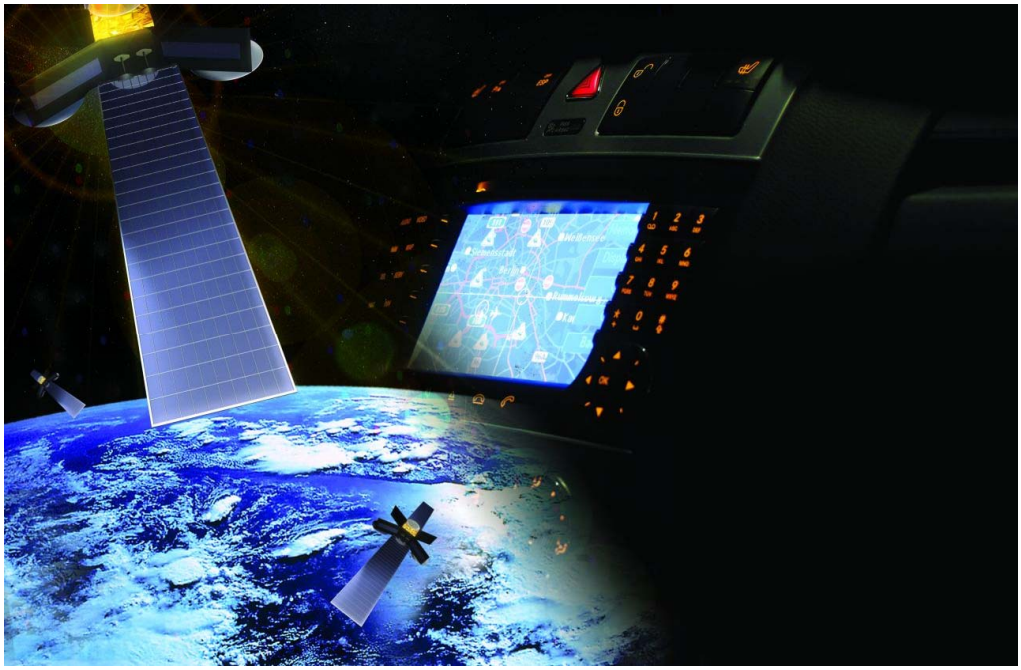
Functional A-GPS Receiver Test using 8960 Wireless Communications Test Set and E4438C ESG Vector Signal Generator

Application Note



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Introduction

Assisted GPS (A-GPS) is an enhanced position location method that uses the satellite-based global positioning system (GPS). A-GPS allows much faster position location by using more precise positioning information obtained from base stations that monitor GPS satellites constantly. This information is called Assistance Data and allows the mobile to determine and report back to the network its exact location within seconds as opposed to minutes using unassisted GPS techniques. Its development was driven by the U.S. Federal Communication Commission (FCC) E911 requirement for quickly providing the location of a cell phone to emergency call dispatchers.

In addition to emergency-related position location, more mobile device applications are emerging that use GPS technology. Some examples are mapping, voice navigation, etc. More service providers around the world are implementing A-GPS in their networks to meet emergency and customer-convenience needs. As a result, more A-GPS capable devices are being introduced into the marketplace. It is important to service providers that A-GPS operation does not interfere with cellular phone calls, especially emergency calls. As a result, service providers require their mobile phone suppliers provide proof of correct operation prior to accepting these phones on their networks.

This application note describes a test system that uses and 8960 Wireless Communications Test Set in conjunction with an E4438C ESG Vector Signal Generator with GPS Personality to perform the types of functional testing needed to meet service provider proof requirements.

Satellite information and location calculation methods

The satellite information provided to the wireless device in the assistance data includes both ephemeris data and almanac data. Satellite ephemeris data is information with exact location data of satellites at a particular time, which enables GPS-capable devices to determine their own location. Almanac data are used to determine which satellites are going to be visible at a given location so that a GPS receiver can search for satellites within range and exclude satellites below the horizon from its search. Almanac data is not highly accurate, but does not need to be frequently updated. The assistance data sent from the network to the wireless device includes both almanac and ephemeris data.

There are two methodologies by which location services data can be sent to and from the wireless device: Control Plane and Secure User Plane. Location services implementations based on control plane architecture have been driven by regulator-led initiatives such as the US Federal Communications Commission (FCC) E911 requirement to report the location of callers to the 911 emergency responders. This requirement mandates the use of control plane messaging to send and receive Location Services data. This data, which includes assistance data, can be sent to and from an A-GPS enabled device through the 8960 Wireless Communication Test Set using control plane messaging including RRLP, RRC, or TIA-801 for UMTS and cdma2000 technologies.

