. Civilian Applications:

a. Clock synchronization.
b. Telephony.
c. Automated vehicles.
d. Disaster relief/emergency services.
e. Geofencing:
   i. vehicle tracking systems,
   ii. person tracking systems,
   iii. and pet tracking systems.
f. Aircraft tracking.
g. Mining.
h. Navigation

2.3. Scientific Applications:

a. Atmosphere:
   i. studying the troposphere delays (recovery of the water vapor content),
   ii. and ionosphere delays (recovery of the number of free electrons).
   iii. Recovery of Earth surface displacements due to the atmospheric pressure loading.
b. Cartography.
c. Geodesy: determination of Earth orientation parameters.
d. Data mining:
   i. movement patterns,
   ii. common trajectories,
   iii. and interesting locations.
e. Robotics:
   i. self-navigating,
   ii. autonomous robots using GPS sensors
f. Tectonics: measurement of earthquakes.

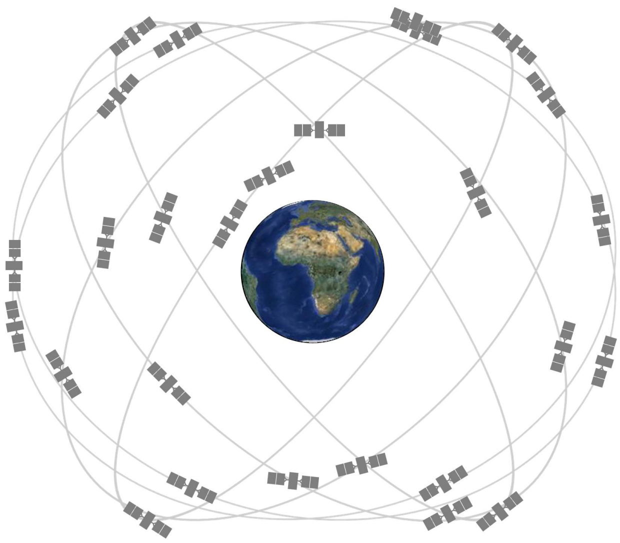
3. Specifications:

<table>
<tr><td>Modulation Used</td><td>BPSK (Binary Phase Shift Keying)
QAM (Quadrature Amplitude Modulation)</td></tr>
<tr><td>Multiple Access</td><td>CDMA (Code Division Multiple Access)</td></tr>
<tr><td>Spectrum</td><td>
<table>
<tr><th>Band</th><th>Frequency</th><th>Description</th></tr>
<tr><td>L1</td><td>1575.42 MHz</td><td>Coarse-acquisition (C/A) and encrypted precision (P(Y)) codes, plus the L1 civilian (L1C) and military (M) codes on future Block III satellites.</td></tr>
<tr><td>L2</td><td>1227.60 MHz</td><td>P(Y) code, plus the L2C and military codes on the Block IIR-M and newer satellites.</td></tr>
<tr><td>L3</td><td>1381.05 MHz</td><td>Used for nuclear detonation (NUDET) detection.</td></tr>
<tr><td>L4</td><td>1379.913 MHz</td><td>Being studied for additional ionospheric correction.</td></tr>
<tr><td>L5</td><td>1176.45 MHz</td><td>Proposed for use as a civilian safety-of-life (SoL) signal.</td></tr>
</table>
</td></tr>
</table>

Accuracy	• Time: accurate within 10ns to 100ns due to clock drifts. • Position: accurate within 4.9m.

4. Segments:

4.1. Space Segment:



The GPS space segment consists of a constellation of satellites transmitting radio signals to users.

The United States is committed to maintaining the availability of at least 24 operational GPS satellites, 95% of the time. To ensure this commitment, the U.S. Space Force has been flying 31 operational GPS satellites for well over a decade.

