QZSS L6 Enabled Multi-band Multi-GNSS Receiver

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Marketing Department. High Precision Product Director
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  ● News

PART 2  Multi-band Multi-GNSS Technology
  ● GNSS Reception Status and Advantages of each band
  ● The design concept of ALLYSTAR cynosure III architecture in SoC
  ● Output Protocol : NMEA, RTCM, Proprietary Messages

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PART 1  ALLYSTAR

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ALLYSTAR Technology Co. Limited (2017)

Allystar is dedicated to GNSS chips designing & algorithm, and products’ designing, R&D, sales and other related business. We provide chipsets and application solutions to terminal market of consumer electronics, national vital industry, automotive industry and IoT

Addition information:  
At a Glance

Team established and entered GNSS market

- Acquired Fujitsu GNSS team (part of MCU business group);
- Re-organized HED wireless LAN team;
- HD8010 (GPS) shipped to Japan and China markets.

2013

1st Beidou SoC supplier in China

Beidou/GNSS products launched to the market.

2014

HD8020 GNSS chipset in MP

- HD8020 Beidou/GNSS SoC chip to China and WW markets;
- HD8020 won the first prize of Technology & Innovation at CSNC.

2015

ALLYSTAR technology established

Spin-out from HED to be location service technology provider.
Dedicated on Multi-Band GNSS chip design

2016

HD8030 GNSS MCU chipset in MP

- HD8030 GNSS MCU chip to consumer markets;
- HD8030 won the first prize of Technology & Innovation at CSNC.

2017

HD8040 GNSS chipset in MP

- Multi-band Multi-GNSS SOC to support high precision applications
- GPS / QZS L1, L2, L5, L6
- BDS B1 B2 B3
- GLO L1OF L2OF
- GAL E1 E5
- IRNSS L5

2018

HD9300 GNSS chipset in MP

Multi-band Multi-GNSS SOC to support high precision applications
GPS / QZS L1, L2, L5, L6
BDS B1 B2 B3
GLO L1OF L2OF
GAL E1 E5
IRNSS L5
Allystar offers dual-antenna GNSS-aided INS platform
Dual-frequency GNSS smartphone supports BDS phase III signal
Allystar launches tiny dual-band GNSS module
Allystar launches multi-band, multi-GNSS chip for devices
Allystar offers GNSS antenna for high-precision positioning
https://www.gpsworld.com/allystar-offers-gnss-antenna-for-high-precision-positioning/
Allystar releases multi-band GNSS raw data chip and module
Allystar Technology Offers Multi-Band, Multi-GNSS Single Chip
International GNSS Seminar & Workshop

ION 2019 September @USA
Multi-Band Multi-GNSS SoC for Mass Market Applications

SUMSAI Summer School 2019 August @TOKYO
QZSS L6 Enabled GNSS receiver

ION GNSS workshop 2019 June @INDIA
NAVIC Enabled GNSS Receiver and Testing by Spirent Simulator

ION PACIFIC PNT 2019 April @USA
Chip-grade Multi-Band Multi-GNSS RTK and Attitude Determination with Low Cost Dual Antennas for Mass Market Applications

ION ITM/PTTI 2019 January @USA
Single-Chip Delivers Multi-Band Multi-GNSS Raw Measurement and Built-In RTK Engine For Mass Market Applications

ION GNSS workshop 2018 October @CHINA
Multi-band Multi-GNSS SoC for Mass and Automotive Applications
PART 2  Multi-band Multi-GNSS Technology

- GNSS Reception Status and Advantages of each band
- The design concept of ALLYSTAR cynosure III architecture in SoC
- output protocol : NMEA, RTCM, Proprietary Messages
What are the advantages of applying in the future?

Has been widely used in the consumer market

- L5 band
- L2 band
- L6 band
- L1 band

IRNSS
- L5
- B2a
- E5a
- E5b
- L2C
- L2OF
- B3I
- QZSS LEX
- E6
- B1I
- L1 C/A
- L1OF

GPS/QZSS
- B1C
- E1
- L1 C/A

BDS
- BDS
- GLONASS
- GALILEO
GNSS Advantages and Applications in each band

**L5 band : Single Point Positioning**
- L5/E5 maximizes measurement accuracy
- Multipath Mitigation based on higher chip rate
- Standalone / Mass market mainly

**L2 band : Relative Positioning**
- maximizes satellites visibility
- common CORS support:
  - GPS L1 / L2
  - GLO L1 / L2
  - BDS B1 / B2
- RTK Technology mainly

**L6 band : Precise Point Positioning**
- SSR-type correction service
- B3I / LEX is operating
- PPP Technology mainly
The design concept of CYNOSURE III architecture