Secure User Plane Location (SUPL) is a technology which utilizes existing infrastructure and standards to transfer Location Services data over a user plane bearer, such as Internet Protocol (IP). The Agilent E6965A Location Server Emulator is the first commercial bench-top solution supporting SUPL functional test using over-the-air connection to a SUPL enabled terminal (SET). It provides the elements of the SLP that are needed to test such devices, and may be combined with an Agilent 8960 Wireless Communications Test Set and an E4438C ESG Vector Signal generator in order to form a system that provides satellite simulation, cellular base-station emulation and the messaging required for SUPL testing.

There are two types of A-GPS techniques specified in the standards: Mobile Station Assisted (MSA) and Mobile Station Based (MSB). With the MSA method, the device receives the GPS assistance data and performs measurements on the received satellite signals and returns the satellite measurement data back to the netowrk but does not use these measurements to determine its own location. The position location calculation is performed in the network by a network processor or location server. This server approximates the position of the wireless device based on the raw satellite data sent by the device back to the network. The MSB approach utilizes the processing power of the wireless device to complete the location calculations. After receiving all GPS assistance data, performing measurements on the GPS satellite signals, and calculating a position estimation based on these measurement results, the device reports back its longitude and latitude to the network. This technique uses more of the device's memory and MIPS and requires more precise ephemeris data. However, this ephemeris data is valid for a number of hours, so it does not require frequent updates.

Test equipment

8960 wireless communications test set

Control plane A-GPS involves the transmission of GPS assistance data from the network to the UE using 3GPP specified signaling messages. Assistance Data Deliver message (ADDM) and Measurement Control message (MCM) are defined for this purpose. The Measurement Report message (MRM) is used to return A-GPS measurement results from the UE to the network.

For testing 2G (GSM/GPRS/EGPRS) A-GPS capable devices the following test set configuration is required:

E5515C (Wireless Communications Test Set) with

- E5515C-002 (2nd RF Source)
- E6701G (GSM/GPRS Lab Application)

For testing 3G (W-CDMA/HSPA) A-GPS capable devices the following test set configuration is required:

E5515C (Wireless Communications Test Set) with

- E5515C-003 (CDMA base station emulator)
- E6703F (W-CDMA/HSPA Lab Application)

If you will be testing either 2G or 3G UMTS A-GPS capable mobile devices, then the following 8960 test set configuration is required:

- E5515C with Options 002 and 003
- E6703F for W-CDMA/HSPA
- E6701G for GSM/GPRS/EGPRS

For testing cdma2000® A-GPS capable devices the following test set configuration is required:

E5515C (Wireless Communications Test Set) with

- E5515C-003 (CDMA base station emulator)
- E6702C (cdma2000 Lab Application)

E4438C ESG vector signal generator

The GPS signals are created by the E4438C ESG vector signal generator with Option 409 GPS personality. The E4438C is a high performance, general-purpose RF signal generator capable of providing comprehensive support for today's wireless signal formats. The GPS personality provides up to eight real-world GPS satellite signals that are developed based on pre-configured scenario files. These signals, including Doppler shifts, are synchronized with the actual satellite orbits so that they are consistent with the navigation message contained in the satellite signals.

This GPS signal simulator provides the following capabilities:

- Multi-satellite GPS configuration (maximum eight satellites)
- Simulation of real-world scenarios (multiple scenarios available)
- Real satellite data (synchronized satellites with Doppler shifts and navigation messages)
- Adjustable number of visible satellites between one and eight
- Automation of signal generation through SCPI commands

The following E4438C configuration is needed for GPS signal generation required for the mobile device A-GPS test system:

E4438C ESG Vector Signal Generator with

- E4438C-005 (6 Gbyte hard drive)
- E4438C-409 (GPS personality)
- E4438C-502 (250kHz to 2 GHz frequency range)
- E4438C-601 or -602 (Internal baseband generator)

Note: a special GPS Scenario file is required for this test setup. This file can be downloaded from the following location: **www.agilent.com/find/msgps**

This GPS scenario file simulates the location information for *GPS Scenarios* as required by 3GPP TS 34.108 clause 10.1.2.1. The assistance data provided with this scenario is defined in 3GPP TS 34.108 clause 10.6

E6965A Location Server Emulator (optional)

The E6965A Location Server Emulator is a PC software program that provides a Secure User Plane for Location (SUPL) server emulator for testing A-GPS over the user plane. This can be combined with the 8960 and E4438C for functional A-GPS testing using a user plane bearer such as IP. This is currently available for W-CDMA/HSPA and GSM/GPRS/EGPRS technologies.