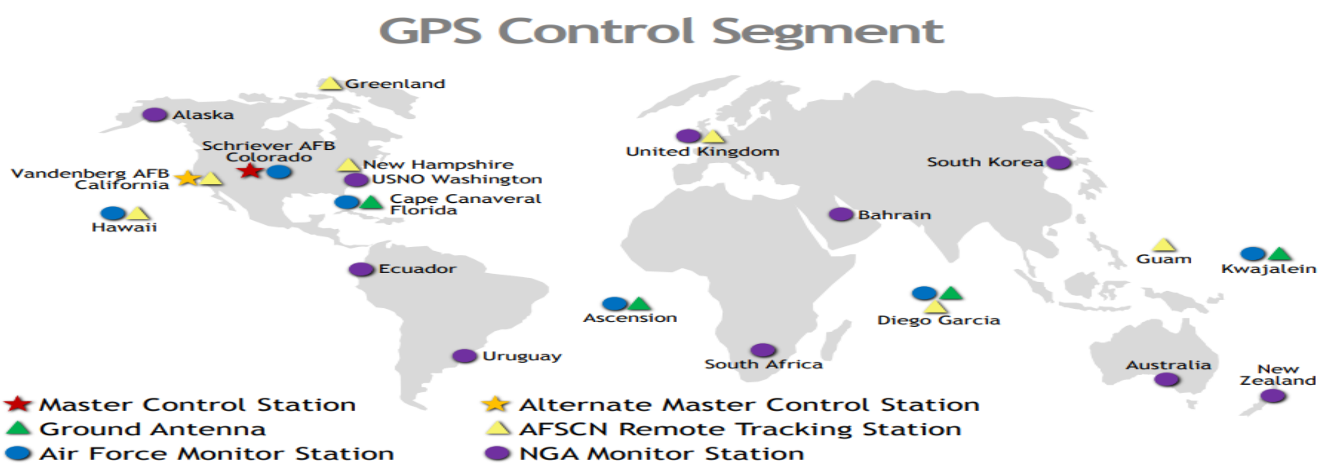
GPS satellites fly in medium Earth orbit (MEO) at an altitude of approximately 20,200 km (12,550 miles). Each satellite circles the Earth twice a day.

The satellites in the GPS constellation are arranged into six equally-spaced orbital planes surrounding the Earth. Each plane contains four "slots" occupied by baseline satellites. This 24-slot arrangement ensures users can view at least four satellites from virtually any point on the planet.

In June 2011, the Air Force successfully completed a GPS constellation expansion known as the "Expandable 24" configuration. Three of the 24 slots were expanded, and six satellites were repositioned so that three of the extra satellites became part of the constellation baseline. As a result, GPS now effectively operates as a 27-slot constellation with improved coverage in most parts of the world.

4.2. Control Segment:

The GPS control segment consists of a global network of ground facilities that track the GPS satellites, monitor their transmissions, perform analyses, and send commands and data to the constellation.
The current Operational Control Segment (OCS) includes a master control station, an alternate master control station, 11 command and control antennas, and 16 monitoring sites.



Monitor Stations	Master Control Station	Ground Antennas
• Track GPS satellites as they pass overhead • Collect navigation signals, range/carrier measurements, and atmospheric data • Feed observations to the master control station • Utilize sophisticated GPS receivers • Provide global coverage via 16 sites: 6 from the Air Force	• Provides command and control of the GPS constellation • Uses global monitor station data to compute the precise locations of the satellites • Generates navigation messages for upload to the satellites • Monitors satellite broadcasts and system integrity • Performs satellite maintenance and anomaly resolution	• Send commands, navigation data uploads, and processor program loads to the satellites • Collect telemetry • Provide anomaly resolution and early orbit support • Consist of 4 dedicated GPS ground antennas plus 7 Air Force Satellite Control Network (AFSCN) remote tracking stations

4.3. User Segment:

Also called GPS user equipment, it varies widely in cost and complexity, depending on the receiver design and application.
Most GPS receivers consist of three basic components:

1. an antenna, which receives the signal and, in some cases, has anti-jamming capabilities;
2. a receiver-processor unit, which converts the radio signal to a useable navigation solution;
3. a control/display unit, which displays the positioning information and provides an interface for receiver control.

5. Coarse acquisition:

The C/A PRN codes are Gold codes with a period of 1023 chips transmitted at 1.023 Mchip/s, causing the code to repeat every 1 millisecond. They are exclusive or with a 50 bit/s navigation message and the result phase modulates the carrier as previously described. These codes only match up, or strongly autocorrelation when they are almost exactly aligned. Each satellite uses a unique PRN code, which does not correlate well with any other satellite's PRN code. In other words, the PRN codes are highly orthogonal to one another. The 1 ms period of the C/A code corresponds to 299.8 km of distance, and each chip corresponds to a distance of 293 m. (Receivers track these codes well within one chip of accuracy, so measurement errors are considerably smaller than 293 m.)

The C/A codes are generated by combining (using "exclusive or") 2-bit streams generated by maximal period 10 stage linear feedback shift registers (LFSR). Different codes are obtained by selectively delaying one of those bitstreams.

6. P-code:

The P-code is a PRN sequence much longer than the C/A code: 6.187104 · 1012 chips (773,388 MByte). Even though the P-code chip rate (10.23 Mchips/s) is ten times that of the C/A code, it repeats only once per week, eliminating range ambiguity. It was assumed that receivers could not directly acquire such a long and fast code so they would first "bootstrap" themselves with the C/A code to acquire the spacecraft ephemerides, produce an approximate time and position fix, and then acquire the P-code to refine the fix.

Whereas the C/A PRNs are unique for each satellite, each satellite transmits a different segment of a master P-code sequence approximately 2.35 · 1014 chips long (235,000,000,000,000 bits, ~26.716 terabytes). Each satellite repeatedly transmits its assigned segment of the master code, restarting every Sunday at 00:00:00 GPS time. (The GPS epoch was Sunday, January 6, 1980, at 00:00:00 UTC, but GPS does not follow UTC leap seconds. So GPS time is ahead of UTC by an integer number of seconds.)

