AEROFLEX

GPSG-1000
GPS/Galileo
Positional Simulator

PRELIMINARY

Maintenance Manual

GPSG-1000

GPS/Galileo Positional Simulator

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Maintenance Manual

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ELECTROMAGNETIC COMPATIBILITY

Double shielded and properly terminated external interface cables must be used with this equipment when interfacing with the RS-232 and Ethernet.

For continued EMC compliance, all external cables must be shielded and 3 meters or less in length.

NOMENCLATURE STATEMENT

In this manual, GPSG-1000, Test Set or Unit refers to the GPSG-1000 GPS/Galileo Positional Simulator.

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Declaration of Conformity

The Declaration of Conformity Certificate included with the Unit should remain with the Unit.

Aeroflex recommends the operator reproduce a copy of the Declaration of Conformity Certificate to be stored with the Operation Manual for future reference.

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Precautions

SAFETY FIRST - TO ALL OPERATIONS PERSONNEL

GENERAL CONDITIONS OF USE

This product is designed and tested to comply with the requirements of IEC/EN61010-1 'Safety requirements for electrical equipment for measurement, control and laboratory use' for Class I portable equipment and is for use in a pollution degree 2 environment. The equipment is designed to operate from installation supply Category II.

Equipment should be protected from liquids such as spills, leaks, etc. and precipitation such as rain, snow, etc. When moving the equipment from a cold to hot environment, allow the temperature of the equipment to stabilize before it is connected to the supply to avoid condensation forming. The equipment must only be operated within the environmental conditions specified in the performance data. This product is not approved for use in hazardous atmospheres or medical applications. If the equipment is to be used in a safety-related application, such as avionics or military applications, the suitability of the product must be assessed and approved for use by a competent person.

CASE, COVER OR PANEL REMOVAL

Opening the Case Assembly exposes the operator to electrical hazards that may result in electrical shock or equipment damage. Do not operate this Test Set with the Case Assembly open.

SAFETY IDENTIFICATION IN TECHNICAL MANUAL

This manual uses the following terms to draw attention to possible safety hazards that may exist when operating or servicing this equipment:

CAUTION	IDENTIFIES CONDITIONS OR ACTIVITIES THAT, IF IGNORED, CAN RESULT IN EQUIPMENT OR PROPERTY DAMAGE, E.G., FIRE.
WARNING	**IDENTIFIES CONDITIONS OR ACTIVITIES THAT, IF IGNORED, CAN RESULT IN PERSONAL INJURY OR DEATH.**

SAFETY SYMBOLS IN MANUALS AND ON UNITS

	CAUTION: Refer to accompanying documents. (This symbol refers to specific CAUTIONS represented on the unit and clarified in the text.)
	Indicates a Toxic hazard.
	Indicates item is static sensitive.
	AC TERMINAL: Terminal that may supply or be supplied with AC or alternating voltage.

SAFETY FIRST - TO ALL OPERATIONS PERSONNEL (cont)

EQUIPMENT GROUNDING PROTECTION

Improper grounding of equipment can result in electrical shock.

USE OF PROBES

Refer to Performance Specifications for the maximum voltage, current and power ratings of any connector on the Test Set before connecting it with a probe from a terminal device. Be sure the terminal device performs within these specifications before using it for measurement, to prevent electrical shock or damage to the equipment.

POWER CORDS

Power cords must not be frayed or broken, nor expose bare wiring when operating this equipment.

USE RECOMMENDED FUSES ONLY

Use only fuses specifically recommended for the equipment at the specified current and voltage ratings. Refer to Performance Specifications for fuse requirements and specifications.

INTERNAL BATTERY

This unit contains a Lithium Ion Battery, serviceable only by a qualified technician.

EMI (ELECTROMAGNETIC INTERFERENCE

CAUTION	SIGNAL GENERATORS CAN BE A SOURCE OF ELECTROMAGNETIC INTERFERENCE (EMI) TO COMMUNICATION RECEIVERS. SOME TRANSMITTED SIGNALS CAN CAUSE DISRUPTION AND INTERFERENCE TO COMMUNICATION SERVICE OUT TO A DISTANCE OF SEVERAL MILES. USER OF THIS EQUIPMENT SHOULD SCRUTINIZE ANY OPERATION THAT RESULTS IN RADIATION OF A SIGNAL (DIRECTLY OR INDIRECTLY) AND SHOULD TAKE NECESSARY PRECAUTIONS TO AVOID POTENTIAL COMMUNICATION INTERFERENCE PROBLEMS.

ELECTRICAL HAZARDS (AC SUPPLY VOLTAGE)

WARNING	**THIS EQUIPMENT IS PROVIDED WITH A PROTECTIVE GROUNDING LEAD THAT CONFORMS WITH IEC SAFETY CLASS I. TO MAINTAIN THIS PROTECTION THE SUPPLY LEAD MUST ALWAYS BE CONNECTED TO THE SOURCE OF SUPPLY VIA A SOCKET WITH A GROUNDED CONTACT.** **BE AWARE THAT THE SUPPLY FILTER CONTAINS CAPACITORS THAT MAY REMAIN CHARGED AFTER THE EQUIPMENT IS DISCONNECTED FROM THE SUPPLY. ALTHOUGH THE STORED ENERGY IS WITHIN THE APPROVED SAFETY REQUIREMENTS, A SLIGHT SHOCK MAY BE FELT IF THE PLUG PINS ARE TOUCHED IMMEDIATELY AFTER REMOVAL.** **DO NOT REMOVE INSTRUMENT COVERS AS THIS MAY RESULT IN PERSONAL INJURY. THERE ARE NO USER-SERVICEABLE PARTS INSIDE.**

SAFETY FIRST - TO ALL OPERATIONS PERSONNEL (cont)

STATIC SENSITIVE DEVICES

CAUTION

INTEGRATED CIRCUITS AND SOLID STATE DEVICES SUCH AS MOS FETS, ESPECIALLY CMOS TYPES, ARE SUSCEPTIBLE TO DAMAGE BY ELECTROSTATIC DISCHARGES RECEIVED FROM IMPROPER HANDLING, THE USE OF UNGROUNDED TOOLS AND IMPROPER STORAGE AND PACKAGING. ANY MAINTENANCE TO THIS UNIT MUST BE PERFORMED WITH THE FOLLOWING PRECAUTIONS:

- BEFORE USE IN A CIRCUIT, KEEP ALL LEADS SHORTED TOGETHER EITHER BY THE USE OF VENDOR-SUPPLIED SHORTING SPRINGS OR BY INSERTING LEADS INTO A CONDUCTIVE MATERIAL.
- WHEN REMOVING DEVICES FROM THEIR CONTAINERS, GROUND THE HAND BEING USED WITH A CONDUCTIVE WRISTBAND.
- TIPS OF SOLDERING IRONS AND/OR ANY TOOLS USED MUST BE GROUNDED.
- DEVICES MUST NEVER BE INSERTED INTO NOR REMOVED FROM CIRCUITS WITH POWER ON.
- PC BOARDS, WHEN TAKEN OUT OF THE SET, MUST BE LAID ON A GROUNDED CONDUCTIVE MAT OR STORED IN A CONDUCTIVE STORAGE BAG. REMOVE ANY BUILT-IN POWER SOURCE, SUCH AS A BATTERY, BEFORE LAYING PC BOARDS ON A CONDUCTIVE MAT OR STORING IN A CONDUCTIVE BAG.
- PC BOARDS, IF BEING SHIPPED TO THE FACTORY FOR REPAIR, MUST BE PACKAGED IN A CONDUCTIVE BAG AND PLACED IN A WELL-CUSHIONED SHIPPING CONTAINER.

CAUTION

THIS EQUIPMENT CONTAINS PARTS
SENSITIVE TO DAMAGE
BY ELECTROSTATIC DISCHARGE (ESD).

SAFETY FIRST - TO ALL OPERATIONS PERSONNEL (cont)

TOXIC HAZARDS

WARNING	SOME OF THE COMPONENTS USED IN THIS EQUIPMENT MAY INCLUDE RESINS AND OTHER MATERIALS WHICH GIVE OFF TOXIC FUMES IF INCINERATED. TAKE APPROPRIATE PRECAUTIONS, THEREFORE, IN THE DISPOSAL OF THESE ITEMS.

BERYLLIA

Beryllia (beryllium oxide) is used in the construction of some of the components in this equipment. This material, when in the form of fine dust or vapor and inhaled into the lungs, can cause a respiratory disease. In its solid form, as used here, it can be handled safely, however, avoid handling conditions which promote dust formation by surface abrasion.
Use care when removing and disposing of these components. Do not put them in the general industrial or domestic waste or dispatch them by post. They should be separately and securely packed and clearly identified to show the nature of the hazard and then disposed of in a safe manner by an authorized toxic waste contractor.

BERYLLIUM COPPER

Some mechanical components within this instrument are manufactured from beryllium copper. This is an alloy with a beryllium content of approximately 5%. It represents no risk in normal use.
The material should not be machined, welded or subjected to any process where heat is involved.
It must be disposed of as “special waste.”
It must NOT be disposed of by incineration.

LITHIUM

A Lithium battery is used in this equipment.
Lithium is a toxic substance so the battery should in no circumstances be crushed, incinerated or disposed of in normal waste.
Do not attempt to recharge this type of battery. Do not short circuit or force discharge since this might cause the battery to vent, overheat or explode.

INPUT OVERLOAD

CAUTION	REFER TO PRODUCT SPECIFICATIONS FOR MAXIMUM INPUT RATING OF ANT AND T/R CONNECTORS TO AVOID INPUT OVERLOAD.

Preface

SCOPE

This Manual contains instructions for maintaining the GPSG-1000.

ORGANIZATION

This manual is composed of the following chapters:

CHAPTER 1 - INTRODUCTION

Chapter contains general Test Set information and theory of operation.

CHAPTER 2 - TROUBLESHOOTING

Chapter contains system and module level troubleshooting procedures.

CHAPTER 3 - VERIFICATION/CALIBRATION PROCEDURES

Chapter describes system and module level verification and calibration procedures.

CHAPTER 4 - REMOVE/INSTALL PROCEDURES

Chapter contains procedures for removing and installing maintainable parts and assemblies.

CHAPTER 5 - PARTS LIST

Chapter identifies customer serviceable parts and assemblies.

CHAPTER 6 - ASSEMBLY AND INTERCONNECT DRAWINGS

Chapter contains system level interconnect and assembly drawings.

APPENDIX A - PIN-OUT TABLES

Contains diagrams and pin identification for external connectors.

APPENDIX B - ABBREVIATIONS

Lists acronyms and terms used throughout manual.

APPENDIX C - TEST EQUIPMENT REQUIREMENTS

Lists equipment needed to perform verification and calibration procedures.

APPENDIX D - CONTROLS & CONNECTORS

Identifies front and rear panel controls and connectors.

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Chapter 1 - Introduction

1.1 PRINCIPLES OF OPERATION

1.1.1 GPSG-1000

Control Panel Assembly

The Control Panel Assembly, provides On/Off, Home Buttons and Status LED's.

Power Supply Assembly

The Power Supply Assembly is responsible for supplying power for module operation and providing +5 Volt bias for applied power status.

Converter Assembly

The Converter Assembly provides the Test Set's AF, RF and Modulated Output signals.

RF Combiner Assembly

The RF Combiner Assembly provides Signal Attenuation and 10MHz system reference.

PXI Backplane Assembly

The PXI Backplane Assembly routes electrical signals between the various system assemblies.

Rear Panel Assembly

The Rear Panel Assembly provides access to Tests Set's Input/Output connectors and AC charger.

Satellite Simulation

The orbit parameters for each satellite are configurable in terms of the standard Keplerian (almanac) elements. The almanac used for simulation may selected from a list, maintained by a file management system. The files may obtained from the built in GPS receiver, as a current almanac load or may be loaded from a USB flash drive in Yuma .alm format.

The standard Keplerian elements (almanac) are used to calculate the enhanced Keplerian Elements (ephemeris), which are in turn used to generate the satellite motion, and are broadcast as part of the navigation message.

As almanac data is typically valid for several days, the GPSG-1000 does not update the standard Keplerian (almanac) elements during the course of the simulation.

The GPSG-1000 computes the enhanced Keplerian (ephemeris) elements by extrapolation of the configured standard Keplerian (almanac) elements. Any enhanced Keplerian elements not includedin the standard Keplerian elements are set to zero. The GPSG-1000 generates updated enhanced Keplerian (ephemeris) elements at a fixed time interval of 4 hours, this being the update rate supported by both GPS and Galileo.

The GPSG-1000 generates in real time the positions of all simulated Satellites i.e. positions are not be pre-computed for the entire simulation run.

Satellite Selection

For each simulated GNSS system the GPSG-1000 will perform an independent satellite selection process and if the total number of visible satellites exceeds the maximum number of hardware channels allocated to that system, then the GPSG-1000 will select those satellites which approximate the minimum DOP for that system. The GPSG-1000 updates its satellite selection every 60 minutes.

Note: In the case of the 6 channel GPSG-1000, with large numbers of simulated satellites it becomes possible for many more satellites to be visible at the user location than there are available hardware satellite channels. If this happens the GPSG-1000 allocates channels on a 'best effort' basis but does allow the operator to override the selection manually.

The GPSG-1000 allows the operator to manually replace any selected satellite with another visible satellite from the same GNSS system, with the manually selected satellite remaining selected until it is no longer visible, or until it is manually replaced. The manually de-selected satellite will remain eligible for re-selection at the next automatic update.

1.1.2 Interconnect Block Diagrams

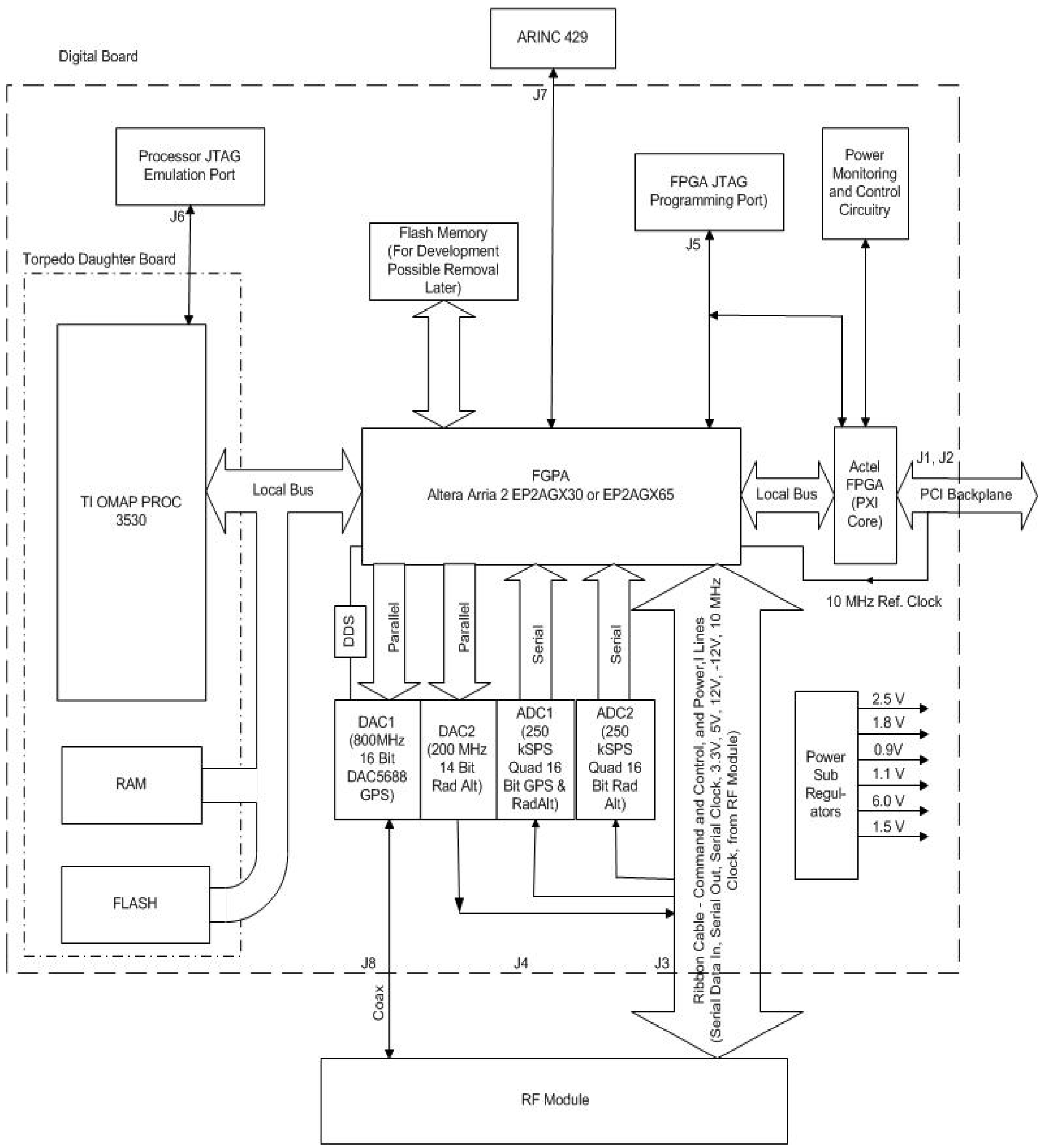

Fig. 1-1 Assembly Interconnect Block Diagram)

1.1.3 GPS System

The **NAVSTAR,** (**N**avigation **S**atellite **T**iming **A**nd **R**anging), GPS, (**G**lobal **P**ositioning **S**ystem) is a satellite based navigation system offering precision navigation capability. The system was originally designed for military use, funded and controlled by the U.S. Department of Defense. Civilian access has been permitted to specific parts of the GPS.

GPS offers a number of features making it attractive for use in aircraft navigation. Civilian users can expect a position accuracy of 100 m or better in three dimensions. The GPS signal is available 24 hours per day throughout the world and in all weather conditions. GPS offers resistance to intentional (jamming) and unintentional interference. The equipment necessary to receive and process GPS signals is affordable and reliable and does not require atomic clocks or antenna arrays. For the GPS user, the system is passive and requires a receiver only, without the requirement to transmit.

GPS determines the position of the user by triangulation. By knowing the position of the satellite and the distance from the satellite, combinations of satellites can be used to determine the exact position of the receiver. The fundamental means for GPS to determine distance is the use of time. Distance is computed by using accurate time standards and by measuring changes in time.

The GPS System is comprised of three segments:

- Space Segment
- Control Segment
- User Segment

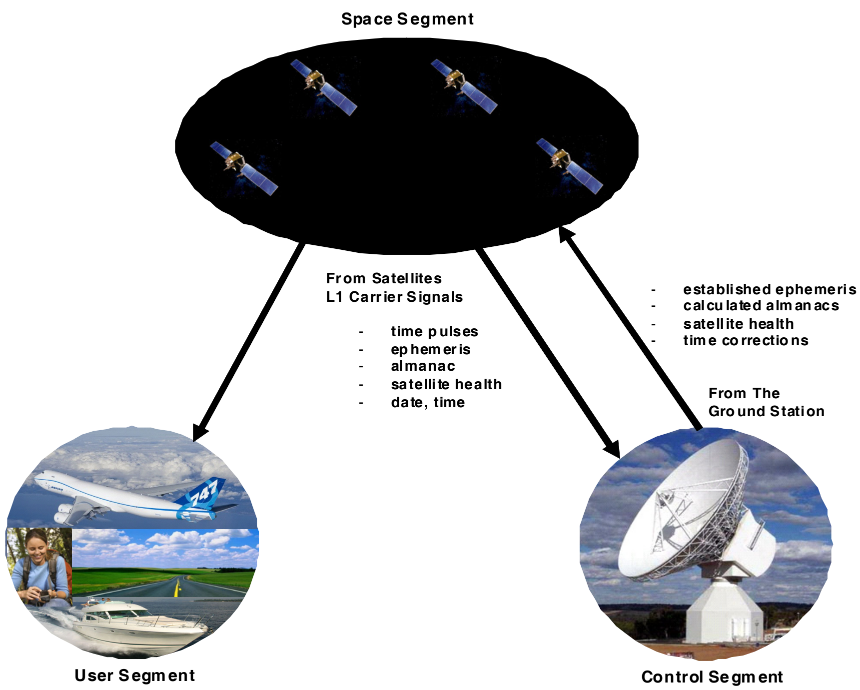

Fig. 1-2 GPS System Segments

1.1.3.A Space Segment

The Space segment consists of the GPS space vehicles (SV's) or Satellites, nominally 24 SV's plus spares. The terms SV and satellite shall be interchangeable in this document. Each vehicle has a 12 hour orbit at 20,200 km above the earth and repeats same ground track daily. 5 to 12 SV's are visible from anywhere on earth.

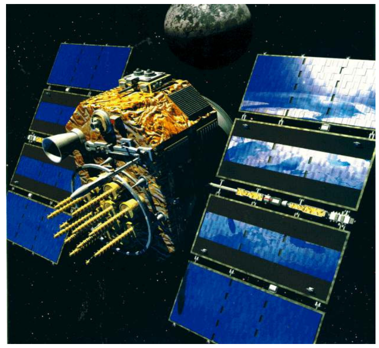

Fig. 1-3 GPS Satellite

Six orbital planes are used, each spaced equally around the earth, separated by 60 degrees (360 degrees/6 planes=60 degrees) and inclined 55 degrees from equatorial plane. The planes are named A to F. Each orbital plane hosts four satellites. These satellites are not spaced evenly on each plane. Spacing between adjacent satellites varies from 31.13 degrees to 119.98 degrees. Each plane exhibits a different angular spacing for the satellites resident to it.

A computer model determines the satellite spacing to accommodate a single satellite failure and still maintain optimal satellite geometry.

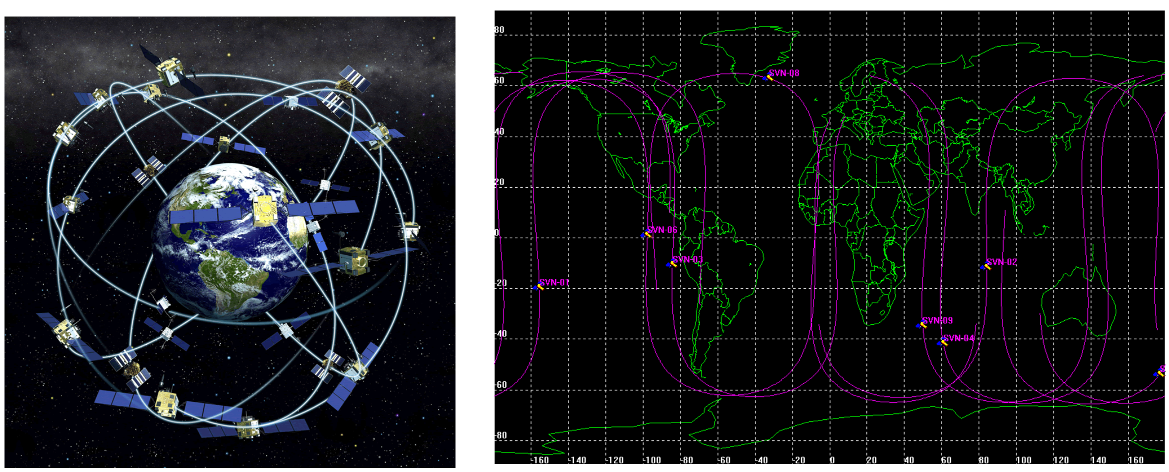

Fig. 1-4 GPS Satellite Orbital Planes

Fig. 1-4 shows the motion of nine satellites. The ground tracks show the movement of these satellites over a twelve hour period and the position of the satellites at one moment in time.

The ground tracks show a number of features. Each satellite follows a unique path over the ground. Also, every satellite operates between 55 degrees North and 55 degrees south.

The primary mission of GPS satellites is the transmission of precisely timed GPS signals and the data stream required to decode the signals to produce a position. The timing signals are referenced to atomic clocks, either cesium or rubidium.

With the GPS satellites in constant motion, the number of satellites in view and their relative location is dynamic. A 24 satellite configuration provides adequate satellite coverage to perform three-dimensional position fixing. Failures of satellites and/or the requirement for more than four satellites may result in inadequate satellite coverage.

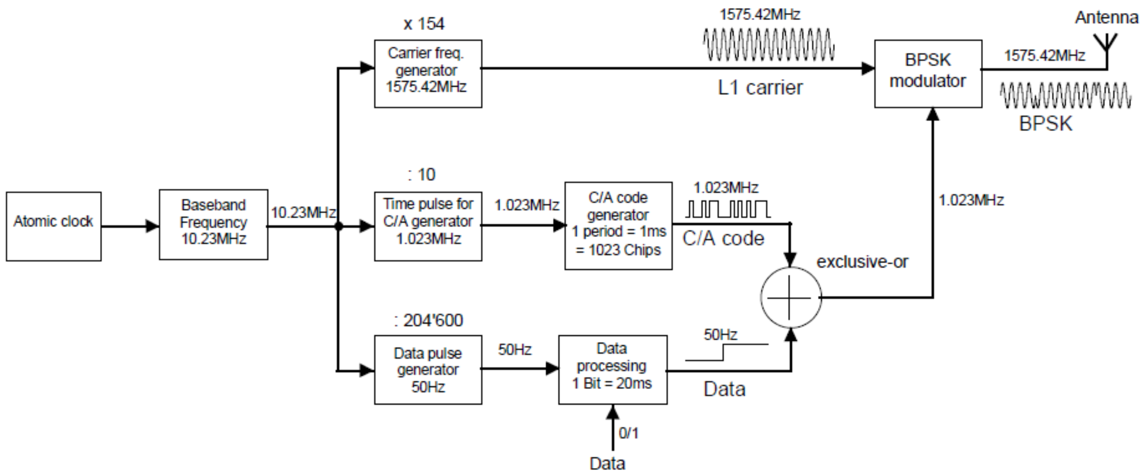

Fig. 1-5 GPS SV Block Schematic

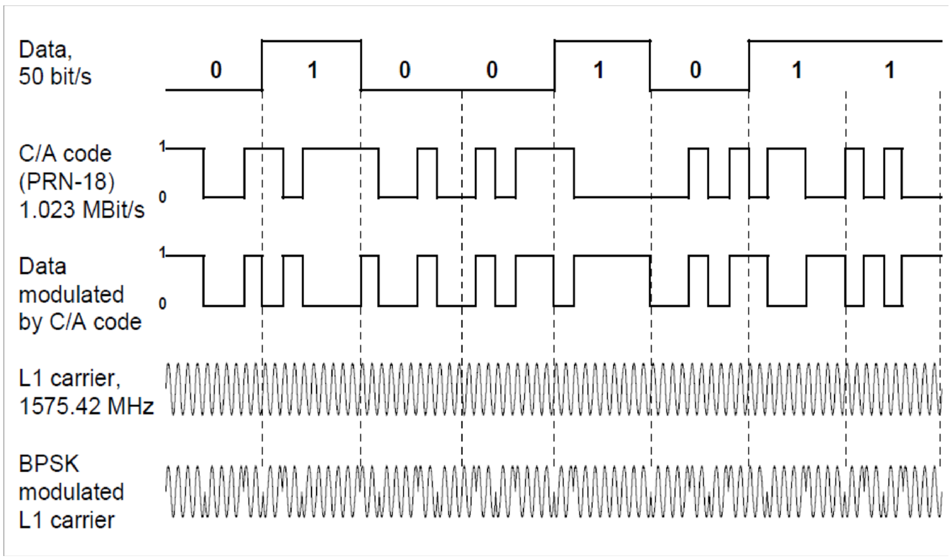

Fig. 1-6 GPS SV Signal Data Structure

Refer to Fig. 1-5 and Fig. 1-6. Each GPS satellite transmits a unique signature assigned to it on the same carrier frequency. This signature consists of a Pseudo Random Noise (PRN) Code of 1023 zeros and ones, broadcast with a duration of 1 ms and continually repeated. The PRN code is exclusively OR'd (modulo 2 added on), with 50 bit/s Navigation Data (Nav Data). The combined code is then used to BPSK modulate a 1575.42 MHz carrier frequency. The resultant signal is spread spectrum.

1.1.3.B Control Segment

Six unmanned monitoring stations are located throughout the world. Each Station constantly monitors and receives information from the GPS satellites and sends the orbital and clock information to the master control station. Five of these stations (except Hawaii) have the ability to upload information to the GPS satellites

Colorado Springs is designated a Master Control Station (MCS). The MCS constantly receives GPS satellite, orbital and clock information from the monitor stations. The MCS makes precise corrections to the data as necessary and sends the information, known as ephemeris data, to the GPS satellites using ground based antennas.

Fig. 1-7 GPS Monitor Stations

The objective of the GPS control segment is:

- Maintain each of the satellites in its proper orbit through infrequent, small commanded maneuvers.
- Make corrections and adjustments to the satellite clocks and payload as needed.
- Track the GPS satellites and generate and upload navigation data to each of the GPS satellites.
- Command major relocations in the event of satellite failure to minimize the impact.