PC Control Software

GS-9000 (recommended)

Software is required to control the test equipment, generate assistance data, encode and decode protocol messages, calculate position location, and return test results. Agilent's GS-9000 test system is a scalable solution that includes software with predefined test cases that conform to individual technology standards. These tests can be configured or modified to fit specific design verification needs and accurately emulate A-GPS operation on a real network. See the Test Setup section for more details on the PC Control Software.

E6584A wireless protocol advisor (WPA) software (optional)

The WPA software is a good debug tool to show the protocol messages being sent between the 8960 and the wireless device under test. This tool can be used to verify that the correct assistance data is being sent to the wireless device and that the results returned from the device are correct.. An example of this can be found in the .tol file downloaded from:
www.agilent.com/find/E6584A >> **Technical Support** >> **Drivers & Software**

Test setup

Setup diagram

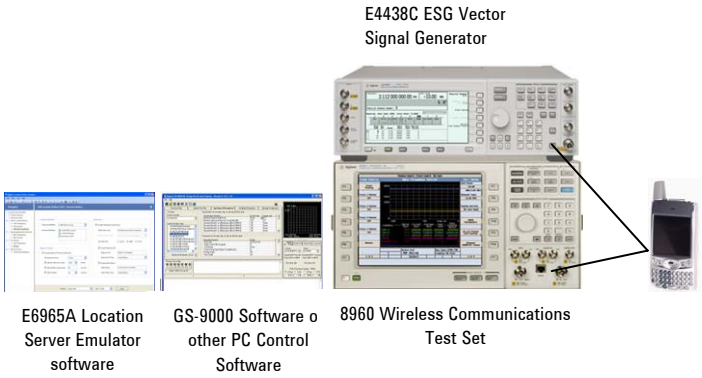

Figure 1. Connection diagram for mobile device A-GPS test system

Figure 1 shows the connections required to set up the mobile device A-GPS functional test system. Both instruments (8960 and E4438C) are connected to the PC controller via GPIB. The PC control software and E6965A Location Server Emulator software are installed on an external PC. The device under test (DUT) is coupled to the instruments either via RF cables or antennas connected at the RF ports of each of the 8960 and E4438C.

E4438C setup

The special GPS Scenario file should be transferred to the USERS/GPS directory on the E4438C hard drive. The procedure to accomplish this is found on the Scenario Files webpage **www.agilent.com/find/msgps**

PC Control Software setup

- The PC should be connected to the 8960 and E4438C over GPIB in order to control the instruments.
- Select the GPS scenario for the ESG
- Generate the assistance data based on the GPS scenario selected
- Encode the assistance data to be sent from the 8960 to the wireless device. For GSM/GPRS/EGPRS devices, the assistance data is exchanged via RRLP (Radio Resource Location Services (LCS) Protocol). For W-CDMA/HSPA devices, the assistance data is sent using the RRC (Radio Resource Control) layer. For cdma2000 devices, TIA-801 messages are used to send the assistance data.
- Send the assistance data and measurement request messages to the 8960 over GPIB ("CALL:PPR:PME:PIPE:DATA:TX 'XXXX'" in GSM/GPRS/EGPRS)
- Execute GPIB command to send the assistance data and measurement request messages from the 8960 to the wireless device ("CALL:PPR:PME:PIPE:SEND" in GSM/GPRS/EGPRS).
- Query the 8960 over GPIB to determine if a response from the wireless device has been received. ("CALL:PPRocedure:PMEasurement:PIPE:DATA:RX:AVAilable?" in GSM/GPRS/EGPRS)
- When a response from the wireless device is available, query the 8960 to return the raw data from the last message received from the wireless device ("CALL:PPRocedure:PMEasurement:PIPE:DATA:RX?" in GGE/GPRS/EGPRS)

Test results

The test results detailed below can be obtained by analyzing the results reported back by the wireless device. This analysis can be performed either by decoding and analyzing the data returned to the 8960 by the wireless device or by using Wireless Protocol Advisor to view the protocol messages. The raw data returned to the 8960 by the wireless device can be queried over GPIB and returned in hexadecimal form. For example, a return of "800000010221F8AF76D8AF38B49C6C00328875CA4DFB5B34E83ACD253E1942911D5292565185558EA34933B2FA910741A55E14724B83A4D2AEF38A8201D429479BCF4F80E8" includes data on 8 satellites that were found by the wireless device as well as some measurement report header information. This hexadecimal data can be parsed and viewed in Wireless Protocol Advisor (WPA) or analyzed by your PC software. Agilent's GS-9000 software uses this data to calculate and report the following results.