The P-code is public, so to prevent unauthorized users from using or potentially interfering with it through spoofing, the P-code is XORed with W-code, a cryptographically generated sequence, to produce the Y-code. The Y-code is what the satellites have been transmitting since the anti-spoofing module was set to the "on" state. The encrypted signal is referred to as the P(Y)-code.

The details of the W-code are secret, but it is known that it is applied to the P-code at approximately 500 kHz,[6] about 20 times slower than the P-code chip rate. This has led to semi-codeless approaches for tracking the P(Y) signal without knowing the W-code.

7. GPS positioning calculations:

7.1. GPS positioning calculations:

GPS positioning works on two basic mathematical concepts. The first is called trilateration, which literally means positioning from three distances. The second concept is the relationship between distance traveled, rate (speed) of travel, and amount of time spent traveling, or: Distance = Rate × Time The first concept, trilateration, is the focus of this activity. It centers around finding your position on the Earth by knowing the location of orbiting GPS satellites and the distance from those satellites to your location on the planet. However, there is no way to actually take a yardstick, tape measure, etc., and measure the distance from your location up to the satellites. So how can we use trilateration if we can't physically measure the distances? The answer lies in the second concept, relating distance, rate, and time. The trick lies in the fact that GPS satellites are always sending out radio signals. In GPS positioning the rate is how fast the radio signal travels, which is equal to the speed of light (299,792,458 meters per second). Time is determined by how long it takes for a signal to travel from the GPS satellite to a GPS receiver on earth. With a known rate and a known time, we can solve for the distance between satellite and receiver.

7.2. Minimum number of satellites needed to calculate positioning:

It needs four satellites to be able to calculate the position accurately because if we used one satellite it will be useless because we have nothing to compare it with. Two will place you somewhere on a circle where two spheres around the satellites intersect. Since this circle will intersect the earth at two points, you could be at either of those two points. Or you could be anywhere else along that circle, such as in an airplane, spacecraft, or underground. Add a third satellite, and you will be able to narrow down your position to a single point, because the spheres around the satellites intersect at two points, but with the earth at only one point, so you could get a crude latitude, longitude, and elevation fix. However, because the spheres around

the satellites really do intersect at two points, your GPS receiver could place you at that other point several thousand kilometers above or below the surface of the earth.
It requires the fourth satellite to determine your latitude, longitude, and elevation because the four spheres of possible position around the satellites intersect at only one point — your location.

8. Sources of error in positioning:

8.1. Satellite Errors

8.1.1. Slight inaccuracies in timekeeping by the satellites can cause errors in calculating positions.
8.1.2. Satellites drift slightly from their predicted orbits which contributes to errors.

Let the GPS receiver receive signals from 4 satellites, then there are two cases:

CASE 1

The satellites are at 90° to each other w.r.t the GPS receiver. For demonstration purpose, we will take 2 satellites. The possible positions are marked by the light green circles. The point of intersection of the two circles is a rather small, more or less quadratic field (dark green), the determined position will be rather accurate.

CASE 2

The satellites are not at 90° to each other w.r.t the GPS receiver, the possible intersection area of the two circles is rather larger hence less accurate.

8.2. Satellite Orbits

Slight shifts of the orbits are possible due to gravitation forces:

- Sun and moon have a weak influence on the orbits
- The resulting error is not more than 2 m

8.3. Multi-path error:

As the GPS signal finally arrives at the earth's surface, it may be reflected by local obstructions before it gets to the receiver's antenna. This is called a multi-path error as the signal is reaching the antenna in a single line path as well as a delayed path. The effect is similar to a double image on a tv set.

The multipath effect is caused by the reflection of satellite signals (radio waves) on objects. For GPS signals this effect mainly appears in the neighborhood of large buildings or other elevations. The reflected signal takes more time to reach the receiver than the direct signal. The resulting error typically lies in the range of a few meters.

8.4. Atmospheric Effects :

The GPS signals have to travel through charged particles and water vapors in the atmosphere which delays its transmission. Since the atmosphere varies at different places and at different times, it is not possible to accurately compensate for the delays that occur.

While radio signals travel with the velocity of light in outer space, their propagation in the ionosphere and troposphere is slower. In the ionosphere (consisting of layers) at a height of 80 – 400 km, a large number of electrons and positively charged ions are formed by the ionizing force of the sun. The layers refract the electromagnetic waves from the satellites, resulting in an elongated runtime of the signals. Since the Electromagnetic waves emit in form of a sphere, therefore, Inverse-square law is employed and the waves are slowed down inversely proportional to the square of their frequency (1/f2) while passing the ionosphere. The reasons for the refraction in the troposphere are different concentrations of water vapors, caused by different weather conditions. The error caused that way is smaller than the ionosphere error, but cannot be eliminated by calculation. It can only be approximated by a general calculation model.