1.1.3.C User Segment

The signals broadcast from the GPS satellites form the means for a GPS receiver to perform the timing and distance calculations. GPS receivers are passive devices, meaning that signals are received only with no requirement or means to transmit.

GPS ranging signals are broadcast on two frequencies: L1 (1575.42 MHz) and L2 (1227.6 MHz).The L1 frequency is available for civilian use. The L2 frequency was designed primarily for Military use.

1.1.4 SPS Standard Positioning Service

The Clear Acquisition Code, or C/A, is the principal civilian ranging signal and is always broadcast in a clear or unencrypted form. The use of this signal is sometimes called the Standard Positioning Service or SPS. This signal may be degraded intentionally but is always available. The signal creates a short Pseudo Random Noise (PRN) code broadcast a rate of 1.023 MHz. The satellite signal repeats itself every millisecond. The C/A code is also used to acquire the P Code.

1.1.4.A PPS Precise Positioning Service

Protected Code or P Code: this is also known as the Precise Positioning Service. The P Code is never transmitted in the clear and is encrypted with a W code. When encrypted the signal is know as P(Y) code and is not available to civilian users. The C/A PRN's are unique for each satellite however, the P-code PRN is actually a small segment of a master P-code approximately 2.35 × 1014 bits in length (235,000,000,000,000 bits) and each satellite repeatedly transmits its assigned segment of the master code.

1.1.5 Position Calculation

Position calculations consists of the following elements:

- Deciding which satellites to acquire and track
- Code and frequency correlation
- Measure distance to satellites
- Obtain satellite positions
- Adjust local clock bias
- Perform triangulation calculations (Trilateration)
- Adjust for time delay errors

1.1.5.A SV's to Acquire and Track

The L1 and L2 frequencies broadcast a GPS Navigation Message (Nav Data) as part of their signal. This low frequency (50 bits per second) data stream provides the receiver with a number of critical items required in determining a position. A data bit frame consists of 1500 bits divided into five, six second 300-bit subframes. A data frame is transmitted every thirty seconds. An entire set of twenty-five frames (125 subframes) makes up the complete Navigation Message that is sent over a 12.5 minute period.

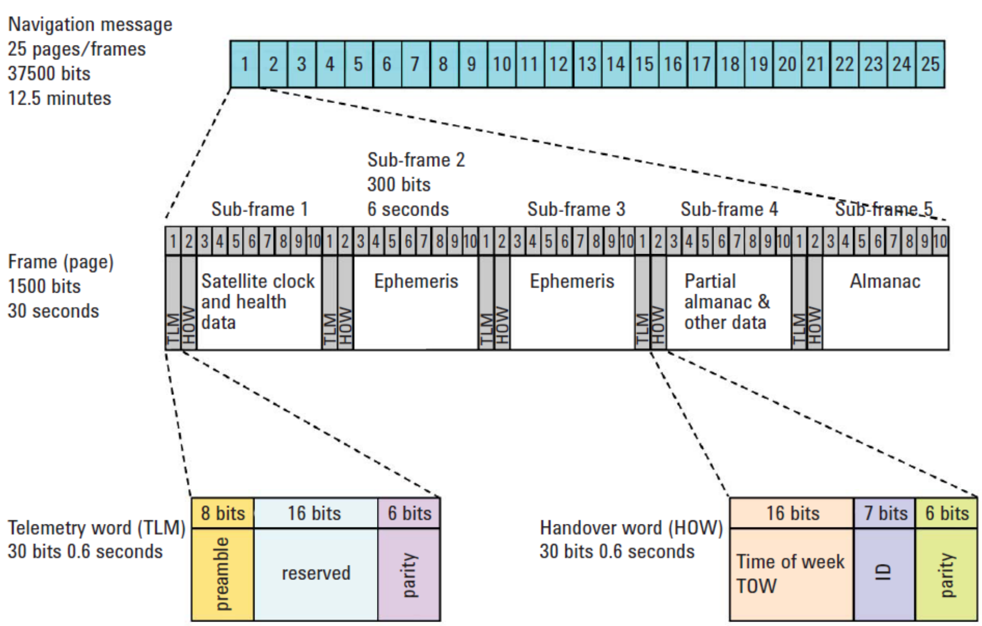

Fig. 1-8 GPS Navigation Data

Subframes

Subframes 1 to 5 each provide a synchronization, hand-over word and a C/A code time ambiguity removal. The remainder of the data is formatted as follows:

Subframe 1:

Contains the time values of the transmitting satellite, including the parameters for correcting signal transit delay and onboard clock time, as well as information on satellite health and an estimate of the positional accuracy of the satellite.

Subframe 2 and 3:

Ephemeris.

Subframe 4:

Ionospheric model, UTC data, flags for each satellite indicating whether anti-spoofing is on, almanac (approximate satellite ephemeris allowing the receiver to select the best set of satellites or to determine which satellites are in view) and health information for satellite number 25 and greater.

Subframe 5:

Almanac and health information for satellite number 1 to 24.

The reception and decoding of the data stream is performed automatically by a receiver without any intervention by the operator. The information within this data is critical to GPS operation. If a GPS receiver has never seen the GPS constellation before and does not know its approximate location, the first action of the receiver is to acquire any SV in view. Once a satellite has been acquired, the almanac is downloaded.

Refer to Fig. 1-9. Subframes 4 and 5 contain almanac information. Once the almanac is acquired, the information it contains is used to determine which satellites are in view and select the set of satellites with the best geometry. The almanac structure for one SV PRN is shown in Fig. 1-9. Almanac data is typically updated every 24 hours. Data for a few weeks is also provided in case of a delay in update. Once a receiver has an almanac loaded in its memory, it can be used for a faster acquisition of satellites on the next occasion of use. Once a satellite has been acquired, it’s ephemeris information can be obtained.

```
******** Week 572 almanac for PRN-03 ********
ID:                           03
Health:                       000
Eccentricity:                 0.1350402832E-001
Time of Applicability(s):    405504.0000
Orbital Inclination(rad):     0.9279594421
Rate of Right Ascen(r/s):    -0.8203642210E-008
SQRT(A)  (m 1/2):             5153.669922
Right Ascen at Week(rad):     0.3102266431E+001
Argument of Perigee(rad):     1.020882249
Mean Anom(rad):              -0.7818025351E+000
Af0(s):                       0.5941390991E-003
Af1(s/s):                     0.3637978807E-011
week:                          572
```

Fig. 1-9 GPS Almanac

The almanac provides a basic description of each satellite orbit. Refer to Fig. 1-10. Two parameters are commonly displayed on GPS receivers which describe the basic position of a satellite relative to a GPS receiver at a specific location.

Elevation describes the angle of a satellite relative to the horizontal plane. If a satellite is directly above the point of observation on the ground, then the elevation is 90°. If the satellite is at the horizon, then the elevation is 0°.

Azimuth is the angle between a reference plane and a point. In the case of satellites the reference plane is the plane of the horizon based on true North. The Azimuth is the angle between the satellite and true North (North = 0°, East = 90°, South = 180°, West = 270°).

Of course many other parameters are used to define satellite orbit. Each satellite will downlink a more precise description of its orbit, which is contained in sub-frames 2 and 3, and is known as ephemeris. With this information the receiver can determine the satellite's position at any time and combine this with the receiver distance from the satellite, yielding a GPS position.

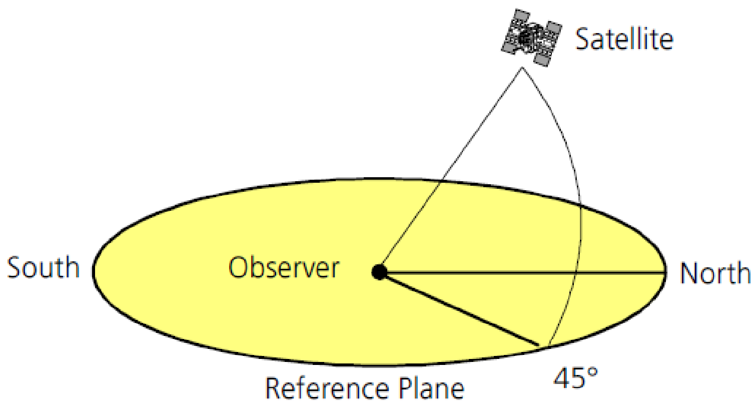

Fig. 1-10 Satellite Relative Position

The health information transmitted in subframe 5, is critical to prevent a receiver from using the ranging information from a satellite that has been declared unfit for navigation purposes.

The remainder of the information found in the data stream (clock corrections, ionospheric model, UTC data) are used to resolve potential sources of GPS position errors.

1.1.5.B Code and Frequency Correlation

The power of the received GPS signal in open sky is at least -160 dBW (-130 dBm). The maximum of the spectral power density of the received signal is -190 dBm/Hz. The spectral power density of the thermal background noise is approximately -174 dBm/Hz (at a temperature of 290 K). Refer to Fig. 1-11. The maximum received signal power is approximately 16 dB below the thermal background noise level.

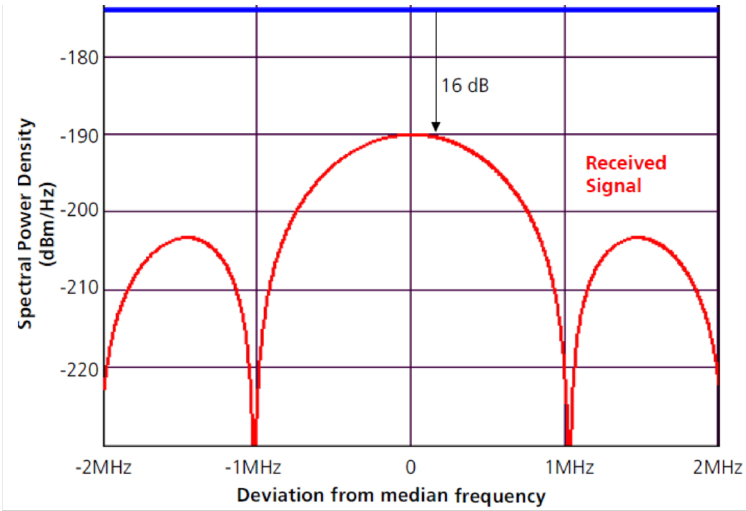

Fig. 1-11 GPS Received Signal

To recover the data from spread spectrum signal at the receiver, the energy spread over a wide bandwidth must be correlated or de-spread into a narrow bandwidth by frequency and code shifting. Fig. 1-12 shows the criticality of correlation in terms of recovering the signal.

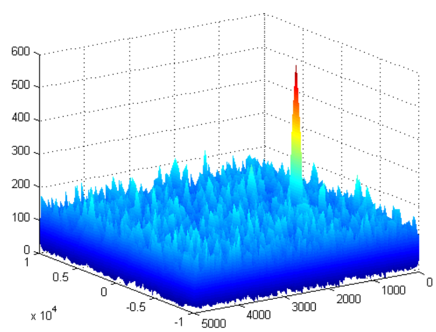

Fig. 1-12 GPS Received Signal

Each GPS satellite transmits unique PRN code. The receiver first demodulates received BPSK signal to extract the satellite PRN code overlaid with Nav Data. The receiver then generates a local copy of the PRN code and then shifts the timing of the local code by 1 bit, relative to a receiver time mark, until all 1,023 bits of the local code are in phase (correlated), with the PRN code received from the satellite. Refer to Fig. 1-13 and Fig. 1-14. A modulo 2 addition process is used to recover the Nav Data.

If all 1,023 bit shifts have been tried without achieving correlation, the receiver local oscillator frequency is offset to the next value and the process is repeated. The reason for this frequency offset, is because satellites and receivers are in relative motion to one another and hence Doppler shift in the transmitted carrier frequency occurs. The transmitted signals can be shifted by up to +/- 5000 Hz at the point of reception.

The determination of the signal travel time and data recovery therefore requires not only correlation with all possible codes at all possible phase shifts, but also identification of the correct phase carrier frequency.

In the case of a receiver cold start, where the receiver does not have a current almanac loaded, every PRN would be tried until an SV is found in view, after which the almanac can be downloaded and used to determine which SV's to acquire next. Because the search for the first SV may take some time, GPS receiver cold starts take appreciably longer than warm starts, where the GPS receiver has a current almanac stored in memory.

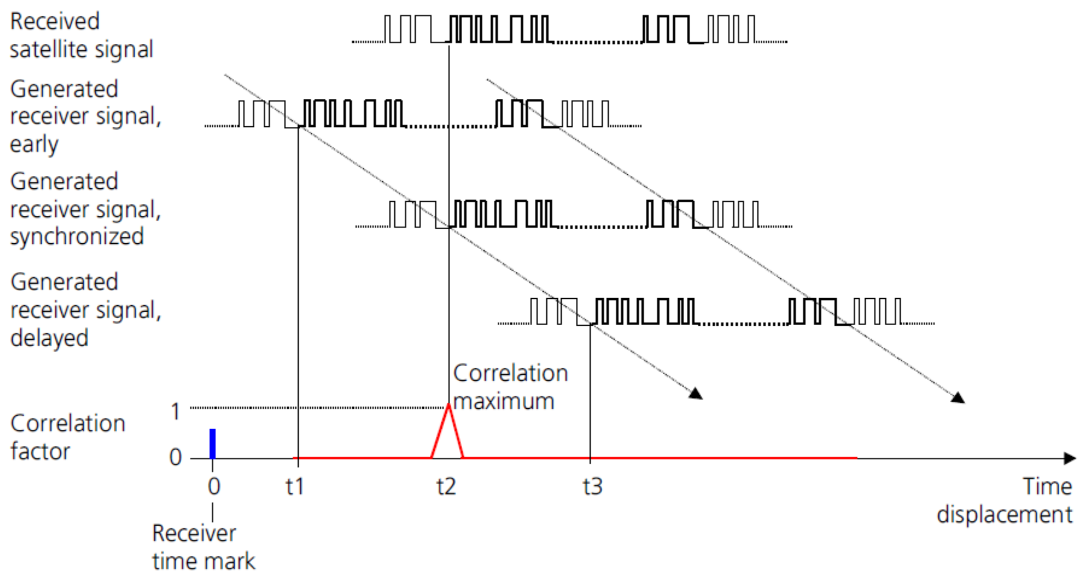

Fig. 1-13 GPS Code Correlation Process

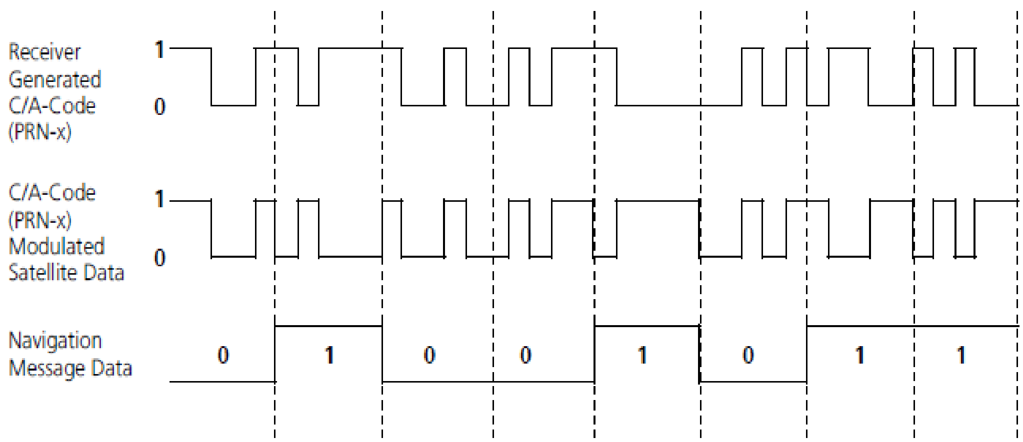

Fig. 1-14 GPS Nav Data Recover by Moduo 2 Addition

Refer to Fig. 1-15. The spectral power density of the received GPS signal lays at approximately 16 dB below the spectral power density of the thermal or background noise. The demodulation and de-spreading of the received GPS signal causes a system gain G of:

After despreading, the power density of the usable signal is greater than that of the ther mal or background signal noise.

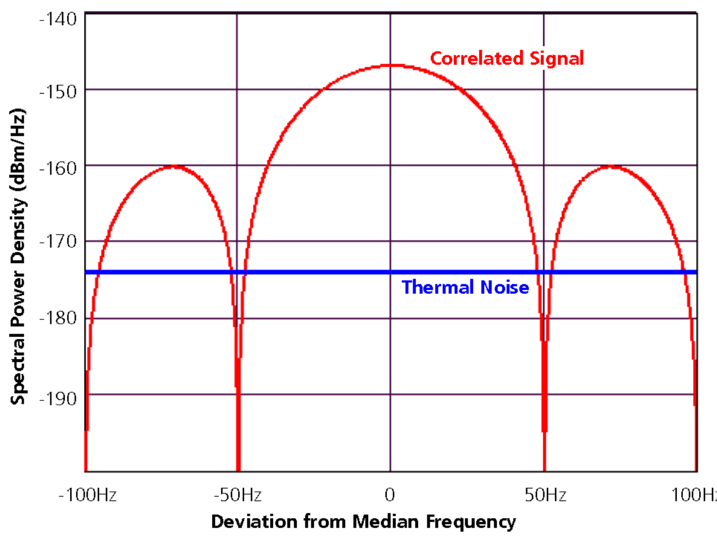

Fig. 1-15 GPS Signal After De-spreading

1.1.5.C Measuring Distance (Pseudo Range)

GPS satellites orbit 200km above the earth and are distributed in such a way that from any point on the ground there is line-of-sight contact to at least four satellites.

Each one of these satellites is equipped with onboard atomic clocks. In order to make them even more accurate, they are regularly adjusted or synchronized from various control points on Earth. GPS satellites transmit their exact position and onboard clock time to Earth.

These signals are transmitted at the speed of light (300,000 km/s) and therefore require approximately 67.3 ms to reach a position on the Earth's surface directly below the satellite. The signals require a further 3.33 µs for each additional kilometer of travel. To establish position, all that is required is a receiver and an accurate clock.

By comparing the arrival time of the satellite signal with the onboard clock time the moment the signal was transmitted, it is possible to determine the signal travel time.

Distance = Velocity * Time: Velocity is 300,000 km/s and Time is the travel time of the signal.

To measure the travel time:

- Receiver generates the same codes as the Satellite (PRN codes)
- Measure delay between incoming codes and self generated codes
- D = Speed of light * measured delay (Pseudo Range)

$$G_G = \frac{\text{Modulation rate of C/A - Code}}{\text{Data rate of information signal}} = \frac{1023\text{bps}}{50\text{bps}} = 20{,}500 = 43\text{dB}$$

The first word of every single frame, the Telemetry word (TLM), contains a preamble sequence 8 bits in length (10001011) used for synchronization purposes, followed by 16 bits reserved for authorized users. As with all words, the final 6 bits of the telemetry word are parity bits.

The handover-word (HOW) immediately follows the telemetry word in each subframe. The handover-word is 17 bits in length (a range of values from 0 to 131071 can be represented using 17 bits) and contains within its structure the start time for the next subframe, which is transmitted as time of the week (TOW).

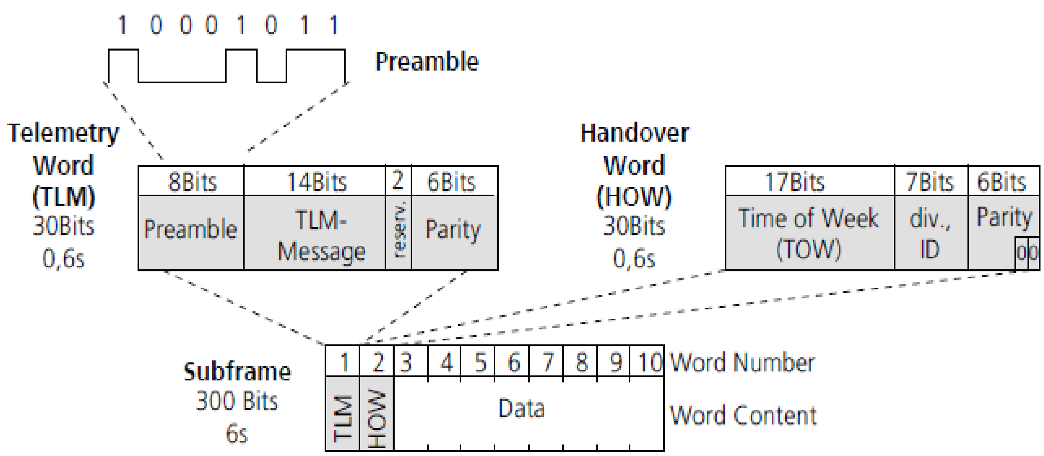

Fig. 1-16 GPS Subframe Hand-Over Word

The transmission time in the first bits of the preamble are provided in the Navigation Message in the TOW Message of the previous frame. This time is given in Satellite Time. Information in the Navigation Message allows translation into Receiver Time. If the preamble is validated, the arrival time of the first bits in the preamble is measured. This time is given in Receiver Time.

Refer to Fig. 1-17. Due to the atomic clocks onboard the satellites, the time at which the satellite signal is transmitted is known very precisely. All satellite clocks are adjusted to be synchronized with each other and UTC (universal time coordinated). In contrast, the receiver clock is not synchronized to UTC and is therefore slow or fast by Δt0 (clock bias). The sign Δt0 is positive when the user clock is fast. The resultant time error Δt0, causes inaccuracies in the measurement of signal travel time and the distance R. As a result, an incorrect distance is measured that is known as a pseudorange.

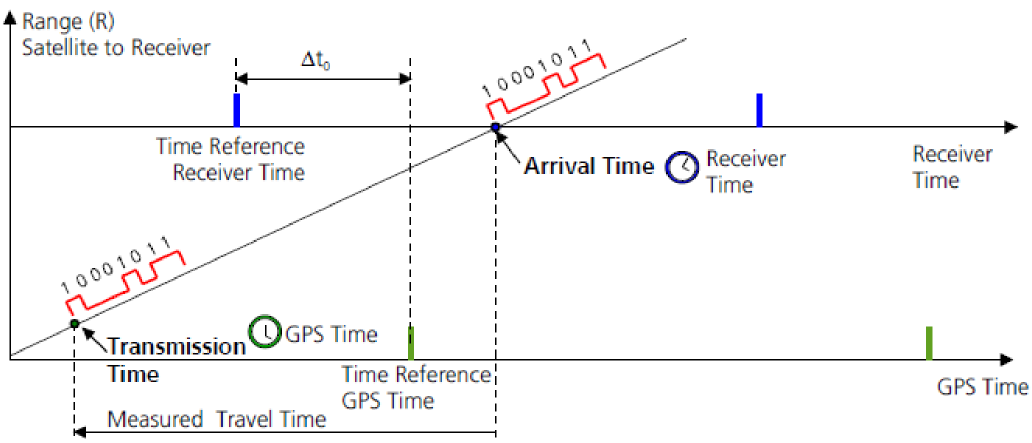

Fig. 1-17 GPS Pseudo Range

1.1.5.D Obtain Satellite Positions

GPS receivers download an almanac into memory which defines where in the sky each satellite is, moment by moment. GPS satellites are constantly monitored by the U.S. Department of Defense. Slight orbital errors are caused by gravitational pulls from the moon and sun and by the pressure of solar radiation on the satellites. Radar is used to check each satellite's exact altitude, position and speed. This information (ephemeris data), is then relayed back up to the respective satellite, which in turn transmits the ephemeris data in Nav Data subframes 2 and 3. Ephemeris data is updated every two hours and is valid for four hours.

1.1.5.E Clock Bias

To solve the problem of clock bias, consider a receiver is placed on a straight line beneath two satellites. As the position of all GPS satellites is known via information contained in the almanac and ephemeris, the distance between any two satellites (S), is known. By measuring the travel times from each satellite, it is possible to exactly establish the distance (D) despite having an imprecise receiver clock, using the following formula:

$$D = \frac{(\Delta t1 - \Delta t2) \times c + S}{2}$$

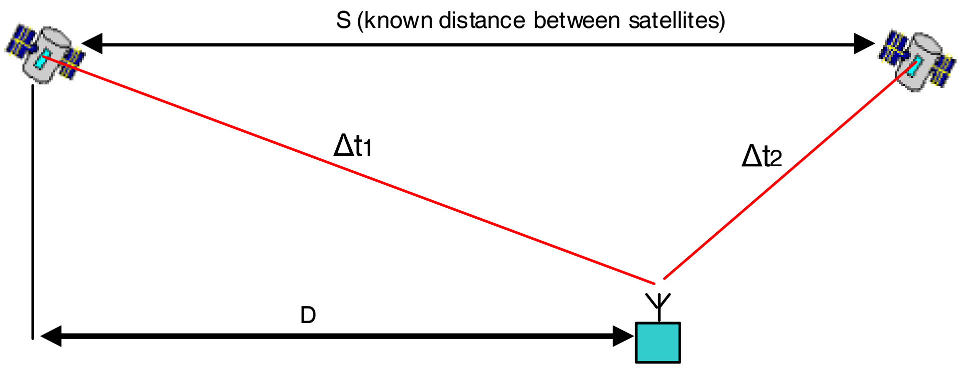

Fig. 1-18 GPS Pseudo Range

In this example two pseudo ranges were employed to determine a position in one dimensional space. To calculate a position in two dimensional space, three pseudo ranges are required, Latitude, Longitude and Δt.

To calculate a position in three dimensional space, four pseudo ranges are required; Latitude, Longitude, Altitude and Δt. The number of pseudo ranges (GPS satellites), must exceed the number of unknown dimensions by a value of one.

1.1.5.F Triangulation Calculations (Trilateration)

Consider triangulation in 2D space. Refer to Fig. 1-19. If location of point A is known, and the distance to point A is known, desired position lies somewhere on a circle.

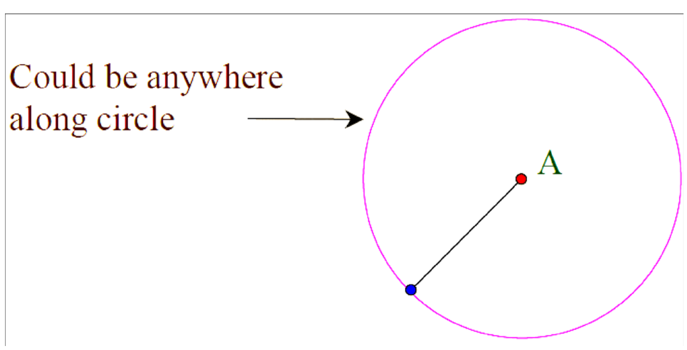

Fig. 1-19 Triangulation using one known point

Refer to Fig. 1-20. Distance to two points is known, desired position is in one of two locations

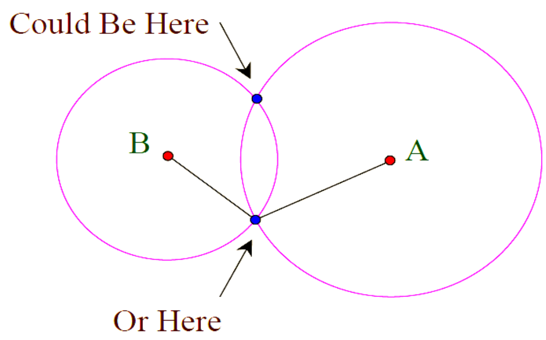

Fig. 1-20 Triangulation using two known point

Refer to Fig. 1-21. Distance to three points is known, position is known.

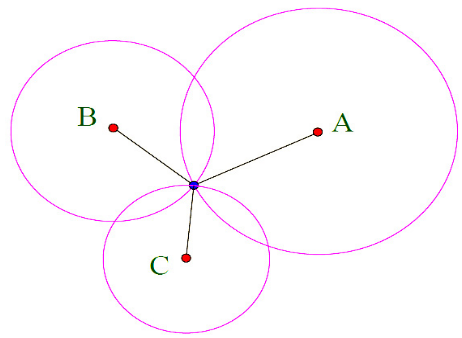

Fig. 1-21 Triangulation using three known point

Refer to Fig. 1-22. Consider triangulation in 3D Space. Distance to two points is known.

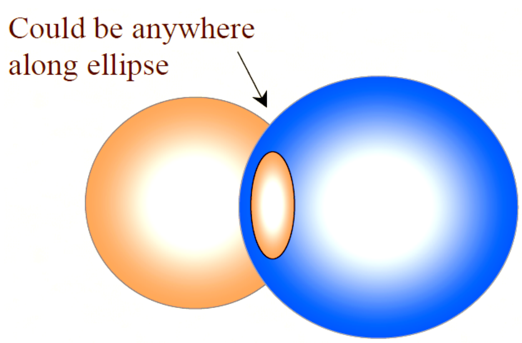

Fig. 1-22 Triangulation using two known points in 3D space

Refer to Fig. 1-23. Distance to three points is known, position is known in 3D space.

