GNSS Automation & Application Testing—Accelerate Your Products to the Market
Spirent Communications
Sep. 25th, 2015
Agenda

- Introduction of Spirent Positioning Technology (PT) (思博伦PT介绍)
- Products & Solution Update（产品及解决方案更新）
  - GSS9000: New Generation platform for Multi-Constellation and Multi-frequencies GNSS testing （GSS9000：测试多模多频GNSS的新平台）
  - Automation Solution(自动化方案）
  - Application testing: （应用测试）
    - Drones（无人机）
    - Timing（时钟）
    - Automotive（汽车）
    - Zoned Chamber（区域屏蔽室）
- Robust PNT（GNSS安全及健壮性）NEW!!!
Introduction
Spirent Positioning Technology History

Team Started in 1985

Now World’s Largest Supplier of GNSS test equipment

Product range covers all GNSS applications

1980’s
Initially Single-channel GPS systems

1990’s
Massive technology lead with the STR2760
Introduced other GNSS Systems test
SBAS (1996), GLONASS (1997)
Testing the Future of Navigation & Positioning

**Simulator Applications**

- Support & Troubleshooting
  - To perform troubleshooting tests in support of malfunctioning receivers and systems

- Research
  - As a research tool in developing new products or new techniques that can be employed in related products or services

- Manufacturing & Production
  - To verify that your manufactured product performs within specification

- Integration & Verification
  - To evaluate how your product performs as part of an integrated system (e.g., a vehicle tracking system)

**360° SOLUTION**

- GLONASS, GPS, GALILEO, SBAS, BEIDOU, QZSS, IRNSS

Solutions Overview
Applications for the GSS9000
The GSS9000 Signal Generator Chassis consists of one or more RF Channel Banks – up to a max of 10.

- Each RF Channel Bank can support up to 16 separate channels.
- Each RF Channel Bank is capable – at any one time – of supporting any GNSS constellation and frequency.
- The function of each RF Channel Bank is controlled by license key.

A fully-populated chassis can support 160 signal channels with 640 multipath channels

- Represents a five times increase in channel density from GSS8000
Products & Solution Updates:
Automation
Challenge for current GNSS Testing

- **Most customers are doing manual test**
  - No generic automation solution
  - R&D and Test teams do test separately
  - Chip manufacturer don’t provide auto tests to downstream manufacturers

- **Difficult to reproduce the found issues**
  - No record for testing process
  - It’s difficult for R&D to reproduce the issue found by Test team
  - Chip manufacturer does not accept the test result from downstream manufacturer

- **Generate test report manually**
  - Each test needs to be executed above 100 times
  - Record test result & calculate result manually
  - Write test report manually, cost a lot of time

- **High repeatability & high human cost**
  - Limited test cases, complicated test scenarios
  - Repeat each case multi-times with different test conditions
  - Two engineers, one week test for one product

- **Tests need to control DUT & Simulator at the same time**
  - Some scenarios needs to send commands to DUT
  - Adjust the arguments of Positioning test simulator at the same time
  - Scan the device log data, then calculate the test result

- **Positioning Simulator Utilization is low in some cases**
  - User does not familiar with using Spirent Positioning simulators
  - Need to provide more support & training
  - Effect purchasing more simulators
Overview of Positioning Test Automation Solution

- **Topology of Testing Environment**

- **Components including:**
  - Server with Spirent iTest installed (Windows or Linux)
  - Device Under Test (Smart Phone or Chip Testing System)
  - Spirent GSS Serial Simulators

Note: Make sure Server connects to DUT and GSS simulator through cables
“Before iTest, manual Positioning test needs 2 engineers to spend 1 whole week to complete one product test.”

“After iTest, we implement all Positioning test scenarios as automation. We can run test suite in the mid-night everyday and get test reports in the morning. It increases our test efficiency dramatically.”