8.5. Receiver Error:

Since the receivers are also not perfect, they can introduce their own errors which usually occur from their clocks or internal noise. Despite the synchronization of the receiver clock with the satellite time during the position determination, the remaining inaccuracy of the time still leads to an error of about 2 m in the position determination. Rounding and calculation errors of the receiver sum up approximately to 1 m.

9. GPS time:

GPS time is established by the GPS Clock, The GPS Clock is a satellite system that provides a very precise timing service. The system uses atomic clocks to provide everyone on Earth with low-cost access to international atomic time standards.

10. NAV Message:

10.1. NAV Message content and format

Every satellite receives from the ground antennas the navigation data which is sent back to the users through the navigation message. The Navigation Message provides all the necessary information to allow the user to perform the positioning service. It includes the Ephemeris parameters, needed to compute the satellite coordinates with enough accuracy, the Time parameters, and Clock Corrections, to compute satellite clock offsets and time conversions, the Service Parameters with satellite health information (used to identify the navigation data set), Ionospheric parameters model needed for single-frequency receivers, and the Almanacs, allowing the computation of the position of ”all satellites in the constellation”, with a reduced accuracy (1 - 2 km of 1-sigma error), which is needed for the acquisition of the signal by the receiver. The ephemeris and clock parameters are usually updated every two hours, while the almanac is updated at least every six days.

Besides the "legacy" L1 C/A navigation message, four additional new messages have been introduced by the so-called GPS modernization: L2-CNAV, CNAV-2, L5-CNAV, and MNAV. The "legacy" message and the first three of the modernized GPS are civil messages, while the MNAV is a military message. In modernized GPS, the same type of content as the legacy navigation message (NAV) is transmitted but at a higher rate and with improved robustness.

The messages L2-CNAV, L5-CNAV, and MNAV have a similar structure and (modernized) data format. The new format allows more flexibility, better control, and improved content. Furthermore, the MNAV includes new improvements for the security and robustness of the military message. The CNAV-2 is modulated onto L1C, sharing the same brand as the "legacy" navigation message.

11. GPS satellite blocks:

A GPS satellite is satellite navigation used by the NAVSTAR Global Positioning System (GPS). The first satellite in the system, Navstar 1, was launched on 22 February 1978. The GPS satellite constellation is operated by the 2d Space Operations Squadron (2SOPS) of Space Delta 8 (formerly the 50th Space Wing Operations Group) of the United States Space Force. The GPS satellites circle the Earth at an altitude of about 20,000 km (12,427 miles) and complete two full orbits every day.

11.1. Block I satellites

Rockwell International was awarded a contract in 1974 to build the first eight Block I satellites. In 1978, the contract was extended to build an additional three Block I satellites. Beginning with Navstar 1 in 1978, ten "Block I" GPS satellites were successfully launched. One satellite, "Navstar 7", was lost due to an unsuccessful launch on 18 December 1981.

The Block I satellites were launched from Vandenberg Air Force Base using Atlas rockets that were converted intercontinental ballistic missiles. The satellites were built by Rockwell International at the same plant in Seal Beach, California where the S-II second stages of the Saturn V rockets were built.

The Block I series consisted of the concept validation satellites and reflected various stages of system development. Lessons learned from the 10 satellites in the series were incorporated into the fully operational Block II series.

Dual solar arrays supplied over 400 watts of power, charging Nickel-cadmium batteries for operations in Earth's shadow. S-band communications were used for control and telemetry, while a UHF channel provided cross-links between spacecraft. A hydrazine propulsion system was used for orbital correction. The payload included two L-band navigation signals at 1575.42 MHz (L1) and 1227.60 MHz (L2).

The final Block I launch was conducted on 9 October 1985, but the last Block I satellite was not taken out of service until 18 November 1995, well past its 5-year design life.

11.2. Block II satellites

Initial Block 2 series

The Block II satellites were the first full-scale operational GPS satellites, designed to provide 14 days of operation without any contact from the control segment. The prime contractor was Rockwell International, which built an SVN 12 qualification vehicle after an amendment to the Block I contract. In 1983, the company was awarded an additional contract to build 28 Block II/IIA satellites.

Block II spacecraft were three-axis stabilized, with ground pointing using reaction wheels. Two solar arrays supplied 710 watts of power, while S-band communications were used for control and telemetry. A UHF channel was used for cross-links between spacecraft. A hydrazine propulsion system was used for orbital correction. The payload included two L-band GPS signals at 1575.42 MHz (L1) and 1227.60 MHz (L2). Each spacecraft carried two rubidium and two cesium clocks, as well as nuclear detonation detection sensors, leading to a mass of 1,660 kg (3,660 lb).