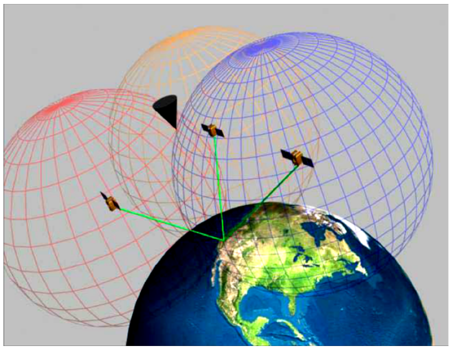

Fig. 1-23 Triangulation using three known points in 3D space

1.1.5.G Time Delay Errors

Sources of Time Delay Error are:

Ephemeris data:

The data concerning ephemeris errors may not exactly model the true satellite motion. The disparity in ephemeris data can introduce 1 to 5 meters of positional error. Ephemeris data is valid for a period of about 4 hours

Satellite clocks:

The data concerning the satellite's four atomic clocks may not reflect the exact rate of clock drift. Distortion of the signal by measurement noise can further increase positional error. Clock drift disparity can introduce 0 to 2.5 meters of positional error and measurement noise can introduce 0 to 10 meters of positional error.

Receiver Clock Inaccuracies and Rounding Errors:

Despite the synchronization of the receiver clock with the satellite time during the position determination (compensation for clock bias), 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.

Multipath:

Refer to Fig. 1-24. GPS signals can also be affected by multi-path issues where the radio signals reflect off of surrounding terrain such as buildings, canyon walls, and hard ground. These delayed signals can result in periodic signal cancellation but typically they change dynamically with location and may just cause short term inaccuracy.

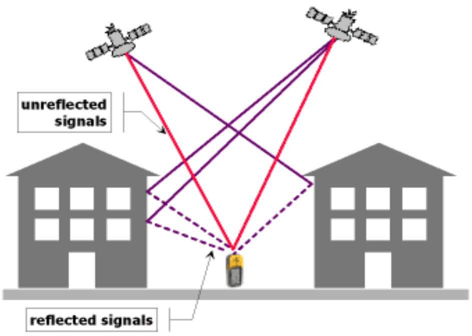

Fig. 1-24 Multipath Delays

1.1.5.H Atmospheric Delays

Ionosphere:

The ionosphere is an atmospheric layer situated between 90 to 1000 km above the Earth's surface. The gas molecules in the ionosphere are heavily ionized. The ionization is caused mainly by solar radiation, hence the thickness of this layer varies during the course of the day. Signals from the satellites travel through a vacuum at the speed of light. However, in the ionosphere the velocity of these signals slows down due to the ionized gas, an effect called dispersion, which is frequency dependent.

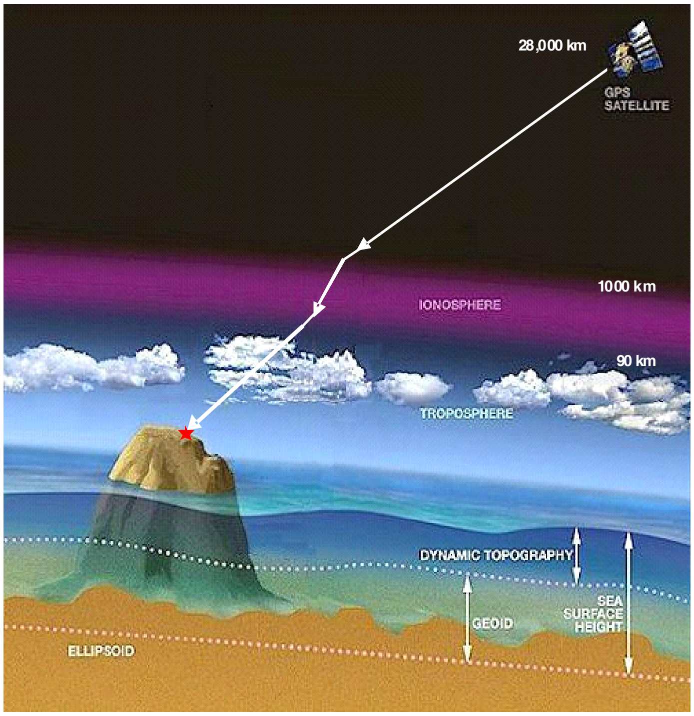

Fig. 1-25 Atmospheric Delays

Ionospheric dispersion is one of the most significant error sources. These effects are smallest when the satellite is directly overhead and become greater for satellites nearer the horizon as the signal passes through the ionosphere at a shallow angle, hence a thicker band has to be traversed. Two methods can be used to correct for Ionospheric delays.

- Once the receiver's approximate location is known, a mathematical model can be used to estimate and compensate for these errors.
- Because ionospheric delay affects the speed of microwave signals differently based on frequency, a second carrier frequency, L2 can be used to measure atmosphere dispersion and apply a more precise correction to help compensate for this error. This is the method employed in military GPS receivers using L1 and L2.

  This can also be realized in more expensive civilian GPS receivers without decrypting the P(Y) signal carried on L2 by tracking the carrier wave instead of the modulated code. To do this on lower cost receivers, a new civilian code signal on L2 called L2C was added to the satellites. This new signal allows a direct comparison of the L1 and L2 signals using the coded signal instead of the carrier wave.

Troposphere:

The troposphere is the lower part of the earth's atmosphere (0 -15km), that encompasses our weather. It's full of water vapor and varies in temperature and pressure and causes a variable but predictable delay. This delay is corrected using a simple model based on pressure, temperature and altitude.[1]

The errors of the GPS system are summarized in Table 1-1. The individual values are no constant values, but are subject to variances, all numbers are approximate values. Altogether this sums up to an error of between ± 12 to ± 15 meters.

Type of Time Delay Error	Positional Error
Ephemeris Errors	± 2.5 m
Satellite Clock Errors	± 2 m
Multipath Delays	± 1 m
Receiver Clock Inaccuracies and Rounding Errors:	± 1 m
Ionospheric Delays	± 5 m
Tropospheric Delays	± 0.5 m

Table 1-1 PS Positional Error Sources

1.1.6 GPS Timekeeping

Most clocks are synchronized to Coordinated Universal Time (UTC) however, the atomic clocks on the satellites are set to GPS time. GPS time is not corrected to match the rotation of the Earth, so it does not contain leap seconds or other corrections that are periodically added to UTC. GPS time was set to match Coordinated Universal Time (UTC) in 1980, but has since diverged. The lack of corrections means that GPS time remains at a constant offset with International Atomic Time (TAI) (TAI - GPS = 19 seconds). Periodic corrections are performed on the on-board clocks to correct relativistic effects and keep them synchronized with ground clocks.

The GPS navigation message includes the difference between GPS time and UTC, which as of 2010 is 15 seconds due to the leap second added to UTC December 31, 2008. Receivers subtract this offset from GPS time to calculate UTC and specific time zone values. New GPS units may not show the correct UTC time until after receiving the UTC offset message.

The GPS-UTC offset field can accommodate 255 leap seconds (eight bits) which, given the current rate of change of the Earth's rotation (with one leap second introduced approximately every 18 months), should be sufficient to last until approximately the year 2300. As opposed to the year, month, and day format of the Gregorian calendar, the GPS date is expressed as a week number and a seconds-into-week number.

GPS	2010-10-12 13:31:38	week 1605	221498 s	cycle 1 week 0581 day 2
UTC	2010-10-12 13:31:23	Tuesday	day 285	MJD 55481.56346

Fig. 1-26 GPS v. UTC Time Format

The week number is transmitted as a ten-bit field in the C/A and P(Y) navigation messages, and so it becomes zero again every 1,024 weeks (19.6 years). GPS week zero started at 00:00:00 UTC (00:00:19 TAI) on January 6, 1980, and the week number became zero again for the first time at 23:59:47 TC on August 21, 1999 (00:00:19 TAI on August 22, 1999).

To determine the current Gregorian date, a GPS receiver must be provided with the approximate date (to within 3,584 days) to correctly translate the GPS date signal. To address this concern the modernized GPS navigation message uses a 13-bit field, which only repeats every 8,192 weeks (157 years), thus lasting until the year 2137 (157 years after GPS week zero).

1.1.7 GNSS Accuracy

A GNSS receiver determines its Position (horizontal and vertical), its Velocity and the Time from the signals of at least four satellites by means of triangulation. The precision of the computations by triangulation depends on the constellation of all satellites of which the signals are taken into account (four or more). As the number and position of satellites will seldom be ideal, the maximum obtainable precision will be diluted in practice. Here we present the different terms of dilution of precision.

Dilution of precision (DOP) is a measure of the quality of the GPS data being received from the satellites. DOP is a mathematical representation for the quality of the GPS position solution. The main factors affecting DOP are the number of satellites being tracked and where these satellites are positioned in the sky. The effect of DOP can be resolved into HDOP, VDOP, PDOP and TDOP.

HDOP (Horizontal Dilution Of Precision) is a measure of how well the positions of the satellites, used to generate the Latitude and Longitude solutions, are arranged. PDOP less than 4 gives the best accuracy, between 4 and 8 gives acceptable accuracy and greater than 8 gives unacceptable poor accuracy. Higher HDOP values can be caused if the satellites are at high elevations.

VDOP (Vertical Dilution Of Precision) is a measure of how well the positions of the satellites, used to generate the vertical component of a solution, are arranged. Higher VDOP values mean less certainty in the solutions and can be caused if the satellites are at low elevations.

TDOP (Time Dilution Of Precision) is a measure of how the satellite geometry is affecting the ability of the GPS receiver to determine time.

PDOP (Positional Dilution OF Precision) is a measure of overall uncertainty in a GPS position solution with TDOP not included in the estimated uncertainty. The best PDOP (lowest value) would occur with one satellite directly overhead a
nd three others evenly spaced about the horizon. PDOP = SQRT(HDOP^2 + VDOP^2).

GDOP (Geometric Dilution Of Precision) is a measure of the overall uncertainty in a GPS position solution. GDOP = SQRT(TDOP^2 + HDOP^2 + VDOP^2) or in another form
GDOP = SQRT(PDOP^2 + TDOP^2). GDOP value should be less than 5.

The Position Accuracy = Dilution Of Precision (DOP) times Measurement Precision. So, if the Measurement Precision = 1m and the DOP = 5, then the best position accuracy will be 5m.

1.1.8 GNSS Augmentation

Augmentation of GNSS, is a method of improving the navigation system accuracy, reliability and availability through the integration of external information into the calculation process. SBAS (Satellite Based Augmentation System) and RAIM (Receiver Autonomous Integrity Monitoring System) are GNSS augmentation systems.

Satellite Based Augmentation System (SBAS)

SBAS is a system that supports wide-area or regional augmentation through use of additional satellite broadcast messages that contain correctional data obtained from multiple ground stations at surveyed locations.

The effects of the ionosphere generally change slowly and can be averaged over time. The effects for any particular geographical area can be easily calculated by comparing the GPS-measured position to a known surveyed location. This correction is also valid for other receivers in the same general location.

The data is transmitted via satellites in the SBAS system and is transmitted on the GPS L1 frequency using a special pseudo-random number, allocated for SBAS use. This allows the civilian L1 C/A code receivers that support SBAS, to use the correctional data. All SBAS satellites support the same protocols and therefore can support seamless augmentation from one region to another.

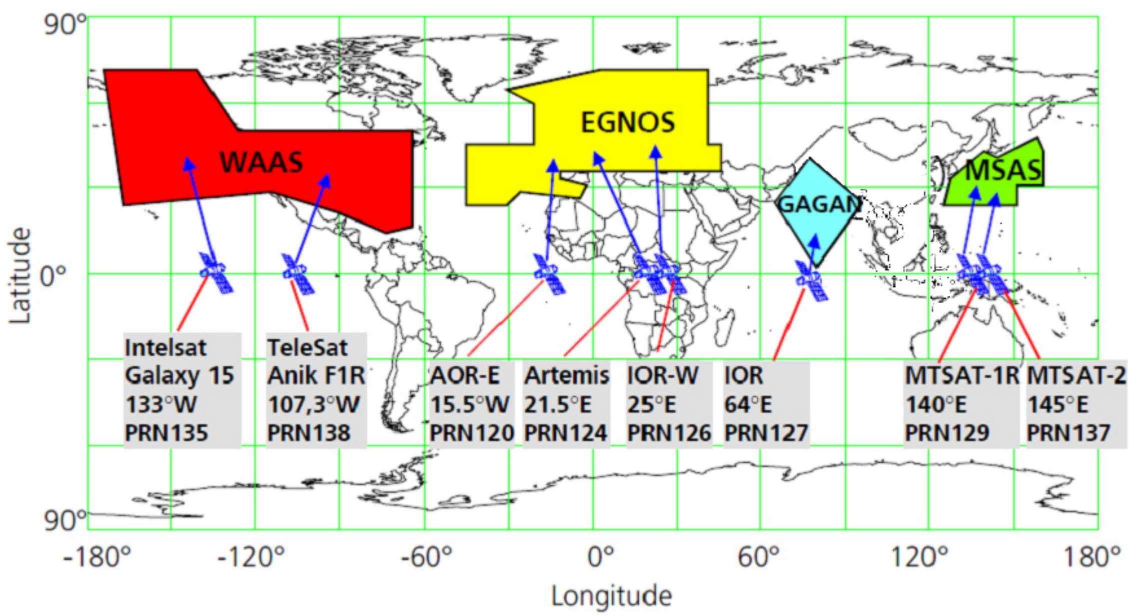

Fig. 1-27 SBAS Coverage

1.1.8.A SBAS Systems

WAAS (Wide **A**rea **A**ugmentation **S**ystem)

Developed and managed by the FAA, to augment GPS, with the goal of improving its accuracy, integrity, and availability. WAAS is intended to enable aircraft to rely on GPS for all phases of flight, including precision approaches to any airport within its coverage area. The system communicates with several ground stations and provides atmospheric corrections & early warning of GPS failures. The data rate is higher that L1 C/A code at 250 Hz and two geostationary satellites provide area coverage.

EGNOS (**E**uropean **G**eostationary **N**avigation **O**verlay **S**ystem)

Managed by the European tripartite group. Corrections for GPS and GLONASS

Similarly to WAAS, EGNOS is mostly designed for aviation users which enjoy unperturbed reception of direct signals from three geostationary satellites up to very high latitudes. The use of EGNOS on the ground, especially in urban areas is limited due to relatively low elevation of geostationary satellites: about 30° above horizon in central Europe and much less in the North of Europe. To address this problem, ESA released in 2002 SISNeT, an Internet service designed for continuous delivery of EGNOS signals to ground users. SV PRN 126 is used for test purposes at this time (2010).

MSAS (**M**ulti-Functional **S**atellite **A**ugmentation **S**ystem

Managed by the Japanese Civil Aviation Bureau (JCAB), a satellite navigation system which supports differential GPS, designed to supplement the GPS system by reporting (then improving) on the reliability and accuracy of those signals. MSAS for aviation use was commissioned on September 27, 2007. Two geostationary satellites provide area coverage.

GAGAN (**G**PS **A**ided **G**eo **A**ugmented **N**avigation)

The GAGAN system is a planned implementation of a regional Satellite Based Augmentation System (SBAS) by the Indian government. It is a system to improve the accuracy of a GNSS receiver by providing reference signals. Two geostationary satellites will eventually provide area coverage. One SV is currently deployed, PRN 127.

1.1.8.B RAIM (Receiver Autonomous Integrity Monitoring System)

A unique aviation requirement of GPS avionics is RAIM. While GPS provides the user with unparalleled levels of accuracy, one significant deficiency of GPS is integrity, or the ability of the system to provide a timely warning if the navigation solution is inaccurate or erroneous. Navigation systems prior to GPS, particularly aviation applications, provided a means to warn the aircraft that the signal was outside certain limits. For example, a Category I ILS provides this warning within six seconds.

The only means available for the GPS system itself to provide the user with a warning of system unreliability is through the data message forming part of the GPS signal. The “health” flag found in subframe 4 and 5 will alert the receiver to a failure of a GPS satellite.

The time lag from the beginning of the failure to when it is incorporated in the health flag (up to eight hours) represents an unacceptably long period of time for aviation.

To overcome this, RAIM was developed and is a mandatory feature of all aviation-grade receivers. RAIM uses combinations of satellites to determine the receiver position. Should a large discrepancy between position solutions occur, a RAIM alert is created rendering the GPS navigator unreliable. Refer to Table 1-2. Different phases of flight use different values of “integrity alarm limits” prior to issuing a RAIM alert.

The ability of a receiver to perform RAIM computations is dependent upon the number of satellites in view, their geometry and the mask angle which is dependent upon the ability of the antenna to track satellites near the horizon and any local terrain. Whereas GPS needs a minimum of four satellites to produce a three-dimensional position, a minimum of five satellites are required for RAIM. For this reason, RAIM may not be available in circumstances of poor satellite coverage or poor satellite geometry.

Phase of Flight	**Alarm Limit**	**Time to Alarm**
Enroute (oceanic, domestic, random and JV routes)	2.0 nm	30 sec
Terminal	1.0 nm	10 sec
RNAV Approach Non Precision	0.3 nm	10 sec

Table 1-2 RAIM Alarms

1.1.9 GPS Modernization Signals

A process of GPS system modernization is now underway, which involves the introduction of new signals to provide improvements in accuracy and integrity.

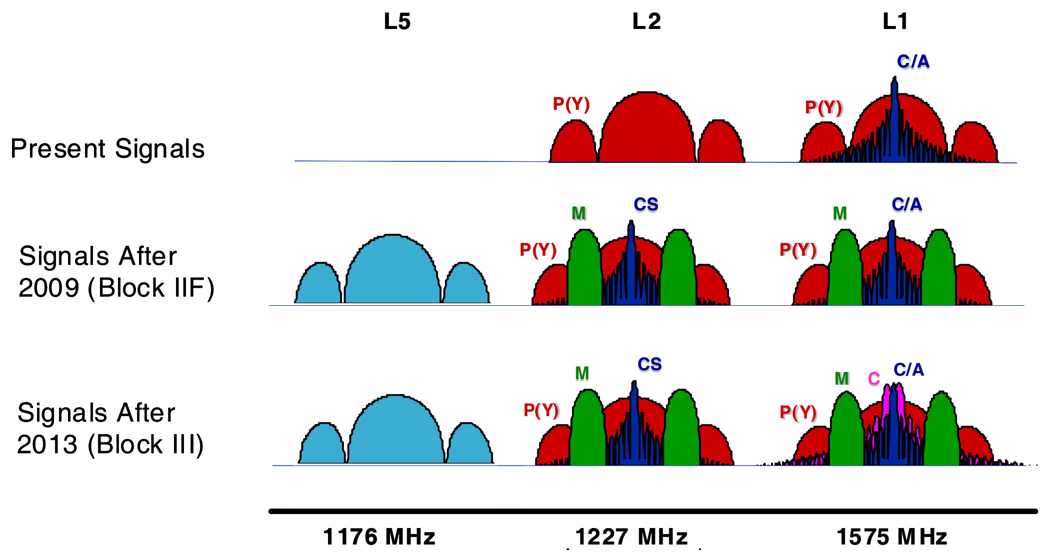

Fig. 1-28 GPS Modernization Signals

1.1.9.A L2CS

The L2CS system provides a civilian-use signal transmitted on a frequency other than the L1 frequency used for the Coarse Acquisition (C/A) signal, and broadcast on the L2 frequency. Because it requires new hardware onboard the satellite, it is only transmitted by the so-called Block IIR-M and later design satellites. The L2CS signal is tasked with improving accuracy of navigation, providing an easy to track signal, and acting as a redundant signal in case of localized interference.

Unlike the C/A code, L2CS contains two distinct PRN code sequences to provide ranging information; the *Civilian Moderate* length code (called CM), and the *Civilian Long* length code (called CL). The CM code is 10,230 bits long, repeating every 20 ms. The CL code is 767,250 bits long, repeating every 1500 ms. Each signal is transmitted at 511,500 bits per second (bit/s); however, they are multiplexed together to form a 1,023,000 bit/s signal.

CM is modulated with the CNAV Navigation Message (see below), whereas CL does not contain any modulated data and is called a *data-less sequence*. The long, data-less sequence provides for approximately 24 dB greater correlation (~250 times stronger) than L1 C/A-code.

When compared to the C/A signal, L2CS has 2.7 dB greater data recovery and 0.7 dB greater carrier-tracking, although its transmission power is 2.3 dB weaker.

1.1.9.B CNAV Navigation Message

The CNAV data is an upgraded version of the original NAV navigation message. It contains higher precision representation and nominally more accurate data than the NAV data. The same type of information (Time, Status, Ephemeris, and Almanac) is still transmitted using the new CNAV format; however, instead of using a frame / subframe architecture, it features a new pseudo-packetized format made up of 12-second 300-bit message packets.

In CNAV, two out of every four packets are ephemeris data and at least one of every four packets will include clock data, but the design allows for a wide variety of packets to be transmitted.

With a 32-satellite constellation, and the current requirements of what needs to be sent, less than 75% of the bandwidth is used. Only a small fraction of the available packet types have been defined; this enables the system to grow and incorporate advances.

Important changes in the new CNAV message

CNAV message uses Forward Error Correction (FEC) in a rate 1/2 convolution code, so while the navigation message is 25 bit/s, a 50 bit/s signal is transmitted.

The GPS week number is now represented as 13 bits, or 8192 weeks, and only repeats every 157.0 years, meaning the next return to zero won't occur until the year 2137. This is longer compared to the L1 NAV message's use of a 10-bit week number, which returns to zero every 19.6 years.

There is a packet that contains a GPS-to-GNSS time offset. This allows for interoperability with other global time-transfer systems, such as Galileo and GLONASS, both of which are supported.

The extra bandwidth enables the inclusion of a packet for differential correction, to be used in a similar manner to SBAS and which can be used to correct the L1 NAV clock data.

Every packet contains an alert flag, to be set if the satellite data can not be trusted. This means users will know within 6 seconds if a satellite is no longer usable. Such rapid notification is important for safety-of-life applications, such as aviation.

Finally, the system is designed to support 63 satellites, compared with 32 in the L1 NAV message.

L2CS Frequency information

An immediate effect of having two civilian frequencies being transmitted is the civilian receivers can now directly measure the ionospheric error in the same way as dual frequency P(Y)-code receivers. However, if a user is utilizing the L2C signal alone, they can expect 65% more position uncertainty than with the L1 signal.

1.1.9.C L5

Civilian, safety of life signal planned to be available with first GPS IIF launch (2009). Two PRN ranging codes are transmitted on L5: the in-phase code (denoted as the I5-code); and the quadrature-phase code (denoted as the Q5-code). Both codes are 10,230 bits long and transmitted at 10.23 MHz (1ms repetition). In addition, the I5 stream is modulated with a 10-bit Neuman-Hofman code that is clocked at 1 kHz and the Q5-code is modulated with a 20-bit Neuman-Hofman code that is also clocked at 1 kHz.

- Improves signal structure for enhanced performance
- Higher transmitted power than L1/L2 signal (-3 db, or twice as powerful)
- Wider bandwidth provides a 10× processing gain
- Longer spreading codes (10× longer than C/A)
- Uses the Aeronautical Radio-Navigation Services band
- The recently launched GPS IIR-M7 satellite transmits a demonstration of this signal.

L5 Navigation message

The L5 CNAV data includes SV ephemerides, system time, SV clock behavior data, status messages and time information, etc. The 50 bit/s data is coded in a rate 1/2 convolution coder. The resulting 100 symbols per second (sps) symbol stream is modulo-2 added to the I5-code only; the resultant bit-train is used to modulate the L5 in-phase (I5) carrier. This combined signal will be called the L5 Data signal. The L5 quadrature-phase (Q5) carrier has no data and will be called the L5 Pilot signal.

L5 Frequency information

Broadcast on the L5 frequency (1176.45 MHz, 10.23 MHz × 115), which is an aeronautical navigation band. The frequency was chosen so that the aviation community can manage interference to L5 more effectively than L2.

1.1.9.D L1C

Civilian use signal, broadcast on the L1 frequency (1575.42 MHz), which currently contains the C/A signal used by all current GPS users. The L1C will be available with first Block III launch, currently scheduled for 2013. The PRN codes are 10,230 bits long and transmitted at 1.023 Mbps. It uses both Pilot and Data carriers like L2C.

The modulation technique used is BOC(1,1) for the data signal and TMBOC for the pilot. The Time Multiplexed Binary Offset Carrier (TMBOC) is BOC(1,1) for all except 4 of 33 cycles, when it switches to BOC(6,1). Of the total L1C signal power, 25% is allocated to the data and 75% to the pilot. Implementation provides C/A code to ensure backward compatibility

Assured of 1.5 dB increase in minimum C/A code power to mitigate any noise floor increase

Data-less signal component pilot carrier improves tracking

Enables greater civil interoperability with Galileo L1

CNAV-2 Navigation message

The L1C navigation message, called CNAV-2, is 1800 bits (including FEC) and is transmitted at 100 bit/s. It contains 9-bit time information, 600-bit ephemeris, and 274-bit packetized data payload

1.1.9.E M Code (Military)

A major component of the modernization process, a new military signal called M-code was designed to further improve the anti-jamming and secure access of the military GPS signals. The M-code is transmitted in the same L1 and L2 frequencies already in use by the previous military code, the P(Y) code. The new signal is shaped to place most of its energy at the edges (away from the existing P(Y) and C/A carriers).

Unlike the P(Y) code, the M-code is designed to be autonomous, meaning that users can calculate their positions using only the M-code signal. P(Y) code receivers must typically first lock onto the C/A code and then transfer to lock onto the P(y)-code.

The M-code is intended to be broadcast from a high-gain directional antenna, in addition to a wide angle (full Earth) antenna. The directional antenna's signal, termed a *spot beam*, is intended to be aimed at a specific region (i.e. several hundred kilometers in diameter) and increase the local signal strength by 20 dB (10X voltage field strength, 100X power). A side effect of having two antennas is that the GPS satellite will appear to be two GPS satellites occupying the same position to those inside the spot beam.

While the full-Earth M-code signal is available on the Block IIR-M satellites, the spot beam antennas will not be available until the Block III satellites are deployed.

Other M-code characteristics are:

- Satellites will transmit two distinct signals from two antennas: one for whole Earth coverage, one in a spot beam.
- Modulation is Binary Offset Carrier (BOC) and occupies 24 MHz of bandwidth
- Uses a new MNAV navigational message, which is packetized instead of framed, allowing for flexible data payloads
- There are four effective data channels; different data can be sent on each frequency and on each antenna.
- Can include FEC and error detection
- The spot beam is ~20 dB more powerful than the whole Earth coverage beam M-code signal at Earth's surface: -158 dBW for whole Earth antenna, -138 dBW for spot beam antennas.

1.1.10 The Galileo System

Galileo is the European global navigation satellite system which provides a highly accurate, guaranteed global positioning service under civilian control. It is inter-operable with GPS and GLONASS, the two other global satellite navigation systems.

Fig. 1-29 Galileo Satellite (GIOVE Test SV)

A user can take a position with the same receiver from any of the satellites in any combination. By offering dual frequencies as standard, Galileo delivers real-time positioning accuracy down to the metre range. Galileo guarantees availability of the service under all but the most extreme circumstances and informs users within seconds of a failure of any satellite. This makes it suitable for applications where safety is crucial, such as running trains, guiding cars and landing aircraft.

The first experimental satellite, part of the so-called Galileo System Test Bed (GSTB-V1), was launched in 2003. The objective of this satellite was to characterize the critical technologies, developed under ESA contracts. Two initial test satellites were launched GIOVE-A, in 2005, and GIOVE-B, in 2008, to validate the basic Galileo space segment. Four In Orbit Validation (IOV) satellites are scheduled to be launched in the 2010 to 2011 time frame, to complete the validation of the space segment in conjunction with the ground segment. A further 16 satellites are currently funded, which will provide a minimum operational capability. The balance of 14 satellites required to reach Full Operational Capability (FOC), as of 2010, are not currently funded.

The fully deployed Galileo system will consist of 30 satellites (27 operational + 3 active spares), positioned in three circular Medium Earth Orbit (MEO) planes at 23 222 km altitude above the Earth, and at an inclination of the orbital planes of 56 degrees with reference to the equatorial plane. The Galileo navigation signals provide good coverage even at latitudes up to 75 degrees north, which corresponds to the North Cape, and beyond.

The large number of satellites together with the optimization of the constellation, and the availability of the three active spare satellites, ensures that the loss of one satellite has no discernible effect on the user. The use of BOC (Binary Offset Carrier) Modulation minimizes interference with GPS BPSK.

1.1.10.A Ground Element

Two Galileo Control Centers:

- Located in Europe
- Combine range of facilities: orbit control, integrity, mission control, satellite control, services products, Precise Time Facilities (PTF)

15 Galileo Up-Link Stations:

- Located around the globe
- 5 Telemetry, Telecommand and Tracking Stations
- 9 Mission Up-Link Stations

30 Galileo Sensor Stations:

- Located around the globe
- Monitor quality of the satellite navigation signal (Signal In Space, SIS) Services

1.1.10.B Services

The Galileo system consists of five main services:

OS (Open Service):

'Free to air' and for use by the mass market; Simple timing and positioning down to 1 meter.