Raw Satellite Data

The following results apply to devices using the Mobile Station Assisted technique: Satellite Identification (ID) Number**:** Each GPS satellite has a unique identification number assigned to it and is the GPS receiver's primary means of identifying individual GPS satellites.

Carrier to Noise Ratio (C/No): This is the ratio of the received carrier power and the noise power in a given bandwidth, expressed in dB. The higher the C/No-value, the better is the strength, and therefore the quality of the received signal.

Pseudorange RMS Error: These values are used to compute a weighting matrix that is used in the WLS (Weighted Least Squares) positions solution (as defined in 34.171).

Doppler: This is the Doppler shift as measured by the GPS receiver. This information is used to calculate the 3D velocity of the mobile.

Whole and Fractional Chips: These parameters represent the code-phase measurements as reported by the mobile. Code-phase can be used to calculate the observed pseudorange between the mobile and a satellite.

Latitude and Longitude

Mobile Station Based capable devices can determine their own longitude and latitude and will report it back to the 8960 in the form of hexadecimal data.

GPS Time of Week (TOW)

GPS time is transmitted by a combination of the current Week Number and the Time of Week. The TOW represents the number of seconds into the week ranging from [0 . . . 604800] seconds and is counted from midnight Saturday/Sunday on the GPS time scale. This is different from Coordinated Universal Time (UTC) in that GPS time is not corrected to match the rotation of the earth (e.g. leap seconds)

Number of Satellites

GPS satellites are arranged in their orbits so a GPS receiver on earth can always receive from at least four of them at any given time. The more satellites the receiver can "see", the better the position location accuracy will be. Buildings, terrain obstacles, electronic interference, or dense vegetation can inhibit signal reception and degrade position location accuracy. Typically four GPS satellite signals are used to compute position.

Time to First Fix (TTFF)

"Time to First Fix" is the time it takes for a GPS receiver to determine its current position. The basic steps are acquiring the GPS satellite signal, tracking the signal, and downloading the navigation information. This process is speeded up using assistance data that is transmitted via the cellular network connection. This value can be calculated by determining the difference in time between when the assistance data was sent from the 8960 to the phone and when the reply is received from the phone by the 8960.

2D Error Calculation

The 2-dimensional error can be calculated based on the difference between the location reported by the wireless device and its expected location.

Types of assistance data messages supported

GSM/GPRS/EGPRS

RRLP (Radio Resource Location Services (LCS) Protocol assistance data messages

W-CDMA/HSPA

RRC (Radio Resource Control) assistance data messages

cdma2000

TIA-801 assistance data messages

Summary

This application note describes how to use Agilent's 8960 Wireless Communications Test Set in conjunction with the E4438C ESG Vector Signal Generator with GPS Personality to perform functional testing of A-GPS performance in cellular devices meant for use on networks that offer this capability.

As more network services are deployed that utilize A-GPS, more cellular device manufacturers will need to test this capability to prove their A-GPS operation does not adversely affect the call performance.

For more information on the Agilent A-GPS test solutions, go to **www.agilent.com/find/AGPS**

For more information on the Agilent GS-9000 A-GPS Design Verification Test system, go to **www.agilent.com/find/GS9000**

Glossary of terms

2G	2nd Generation
3G	3rd Generation
A-GPS	Assisted GPS
CDMA	Code Domain Multiple Access
DUT	Device Under Test
EGPRS	Enhanced General Packet Radio Service
FCC	Federal Communications Commission
FTP	File Transfer Protocol
GPIB	General Purpose Interface Bus
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communication
HSPA	High Speed Packet Access
ID	Identification
IP	Internet Protocol
LCS	Location Services
Msa	Mega Samples
PC	Personal Computer
RF	Radio Frequency
RRC	Radio Resource Control
RRLP	Radio Resource LCS (Location Services) Protocol
SUPL	Secure User Plane Location
SVN	Satellite Vehicle Number
TIS	Total Isotropic Sensitivity
TOW	Time of Week
TTFF	Time to First Fix
UTC	Coordinated Universal Time
W-CDMA	Wideband Code Domain Multiple Access
WPA	Wireless Protocol Advisor

Reference literature

GSM/EDGE Radio Access Network; Location Services (LCS); Mobile Station (MS) - Serving Mobile Location Centre (SMLC) Radio Resource LCS Protocol (RRLP), 3GPP TS 04.31

Agilent Customizing the E656XC/N588XA Wireless Test Manager, application note; literature number 5989-7099EN

Typical GPS Receiver Verification Tests Using a GPS Signal Simulator, application note; literature number 5989-8572EN

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