The first of the nine satellites in the initial Block II series was launched on 14 February 1989; the last was launched on 1 October 1990. The final satellite of the series to be taken out of service was decommissioned on 15 March 2007, well past its 7.5-year design life.

Block IIA series

The Block IIA satellites were slightly improved versions of the Block II series, designed to provide 180 days of operation without contact from the control segment. However, the mass increased to 1,816 kg (4,004 lb).

Nineteen satellites in the Block IIA series were launched, the first on 26 November 1990 and the last on 6 November 1997. The last satellite of the Block IIA (SVN-34), broadcast on the PRN 18 signal It was removed from service on 9 October 2019.

Two of the satellites in this series, numbers 35 and 36, are equipped with laser retro-reflectors, allowing them to be tracked independently of their radio signals, providing unambiguous separation of clock and ephemeris errors.

Block IIR series

The Block IIR series are "replenishment" (replacement) satellites developed by Lockheed Martin. Each satellite weighs 2,030 kg (4,480 lb) at launch and 1,080 kg (2,380 lb) once on orbit. The first attempted launch of a Block IIR satellite failed on 17 January 1997 when the Delta II rocket exploded 12 seconds into flight. The first successful launch was on 23 July 1997. Twelve satellites in the series were successfully launched. At least ten satellites in this block carried an experimental S-band payload for search and rescue, known as Distress Alerting Satellite System.

Block IIR-M series

The Block IIR-M satellites include a new military signal and a more robust civil signal, known as L2C. There are eight satellites in the Block IIR-M series, which were built by Lockheed Martin. The first Block IIR-M satellite was launched on 26 September 2005. The final launch of an IIR-M was on 17 August 2009.

Block IIF series

The Block IIF series are "follow-on" satellites developed by Boeing. The satellite has a mass of 1,630 kg (3,590 lb) and a design life of 12 years. The first Block IIF space vehicle was launched in May 2010 on a Delta IV rocket. The twelfth and final IIF launch was on 5 February 2016.

11.3. Block III satellites

Block IIIA series

GPS Block IIIA is the first series of third-generation GPS satellites, incorporating new signals and broadcasting at higher power levels. In September 2016, the Air Force awarded Lockheed Martin a contract option for two more Block IIIA satellites, setting the total number of GPS IIIA satellites to ten. On 23 December 2018, the first GPS III satellite was launched aboard a SpaceX Falcon 9 Full Thrust. On 22 August 2019, the second GPS III satellite was launched aboard a Delta IV. The third GPS III satellite was launched on 30 June 2020, aboard a SpaceX Falcon 9 launch vehicle. The fourth GPS III satellite launched on 5 November 2020, also aboard a Falcon 9.

Block IIIF series

The Block IIIF series is the second set of GPS Block III satellites, which will consist of up to 22 space vehicles. Block IIIF launches are expected to begin no earlier than 2026 and continue through 2034.

Part2: Experiment Related Questions

1. $GPGLL

Geographic Position, Latitude / Longitude, and time.

Example: $GPGLL,4027.027912,N,08704.857070,W, 180432.00,A,D*7A

Field	Value	
1	4027.027912	Geographic latitude in ddmm.mmmmmm format (40 degrees and 27.027912 minutes)
2	N	Direction of latitude (N - North, S - South)
3	08704.857070	Geographic longitude in dddmm.mmmmmm format (87 degrees and 4.85707 minutes
4	W	Direction of longitude (E - East, W - West)
5	180432.00	UTC of position fix in hhmmss.ss format (18 hours, 4 minutes and 32 seconds)
6	A	'A' shows that data is valid
7	D	Mode indication (A - autonomous, D - differential, N - data not valid)

$GPGSV

The GSV message string identifies the number of SVs in view, the PRN numbers, elevations, azimuths, and SNR values.

example:

$GPGSV,4,1,13,02,02,213,,03,-3,000,,11,00,121,,14,13,172,05*67

Field	Meaning
0	Message ID $GPGSV
1	Total number of messages of this type in this cycle
2	Message number
3	Total number of SVs visible
4	SV PRN number
5	Elevation, in degrees, 90° maximum
6	Azimuth, degrees from True North, 000° through 359°
7	SNR, 00 through 99 dB (null when not tracking)
8-11	Information about second SV, same format as fields 4 through 7
12-15	Information about third SV, same format as fields 4 through 7
16-19	Information about fourth SV, same format as fields 4 through 7
20	The checksum data, always begins with *

2. Results of lab 2 are not accurate results, as experiments are done indoors, for accurate results, experiments must be done outdoors.

3.