CS (Commercial Service) (Encrypted):

Higher data rate, improved accuracy to the centimeter. Guaranteed service for which service providers charge fees.

SoL (Safety Of Life):

Open service; For applications where guaranteed accuracy is essential; Integrity messages will warn of errors.

PRS (Public Regulated Service): (Encrypted):

Continuous availability even in time of crisis; Government agencies will be main users.

SAR (Search And Rescue):

System picks up distress beacon locations; Feasible to send feedback, confirming help is on its way. Based on Cospas-Sarsat system re-broadcasts distress messages.

Signal	E5 (E5a + E5b)				E6			E1		
Centre Frequency	1191.795 (E5)				1278.75			1575.42		
	1176.45 (E5a)		1207.14 (E5b)							
Nominal Bandwidth	51.15 (E5)				40.92			24.552		
	20.46 (E5a)		20.46 (E5b)							
Modulation	ALTBOC				INTERPLEX			INTERPLEX/CBOC		
Sub-carrier	a-I	a-Q	b-I	b-Q	A	B	C	A	B	C
Sub-modulation	None	None	None	None	BOC(10,5)	None	None	BOC(15,2.5)	CBOC(6,1,1)	CBOC(6,1,1)
Services	F/NAV (OS)	Pilot	I/NAV (OS/CS/SoL)	Pilot	G/NAV (PRS)	C/NAV (CS)	Pilot	G/NAV (PRS)	I/NAV (OS/CS/SoL)	Pilot
Code Rate (Mc/s)	10.23	10.23	10.23	10.23	5.115	5.115	5.115	2.5575	1.023	1.023
Encrypted	No	No	No	No	Yes	Yes	Yes	Yes	No	No
Sequence Length (primary x secondary)	10230 x 20	10230 x 100	10230 x 4	10230 x 100	TBC	TBC	TBC	TBC	4092 x 1	4092 x 25
Symbol rate (sps)	50	N/A	250	N/A	TBC	1000	N/A	TBC	250	N/A

Table 1-3 Galileo Signals

1.1.10.C GPS Receivers

Signal

The strength of the received GPS signal relies on the following parameters:

- Signal strength of satellite
- Attenuation in transmitter hardware
- Gain of transmission antenna (in direction to the receiver)
- Free space loss due to distance of satellite and receiver
- Attenuation by the atmosphere (negligible)
- Deflection and superposition of the direct signal by reflected indirect signals (multipath)
- Gain of receiver antenna
- Attenuation in receiver hardware
- Signal tracking technique

Noise

The level of noise seen by a GPS receiver consists mainly of thermal noise but also background and inter-modulation noise. Most of the single influences are constant or can be assumed to be constant in the order of measurement accuracy.

SNC

Many GPS receivers indicate signal strengths in manufacturer specific units, which are determined from measurements made on the signals by the signal processing hardware. The values are the result of integrating the output of a signal correlator, that is fed the noisy input signal and a clean local replica of the expected PRN code. The integrated result is a linear indication of the signal-to-noise-ratio, over the bandwidth of the correlated signals.

In any particular receiver, this result can vary due to differences in receiver bandwidth and integration time. Often the result is scaled to be consistent across a product range. The resultant values are often referred to as SNC (Signal-to-Noise-Counts) and are scaled to match a measurement made over a 1KHz bandwidth. The 1KHz comes from the fact that many of the early receivers integrated for 1 millisecond, resulting in an effective 1KHz bandwidth.

Converting SNC to SNR

Normally SNR (Signal to Noise Ratio) is expressed as a power ratio on a logarithmic scale instead of an amplitude ratio on a linear scale.

To convert:

- SNC in a 1KHz bandwidth = (sA/nA).
- Where sA = Signal Amplitude and nA is the Noise Amplitude.
- SNR in a 1KHz bandwidth [in dB] = 20*Log10(SNC) - 3db

Converting to C/N_0

A more technically precise and common measurement of GNSS signal strength is known as C/N_0 (carrier-to-noise density) and is the ratio of received carrier (i.e., signal) power to noise density.

Many receivers have the ability to display or output values in these units however, these values are not measured directly, but are calculated from the directly measured SNC count values, refer to Table 1-4.

NOTE:

C/N_0 is *not* the same as SNR (signal-to-noise ratio), although the terms are sometimes used interchangeably. Effectively, C/N_0 assumes that the noise has infinite bandwidth (and thus power) and therefore characterizes it using a density, that is, as the amount of noise power per unit of bandwidth.

C/N_0 = the SNR (usually in dB) in a 1Hz bandwidth. That bandwidth is typically 1000 times less than the actual receiver bandwidth, which implies a 30db change in dB-power units:

- C/N_0 = SNR[dB]@1KHz + 30db
- Therefore. C/N_0 = 30 + 10*Log10(SNC^2/2)
- = 30 + 10*Log10(SNC^2) – 3
- = 27 + 20*Log10(SNC)

SNC	SNR (dB - 1KHz)	C/N_0 (dB - 1Hz)
3	6.5	36.5 (very weak signal)
5	11	41
10	7	47
20	23	53
30	26.5	56.5
40	29	59 (very strong signal)

Table 1-4 SNC, SNR and C/N_0

C/N_0 provides a metric that is more useful for comparing one GPS receiver to another than SNR because the bandwidth of the receivers is eliminated in the comparison. Higher C/N_0 results in reduced data bit error rate (when extracting the navigation data from the GPS signals) and reduced carrier and code tracking loop jitter. Reduced carrier and code tracking loop jitter, in turn, results in less noisy range measurements and thus more precise positioning.

Determining Noise Figure

Generally, the GPS decoding chipset on a receiver determines the minimum C/N_0 ratio, required to achieve a position fix. However, it is the noise figure of the entire receiver that determines the C/N_0 ratio that you can achieve at a given power level. When measuring sensitivity it is important to know the minimum C/N_0 ratio required to achieve a position fix.

Referring to Table 1-5, assuming a constant satellite power, you can observe that the C/N_0 ratio reported by the receiver is a function of the noise figure of the receiver.

Noise Figure	RF Power Level	C/N_0
1 dB	-143 dBm	31 dB -Hz
2 dB	-143 dBm	30 dB -Hz
3 dB	-143 dBm	29 dB -Hz
4 dB	-143 dBm	28 dB -Hz
5 dB	-143 dBm	27 dB -Hz
6 dB	-143 dBm	26 dB -Hz

Table 1-5 C/N_0 as a Function of Noise Figure

Table 1-5 shows that the noise figure of a receiver is directly proportional to the RF power level and C/N_0 ratio. Based on this relationship, you can measure the receivers noise figure by applying the following formula. *N figure = -174dBm/Hz + SVpower +* C/N_0

For example: -174.0 dBm + -136.1 dBm + 30.0 dB-Hz = 7.9 dB.

Rounding C/N_0

Receivers that support the NMEA-183 protocol, report satellite C/N_0 to the nearest decimal digit, therefore estimating noise figure beyond one digit of precision requires you to investigate the C/N_0 rounding of the receiver.

Table 1-6 example results show that RF power levels between -136.6 and -135.7 dBm all produce the same C/N_0 ratio of 30 dB-Hz. Based on the rounding principles involved when reporting NMEA-183 data, it is safe to assume that a power level of -136.1 dBm produces a C/N_0 ratio of 30.0 dB-Hz.

RF Power Level	Receiver C/N_0
-135.6 dBm	31 dB -Hz
-135.7 dBm	31 dB -Hz
-135.8 dBm	30 dB -Hz
-135.9 dBm	30 dB -Hz
-136.0 dBm	30 dB -Hz
-136.1 dBm	30 dB -Hz
-136.2 dBm	30 dB -Hz
-136.3 dBm	30 dB -Hz
-136.4 dBm	30 dB -Hz
-136.5 dBm	30 dB -Hz
-136.6 dBm	30 dB -Hz
-136.7 dBm	30 dB -Hz
-136.8 dBm	29 dB -Hz
-136.9 dBm	29 dB -Hz
-137.0 dBm	29 dB -Hz
-137.1 dBm	29 dB -Hz

Table 1-6 Correlation of RF Power Level and Receiver C/N_0

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Chapter 2 - Troubleshooting

2.1 GENERAL INFORMATION

GPSG-1000 Troubleshooting procedures are divided into the Troubleshooting Table and Assembly Troubleshooting procedures.

This manual cannot list all malfunctions that may occur, nor all tests or inspections and corrective actions. Perform tests/inspections and corrective actions in order listed.

If a malfunction is not listed or is not corrected by listed corrective actions, the troubleshooting technique (the formulation of a logical approach in locating the source of trouble) is left to the technician’s discretion.

The Troubleshooting Table lists malfunctions which may occur during Test Set operation. Assembly Troubleshooting Procedures are intended to determine whether or not an assembly is functioning properly; these procedures do not determine if an assembly is operating within specified parameters. Perform Test Set Verification Procedures to determine if an assembly is operating within specified parameters.

After the faulty assembly has been located, refer to Remove/Install Procedures for remove/install instructions.

2.1.1 Preventive Maintenance Procedures

Contains routine maintenance instructions for cleaning and inspecting the Test Set.

CAUTION	DISCONNECT TEST SET FROM AC POWER SUPPLY TO AVOID POSSIBLE INJURY TO PERSONNEL AND DAMAGE TO ELECTRONIC CIRCUITS.

2.1.1.A External Cleaning

The following procedure contains routine instructions for cleaning the outside of the GPSG-1000.

- Remove grease, fungus and ground-in dirt from surfaces with soft lint-free cloth dampened (not soaked) with isopropyl alcohol.
- Remove dust and dirt from connectors with soft-bristled brush.
- Cover connectors, not in use, with suitable dust cover to prevent tarnishing of connector contacts.
- Clean cables with soft lint-free cloth.
- Paint exposed metal surface to avoid corrosion.
- Clean Front Panel display with soft lint-free cloth dampened (not soaked) with non-ammonia based glass cleaner.

2.1.1.B Internal Cleaning

Remove dust with hand-controlled dry air jet of 15 psi (1.054 kg/cm) and wipe internal chassis parts and frame with soft lint-free cloth moistened with isopropyl alcohol.

CAUTION	TO AVOID POSSIBLE DAMAGE, DO NOT NEEDLESSLY DISCONNECT CONNECTORS FROM ASSEMBLIES OR REMOVE ASSEMBLIES FROM TEST SET. DO NOT OPEN ASSEMBLIES FOR PURPOSE OF CLEANING AND INSPECTION.

2.1.1.C Visual Inspection

Inspect Installation:

- Ensure Test Set is properly ventilated.
- Ensure that AC Power Cord and supply connector(s) are in good condition and easily accessible.
- Ensure that the AC Power Supply Switch isolates the equipment from the AC Power Supply.
- Verify the correct rating and type of supply fuses are used.
- Examine the stability and condition of covers and handles.

Inspect Chassis for:

- Tightness of sub-assemblies and chassis mounted connectors.
- Corrosion or damage to metal surfaces.
- Check the presence and condition of all warning labels and markings and supplied safety information.

Inspect Wiring anc Connectors for:

- Loose or broken parts, cracked insulation and bad contacts.
- Broken or loose ends and connections.
- Proper dress relative to other chassis parts.
- Verify wrapped wiring is tight.

2.1.2 Troubleshooting Guidelines

Troubleshooting Procedures contain Operator Level and Maintenance Level corrective actions.

Operator Level corrective actions identify probable hardware configuration errors which may be the cause of the malfunction. Maintenance Level corrective actions list hardware issues which may be the cause of the malfunction. Maintenance Level corrective actions should only be performed by Qualified Service Personnel.

Many problems on Test Sets in service are caused by corrosion. Removing and reseating an affected cable or circuit card may correct the malfunction. Cleaning connector and/or switch contacts with alcohol repairs many types of digital and analog circuit malfunctions.

The Test Set has a automated self test to assist the technician in troubleshooting.

2.1.3 Tool Requirements

2.1.4 TBD

Equipment Inspection

The following inspection procedures are used to locate obvious malfunctions with the Test Set:

- Inspect all external surfaces of the Test Set for physical damage, breakage, loose or dirty contacts and missing components.

WARNING	**DANGEROUS VOLTAGES ARE PRESENT WITH COVERS REMOVED.**

CAUTION	DO NOT DISCONNECT OR REMOVE ANY BOARD ASSEMBLIES IN THE TEST ADAPTER UNLESS INSTRUMENT IS UNPLUGGED. SOME ASSEMBLIES CONTAIN DEVICES THAT CAN BE DAMAGED IF BOARD IS REMOVED WHEN POWER IS ON. SEVERAL COMPONENTS, INCLUDING MOS DEVICES, CAN BE DAMAGED BY ELECTROSTATIC DISCHARGE. USE CONDUCTIVE FOAM AND GROUNDING STRAPS WHEN SERVICING IS REQUIRED AROUND SENSITIVE COMPONENTS. USE CARE WHEN UNPLUGGING ICS FROM HIGH-GRIP SOCKETS.

- Inspect printed circuit board surfaces for discoloration, cracks, breaks and warping and printed circuit board conductors for breaks, cracks. cuts, erosion or looseness.
- Inspect all assemblies for burnt or loose components.
- Inspect all chassis-mounted components for looseness, breakage, loose contacts or conductors.
- Inspect Test Set for disconnected, broken, cut, loose or frayed cables or wires.

2.1.5 Safety Precautions

WARNING	REMOVE ALL JEWELRY OR OTHER COSMETIC APPAREL BEFORE PERFORMING ANY TROUBLESHOOTING INVOLVING LIVE CIRCUITS. WHEN WORKING WITH LIVE CIRCUITS OF HIGH POTENTIAL, KEEP ONE HEN WORKING WITH LIVE CIRCUITS OF HIGH POTENTIAL, KEEP ONE HAND IN POCKET OR BEHIND BACK TO AVOID SERIOUS SHOCK HAZARD. USE ONLY INSULATED TROUBLESHOOTING TOOLS WHEN WORKING WITH LIVE CIRCUITS. FOR ADDED INSULATION, PLACE RUBBER BENCH MAT UNDERNEATH ALL POWERED BENCH EQUIPMENT, AS WELL AS A RUBBER MAT UNDERNEATH TECHNICIAN'S CHAIR. HEED ALL WARNINGS AND CAUTIONS CONCERNING MAXIMUM VOLTAGES AND POWER INPUTS.

CAUTION

THIS EQUIPMENT CONTAINS PARTS
SENSITIVE TO DAMAGE
BY ELECTROSTATIC DISCHARGE (ESD).

CAUTION	ALL ASSEMBLIES CONTAIN PARTS SENSITIVE TO DAMAGE BY ELECTROSTATIC DISCHARGE (ESD). ALL PERSONNEL PERFORMING TROUBLESHOOTING PROCEDURES SHOULD HAVE KNOWLEDGE OF ACCEPTED ESD PRACTICES AND/OR BE ESD CERTIFIED.

2.1.6 EMC/Safety Compliance

All assemblies, cables, connectors, plastic fasteners, gaskets, fingerstock and miscellaneous hardware within the Test Set are configured to satisfy the safety and EMC compliance standards.

CAUTION	UPON COMPLETION OF ANY MAINTENANCE ACTION; ALL ASSEMBLIES, CABLES, CONNECTORS, PLASTIC FASTENERS, GASKETS, FINGERSTOCK AND MISCELLANEOUS HARDWARE MUST BE CONFIGURED AS INSTALLED AT THE FACTORY.

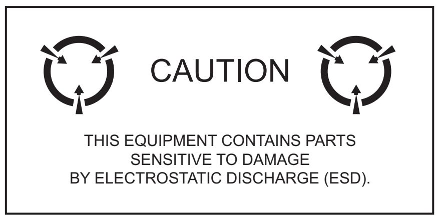
Chapter 3 - Calibration/Verification

3.1 GENERAL INFORMATION

This chapter provides step-by-step instructions for performing Test Set Calibration and Verification Procedures.

3.1.1 Testing Conditions

Calibration and Verification Procedures should be performed in an ESD environment at ambient room temperature (+20° C to +30° C).



CAUTION	ONLY PERFORM CALIBRATION PROCEDURES IN AN ESD ENVIRONMENT. ALL PERSONNEL PERFORMING CALIBRATION PROCEDURES SHOULD HAVE KNOWLEDGE OF ACCEPTED ESD PRACTICES AND/OR BE ESD CERTIFIED.

3.1.2 Required Equipment

Refer to Appendix C - Test Equipment Requirements for list of equipment required to perform Verification and Calibration Procedures.

3.1.3 Safety Precautions

Use extreme caution when working with “live” circuits. Observe all precautions when performing the Verification and Calibration Procedures.

WARNING	**HEED ALL WARNINGS AND CAUTIONS CONCERNING MAXIMUM VOLTAGES AND POWER INPUTS.**

3.2 TEST SET CALIBRATION

This section provides instructions on accessing and using the GPSG-1000 Series Calibration Function. The Calibration Function is an optional feature that is only available when the GPSG-1000 Calibration Option is installed on the Test Set.

The GPSG-1000 Calibration Function is a user-friendly automated system that has been integrated into the Test Set. On-screen instructions guide the user through selecting, running and performing each calibration procedure.

After a calibration procedure is selected and initiated, status indicators and messages are displayed throughout the procedure which provide instructions, feedback and calibration information.

Calibration Procedures should only be performed by Technicians familiar with the setup and operation of the required test equipment.

3.2.1 Calibration Schedule

System Calibration Procedure should be performed as a result of one or more of the following conditions:

Failure to Meet Specifications	If, during the course of normal operation, the Test Set or any major function thereof fails to meet the performance specifications.
Module/Assembly Replacement	If one or more of the Test Set assemblies are replaced.
2 Year Calibration/Verification	Aeroflex recommends Calibration/Verification on the Test Set every two years to maintain proper testing standards.

3.2.2 Preliminary Procedures

Perform the calibration procedure in its entirety. The procedure should be performed in the order that the procedure specifies. Some of the steps are dependent on successful completion of previous steps.

3.2.3 Test Setup

Calibration times are approximate and may vary slightly per unit. Procedures are listed in the order they appear on the Calibration menu screen.

3.2.4 Test Equipment

The test equipment listed is suitable for performing any procedure contained in this manual.

Required Test Equipment	Model
Frequency Counter	Agilent 52132A or equivalent
Measuring Receiver	Rhode & Schwarz FSMR or equivalent
Power Sensor	Rhode & Schwarz NRP-Z11 or equivalent
Spectrum Analyzer (optional)	Agilent E4407B
10 MHz Time Base Standard	
Coaxial Cables	
Adapter (N-TNC)	

3.2.5 Test Set Calibration Procedure

EQUIPMENT: Frequency Counter
Measuring Receiver
Coaxial Cables

STEP	PROCEDURE
1.	Allow the GPSG-1000 a 30 minute warm-up period before calibrating.
2.	Connect a 10 MHz source to both the Frequency Counter and the Measuring Receiver.
3.	Connect the Measuring Receiver to a calibrated signal source. Calibrate and save the Measuring Receiver in Tuned RF Levels at the following frequencies:

Frequency
1176.45 MHz
1207.14 MHz
1227.60 MHz
1278.75 MHz
1575.42 MHz

STEP	PROCEDURE

4. If an optional Spectrum Analyzer is used, setup the Spectrum Analyzer as follows:

Field	Setting
Center Frequency	Calibrated Frequency
Span	5 kHz
Attenuation	0 dB
Ref. Level	Calibrated Level Dependent
Log Scale	2 dB/div.
RBW	5 kHz
VBW	100 Hz
Sweep	10 ms
Display Average	On with # of averages = 10
Marker 1	On

5. If an external coaxial cable is used with the RF Output level calibration, record the coaxial cable loss at each of the frequencies listed in step 3.

3.2.6 Calibration Menu

The Calibration Window is enabled by pressing the Press the (symbol) key to scroll down to the Maintenance button on the Launch Bar and selecting Calibrations from the drop down menu.

STEP	PROCEDURE

1. Press the Down Arrow key to scroll down to the Maintenance key. Press the Maintenance key to display both the Calibration and Diagnostics sub keys. Press the Calibration key.
2. To enter the password touch the Password: rectangle box to display keyboard. Enter the password and press Enter key. Factory default password is **gpsg**.
3. RF Level Cal and RF Freq Cal keys will be displayed.

3.2.7 Reference Frequency Calibration

The Reference Frequency Calibration procedure is used to calibrate the INTERNAL 10 MHz OCXO. Specification: 10 MHz $\pm$ 1 Hz.

STEP	PROCEDURE
1.	Press the RF Freq Cal key.
2.	Press the Abort key to abort the calibration procedure without saving the calibration values and return to the main menu.
3.	Attach a coaxial cable from the REF OUT 10 MHz connector to the input of the Frequency Counter.
4.	Set the Frequency Counter to gate time of 500 mS and with an input impedance of 50 ohms.
5.	Press the Value: rectangle box to display keypad.
6.	Adjust the value using either the keypad enter or with the scroll bar and press Enter to review the change. Repeat as required until the 10 MHz reference frequency is within 10 MHz $\pm$ 1 Hz.
7.	Press the Done key to save the calibration value. The GPSG-1000 will exit back to the main menu.

3.2.8 Output Level Calibration

The Output Level Calibration procedure calibrates the Antenna Coupler RF and Direct RF port output level. Specification: RF Level at $\pm$ 0.5 dB.

STEP	PROCEDURE
1.	Press the RF Level Cal key.
2.	Press the Abort key to abort the calibration procedure without saving the calibration values and return to the main menu.
3.	Press the Back key to return to the previous calibration menu.
4.	Connect the Measuring Receiver (or Spectrum Analyzer) to the GPS TX Coupler port.
5.	Set the Measuring Receiver (or Spectrum Analyzer) to 1176.45 MHz or desired output frequency.
6.	Press the Value: rectangle box to display keypad.
7.	Adjust the value using the keypad enter or scroll bar and press Enter to review the change. Repeat as required until the RF output level is within -55 dBm $\pm$ 0.5 dB.
8.	Press the Next key.
9.	Adjust the value using the keypad enter or the scroll bar and press Enter to review the change. Repeat as required until the RF output level is within -86 dBm $\pm$ 0.5 dB.
10.	Press the Next key.
11.	Connect the Measuring Receiver (or Spectrum Analyzer) to the GPS TX Direct port.
12.	Adjust the value using the keypad enter or the scroll bar and press Enter to review the change. Repeat as required until the RF output level is within -80 dBm $\pm$ 0.5 dB.
13.	Press the Next key.
14.	Repeat steps 1 thru 13, using the values 1227.60, 1278.75 and 1575.42 MHz to set the Measuring Receiver (or Spectrum Analyzer) in step 5.
15.	Press the Cal End key to save the calibration values. The GPSG-1000 will exit back to the main menu.

3.3 TEST SET VERIFICATION

3.3.1 Verification Schedule

Verification Procedures should be performed as a result of one or more of the following conditions:

Failure to Meet Specifications	If, during the course of normal operation, the Test Set or any major function thereof fails to meet performance specifications.
Assembly Replacement	If one or more of the Test Set assemblies are replaced.
Annual Calibration/Verification	Aeroflex recommends Calibration/Verification on the Test Set every year to maintain proper testing standards.

3.3.2 Precautions

The Verification Procedures are performed with the Test Set covers in place. No internal adjustments or probing points are required.

3.3.3 Test Equipment

The test equipment listed is suitable for performing any procedure contained in this manual.

Required Test Equipment	Model
Frequency Counter	Agilent 52132A or equivalent
Measuring Receiver	Rhode & Schwarz FSMR or equivalent
Power Sensor	Rhode & Schwarz NRP-Z11 or equivalent
Network Analyzer	HP 8753D or equivalent
Spectrum Analyzer	Agilent E4407B or equivalent
Signal Generator	Aeroflex IFR-3412 or equivalent
Oscilloscope	Tektronix TDS 2024B or equivalent
ARB Generator	Agilent 33220A or equivalent
DMM	Fluke 73 or equivalent
RF Amplifier	Low Noise with 50 dB gain
10 MHz Time Base Standard	
Coaxial Cable	
Ethernet Cable	
Adapter (N-TNC)	

3.3.4 Test Setup

The Test Setup lists the general requirements for verifying the GPSG-1000 operation.

EQUIPMENT: Frequency Counter
Measuring Receiver
Coaxial Cable

STEP	PROCEDURE
1.	Verify the battery is fully charged before running the verification tests.
2.	Allow the GPSG-1000 a 30 minute warm-up period before running the tests.
3.	Connect a 10 MHz source to both the Frequency Counter and the Measuring Receiver.
4.	Connect the Measuring Receiver to a calibrated signal source. Calibrate and save the Measuring Receiver Tuned RF Levels at the following frequencies: 1176.45 MHz 1207.14 MHz 1227.60 MHz 1278.75MHz 1575.42 MHz
5.	If an external coaxial cable is used with the RF Output level calibration, record the coaxial cable loss at each of the frequencies listed in step 4.

3.3.5 Preset Conditions

Set the GPSG-1000 to factory default mode for product verification.

STEP	PROCEDURE
1.	Press File.
2.	Press Settings.
3.	Press Default.
4.	Verify the yellow bubble indicates Default Settings Loaded.

3.3.6 Remote Communication

The Remote Communication procedure checks the GPSG-1000 ethernet, USB port and internal drive operation.

EQUIPMENT: Ethernet Cable

STEP	PROCEDURE
1.	Connect an ethernet cable from the GPSG-1000 to a local area network hub.
2.	Setup the GPSG-1000 and press: System System Configuration Network Network Mode Select DHCP.
3.	In the Network screen, the GPSG-1000 will acquire and display the IP address. example: 10.123.456.789
4.	Using a network communication terminal program, such as PuTTY, enter the IP address displayed by the GPSG-1000. Select Telnet connection type and set the port to 5025.
5.	Send the command ***IDN?** twice to the GPSG-1000.
6.	The GPSG-1000 will respond with: Aeroflex,GPSG-1000,(test set serial number),(software version,date,time) example: Aeroflex,GPSG-1000,10002000901,201203271213
7.	Send the command **GPS:SET:RSRC?** to query the SPSG-1000 external reference source.
8.	The GPSG-1000 will reply INTERNAL.
9.	Send the command **GPS:SET:RSRC EXTERNAL** to the GPSG-1000 to set the external reference source to external.
10.	Send the query **GPS:SET:RSRC?** and verify response is **EXTERNAL**.
11.	Send the command **GPS:SET:RSRC INTERNAL** to the GPSG-1000 to set the external reference source to internal.
12.	Setup the GPSG-1000 and press: System System Configuration Network Network Mode Select DHCP Network Off.
13.	Check the USB port operation by plugging a USB Flash memory stick into either of the USB ports.
14.	Setup the GPSG-1000, press: File Settings Export to USB Yellow bubble indicates Settings Export Successful.
15.	Setup the GPSG-1000, press: File Settings Import to USB Yellow bubble indicates Settings Import Successful.

STEP	PROCEDURE
16.	Unplug the USB flash memory drive stick from the USB port.
17.	Check the operation of the internal drive by saving and retrieving a file. Setup the GPSG-1000, press: File Settings Manage Press File Name and enter **test** using popup keyboard. Press Save to close Manage Setting popup. Current Settings File displays **test**. Press Manage then File name and enter **new1** using the popup keyboard. Press Save to close Manage Setting popup. Current Settings file displays **new1**.
18.	Setup the GPSG-1000, press: File Settings Load Select **test** in Load Settings Press Open to close Manage Setting popup. Current Settings file displays **test**.
19.	Setup the GPSG-1000, press: File Settings Manage Select **test**. Press Delete to display Yes, indicating the file **test** has been removed. Press Manage and select **test1**. Press Delete to display Yes, indicating the **new1** file has been removed. Close popup.
20.	Setup the GPSG-1000, press: File Settings EDefault Yellow bubble indicates Default Settings Loaded.

3.3.7 Static Simulation

The Static Simulation procedure checks the GPSG-1000 simulator operation.

EQUIPMENT: Coaxial Cable

STEP	PROCEDURE
1.	Connect a coaxial cable from GPS TX COUPLER output port to GPS RX ANT input port.
2.	From the Launch bar press the SETUP button and enter the following data into each field:

Setup Field	Setup Data
Simulation	
GNSS	GPS
Carrier	L1
SBAS	Auto
Simulation	Static
Digital Noise	On
Fading	None
PRN Signal	Fixed
Position Source	User
Clock	User Setting
RF Level	-120.0 dBm
RF Port	Coupler
Channels	
Total SV's	12, then press Apply
I/O	
Coupler Loss	0.0 dB
Coupler Cable	0.0 dB
Direct Cable	0.0 dB
Ext Ref Out	OFF
Reference Source	INT
Trigger	Auto

3. Return to the Launch bar and press the Simulation button.

Setup Field	Setup Data
GPS	
Latitude	37°38.9966N
Longitude	39°25.9834W
Altitude	1333 ft
Run	

STEP PROCEDURE

4. Verify the following results on the Simulation/GPS page functions:

Simulation Field	Simulation Results
GPS	
Running	Green light
Current Sim Date	Using starting date from Setup/Simulation page
Current Sim Time	Using starting time from Setup/Simulation page and counting up at one second rate
Latitude	Locked and cannot be changed
Longitude	Locked and cannot be changed
Altitude	Locked and cannot be changed
Visible SVs	Note quantity visible
SV PRN	Quantity of SV's indicated must equal Visible SVs
Elapsed Time	Counting up at one second rate
From	Blank
To	Blank
Heading	Blank
Speed	0 mph
Distance To Go	0 ft

3.3.8 GPS Receiver Test and Loopback Operation

The GPS Receiver Test and Loopback Operation procedure checks the built-in receiver operation.