<table>
<thead>
<tr>
<th>Items</th>
<th>Before iTest</th>
<th>After iTest</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (Hour)</td>
<td>80</td>
<td>10</td>
<td>Decrease 87%</td>
</tr>
<tr>
<td>Report Writing (Hour)</td>
<td>2</td>
<td>0</td>
<td>Increase 200%</td>
</tr>
<tr>
<td>Problem Solving (/man-day)</td>
<td>7</td>
<td>1</td>
<td>Decrease 700%</td>
</tr>
<tr>
<td>Testing Period (Day)</td>
<td>10</td>
<td>0.5</td>
<td>Decrease 95%</td>
</tr>
</tbody>
</table>
Products & Solutions Updates:
- Application Testing:
- Drones
Tests for Drones/UAVs

Background

- Types of UAVs
  - Rotors (Multi/Quad/Hexa/ Octo – copters)
  - Fixed-Wing

- Commercial Applications
  - Aerial photography/videography
  - Mapping
  - Surveying

- Control
  - By “pilots” from the ground
  - Autonomously follow set of waypoints
Tests for Drones/UAVs

Problems

- Basic Tester: Fly drone in big open space with live GNSS signals outside.
- Comprehensive Tester: See below problems

- Motion Vibration Tilting
- Multi-frequency antenna (L1 only) (L1 and L2 to remove atmospheric effect: greater accuracy)
- Flight Control User control or set a course of waypoints for drone to follow
- Integration Check receiver can still work with other components
- Geo-fencing Meets regulations for no-fly places
- DGPS (e.g. RTK) Required to enhance accuracy
Tests for Drones/UAVs

Conclusion

- Drones/UAVs have special type of motion: Small and Dynamic movement
- Not allowed in specific places, airports, at certain heights, government buildings, etc
- In future: more common for drones to fly on their own with waypoints
  - Accuracy and alarm system important
- Solutions at all levels at all price: Research -> Integration -> Production

![Diagram of a drone with labeled components: Novatel Dual Frequency GPS Antenna, Microstrain IMU, Gumstix Computer, Novatel Dual Frequency GPS Receiver, Ibeo LUX Scanner, Contour Camera.]

![Table of simulated signal types: GPS L1, L2, L5.]

- L1 and L2
- Multipath
- Interference
- Obscuration
- Regulations
- Vibrations
- Verification
Products & Solution Updates:
- Application Testing:
- Timing
Calibrating Timing Error for Timing Receivers

Background

- Time and phase is a synchronisation problem in modern and future communication networks.

<table>
<thead>
<tr>
<th>Time Error Requirement (with respect to ideal reference)</th>
<th>Typical Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ms - 500 ms</td>
<td>Billing, Alarms</td>
</tr>
<tr>
<td>5 - 100 μs</td>
<td>IP Delay monitoring</td>
</tr>
<tr>
<td>1.5 μs - 5 μs</td>
<td>LTE TDD (cell &gt;3km)</td>
</tr>
<tr>
<td>1 μs - 1.5 μs</td>
<td>UTRA-TDD, LTE-TDD (cell ≤ 3Km), Wimax-TDD (some configurations)</td>
</tr>
<tr>
<td>1 μs</td>
<td>Wimax-TDD (some configurations)</td>
</tr>
</tbody>
</table>

- If time error is not satisfied:
  - Call interference
  - Dropped calls
  - Packet loss/collisions
  - Reduced spectral efficiency
  - Streaming interruption (video broadcast)
  - Poor signal edge of cells
  - Location-based services lose accuracy
  - Lower data speeds
Calibrating Timing Error for Timing Receivers

G.8272 Recommendation from ITU

- Recommendation ITU (International Telecommunications Union) G.8272 specifies error allowed at the time output of the primary reference time clocks (PRTCs) for time and phase synchronisation in packet networks, such as LTE.

- 3 specifications:

  1. Max|TE| < 100ns
     Time output of PRTC accurate within 100 ns when verified against applicable time standard, e.g. UTC.