Delay_ms(10000);

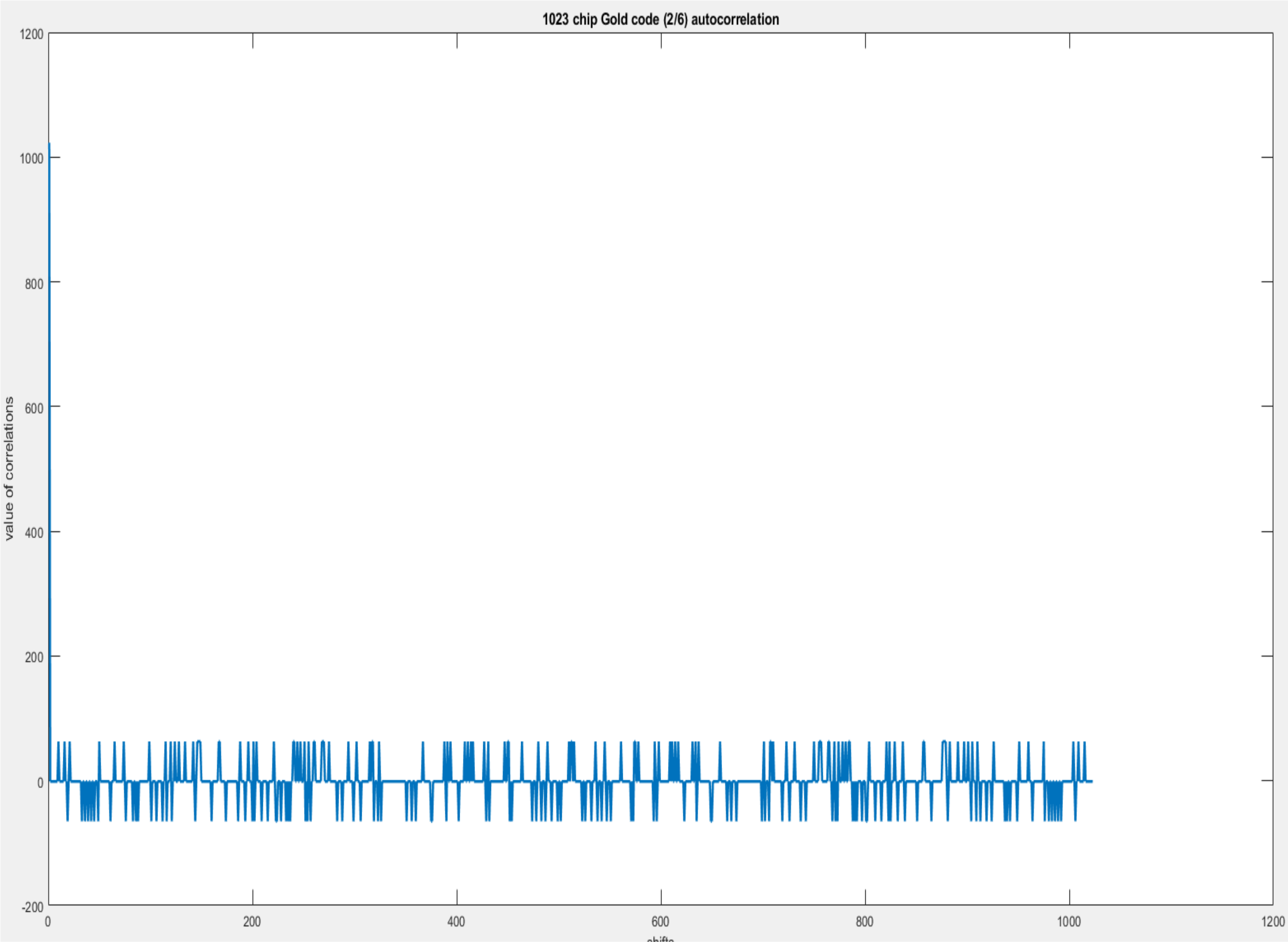
4. UART1_Init(9600);