EQUIPMENT: Coaxial Cable

STEP	PROCEDURE
1.	Connect a coaxial cable from GPS TX COUPLER output port to GPS RX ANT input port.
2.	Press GPS RX, then press GPS Receiver Reset.
3.	Wait one minute, then verify the following data:

Field	Data
Current Date	Displays the same date from the Setup/Simulation page
Current Time	Displays the same time from the Setup/Simulation page
Position Fix	3D solution
Latitude	Similar to Latitude on Simulation screen
Longitude	Similar to Longitude on Simulation screen
Altitude	Similar to Altitude on Simulation screen
Speed	<=0.1 Mph
Active Satellites	Identical to the satellites being simulated on Simulation screen
SNR	>45 dBc for each satellite (unit is dB-Hz Carrier-to-Noise Density C/No)

STEP	PROCEDURE

4. From the Launch bar select Simulation. Press the Stop button to stop the simulation. From the Launch bar select Setup and enter the following data into each field:

Setup Field	Setup Data
Simulation	
GNSS	GPS
Carrier	L1
SBAS	Off
Simulation	Static
Digital Noise	Off
Fading	None
PRN Signal	Fixed
Position Source	User
Clock	User Setting
RF Level	-125.0 dBm
RF Port	Direct
Channels	
Total SV's	12, then press Apply
I/O	
Coupler Loss	0.7 dB
Coupler Cable	1.0 dB
Direct Cable	2.2 dB
Ext Ref Out	OFF
Reference Source	INT
Trigger	Auto

5. From the Launch bar select Simulation.

Setup Field	Setup Data
GPS	
Latitude	33° 57.8884S
Longitude	18° 36.1000E
Altitude	151 ft
Run	

STEP	PROCEDURE
6.	Remove the coax cable for the GPS TX COUPLER port and connect it to the GPS TX DIRECT port. From the Launch bar select GPS RX.
7.	Wait one minute, then verify the following data:

Field	Data
Current Date/Time	Displays the same date from the Setup/Simulation page
Position Fix	3D solution
Latitude	Similar to Latitude on Simulation screen
Longitude	Similar to Longitude on Simulation screen
Altitude	Similar to Altitude on Simulation screen
Speed	<=0.1 Mph
Active Satellites	Identical to the satellites being simulated on Simulation screen
SNR	>45 for each satellite (unit is dB-Hz Carrier-to-Noise Density C/No)

8.	From the Launch bar select Simulation. Press Stop to stop the simulation.
9.	Disconnect the coaxial cable from the GPS RX ANT input port.
10.	With the DMM, measure the GPS antenna bias voltage between the center conductor to the outside side housing. GPS antenna bias voltage should be 2.85 ± 0.1 VDC

3.3.9 External Trigger Input

The External Trigger Input procedure verifies the External Trigger Input functionality.

EQUIPMENT: ARB Generator

STEP	PROCEDURE

1. Setup the ARB Generator with the following data:

Setup Field	Setup Data
High Impedance Output	
Pulse Function	
Pulse Width	100 uS
Amplitude Level	low = 0 V; high = 3.3 V
Burst	1 cycle with manual trigger
Output	On

2. Connect the output from the ARB Generator to the AUX connector.
   Input: Pin 19
   Ground: Pin 26

STEP	PROCEDURE

3. From the Lunch bar select Simulation. Press the Stop button to stop the simulation. From the Launch bar select Setup and enter the following data into each field.

Setup Field	Setup Data
Simulation	
GNSS	GPS
Carrier	L1
SBAS	Off
Simulation	Static
Digital Noise	Off
Fading	None
PRN Signal	Fixed
Position Source	User
Clock	User Setting
RF Level	-125.0 dBm
RF Port	Direct
Channels	
Total SV's	12, then press Apply
I/O	
Coupler Loss	0.7 dB
Coupler Cable	1.0 dB
Direct Cable	2.2 dB
Ext Ref Out	OFF
Reference Source	INT
Trigger	External

4. From the Launch bar select Simulation.

Setup Field	Setup Data
GPS	
Latitude	33° 57.8884S
Longitude	18° 36.1000E
Altitude	151 ft
Run	

STEP	PROCEDURE

5. Verify the following operations:

Field	Data
Setup I/O	
Trigger	External
Simulation GPS	
Configuring	Green light
Current Sim Date	Blank
Current Sim Time	Blank
Latitude	Locked, cannot be changed
Longitude	Locked, cannot be changed
Altitude	Locked, cannot be changed
Visible SVs	Blank
SV PRN	Blank
Elapsed Time	Blank
From	Blank
To	Blank
Heading	Blank
Speed	0 mph
Distance to go	0 ft

STEP	PROCEDURE

6. Press the manual trigger button on the ARB Generator and verify the following operations:

Field	Data
Simulation GPS	
Running	Green light
Current Sim Date	Using starting date from the Setup/Simulation page
Current Sim Time	Using starting date from the Setup/Simulation page and counting up at one second rate
Latitude	Locked and cannot be changed
Longitude	Locked and cannot be changed
Altitude	Locked and cannot be changed
Visible SVs	Note quantity visible
SV PRN	Quantity of SVs indicated must equal Visible SVs
Elapsed Time	Count up at one second rate
From	Blank
To	Blank
Heading	Blank
Speed	0 mph
Distance to go	0 ft

7. From the Lunch bar select Simulation. Press the Stop button to stop the simulation.
8. Disconnect the ARB Generator from the GPSG-1000.

3.3.10 Internal 10 MHz Reference

The Internal 10 MHz Reference procedure verifies the accuracy of the internal 10 MHz clock source.

EQUIPMENT: Frequency Counter
Coaxial Cable

STEP	PROCEDURE

1. Setup the Frequency Counter as follows:

Field	Setting
Input Port	CH1
Input Impedance	50 Ω
Gate Time	500 mS
Pulse Width	100 uS

2. Connect a coaxial cable from the REF OUT 10 MHZ connector on the GPSG-1000 to the channel 1 input on the Frequency Counter.
3. Setup the GPSG-1000 and verify the following operations:
   Setup I/O
   Reference Source INT
   Ext Ref Out ON
4. Verify the measured frequency:
   Spec = 10.0 MHz +/- 10 Hz
5. Reconfigure the Frequency Counter as follows:

Field	Setting
Input Port	CH1
Input Impedance	50 Ω
Other Meas	Volt Peaks 1
Input	DC

6. Verify the measured amplitude output level:
   Spec = 1.5 Vpp +/- 0.2 Vpp into 50 Ω

3.3.11 External 10 MHz Reference

The External 10 MHz Reference procedure verifies the operation of the external 10 MHz input.

EQUIPMENT: Frequency Counter
Signal Generator
Coaxial Cable

STEP PROCEDURE

1. Setup the Frequency Counter as follows:

Field	Setting
Input Port	CH1
Input Impedance	50 Ω
Gate Time	500 mS
Pulse Width	100 uS

2. Connect a coaxial cable from the REF OUT 10 MHZ connector on the GPSG-1000 to the channel 1 input on the Frequency Counter.
3. From the Launch bar select Maintenance, then Diagnostics from the drop down menu. Press Maintenance and verify the following diagnostic operations:

Field	Setting	Indication
Reference Source	EXT	
EXT REF OUT	ON	
PLL Lock Status	LO	Green/Locked
PLL Lock Status	800 MHz	Green/Locked
PLL Lock Status	EXT.REF	No Light
PLL Lock Status	EXT.REF DET	Green/Locked

4. Setup the Signal Generator:
   Frequency 10 MHz
   Output Level +/- 10 dBm
5. Connect a coaxial cable from the REF IN 10 MJHZ connector on the GPSG-1000 to the RF output port of the Signal Generator.

STEP	PROCEDURE

6. Setup the GPSG-1000, press Maintenance and verify the following diagnostic operations:

Field	Setting	Indication
Reference Source	EXT	
EXT REF OUT	ON	
PLL Lock Status	LO	Green/Locked
PLL Lock Status	800 MHz	Green/Locked
PLL Lock Status	EXT.REF	Green/Locked
PLL Lock Status	EXT.REF DET	Green/Locked

7. Verify the measured frequency:
   Spec = 10,000,000 Hz +/- 10 Hz
8. Change the output frequency on the Signal Generator to 10,000 010 Hz and verify the frequency increases by 10 Hz on the Frequency Counter.
   Spec = + 10 Hz +/- 0.1 Hz
9. Change the output frequency on the Signal Generator to 9,999,990 Hz and verify the frequency increases by 10 Hz on the Frequency Counter.
   Spec = + 10 Hz +/- 0.1 Hz
10. On the Diagnostics screen set the GPSG-1000 to the following:

Field	Setting
Reference Source	INT
EXT REF OUT	OFF

3.3.12 VSWR at Antenna Port

The VSWR at Antenna Port procedure verifies the VSWR of the Antenna Port.

EQUIPMENT: Network Analyzer
Coaxial Cable

STEP	PROCEDURE

1. Setup the Network Analyzer and calibration port and coaxial cable together. Verify the following:

Field	Setting
Input Port	Port 1
Start Frequency	1.0 GHz
Stop Frequency	1.6 GHz
Meas	S_{11}
Format	VSWR

2. Connect the coaxial cable to the GPS TX ANT COUPLER port.
3. From the Launch bar select Setup. On the Simulation screen set RF Output RF Port to Direct and verify the following operations:
   Setup Simulation
   RF Port Coupler
4. Measure and verify that VSWR is below 1.5:1 across the frequency range.
   Spec = VSWR < 1.5:1

3.3.13 VSWR at Direct Port

The VSWR at Direct Port procedure verifies the VSWR of the Direct Port.

EQUIPMENT: Network Analyzer
Coaxial Cable

STEP	PROCEDURE

1. Setup the Network Analyzer, calibration port and coaxial cable together. Verify the following:

Field	Setting
Input Port	Port 1
Start Frequency	1.0 GHz
Stop Frequency	1.6 GHz
Meas	S_{11}
Format	VSWR

2. Connect the coaxial cable to the GPS TX DIRECT port.
3. Setup the GPSG-1000 and verify the following operations:
   Setup Simulation
   RF Port Direct
4. Measure and verify that VSWR is below 1.5:1 across the frequency range.
   Spec = VSWR < 1.5:1

3.3.14 RF Output Frequency

The RF Output Frequency procedure measures the accuracy of the different frequencies generated by the GPSG-1000.

EQUIPMENT: Measuring Receiver
Coaxial Cable

STEP	PROCEDURE

1. Setup the Measuring Receiver as follows:

Field	Setting
Mode	Spectrum Analyzer
Frequency	1176.45 MHz
Amplitude	-50 dBm
Span	10 kHz/div
Format Marker 1	On peak

2. Connect the Measuring Receiver to the GPS TX ANT COUPLER port.
3. From the Launch bar select Setup and verify the following operations:

Field	Data
Setup Simulation	
RF Port	Coupler

4. From the Launch bar select Maintenance, then Diagnostics from the drop down menu.

Field	Data
Maintenance Diagnostics	
Frequency	1176.45 MHz
Amplitude	-68 dBm
Mode	CW

5. Measure and verify the output frequency on the Measuring Receiver is within specifications.
   Spec = 1176.45 MHz +/- 1000 Hz
6. Measure and record the following output frequencies:

Spec
1207.14 MHz +/- 1000 Hz
1227.60 MHz +/- 1000 Hz
1278.75 MHz +/- 1000 Hz
1575.42MHz +/- 1000 Hz

7. Set Mode to Off.

3.3.15 RF Output Harmonics

The RF Output Harmonics procedure measures the accuracy of the different harmonics generated by the GPSG-1000.

EQUIPMENT: Measuring Receiver
Coaxial Cable

STEP PROCEDURE

1. Setup the Measuring Receiver as follows:

Field	Setting
Mode	Spectrum Analyzer
Frequency	1176.45 MHz
Amplitude	-50 dBm
Span	200 Hz/div
RBW	10 Hz
Sweep Time	20 S

2. Connect the Measuring Receiver to the GPS TX ANT COUPLER port.
3. From the Launch bar select Setup and verify the following operations:

Field	Data
Setup Simulation	
RF Port	Coupler

4. From the Launch bar select Maintenance, then Diagnostics from the drop down menu.

Field	Data
Maintenance Diagnostics	
Frequency	1176.45 MHz
Amplitude	-68 dBm
Mode	CW

5. Measure and verify that the 2nd and 3rd harmonic levels output from the GPSG-1000 on the Measuring Receiver is within specifications.
   Spec = 2nd and 3rd harmonics < -45 dBc

STEP	PROCEDURE

6. Measure and record the 2nd and 3rd harmonic levels at the following output frequencies:

Spec
1207.14 MHz at 2nd and 3rd harmonics < -45 dBc
1227.60 MHz at 2nd and 3rd harmonics < -45 dBc
1278.75 MHz at 2nd and 3rd harmonics < -45 dBc
1575.42MHz at 2nd and 3rd harmonics < -45 dBc

7. Set Mode to Off.

3.3.16 RF Output Spurious Levels

The RF Spurious Levels procedure measures the accuracy of the different spurious levels generated by the GPSG-1000.

EQUIPMENT: Measuring Receiver
RF Amplifier

STEP	PROCEDURE

1. Setup the Measuring Receiver as follows:

Field	Setting
Mode	Spectrum Analyzer
Frequency	1176.45 MHz
Amplitude	-10 dBm
Span	4 Hz/div
RBW	500 Hz
VBW	2 kHz
Sweep Time	400 S

2. Connect the Measuring Receiver to the output of the RF Amplifier. Connect the input of the RF Amplifier to the GPS TX ANT COUPLER port.
3. From the Launch bar select Setup and verify the following operations:

Field	Data
Setup Simulation	
RF Port	Coupler

4. From the Launch bar select Maintenance, then Diagnostics from the drop down menu.

Field	Data
Maintenance Diagnostics	
Frequency	1176.45 MHz
Amplitude	-68 dBm
Mode	CW

5. Wait for the Measuring Receiver to complete the sweep. Measure and verify the spurious output levels are within specifications.
   Spec = 1176.45 MHz at < -35 dBc

STEP PROCEDURE

6. Measure and record the spurious levels at the following output frequencies:

Spec
1207.14 MHz at 2nd and 3rd harmonics < -35 dBc
1227.60 MHz at 2nd and 3rd harmonics < -35 dBc
1278.75 MHz at 2nd and 3rd harmonics < -35 dBc
1575.42MHz at 2nd and 3rd harmonics < -35 dBc

7. Set Mode to Off.

3.3.17 RF Output Level at Antenna Port

The RF Output Level at Antenna Port procedure measures the accuracy of the RF output level from the GPSG-1000 across the operation frequency and level range.

EQUIPMENT: Measuring Receiver
Coaxial Cable

STEP	PROCEDURE

1. Setup the Measuring Receiver as follows:

Field	Setting
Mode	Measuring Receiver
Frequency	1176.45 MHz
10 MHz Reference	External
Averaging	8

2. Connect a coaxial cable from the REF OUT 10 MHZ connector of the GPSG-1000 to the External Reference In on the Measuring Receiver. Connect the Measuring Receiver sensor head to GPS TX ANT COUPLER port on the GPSG-1000.
3. From the Launch bar select Setup and verify the following operations:

Field	Data
Setup Simulation	
RF Port	Coupler

4. From the Launch bar select Maintenance, then Diagnostics from the drop down menu.

Field	Data
Maintenance Diagnostics	
Frequency	1176.45 MHz
Amplitude	-68 dBm
Mode	CW

5. Measure and record the spurious levels at the following output frequencies:

Spec
1207.14 MHz -68 dBm +/- 2 dB
1227.60 MHz -68 dBm +/- 2 dB
1278.75 MHz -68 dBm +/- 2 dB
1575.42MHz -68 dBm +/- 2 dB

STEP	PROCEDURE

6. Set the GPSG-1000 for an RF output frequency of 1176.45 MHz and RF output level from -69 dBm to -73 dBm in 1 dB steps. Measure and record the output levels at the following frequencies:

Spec
1176.45 MHz 1 dB steps +/- 0.2 d
1207.14 MHz 1 dB steps +/- 0.2 dB
1227.60 MHz 1 dB steps +/- 0.2 dB
1278.75 MHz 1 dB steps +/- 0.2 dB
1575.42MHz 1 dB steps +/- 0.2 dB

7. Set the GPSG-1000 for an RF output frequency of 1176.45 MHz and RF output level from -80 dBm to -130 dBm in 10 dB steps. Measure and record the output levels at the following frequencies:

Spec
1176.45 MHz Setting Level +/- 0.2 dB
1207.14 MHz Setting Level +/- 0.2 dB
1227.60 MHz Setting Level +/- 0.2 dB
1278.75 MHz Setting Level +/- 0.2 dB
1575.42MHz Setting Level +/- 0.2 dB

3.3.18 RF Output Level at Direct Port

The RF Output Level at Direct Port procedure measures the accuracy of the RF output level from the GPSG-1000 across the operation frequency and level range.

EQUIPMENT: Measuring Receiver
Coaxial Cable

STEP	PROCEDURE

1. Setup the Measuring Receiver as follows:

Field	Setting
Mode	Measuring Receiver
Frequency	1176.45 MHz
10 MHz Reference	External
Averaging	8

2. Connect a Coaxial cable from the REF OUT 10 MHZ connector of the GPSG-1000 to the External Reference In on the Measuring Receiver. Connect the Measuring Receiver sensor head to GPS TX ANT COUPLER port on the GPSG-1000.
3. From the Launch bar select Setup and verify the following operations:

Field	Data
Setup Simulation	
RF Port	Coupler

4. From the Launch bar select Maintenance, then Diagnostics from the drop down menu.

Field	Data
Maintenance Diagnostics	
Frequency	1176.45 MHz
Amplitude	-68 dBm
Mode	CW

5. Set the GPSG-1000 for an RF output frequency of 1176.45 MHz and RF output level from -69 dBm to -73 dBm in 1 dB steps. Measure and record the output levels at the following frequencies:

Spec
1176.45 MHz 1 dB steps +/- 0.2 d
1207.14 MHz 1 dB steps +/- 0.2 dB
1227.60 MHz 1 dB steps +/- 0.2 dB
1278.75 MHz 1 dB steps +/- 0.2 dB
1575.42MHz 1 dB steps +/- 0.2 dB

STEP	PROCEDURE
6.	Set the GPSG-1000 for an RF output frequency of 1176.45 MHz and RF output level from -80 dBm to -130 dBm in 10 dB steps. Measure and record the output levels at the following frequencies:

Spec
1176.45 MHz Setting Level +/- 0.2 dB
1207.14 MHz Setting Level +/- 0.2 dB
1227.60 MHz Setting Level +/- 0.2 dB
1278.75 MHz Setting Level +/- 0.2 dB
1575.42MHz Setting Level +/- 0.2 dB

3.3.19 1 PPS Output Signal

The 1 PPS Output Signal procedure verifies the 1 PPS Output Signal characteristics.

EQUIPMENT: Oscilloscope
Coaxial Cable

STEP	PROCEDURE

1. Setup the Oscilloscope as follows:

Field	Setting
Vertical	1 V/div
Horizontal	20 mS/div
Trigger	2.5 V
Averaging	2

2. Connect the Oscilloscope to the 1 PPS output on the AUX connector as follows:

Field	Setting
Input	Pin 25
Horizontal Ground	Pin 26

3. From the Launch bar select Setup and enter the following data into each field:

Setup Field	Setup Data
Simulation	
GNSS	GPS
Carrier	L1
SBAS	Off
Simulation	Static
Digital Noise	Off
Fading	OFF
PRN Signal	Fixed
Position Source	User
Clock	User Setting
RF Level	-125.0 dBm
RF Port	Direct

4. From the Launch bar select Simulation, then Run.

STEP	PROCEDURE

5. Measure and verify the Amplitude and Pulse Width of the 1 PPS signal:

Spec	Setting
Amplitude	3.3 +/- 0.1 V
Pulse Width	100 +/- 1 mS

6. Change the Oscilloscope horizontal sweep rate to 200 mS/div.
7. Measure and verify the period of the 1 PPS signal is 1.0 +/- 0.1 second.
8. Turn off CW RF output and restore factory default settings. Turn off the GPSG-1000 at the power switch; Maintenance, Diagnostics, Mode, Off.
9. Verify File Settings Default displays yellow bubble indicating Default Settings Loaded.

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Chapter 4 - Remove/Install Procedures

4.1 GENERAL INFORMATION

This chapter contains Operator Level and Technician Level Maintenance procedures.

Operator Level Procedures can be performed by Operator Personnel. Technician Level Maintenance Procedures should only be performed by qualified Service Personnel. Prerequisite and follow-up instructions are identified as needed.

4.2 PRELIMINARY CONSIDERATIONS

4.2.1 Tools Requirements

TOOL	SIZE
Hex Screwdriver	2 mm, 2.5 mm, 3 mm
6” & 10” Screwdriver	Cross-recessed

Table 4-1 Remove/Install Tool Requirements

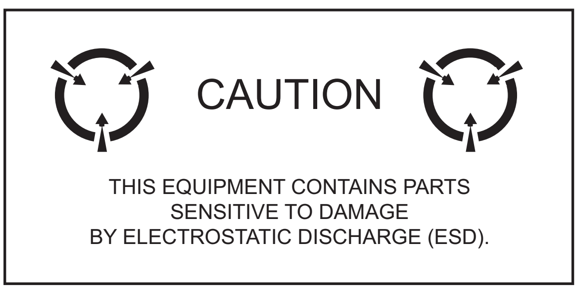
4.2.2 ESD and Safety Precautions

4.2.2.A Safety Precautions

Disconnect Test Set from AC Power Source before initiating any procedure.

WARNING	DANGEROUS VOLTAGES ARE PRESENT WHEN CASE ASSEMBLY IS REMOVED AND POWER IS PRESENT.

4.2.2.B ESD Precautions



CAUTION	THE TEST SET CONTAINS PARTS SENSITIVE TO DAMAGE BY ELECTROSTATIC DISCHARGE (ESD). ALL PERSONNEL PERFORMING DISASSEMBLY/REASSEMBLY PROCEDURES SHOULD HAVE KNOWLEDGE OF ACCEPTED ESD PRACTICES AND/OR BE ESD CERTIFIED.

4.2.3 Specified Replacement Screws

Specified replacement screws are pre-treated with grip adhesive.

4.2.4 Inverting Test Set

The Test Set can be inverted and stood on the Front Handles to remove/install the Case Assembly. The Test Set should not be left in an inverted position to perform any other remove/install procedures.

CAUTION	TO AVOID DAMAGING FRONT PANEL CONNECTORS, DO NOT INVERT THE GPSG-1000 IF THE FRONT HANDLES HAVE BEEN REMOVED.

4.2.5 Connectors and Cables

CAUTION	USE CARE WHEN DISCONNECTIONG CABLES TO AVOID DAMAGING CONNECTORS.

4.2.6 Preliminary Procedures

Aeroflex recommends that the Test Set's internal Calibration Files be saved to a USB device prior to servicing the unit.

Chapter 5 - Parts List

5.1 GENERAL INFORMATION

This chapter identifies GPSG-1000 serviceable parts and assemblies. Contact Aeroflex Customer Service regarding items not listed in this chapter.

Fig. 5-1 GPSG-1000 Radio Altimeter Test Set

5.2 PARTS LIST

5.2.1 Ship Unit, GPSG1000 (A1)

86993			A
ITEM	**PART NUMBER**	**CAGE CODE**	**DESCRIPTION**
05	87823	51190	GASKET,O-RING,HOUSING
08	87057	51190	LABEL, LEFT CONNECTOR, GPSG-1000
09	87058	51190	LABEL, RIGHT CONNECTOR, GPSG-1000
13	86950	51190	SM, M4 X .7 X 20, ABT, A2, PA, TL
14	87758	51190	SM, M4 X .7 X 30, ABT, A2, AB, TL
15	88354	51190	SM, M4 X .7 X 50, ABT, A2, PA, TL
22	87189	51190	SM, M4 X .7 X 45, ABT, A2, PA, TL
23	36272	51190	WASHER,NYL,.312OD,.171ID,.032T
27	89136	51190	TAPE,ACETATE CLOTH,4560
28	89493	51190	SPACER, BATTERY
A01	87014	51190	MECH ASSY, TOP
A02	86997	51190	MECH ASSY, BASE, GPS
BT01	86196	51190	BATTERY PACK LITHIUM ION 14.4V,6.75AHr
W01	88606	51190	PURCH CABLE ASSY,TOUCHSCREEN

5.2.2 Mechanical Assembly (A1A1)

87014			A
ITEM	**PART NUMBER**	**CAGE CODE**	**DESCRIPTION**
1	87872	51190	ENCLOSURE,TOP,"MACHINED"
2	86490	51190	BRACKET,LID SENSOR
3	87016	51190	GASKET, TOUCH SCREEN
4	34253	51190	GASKET,SILICON SEAL,.25W,062TH
5	86593	51190	SHIELD, DISPLAY
6	86173	51190	MAGNET 3/8 X 1/4
7	71387	51190	WASHER NYLON .228 OD .122 ID .
8	36238	51190	WASHER,LOCK,INT TOOTH,4
9	37769	51190	NUT,HEX,REG PAT,4-40
10	87387	51190	WSHR, M3 INTL LK, 6MM O.D., .4MM THK, A2
11	87190	51190	SM, M3 X .5 X 5, ABT, A2, PA, TL
12	86971	51190	SM, M3 X .5 X 6, ABT, A2, PA, TL
13	87416	51190	ADHESIVE, ACRYLIC, LOCTITE 331 MAGNET
14	7092	51190	7387 ACTIVATOR
15	7090	51190	TAPE, SCOTCH VHB 1/2" WIDE
16	89136	51190	TAPE,ACETATE CLOTH,4560
A01	88607	51190	PURCH ASSY,DRIVER BD,LED,LOW PROFILE,8W
A02	87732	51190	PURCH ASSY,PANEL,CONTROL
A03	88608	51190	PURCH,168,COLOR,12.1" SVGA TFT,1000 NITS
A04	88609	51190	PURCH,TOUCH SCREEN,12.1",RESISTIVE,GLASS
A05	88610	51190	PURCH ASSY,CONTROLLER,TOUCHSCREEN, 5W,USB

5.2.3 Base Mechnical Assembly (A1A2)

86997			A
ITEM	**PART NUMBER**	**CAGE CODE**	**DESCRIPTION**
1	89703	51190	ENCLOSURE, BASE, GPS, HHCP
2	87818	51190	COVER,RUBBER,BNC/TNC
3	87819	51190	COVER, RUBBER,26 PIN
4	87416	51190	ADHESIVE, ACRYLIC, LOCTITE 331 MAGNET
5	7092	51190	7387 ACTIVATOR
6	85656	51190	WASHER,M3 FLAT,7MMOD,.5MM THK
7	88285	51190	DUST COVER,MINI USB,BLACK
8	87387	51190	WSHR, M3 INTL LK, 6MM O.D., .4MM THK, A2
9	86964	51190	SM, M3 X .5 X 8, ABT, A2, PA, TL
11	86971	51190	SM, M3 X .5 X 6, ABT, A2, PA, TL
12	88286	51190	DUST COVER,USB,BLACK
13	86173	51190	MAGNET 3/8 X 1/4
14	86594	51190	GASKET,BATTERY CAVITY
15	86973	51190	SM, M3 X .5 X 4, ABT, A2, PA
16	87852	51190	COVER,ETHERNET
17	10259	51190	COVER,MINI POWER JACK
18	35530	51190	SCREW,2-56 X 1/4 PPHM
19	88052	51190	LABEL,DC IN
20	86500	51190	KIT, ub D locking with hardware
21	89136	51190	TAPE,ACETATE CLOTH,4560
23	87386	51190	NUT, HEX, M3 X .5, THIN, A2
24	71038	51190	NUT HEX #2 SM PAT SS
25	89192	51190	SM,M3 X .5 X10,ABT,A2,PA,CS
26	89194	51190	SM,2-56 x 3/8,P BH,SS,PA, TL,CS
27	86963	51190	SM, M3 X .5 X 10, ABT, A2, PA, TL
28	88699	51190	RETAINER, RIBBON CBL, DIGITAL-CONVERTER
A01	66349	51190	PCB ASSY,HHCP REAR PANEL I/O
A02	87000	51190	MECH ASSY, CHASSIS, GPS
A03	85904	51190	PCB ASSY, BATTERY INTERFACE,HHCP
A04	66350	51190	PCB ASSY,GPS RX
A05	87334	51190	PCB ASSY,AUX INTERFACE ADAPTER,GPS
J01	20953	51190	CONN,F,BNC,BH,ADP,SMB,WTRPRF
J02	20952	51190	CONN,F,TNC,BH,ADP,SMA,WTRPRF
J03	20952	51190	CONN,F,TNC,BH,ADP,SMA,WTRPRF
J05	20953	51190	CONN,F,BNC,BH,ADP,SMB,WTRPRF
J06	20953	51190	CONN,F,BNC,BH,ADP,SMB,WTRPRF
W01	87002	51190	CABLE ASSY, POWER, "Y"
W011	88992	51190	COAX ASSY,RG316,5.5,SMB-F-RA/SSMB-F-ST