- Cover all GNSS civil signals in three RF settings
- Integrate RF and Baseband into SoC
Option A:

- Supports: GPS L1/L5, QZS L1/L5, BDS B1/B2a, GAL E1/E5a, GLO L1OF, and IRNSS
Option B:

- supports: GPS L1/L2, QZS L1/L2, BDS B1/B2, GAL E1/E5b, GLO L1OF/L2OF
Option C:

- Supports: GPS L1, QZS L1/L6, BDS B1/B3I, GAL E1/E6, GLO L1OF
Highlights of CYNOSURE III GNSS SoC (1/2)

- Integrate RF and Baseband into SoC
- Smallest Package: 5x5 mm$^2$ in QFN, 3x3 mm$^2$ in WLCSP
- Smallest Power Consumption: < 45 mA in dual-band mode
- Support all civil GNSS signals in three RF settings
- Support Raw data output for high precision developments
Highlights of CYNOSURE III GNSS SoC (2/2)

Receiving 5 systems (GPS+QZS+BDS+GAL+GLO) at the same time to maximize satellites visibility
Output Protocol

- Standardization
- Compatibility
- Feasibility

- NMEA 0183 4.1 version (PVT solution)
- RTCM Standard 3.x
  - Multi-band Multi-system GNSS Raw
    e.g. Pseudo range, Phase range, SNR, Doppler
- Proprietary Binary Messages
  - IRNSS raw data, QZSS L6 raw data
### Standard RTCM 3 Protocol (GNSS Raw Data)

<table>
<thead>
<tr>
<th>Message type</th>
<th>Intended Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSM1</td>
<td>Conventional and advanced DGNSS</td>
</tr>
<tr>
<td>MSM2</td>
<td>Conventional RTK modes</td>
</tr>
<tr>
<td>MSM3</td>
<td>Storing data in a complete set of RINEX observables</td>
</tr>
<tr>
<td>MSM4</td>
<td>RTK with extended resolution. Real time Network data streaming.</td>
</tr>
<tr>
<td>MSM5</td>
<td>Transmission of a complete set of RINEX observations with extended resolution</td>
</tr>
</tbody>
</table>

**RTCN STANDARD 10403.3 DIFFERENTIAL GNSS (GLOBAL NAVIGATION SATELLITE SYSTEMS) SERVICES – VERSION 3**

<table>
<thead>
<tr>
<th>System</th>
<th>MSM4</th>
<th>MSM7</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>L1 / L2 / L5</td>
<td>L1 / L2 / L5</td>
</tr>
<tr>
<td>BDS</td>
<td>B1 / B2 / B3</td>
<td>B1 / B2 / B3</td>
</tr>
<tr>
<td>GAL</td>
<td>E1 / E5</td>
<td>E1 / E5</td>
</tr>
<tr>
<td>GLO</td>
<td>L1 / L2</td>
<td>L1 / L2</td>
</tr>
<tr>
<td>QZS</td>
<td>L1 / L2 / L5</td>
<td>L1 / L2 / L5</td>
</tr>
<tr>
<td>SBS</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>IRNSS</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**CYNOSURE III support MSM table (I/O)**

<table>
<thead>
<tr>
<th>System</th>
<th>Ephemeris</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>MSG 1019</td>
</tr>
<tr>
<td>BDS</td>
<td>MSG 1042</td>
</tr>
<tr>
<td>GAL</td>
<td>MSG 1045 / MSG 1046</td>
</tr>
<tr>
<td>GLO</td>
<td>MSG 1020</td>
</tr>
<tr>
<td>QZS</td>
<td>MSG 1044</td>
</tr>
<tr>
<td>SBS</td>
<td>-</td>
</tr>
<tr>
<td>IRNSS</td>
<td>-</td>
</tr>
</tbody>
</table>

**CYNOSURE III support Navigation MSG Table (O)**
There is no standard RTCM protocol to support NAVIC yet.

- Allystar supports proprietary binary messages of NAVIC sub frame output.