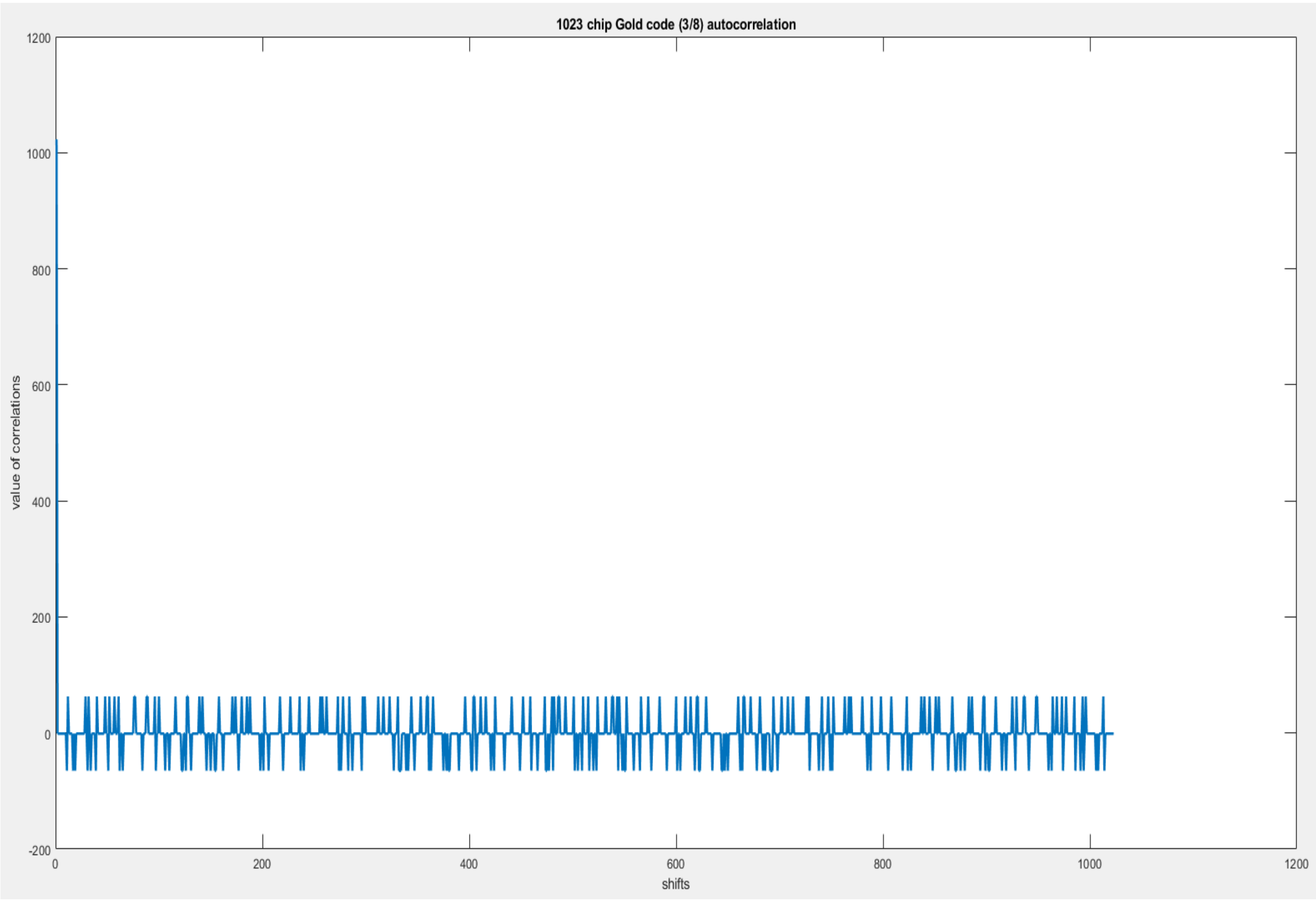
UART3_Init_Advanced(9600, _UART_8_BIT_DATA, _UART_NOPARITY, _UART_ONE_STOPBIT, &_GPIO_MODULE_USART3_PD89);