Chapter 6 - Assembly and Interconnect Drawings

6.1 DRAWINGS LIST

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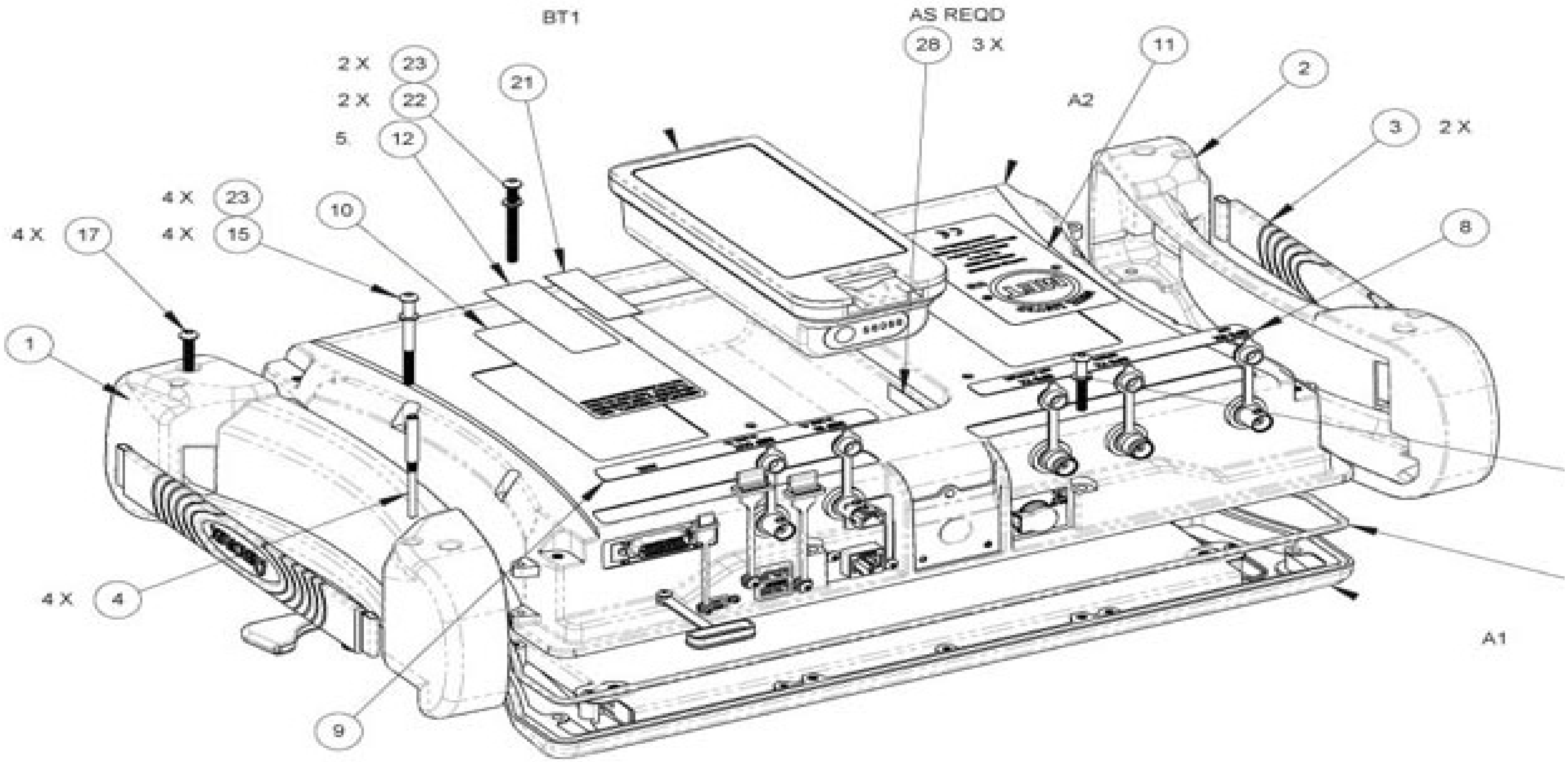


Fig. 6-1 GPSG-1000 Ship Unit (A1)
(Sheet 1 of 2)

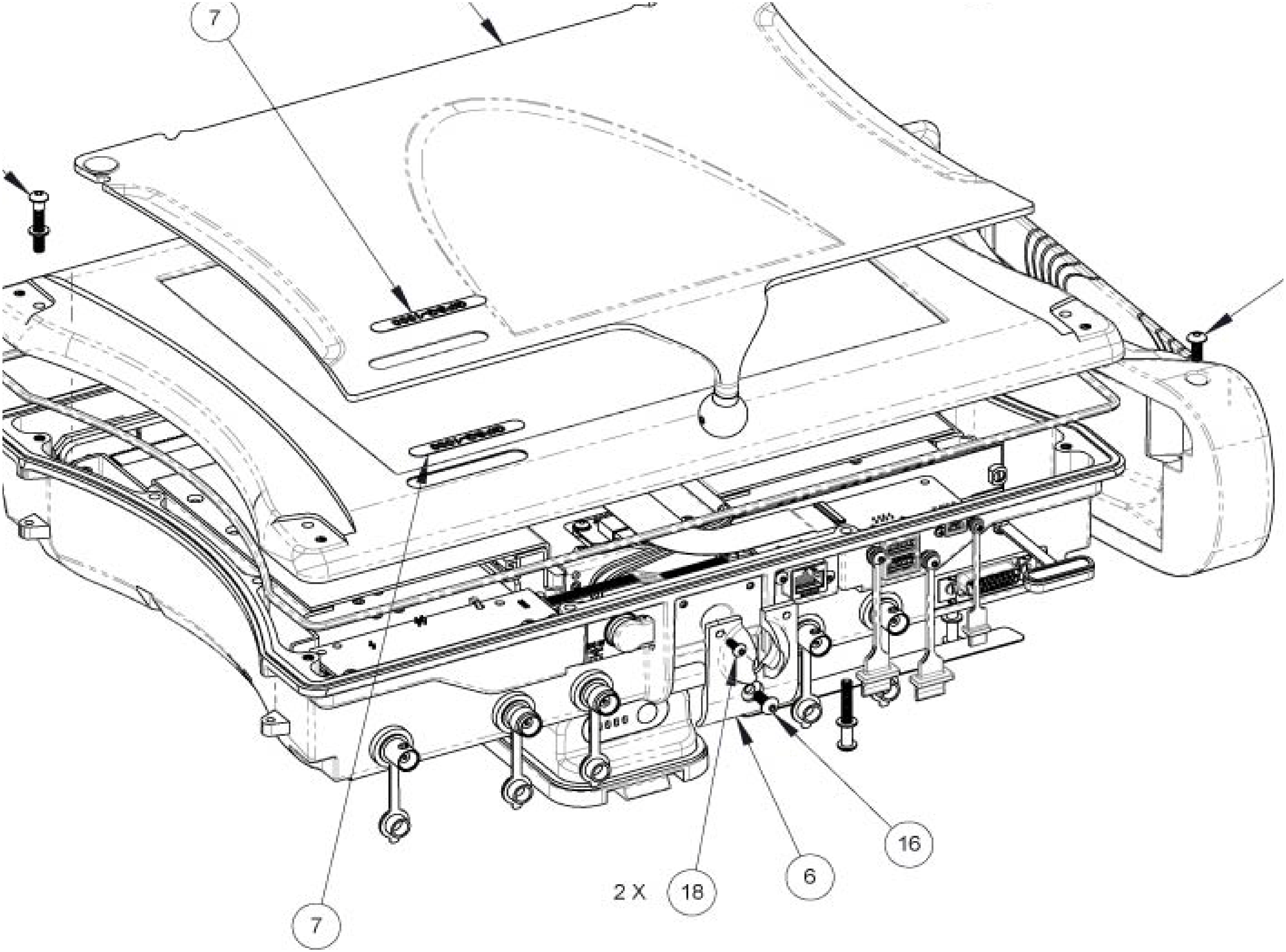


Fig. 6-2. GPSG-1000 Ship Unit (A1)

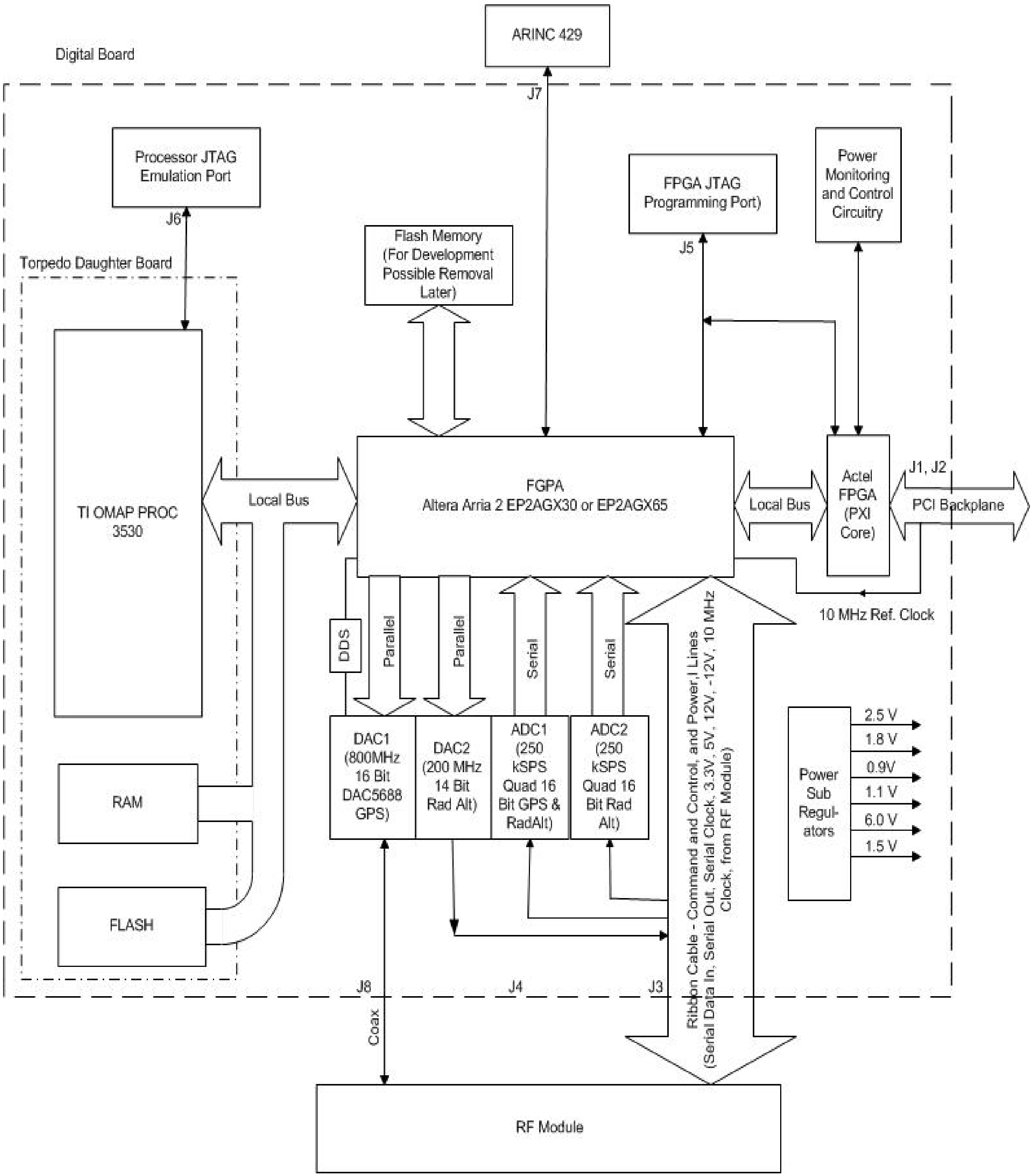


Fig. 6-3 GPSG-1000 Interconnect and Block Diagram

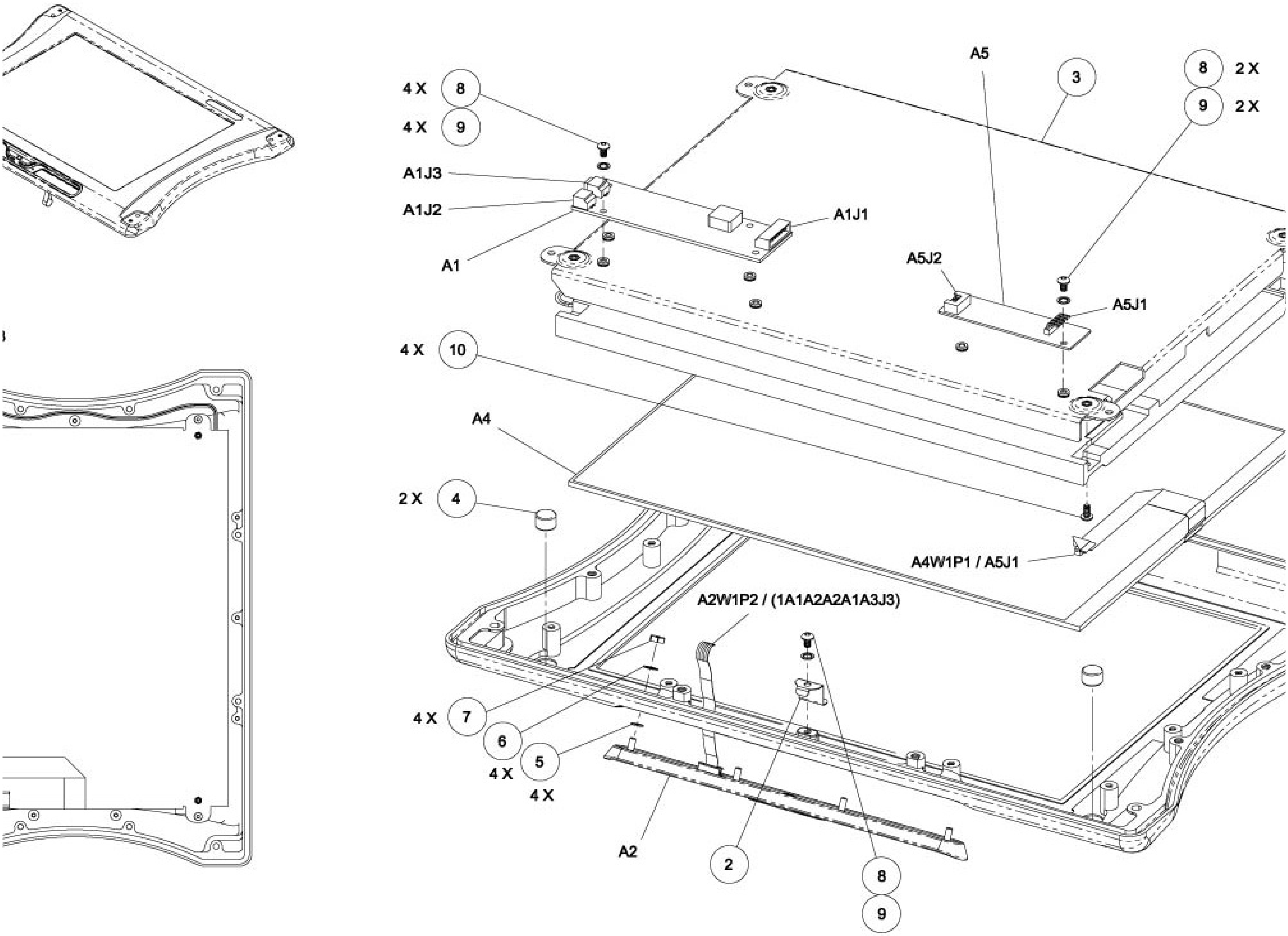


Fig. 8-4. CPSC-1000 Mechanical Assembly (A1A1)

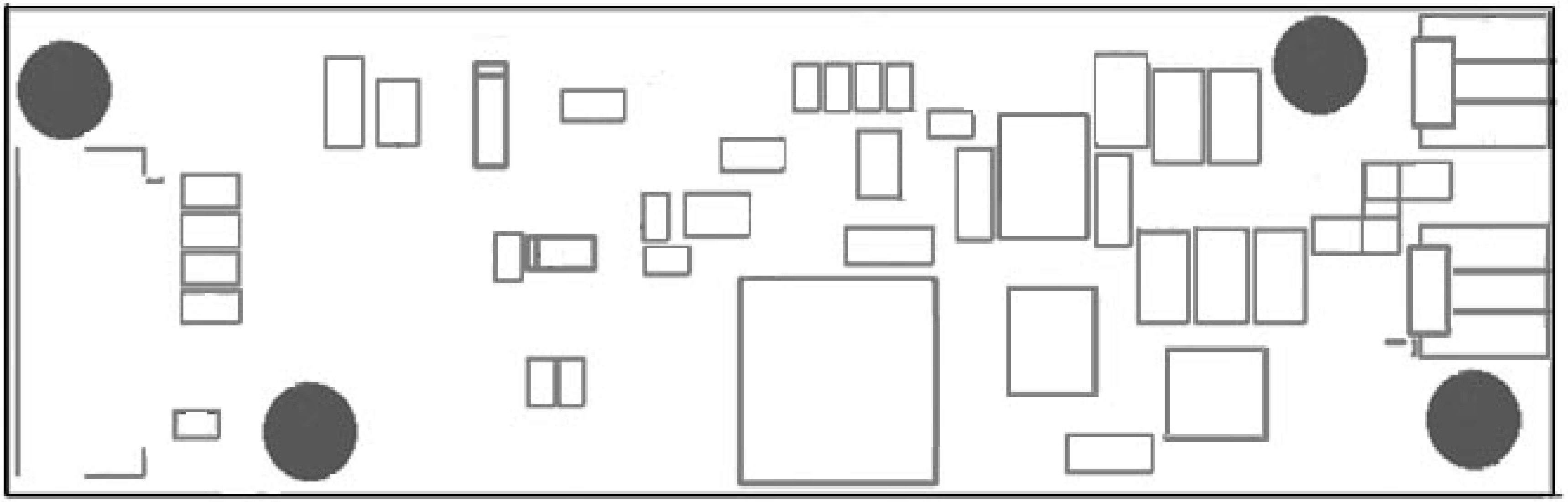


Fig. 6-5 GPSG-1000 Driver Board Assembly (A1A1A1)

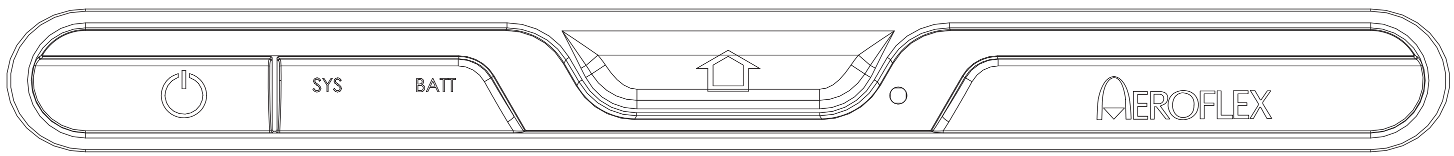


Fig. 6-6 GPSG-1000 Panel Control Assembly (A1A1A2)

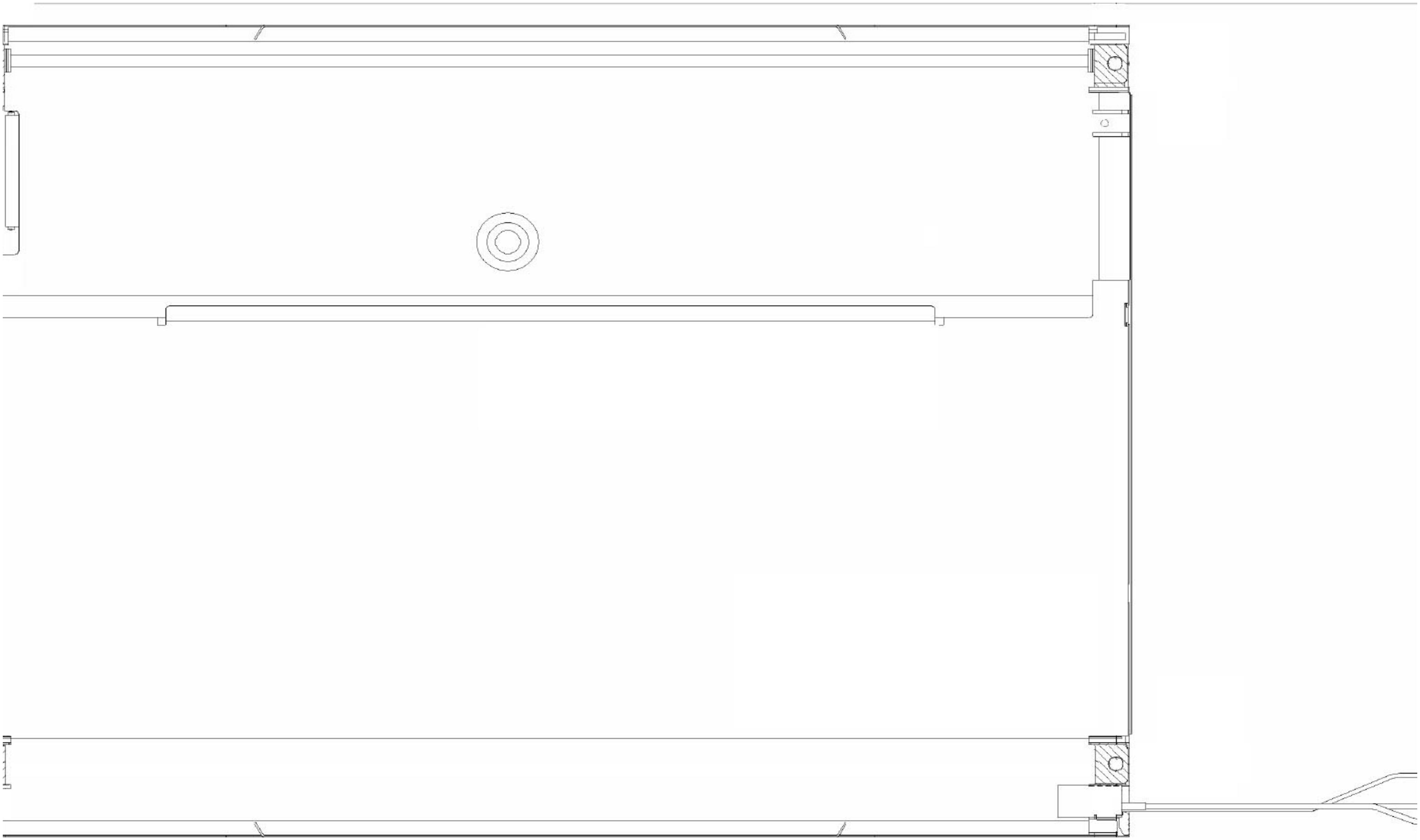


Fig. 6-7 GPSG-1000 168 Color 12.1" SVGA TFT 1000 NITS Assembly (A1A1A3)

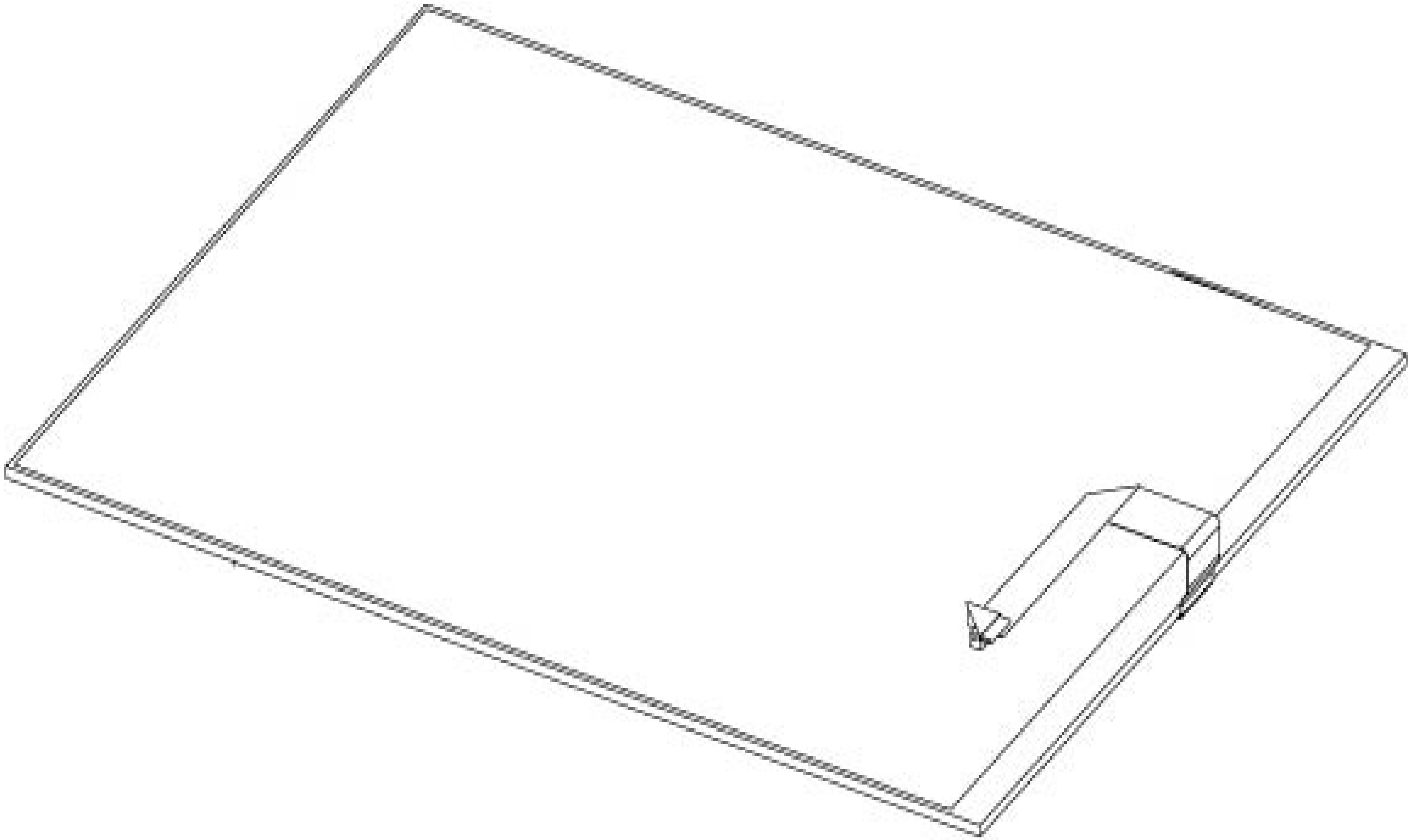


Fig. 6-8. GPSG-1000 Touchscreen Assembly (A1A1A4)