$\text{SPIRNSF}, \ldots$
### QZSS L6 Raw Data Output (1/2)

#### Original Data Structure:

- Sync word (2)
- Class ID (1)
- Message ID (1)
- Payload length (2)
- SVN (2)
- Freq ID (1)
- Data length (N), value = N + 2
- Data (N*4)
- Checksum (2)

#### New Data Structure:

- Sync word (2)
- Class ID (1)
- Message ID (1)
- Payload length (2)
- SVN (2)
- Freq ID (1)
- Data length (N), value = N + 2
- GPS Week Number (2)
- GPS Time of week in ms (4)
- SNR (1)
- Flag (1)
- Data (N*4)
- Checksum (2)

**Extend data:** big endian  
**Others:** little endian

---

**L6 MESSAGE**

**Direction of Data Flow from Satellite:** Most significant bit (MSB) transmitted first

- 2000 Bits - 1 Second

**Header:** 49 Bits  
**Data Part:** 1695 Bits  
**Reed-Solomon Code:** 256 Bits
# QZSS L6 Raw Data Output (2/2)

**Original:**

<table>
<thead>
<tr>
<th>Sync word</th>
<th>Class ID</th>
<th>Message ID</th>
<th>Payload length</th>
<th>SVN(2)</th>
<th>Freq ID</th>
<th>data length(1), value = N</th>
<th>data (N*4)</th>
<th>checksum(2)</th>
</tr>
</thead>
</table>

**New:**

<table>
<thead>
<tr>
<th>Sync word</th>
<th>Class ID</th>
<th>Message ID</th>
<th>Payload length</th>
<th>SVN(2)</th>
<th>Freq ID</th>
<th>data length(1), value = N + 2</th>
<th>GPS Week Number(2)</th>
<th>GPS Time of week in ms(4)</th>
<th>SNR(1)</th>
<th>Flag(1)</th>
<th>data (N*4)</th>
<th>checksum(2)</th>
</tr>
</thead>
</table>

*Extend data: big endian*
*Others: little endian*

## Flag definition:

```c
// QZSS L6 raw data flag, there is 8 bit can be used.
enum {
    QZSL6_ALL_GOOD = 0x0,
    QZSL6_RS_FAILED = 0x1,
    QZSL6_WEEK_NOT_CONFIRM = 0x2,
    QZSL6_TOW_NOT_CONFIRM = 0x4,
};
```

## Header Description:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sync word</td>
<td>0xF1D9</td>
</tr>
<tr>
<td>Class ID</td>
<td>0x2</td>
</tr>
<tr>
<td>Message ID</td>
<td>0x10</td>
</tr>
<tr>
<td>SVN</td>
<td>Follow the NMEA format, QZSS L6 SVN is &quot;prn +700&quot;</td>
</tr>
<tr>
<td>Freq ID</td>
<td>0</td>
</tr>
<tr>
<td>Data length</td>
<td>Word size</td>
</tr>
</tbody>
</table>
Flexible channels to track L6D and L6E

- Tracking L6D and L6E at the same time (max. 8 dedicated channels)
- Standard RTCM SSR-Type output
- Lowest Power consumption: 38 mA
- Smallest module size: 7.6mm x 7.6mm x 1.9mm

Reference Stations

GPS  BDS  GAL  GLO

QZSS

LEX Signal

Orbit/Clock

ALLYSTAR L6D / L6E Decoder

Real Time PPP on
- Automated Vehicle
- High Precision Applications

L6E @MADECA
L6D @CALS

7 x 7 mm
QZSS L6 Application Note:

- One module to access L1/L5 (Option A) or L1/L2 (Option B)
- One module to access QZS LEX signal (Option C)
- Overall power consumption is < 90 mA
- Overall size is about 7mm x 14 mm
PART 3 Demonstration

- RF Option A: L1 & L5 band
- RF Option B: L1 & L2 band
- RF Option C: L1 & L6 band
**Tools**

### FTP server

- **Address**: fcd.allystar.com
- **user**: hd_cynosure3
- **password**: hd_cynosure3@0929

- **EVB**
- **Driver**
- **GUI program**
  - Satrack.exe
  - RTKLIB
- **Firmware**

RTCM Protocol compatible with RTKLIB
(Open source tool, Author: T. Takasu)
Steps to access GNSS signal via Satrack and EVB

Step 1: connect EVB to PC
Step 2: open Satrack.exe
Step 3: choose com port & connect
Step 4: monitor GNSS signal

Choose com port
Connect
External Active GNSS Antenna

NMEA data
USB

2018 ALLYSTAR Confidential
Change Firmware

**FTP server**

**Address**: fcd.allystar.com  
**User**: hd_cynosure3  
**Password**: hd_cynosure3@0929
Configure the GNSS receptions and bands

▲ Cynosure III SoC has only 40 tracking channels

● Flexible command to choose specific Reception and frequency

Satrack.exe:
- View
- AS Messages
- CFG
- NAVSAT
  - Choose frequencies
  - Send

Relevant commands, please refer to PI-4-1712-Sattrack V1.29-User Manual.pdf
Demo via RTKLIB (1/2)

RTKLIB is an open source program package by Tomoji Takasu
Demo via RTKLIB (2/2)

**Receiver**
- HD9310

**Software**
- RTKNAVI.exe

**GNSS Mode**
- GPS L1CA / L2CM
- BDS B1I / B2I

**Base**
- HK (VRS)

**Baseline**
- 2409.67 m
PART 4  Competitive Solutions

- TAU module series
- Compatible antennas
Advantages based on CYNOSURE III Technology

Can easily design competitive multi-band multi-GNSS solutions with smallest size and lowest power consumption.