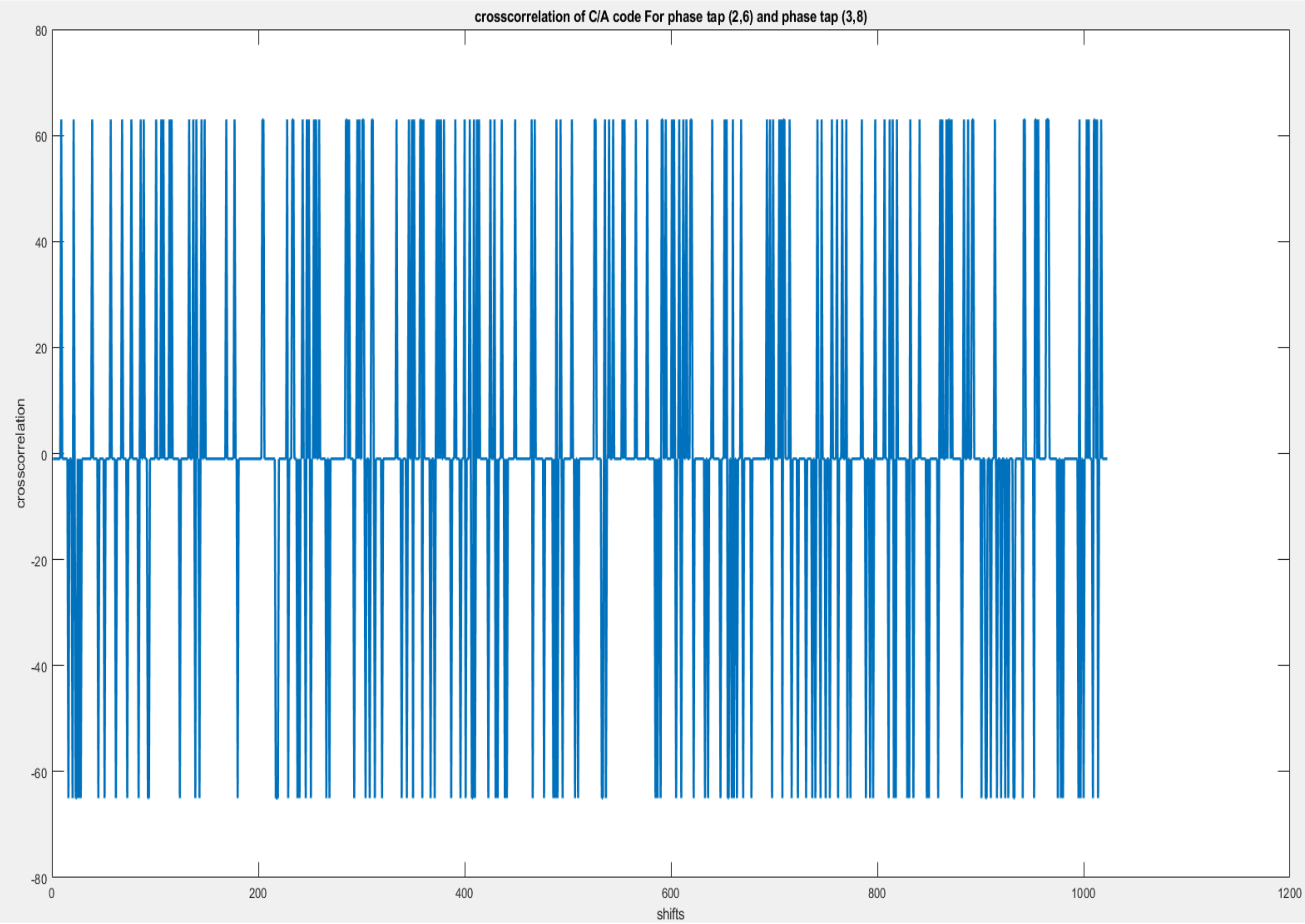
Part3: Mini-Simulations

```
%% Building C/A 1 and 2
SR1 = ones(1,10);     % Creating main shift register 1
SR2 = ones(1,10);     % Creating main shift register 2

CA_code1 = []; CA_code2 = [];

for i = 1:1023        % Iterating through each of the chips
    update_1 = xor(SR1(3), SR1(10));
    update_2 = xor(SR2(2), xor(SR2(3), xor(SR2(6), xor(SR2(8),
xor(SR2(9), SR2(10))))));
    CA_code1(i) = xor( SR1(10), (xor(SR2(3) ,SR2(8))) );
    CA_code2(i) = xor( SR1(10), (xor(SR2(2) ,SR2(6))) );
    SR1 = circshift(SR1 , 1);
    SR2 = circshift(SR2 , 1);
    SR1(1) = update_1;
    SR2(1) = update_2;
end

%% Calculate correlations
autocorrelation1 = zeros(1,1023);
autocorrelation2 = zeros(1,1023);
crosscorrelation = zeros(1,1023);

for i = 1:1023
    if (CA_code1(i) == 0)
        CA_code1(i) = -1;
    end
```

```
    if (CA_code2(i) == 0)
        CA_code2(i) = -1;
    end
end

for shift = 0:1022
    %correlation for code 1
    CA_code1_shifted = circshift(CA_code1, shift);
    autocorrelation1(shift+1) = CA_code1*CA_code1_shifted';

    %correlation for code 2
    CA_code2_shifted = circshift(CA_code2, shift);
    autocorrelation2(shift+1) = CA_code2*CA_code2_shifted';

    %cross correlation
    crosscorrelation(shift+1) = CA_code2*CA_code1_shifted';
end

%% Plot correlations
figure
plot(autocorrelation1,'linewidth',2)
title('1023 chip Gold code (3/8) autocorrelation')
xlabel('shifts');ylabel('value of correlations');

figure
plot(autocorrelation2,'linewidth',2)
title('1023 chip Gold code (2/6) autocorrelation');
xlabel('shifts');ylabel('value of correlations');
%% Plot Cross correlation
figure
plot(crosscorrelation,'linewidth',2)
title('crosscorrelation of C/A code For phase tap (2,6) and phase tap
(3,8)')
xlabel('shifts','linewidth',2)
ylabel('crosscorrelation','linewidth',2)
%% End of code %%
```


1023 chip Gold code (2/6) autocorrelation
value of correlations
shifts
1200
1000
800
600
400
200
0
-200
0
200
400
600
800
1000
1200


1023 chip Gold code (3/8) autocorrelation
value of correlations
shifts
1200
1000
800
600
400
200
0
-200
0
200
400
600
800
1000
1200


crosscorrelation of C/A code For phase tap (2,6) and phase tap (3,8)
crosscorrelation
shifts
80
60
40
20
0
-20
-40
-60
-80
0
200
400
600
800
1000
1200