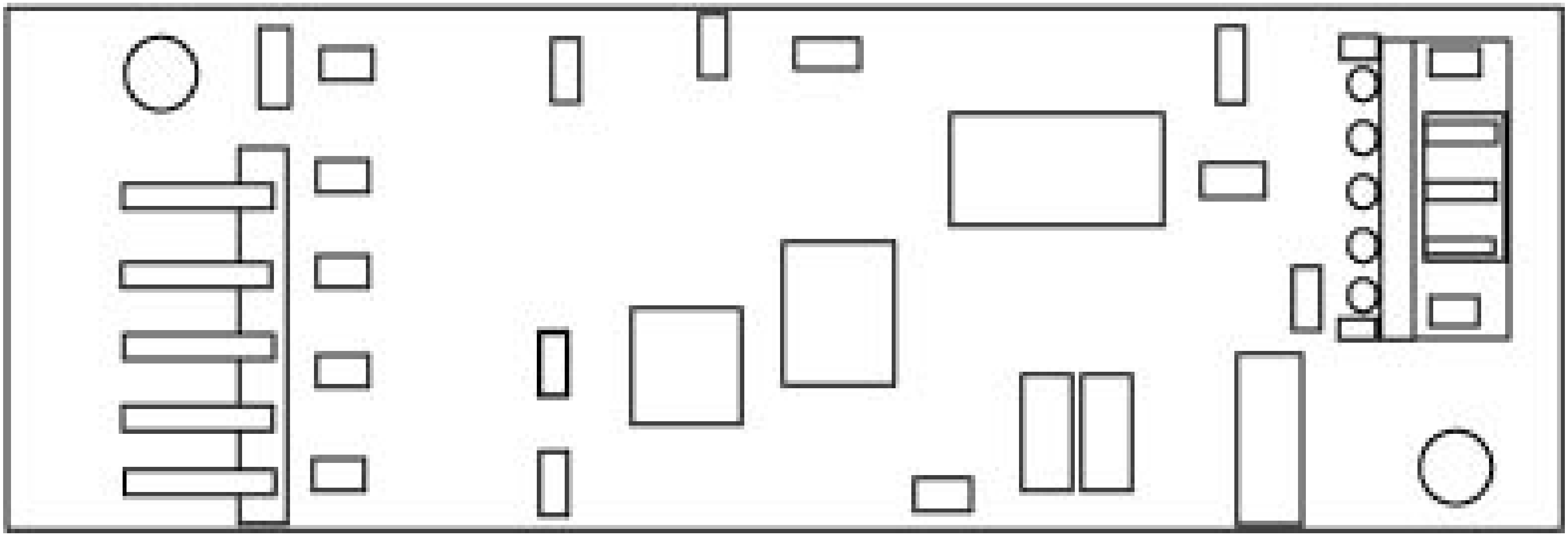
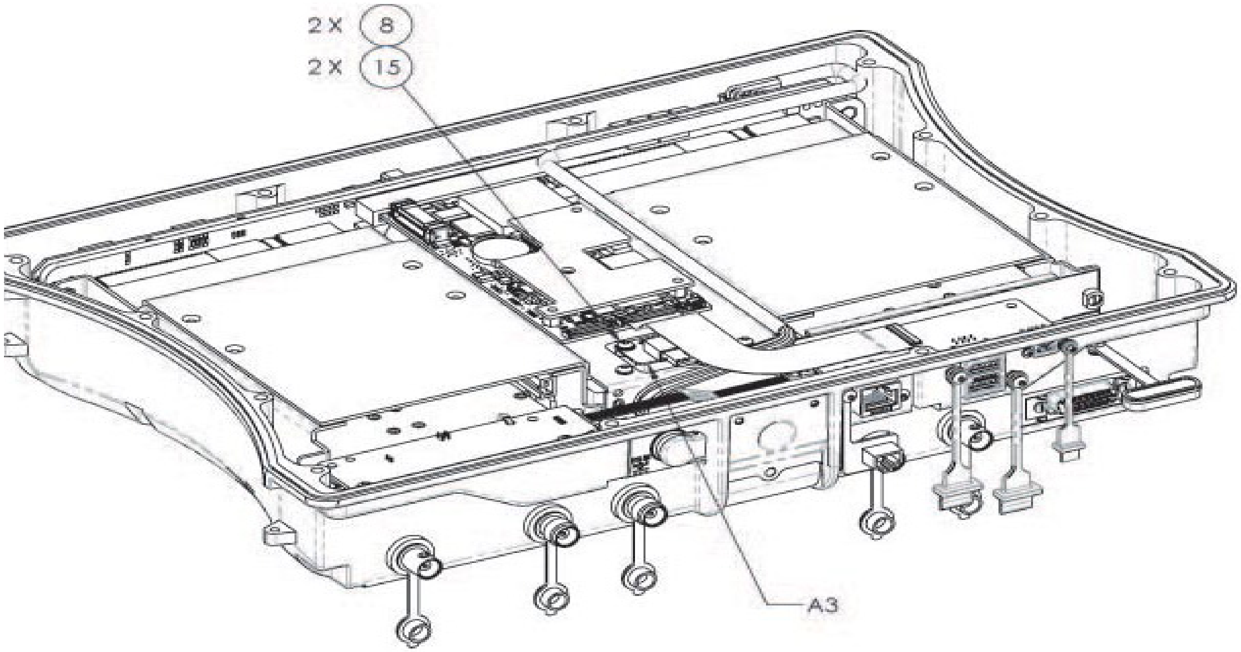
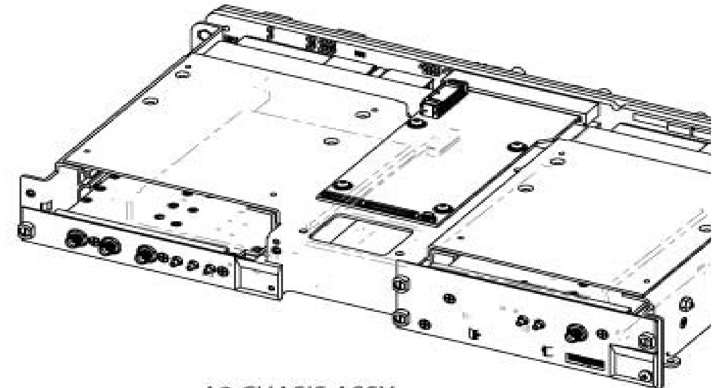


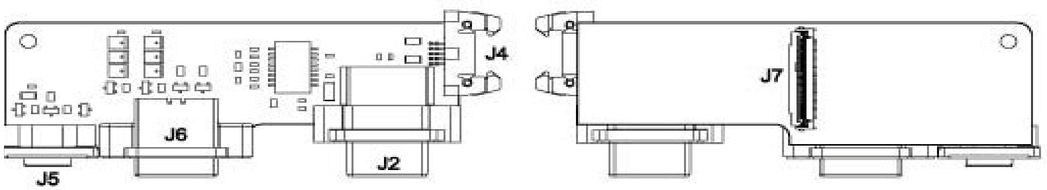
Fig. 6-9. GPSG-1000 Touchscreen Control Assembly (A1A1A5)





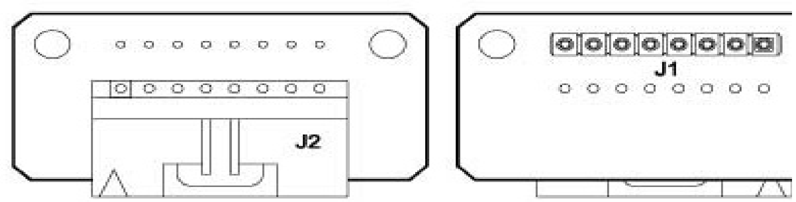
A2 CHASIS ASSY

AUTION:
ONTAINS PARTS AND ASSEMBLIES SUSCEPTIBLE
O DAMAGE BY ELECTROSTATIC DISCHARGE (ESD).



TOP VIEW BOTTOM VIEW

A1 REAR PANEL I/O PCB ASSY



TOP VIEW BOTTOM VIEW

A3 BATTERY INTERFACE PCB ASSY

Fig. 6-10 GPSG-1000 Base Mech Assembly (A1A2)
(Sheet 1 of 2)

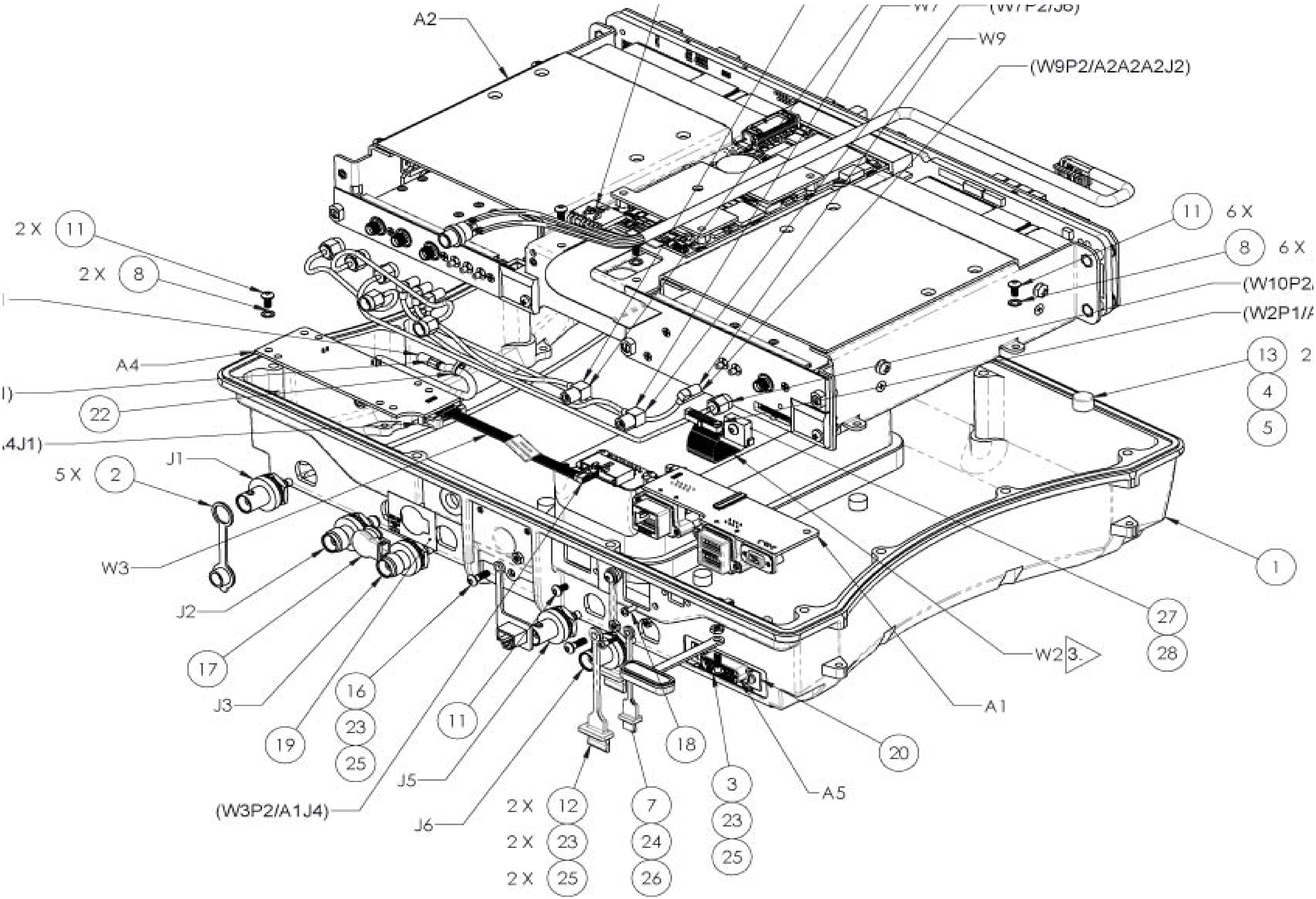


Fig. 6-11 GPSG-1000 Base Mech Assembly (A1A2)

(Sheet 2 of 2)

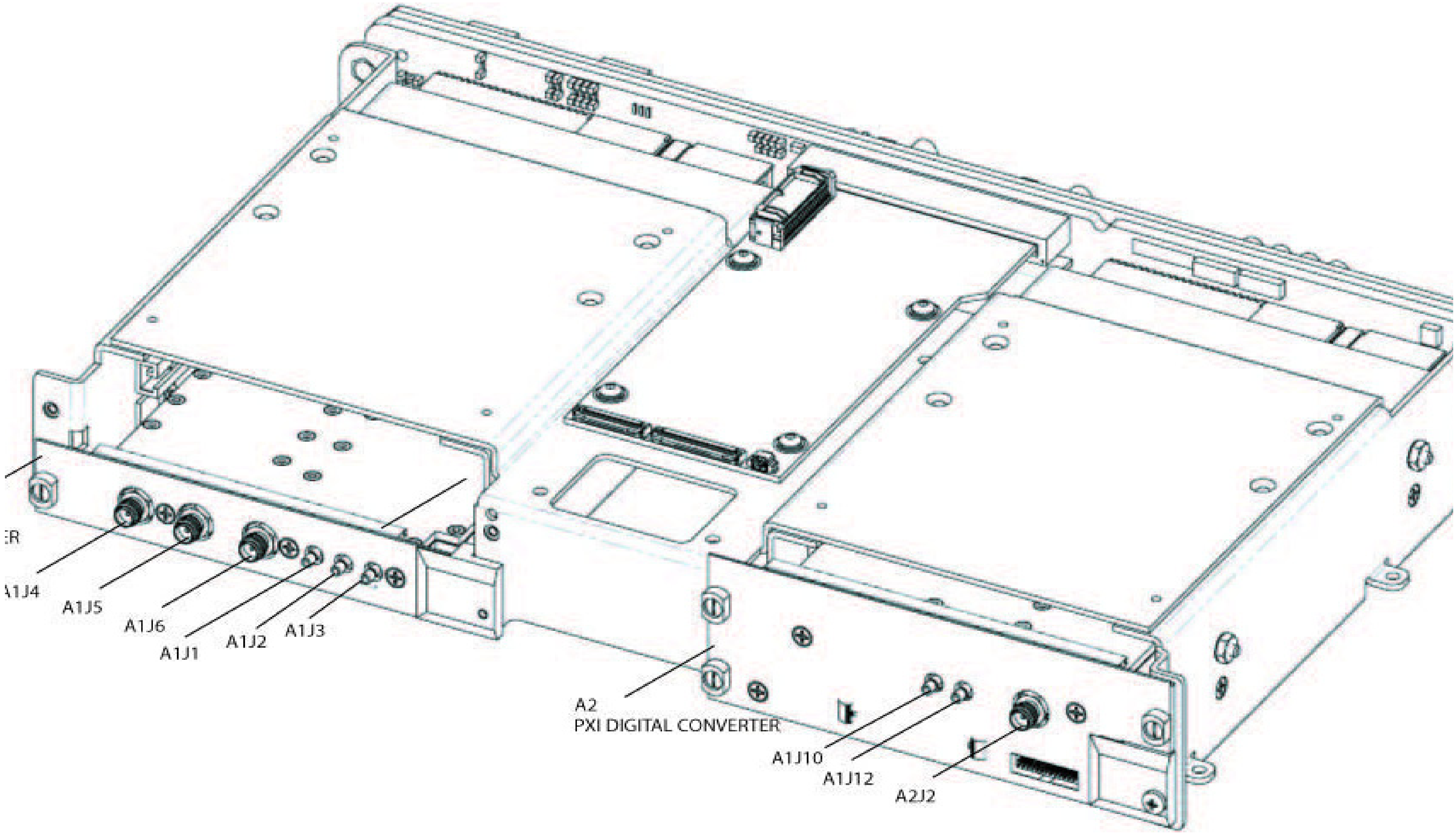


Fig. 6-12. GPSG-100 GPS Chasis Mech Assembly (A1A2A2)

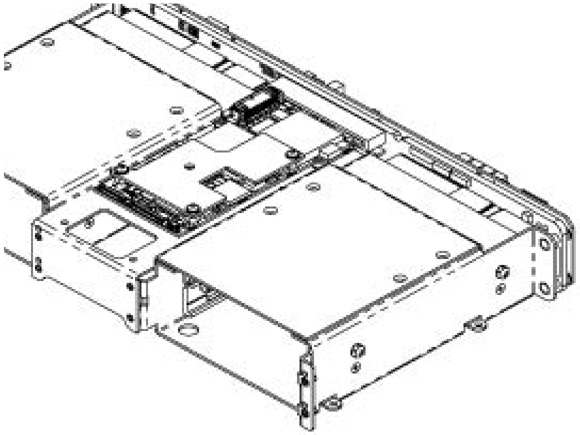
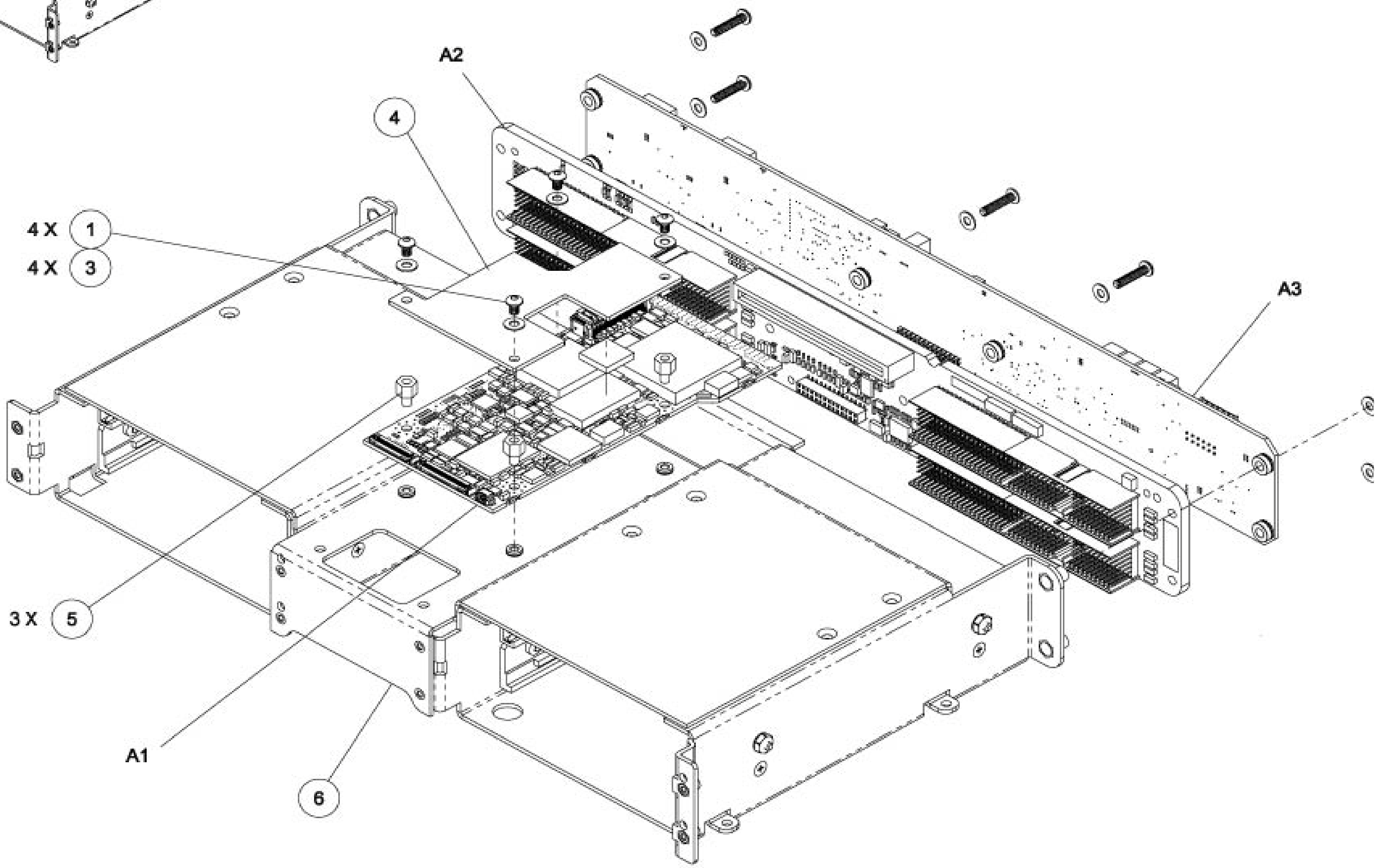
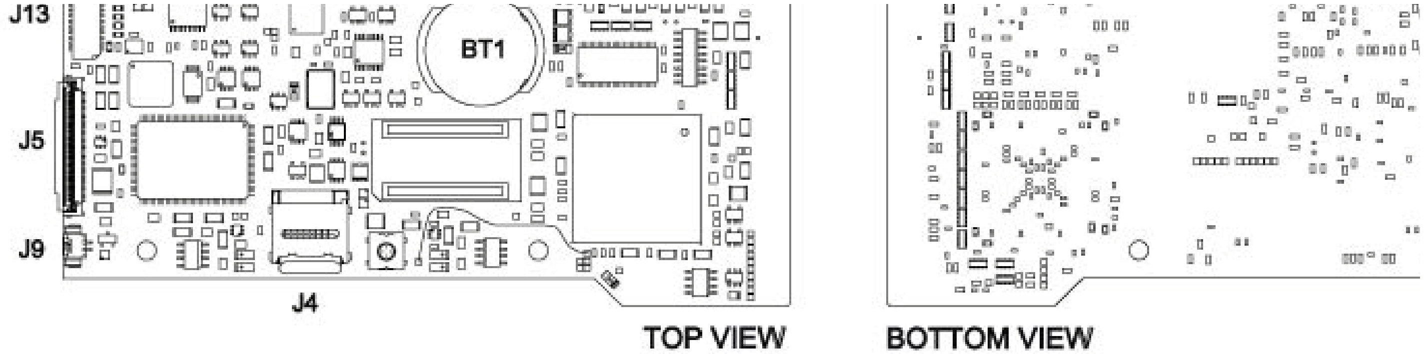
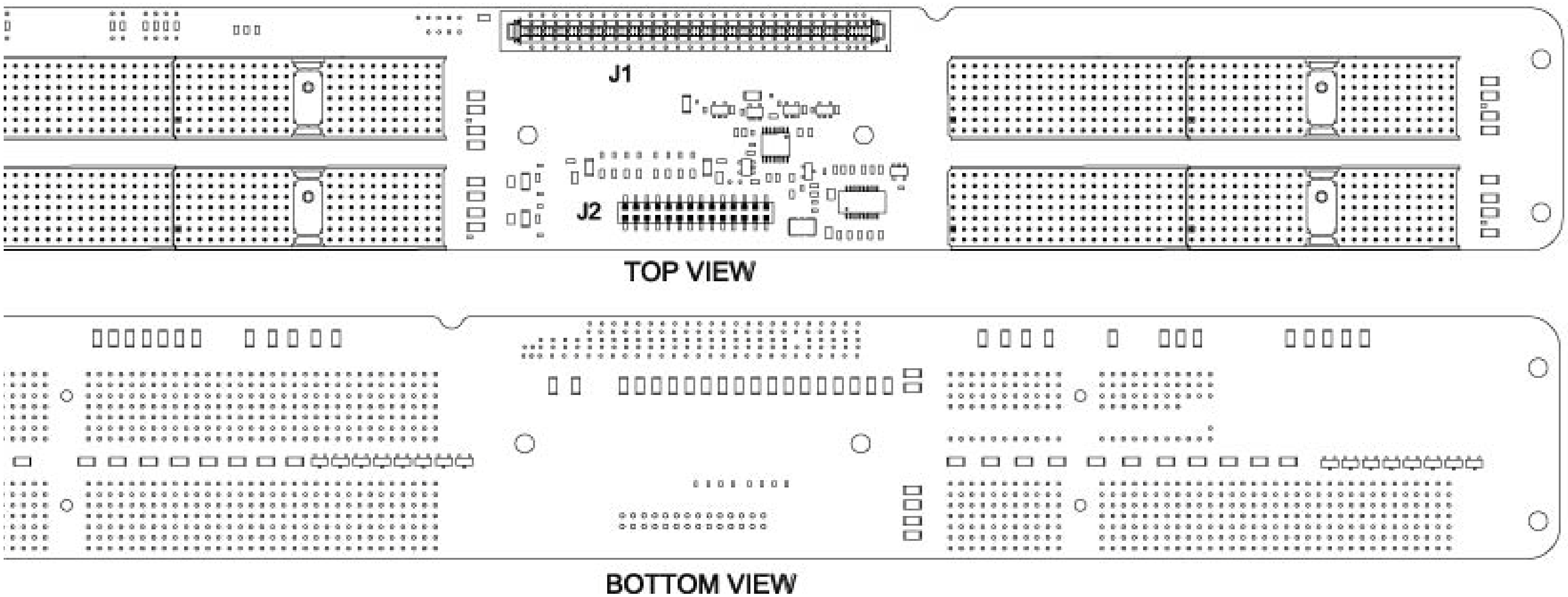



Fig. 6-13 GPSG-1000 RAD/ALT Base Card Cage Mech Assembly (A1A2A2A1)

A1 SLOT 1 CONTROLLER PCB ASSY





A2 PXI BACKPLAI

ER SUPPLY CHARGER
ASSY

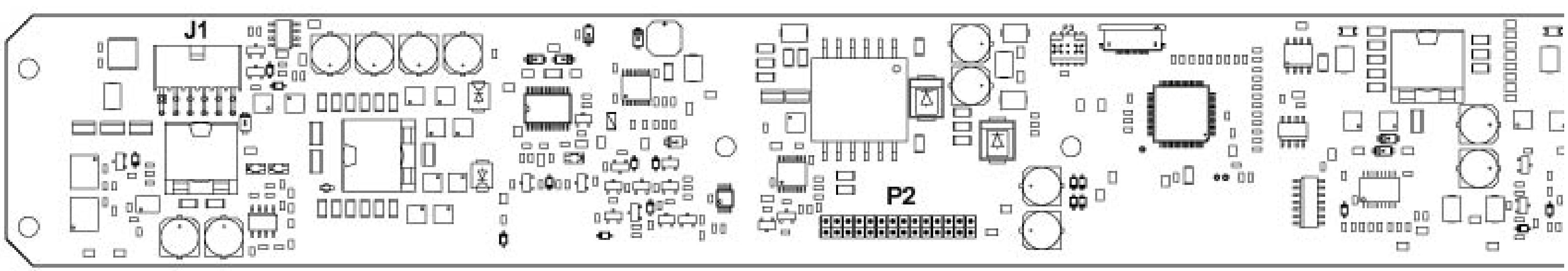
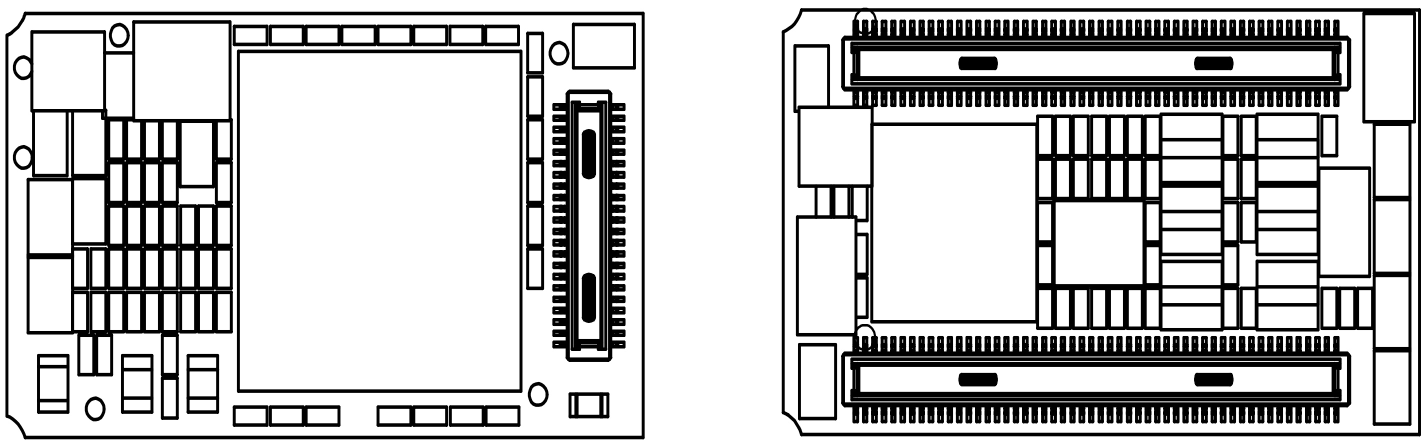


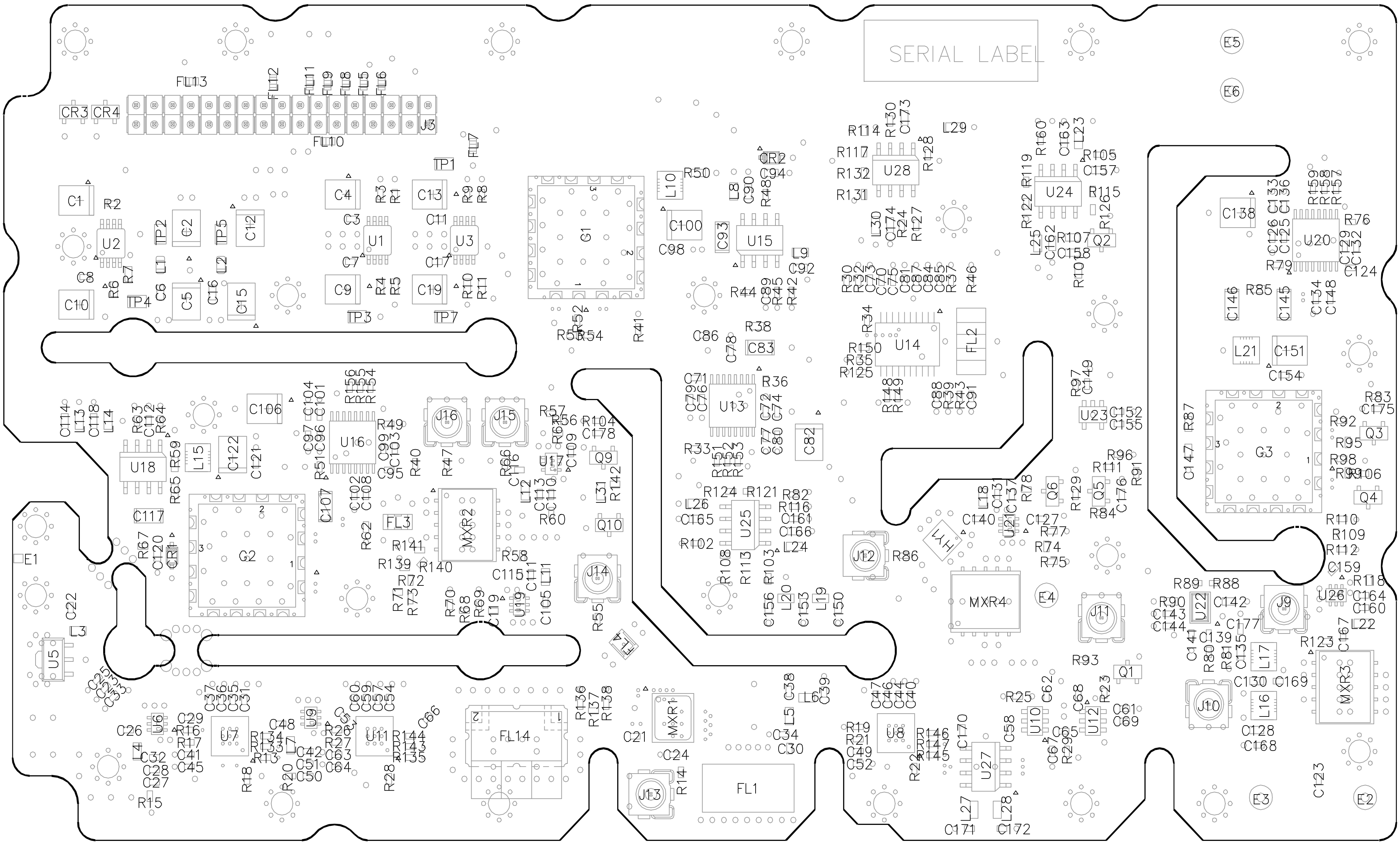
Fig. 6-14. GPSG-1000 RAD/ALT Base Card Cage Mech Assembly (A1A2A2A1)



TOP

BOTTOM

Fig. 6-15. GPSG-1000 Torpedo Assembly (A1A2A2A1A1A1)



CAUTION:
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DAMAGE BY ELECTROSTATIC DISCHARGE (ESD).