  2. Maximum Time Interval

  3. Time Deviation, TDEV
Calibrating Timing Error for Timing Receivers

*Example: 4G LTE Application*

- ITU G.8272 currently suggests three main ways of testing – **All not good enough:**

1. **Comparison to a PRC frequency standard**
   - Only addresses phase wander (i.e. dTE)
   - Cannot verify max|TE| value – **No good**

2. **Comparison to a reference receiver**
   - Addresses both phase wander and max|TE|
   - Uncertainty of the reference receiver may be too high – **No good**

3. **Comparison to a national time standard**
   - Addresses both phase wander and max|TE|
   - Only available from a certified national time laboratory – **No good**
Calibrating Timing Error for Timing Receivers

Example: 4G LTE Application

- **Simulator**
  - Repeatable/ Controllable/ Current and Future signals.
  - Full Navigation Data Generation – Important for receivers to see full messages.
  - Atmospheric/ Orbital/ Multipath models allow tests for PRTCs to see such impairments.
  - 1PPS and Time of Day output produced, synchronised to RF signals.

- **Tests**
  - Basic scenarios
  - Verification purpose: Go/ No Go
  - Multipath
  - Antenna Pattern
  - Obscuration
  - Leap seconds
Calibrating Timing Error for Timing Receivers

Important tests to check software algorithm in timing receiver

- GPS Satellite
  - Force satellites SVID into different channels. Checks algorithm to see which satellites are used for timing.
- Add different tests/ Keep running for as long as possible / Repeat / make changes

Tests

1. All Satellites off
2. Turn on channels 1 to 6
3. Force satellite 13 to CH: 1
4. Force satellite 16 to CH: 4
5. Turn all satellites off
Calibrating Timing Error for Timing Receivers

Important tests to check software algorithm in timing receiver

- GPS Multipath and fading effect
- Introduce these effects for complex scenarios of receiver location, i.e., surrounded by urban tall buildings.

1. Reduce power on channels 5 and 6
2. Change signals from satellites 16 and 22 to multipath
Calibrating Timing Error for Timing Receivers

*Important tests to check software algorithm in timing receiver*

- GPS Leap Seconds
  - Important to test for introduction of leap seconds if correct warnings and actions occur when event happens.
- **Receiver manufacturers do not always test this.**
  - 1998: Mobile Phone Blackout in USA – time change was outside network tolerance
  - 2012: Qantas Airline over 400 flights by 2 hours – operating system using UTC did not update correctly.

- Tests for switching between constellations
  - Perform tests with both GPS/Beidou satellites on, turn off all Beidou satellites to see if receiver will start tracking GPS.
  - Force GPS to track – do the same with Beidou.
Products & Solution Updates:
- Application Testing:
- Automotive
GPS/GNSS Record/Playback Approach – GSS6425

http://v.youku.com/v_show/id_XMTMxMjgxMTk0MA==.html?from=y1.7-1.2#paction (Spirent Automotive application Video)
eCall/ERA-GLONASS Emergency Services Overview

1. Emergency Call
   - Automatic: As soon as the on board sensors (airbag sensors) register an accident
   - Manual: By pushing a dedicated button in the car

2. Positioning
   - The accurate position and vehicle information is sent to the nearest emergency call centers through the satellite positioning and mobile telephony caller location.

3. Emergency call center (PSAP)
   - A trained operator tries to talk with the vehicle’s occupant to get more information. In the case of no response, emergency services are sent out without delay.

4. Emergency services dispatched
   - Automatic notification on crash site enables the emergency services to be quickly dispatched for immediate help.

* eCall – Mandatory across EU from March 2018
* ERA-GLONASS – Mandatory in Russia from January 2015
Spirent’s eCall & ERA-GLONASS solution

- Tests In-Vehicle System by simulating GNSS signals (with cellular network and PSAP emergency center).
  - Supports Europe’s eCall
  - Supports Russia’s ERA-GLONASS

[Diagram showing GNSS Simulator, Controller PC, Vehicle System under tested, GSM Emulator.]
Products & Solution Updates:
- Application Testing:
- Zoned Chamber
Zoned Chamber: Description of the Test Problem