Fig. 6-16. GPSG-1000 Digital PCB Assembly (A1A2A2A2A1)

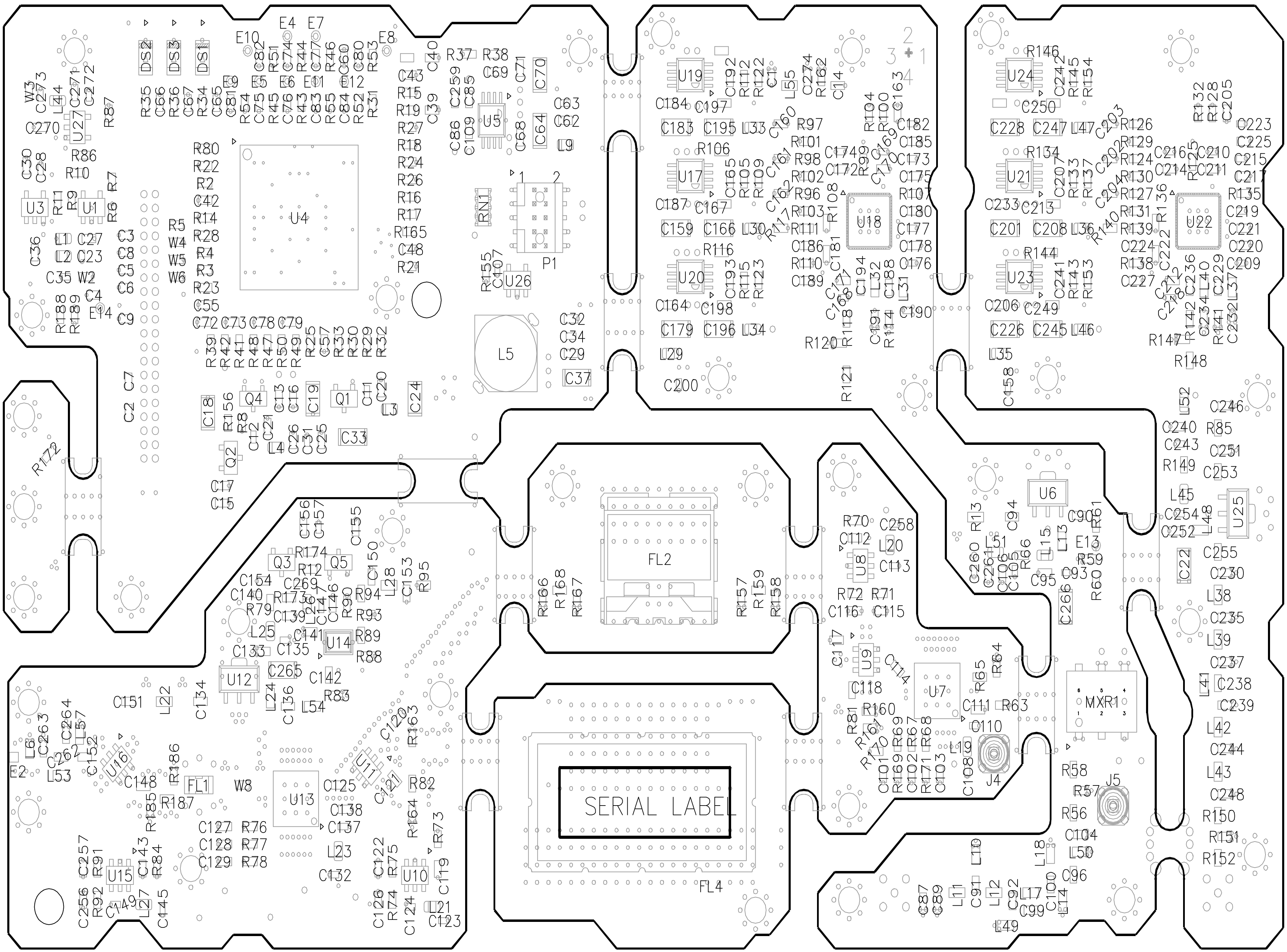


Fig. 6-17. GPSG-1000 RF Upconverter PCB Assembly (A1A2A2A2A2A1)

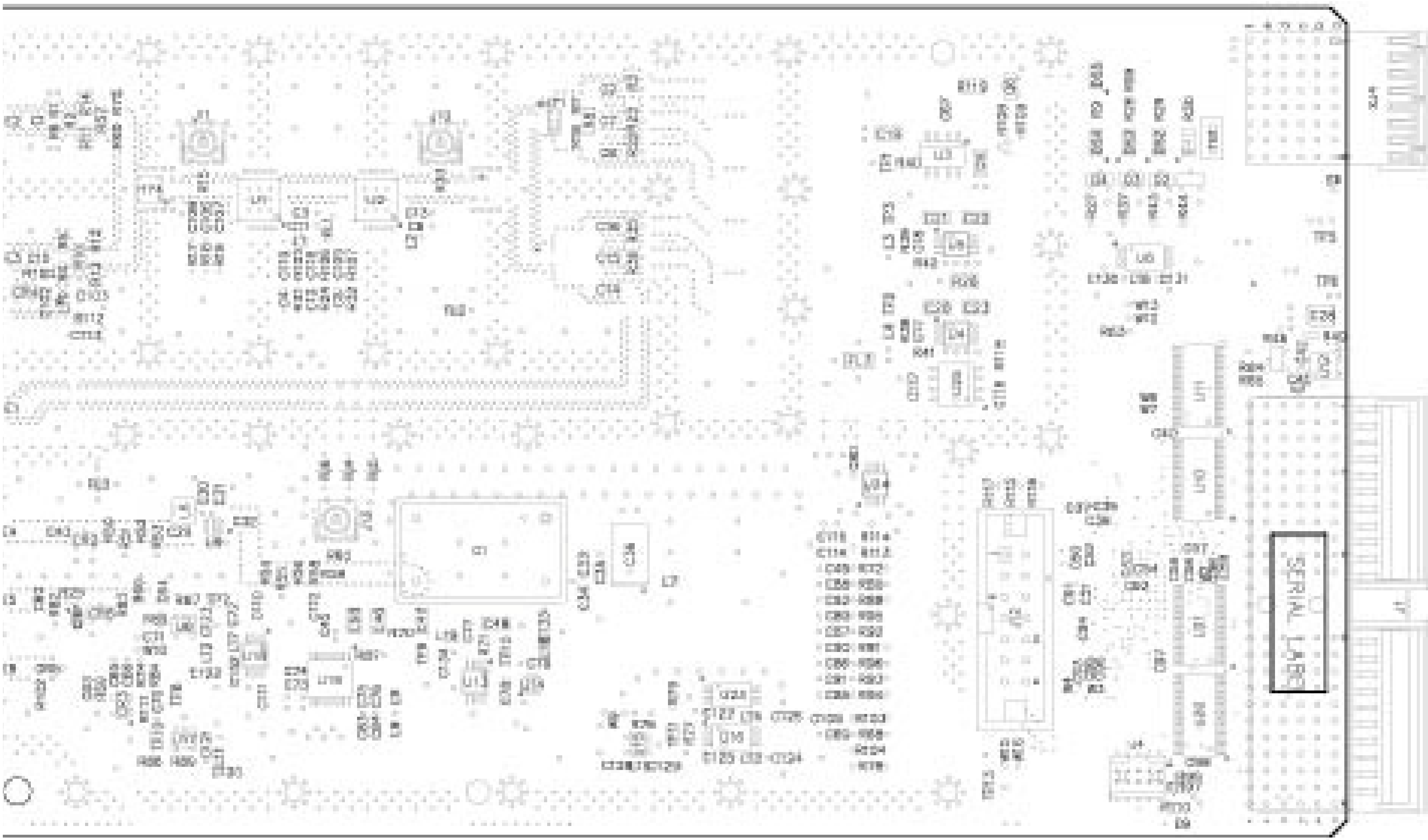


Fig. 6-18. GPSG-1000 RF Combiner PCB Assembly (A1A2A3A1)

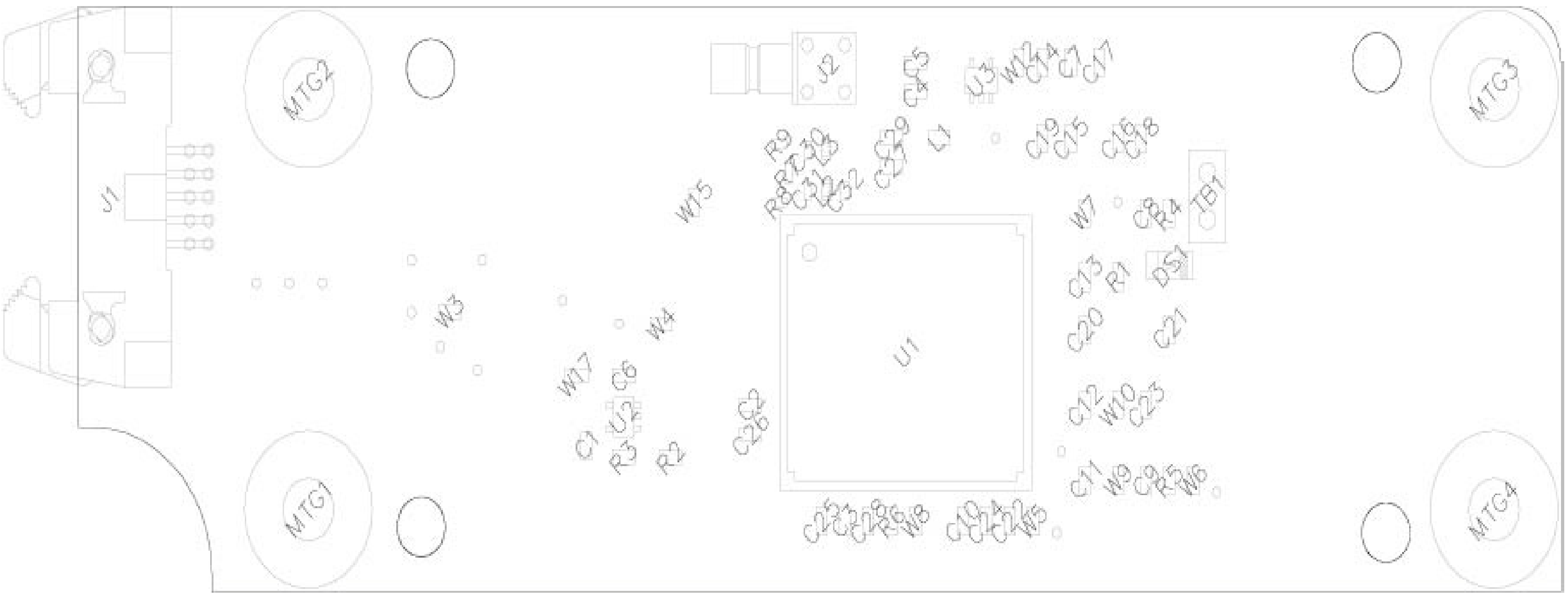


Fig. 6-19 GPSG-1000 GPS RX PCB Assembly (A1A2A4)

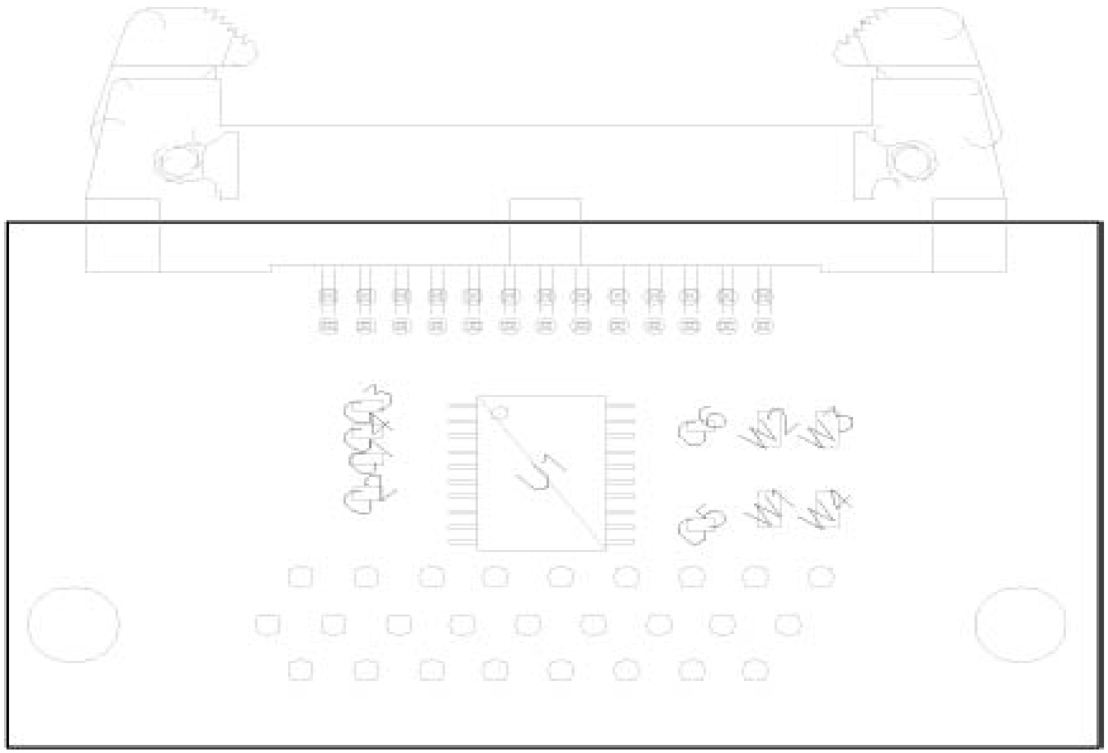
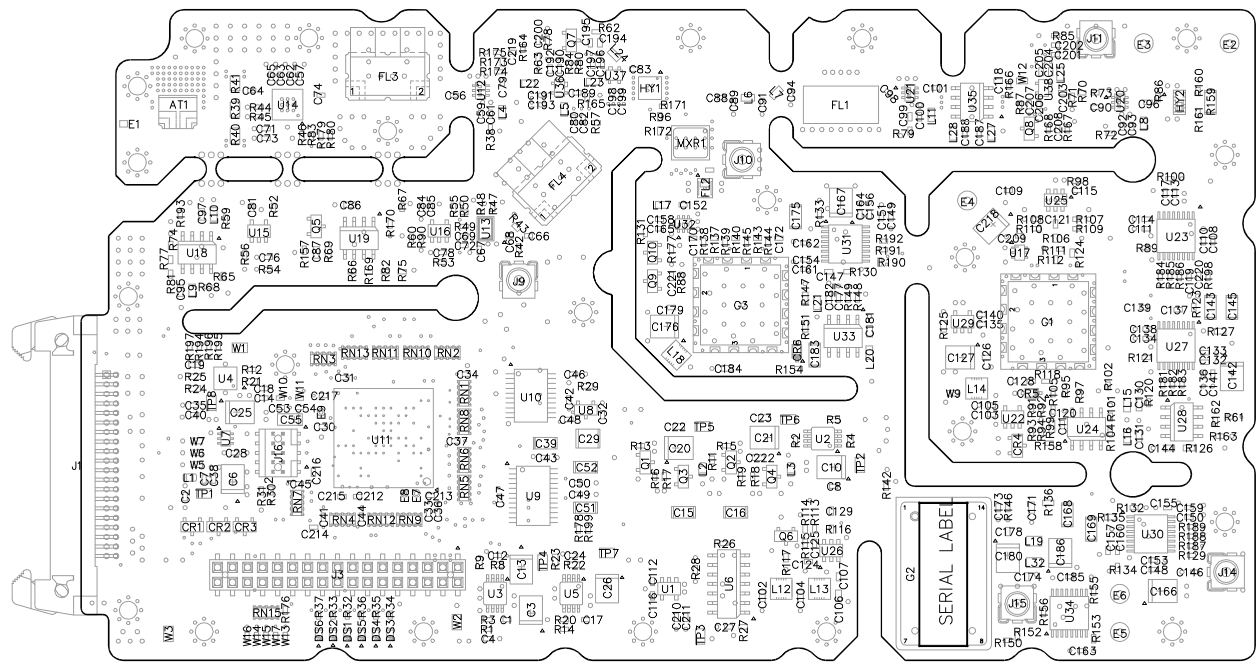


Fig. 6-20 GPSG-1000 Auxiliary Interface GPS PCB Assembly (A1A2A5)



CAUTION:
CONTAINS PARTS AND ASSEMBLIES SUSCEPTIBLE TO DAMAGE BY ELECTROSTATIC DISCHARGE (ESD).

Appendix A - Pin-Out Tables

ETHERNET CONNECTOR

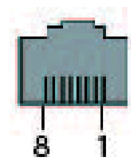


Fig. A-1 Ethernet Pin-Out Diagram

Pin Number	Signal Type	Signal Type	Function
1	Data	Transmit +	Ethernet TX +
2	Data	Transmit -	Ethernet TX -
3	Data	Receive +	Ethernet RX +
4	NC	NC	
5	NC	NC	
6	Data	Receive -	Ethernet RX -
7	NC	NC	
8	NC	NC	

USB HOST 1 CONNECTOR

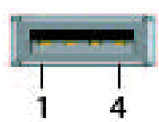


Fig. A-2 USB Host 1 Pin-Out Diagram

Pin Number	Signal Type	Signal Type	Function
1	Power	VCC	USB Power
2	Data	Data -	USB Data -
3	Data	Data +	USB Data +
4	GND	GND	Ground

USB HOST 2 CONNECTOR

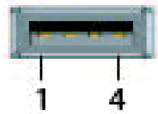


Fig. A-3 USB Host 2 Pin-Out Diagram

Pin Number	Signal Type	Signal Type	Function
1	Power	VCC	USB Power
2	Data	Data -	USB Data -
3	Data	Data +	USB Data +
4	GND	GND	Ground

USB OTG CONNECTOR

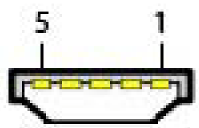


Fig. A-4 USB OTG Pin-Out Diagram

Pin Number	Signal Type	Signal Type	Function
1	Power	VCC	USB Power
2	Data	Data -	USB Data -
3	Data	Data +	USB Data +
4	Control	ID	Identify
5	GND	GND	Ground

DC POWER CONNECTOR

Fig. A-5 DC Power Connector Pin-Out Diagram

Pin Number	Signal Type	Signal Type	Function
Inner	Power	VCC	HHCP Power
Outer	GND	GND	Ground

AUX CONNECTOR

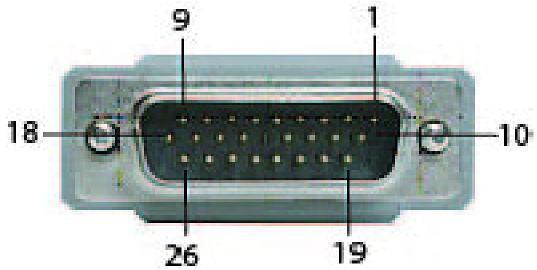


Fig. A-6 AUX Connector Pin-Out Diagram

Pin Number	Signal Type	Signal Type	Function
1	DATA	ARINC 429 in A	ARINC 429 Channel 1 RX A
2	DATA	ARINC 429 in B	ARINC 429 Channel 1 RX B
3	NC	NC	
4	DATA	ARINC 429 Out A	ARINC 429 Channel 1 TX A
5	DATA	ARINC 429 Out B	ARINC 429 Channel 1 TX B
6	NC	NC	
7	Control	RS232 CTS	RS 232 Clear to Send
8	DATA	RS232 TX	RS 232 Transmit
9	Control	RS232 RTS	RS 232 Ready to Send
10	DATA	RS232 RX	RS 232 Receive
11	NC	NC	
12	NC	NC	
13	NC	NC	
14	NC	NC	
15	NC	NC	
16	NC	NC	
17	NC	NC	
18	NC	NC	
19	Ext Trigger Input	3.3V LVTTL	Trigger In
20	NC	NC	
21	NC	NC	
22	NC	NC	
23	NC	NC	
24	NC	NC	
25	DATA	1 PPS Sync	One Pulse Per Second
26	GND	GND	Ground

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Appendix B - Abbreviations

B.1 ABBREVIATIONS

A2D	Analog to Digital
AC	Alternating Current
ADPLL	All Digital Phase Locked Loop
AF	Analog Frequency
ANT	Antenna
APLL	Analog Phase Locked Loop
BPF	Bandpass Filter
Cal	Calibration
CPU	Central Processing Unit
D2A	Digital to Analog
dB	Decibel
DC	Direct Current
DMM	Digital Multimeter
EMI	Electromagnetic Interference
ESD	Electro Static Discharge
FPGA	Field Programmable Gate Array
GEN	Generator
GHz	Gigahertz
GPIB	General Purpose Interface Bus
Hz	Hertz
I/O	Input/Output
IPMB	Intelligent Platform Management Bus
kHz	kilo hertz
LPF	Lowpass Filter
MHz	Megahertz
PCI	Peripheral Component Interconnect
PCIe	Peripheral Component Interconnect Express
PWM	Pulse Width Modulation
PXI	PCI eXtensions for Instrumentation
RF	Radio Frequency
RSSI	Residual Signal Strength Indicator
SATA	Serial Advanced Technology Attachment
sRIO	Serial Rapid IO

T/R	Transmit/Receive
TACH	Tachometer
USB	Universal Service Bus
VGA	Video Graphics Adapter

Appendix C - Test Equipment

C.1 TEST EQUIPMENT

The test equipment listed is suitable for performing any procedure contained in this manual.

Required Test Equipment	Model
Frequency Counter	Agilent 52132A or equivalent
Measuring Receiver	Rhode & Schwarz FSMR or equivalent
Power Sensor	Rhode & Schwarz NRP-Z11 or equivalent
Network Analyzer	HP 8753D or equivalent
Spectrum Analyzer	Agilent E4407B or equivalent
Signal Generator	Aeroflex IFR-3412 or equivalent
Oscilloscope	Tektronix TDS 2024B or equivalent
ARB Generator	Agilent 33220A or equivalent
DMM	Fluke 73 or equivalent
RF Amplifier	Low Noise with 50 dB gain
10 MHz Time Base Standard	
Coaxial Cable	
Ethernet Cable	
Adapter (N-TNC)	

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Appendix D - Controls and Connectors

D.1 FRONT PANEL CONTROLS AND CONNECTORS

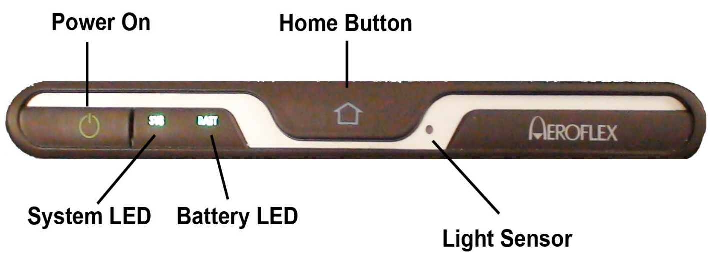

Fig. D-1 Front Panel Controls

Control	Description
Power ON/OFF	The Power On/Off Button is used to power the Test Set on and off.
System LED	**Powered On** (green) Indicates the unit is in an operational status.
	Failure (red) Some form of failure has occurred which precludes using the display to indicate the problem (e.g. main processor failure, power supply fault, etc.).
	Boot (blinking blue) Unit is booting and is not yet able to indicate status on the display (during initial OS and application load).
	Off/Standby (orange) Unit is off, but power is supplied to the power supply from the AC power supply.
	Off w/o External Supply (off) Unit is off, no external power supplied.
Home Button	Pressing and holding the Home Button for 5 sec sets the backlight to maximum brightness.
Light Sensor	Monitors the ambient light and adjusts the display brightness. The light sensor is not operational at this time. Currently the display brightness must be set manually.
Magnetic Sensor	Detects if the display cover is open or closed and used to turn off the display as part of power management.

Control	Description
Battery LED	**Battery Voltage Low** (red) The unit turns off within one minute without charger **Battery Pre-Charge** (flashing yellow) Trickle charge during extremely low voltage on the battery. **Battery Charging** (flashing green) Charge in progress **Battery Fully Charged** (green) **Battery Temperature Extreme** (blue) Temperature <0^{o} C or >45^{o} C can't charge battery **Battery Error** (red) Problem with the battery or charging system. **Battery Missing** (Off) AC applied without battery in place. **Battery Suspended Charge** (flashing Red) AC applied w/ battery charging suspended

D.2 REAR PANEL CONTROLS AND CONNECTORS

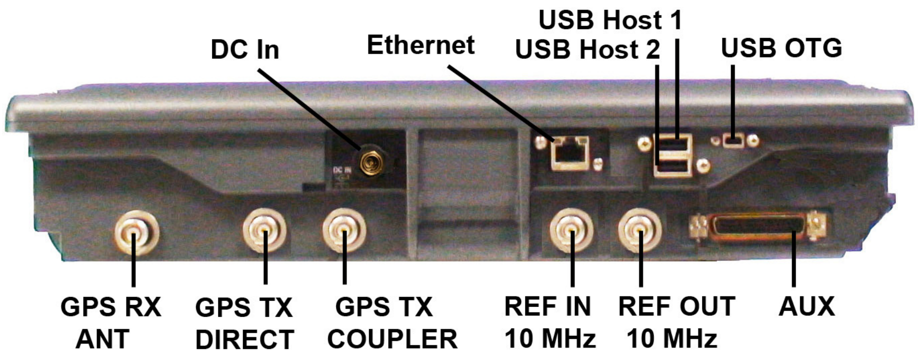

Fig. D-2 Test Set Rear Panel Controls and Connectors

Connector	Description
USB Host 1	USB standard connection that allows connection of USB devices (e.g. a USB memory stick or Network connectors). Recommended USB memory device is Aeroflex PN 67325.
USB Host 2	USB standard connection that allows connection of USB devices (e.g. a USB memory stick or Network connectors). Recommended USB memory device is Aeroflex PN 67325.
USB OTG	USB On The Go, for future expansion.
GPS Rx Ant	External Antenna connection for Test Set internal GPS receiver.
GPS Tx Direct	RF output for direct connection to receiver under test. AC coupled, Maximum DC 50 V.
GPS Tx Coupler	RF output for connection to Antenna Coupler.
REF In 10MHz	The 10MHz In (5V p-p Max) Connector, is a BNC connection, used to connect the Test Set to an external frequency standard, providing a TTL signal.
REF Out 10MHz	The10MHz Out (1.5V p-p Nom) Connector, is a BNC connection, providing an output of the internal 10MHz reference Oscillator.
Ethernet	Standard Base T RJ45 connection. This connection can be used for software upgrades and for remote operation.
Aux	26 pin D type, providing ARINC 429 I/O, RS-232 I/O, a 3.3 VDC LVTTL trigger input and a 1PPS TTL L1 C/A code frame sync output.

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JAPAN	Tel: [+81] 3 3500 5591	Fax: [+81] 3 3500 5592
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	Freephone: 0800 282388	
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	Toll Free: 800 835 2352	

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