- Can ‘Outdoors’ be brought ‘Indoors’?
- Test with real antennas
  - Single element
  - Multiple element adaptive antenna arrays
- Test with real geometry
  - Changes automatically with time change or position change for the test
Zoned Approach – Antenna Testing

Directional Antennas (One per zone)
potential ‘Dead’ zone

SimGEN Controller

USB Hub

X ‘n’ o/p
Products & Solution Updates:
- Robust PNT
Typical GNSS Vulnerabilities

Spoofing
- Covert
- Deception

Multipath

Interference
- Intentional
- Unintentional

Cyber Attacks
- Non-RF

GNSS Segment Errors
- Erroneous upload data
- SV Faults (E.g., SVN49)

Atmosphere
- Scintillation
- Solar Activity
Robust PNT Framework

Cyber Threat Intelligence Library
- Interference
- System effects
- Atmosphere
- Spoofing

Test Bench
- Automated analysis & reporting
- Performance testing for R&D

Audit & Test Services
- Evaluate
- Report
- Improve
Robust PNT Test Framework: Products & Services

Practical solution for improving robustness

1. DETECTOR
Sensor to capture & analyse real interference

2. THREAT INTELLIGENCE LIBRARY
Actual & typical threats
Constantly updated

3. LAB TEST BENCH
Automated analysis & reporting

4. AUDIT & CONSULTING
Assess threat impact
Practical advice

5. TEST SERVICES
Test o Analyse o Report

GNSS segment errors
Spoofing
Space weather
Events
Recorded real events
Detector System Operation

- 24/7 continuous monitoring
- Event alert via e-mail
- GPS L1 16 MHz bandwidth (v1 Detector)
- Automatic detection of jamming and spoofing events
  - Store sample of RF data
  - Preliminary analysis
  - Results stored in Detector database, accessible via web server, e-mail send option
- Enables full Impact analysis
  - Intentional or unintentional interference
  - Jammer type
  - Analysis of multiple instances of the same interference
  - Correlation of equipment problems with detected events
  - Identify trends in interference threats
  - Enables informed actions and decisions for countermeasures

Typical log report

Event ID: pr000234020150362000
Device ID: pr5366
Start Time (UTC): 23/07/2015 09:38:02
Duration (sec): 55
Event Type: Automatic_Detection
Max Power: E.352275
Type Of Signal: CHIRPSAWTOOTH

Characterization:
HIGH confidence => signal IS spectrally periodic.
HIGH confidence => signal IS spectrally varying.
HIGH confidence => signal NOT freq hopping.
HIGH confidence => signal NOT pulsed.
Overview: Test Bench Vision

- **Test Automation**
  - Select → Run → Analyse → Report

- **Threats**
  - Real threats
  - System events
  - Atmosphere
  - Spoofing

- **Test Library**
  - Test cases
  - Test scenarios
  - Test parameters

- **Test Systems**

Fake Signals
Test Bench @ October 2015

- Typical GPS Threat Commercial Test Pack
  - 30 real detected threats initially
  - Test scenario pack, incorporating threats
  - Delivery via .ftp download
  - Updates quarterly during initial 12 months period

- Interference Generation System: GSS7765
- Multi-GNSS Simulator: GSS9000 or GSS6700
- SimGEN control software

- SimSAFE GNSS spoofing lab test system
Robust PNT Audit & Report Service

- Spirent will provide equipment and personnel to carry out a Robust PNT audit of your receiver, system or application – including:
  - Performance against real-world jamming/spoofing/multi-path/solar flare scenarios
  - Identification of any significant vulnerabilities
  - Overall Spirent Resilience Rating score
  - Risk and impact assessment
  - Recommendations for improvement

- At Spirent location or your chosen location

DETECTOR Installation support

- Set-up and check of GNSS Interference Detector or network installation

Robust PNT Professional Services Solutions

- Implementation services – helping you get up and running
- Test services – targeted expertise from qualified Spirent engineers
- Resident engineer service – extended on-site technical expertise from Spirent for long-term projects
Visit Spirent website to find out more about GNSS testing solution and products.

www.spirent.com
www.spirent.cn

Thank you

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