- **Down size**: 75%
- **Down Power**: 50%

<table>
<thead>
<tr>
<th>Size</th>
<th>Power</th>
<th>Other Competitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>7x 7 mm² (w/o LNA)</td>
<td>Power &lt; 45 mA</td>
<td>12 x 16 mm²</td>
</tr>
<tr>
<td>10x 10 mm² (w/ LNA inside)</td>
<td>Power &lt; 45 mA</td>
<td></td>
</tr>
<tr>
<td>12x 16 mm²</td>
<td>Power &gt; 85 mA</td>
<td></td>
</tr>
</tbody>
</table>
**L1 Band GNSS Antenna – AGR6301**

<table>
<thead>
<tr>
<th>GNSS Reception</th>
<th>GPS/QZS L1, BDS B1, GAL L1OF, GAL E1, SBAS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specifications</strong></td>
<td></td>
</tr>
<tr>
<td>Architecture</td>
<td>Dual Feed Network</td>
</tr>
<tr>
<td>Axial Ratio</td>
<td>&lt; 2dB</td>
</tr>
<tr>
<td>Gain</td>
<td>3~5dBi</td>
</tr>
<tr>
<td>Polarization</td>
<td>RHCP</td>
</tr>
<tr>
<td>LNA gain</td>
<td>25dB typ.</td>
</tr>
<tr>
<td>Noise Figure</td>
<td>&lt; 2dB</td>
</tr>
<tr>
<td>Output SWR</td>
<td>&lt; 1.5</td>
</tr>
<tr>
<td>Output Impedance</td>
<td>50 Ohm</td>
</tr>
<tr>
<td>Out-band rejection</td>
<td>&gt; 1640Mhz (&gt;40dB)</td>
</tr>
<tr>
<td>Support Voltage</td>
<td>1.8~5.5 V</td>
</tr>
<tr>
<td>Power consumption</td>
<td>7.5mA (3.3V typ.)</td>
</tr>
<tr>
<td><strong>Mechanicals</strong></td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>L45.8 x W47 x H14mm</td>
</tr>
<tr>
<td>Interface</td>
<td>SMA-M-M</td>
</tr>
<tr>
<td>Mounting</td>
<td>Magnet mount</td>
</tr>
<tr>
<td>Water Proof</td>
<td>IP67</td>
</tr>
</tbody>
</table>
# L1 / L2 band GNSS Antenna – AGR6302

## GNSS Reception
- GPS/QZS L1 L2, BDS B1 B2I, GLO L1OF, GAL E1 E5b, SBAS

## Specifications
- Architecture: Quad Feed Network
- Axial Ratio: < 2dB
- Gain: 3~5dBi
- Polarization: RHCP
- LNA gain: 31dB typ.
- Noise Figure: < 2dB
- Output SWR: < 2
- Output Impedance: 50 Ohm
- Out-band rejection: In-Band ± 80Mhz (>35dB)
- Support Voltage: 2.5~5.5 V
- Power consumption: 22mA (3.3V typ.)

## Mechanicals
- Size: D79 x H24mm
- Interface: SMA-M-M
- Mounting: Magnet mount
- Water Proof: IP67
# L1 / L5 band GNSS Antenna – AGR6303

## GNSS Reception
- GPS/QZS L1 L5, BDS B1 B2a, GLO L1OF, GAL E1 E5a, SBAS

## Specifications
- **Architecture**: Quad Feed Network
- **Axial Ratio**: < 2dB
- **Gain**: 3~5dBi
- **Polarization**: RHCP
- **LNA gain**: 31dB typ.
- **Noise Figure**: < 2dB
- **Output SWR**: < 2
- **Output Impedance**: 50 Ohm
- **Out-band rejection**: In-Band +/- 80Mhz (>35dB)
- **Support Voltage**: 2.5~5.5 V
- **Power consumption**: 22mA(3.3V typ.)

## Mechanicals
- **Size**: D79 x H24mm
- **Interface**: SMA-M-M
- **Mounting**: Magnet mount
- **Water Proof**: IP67
L1 / L6 band GNSS Helix Antenna

**GNSS Reception**
- GPS/QZS L1 L6

**Specifications**
- Architecture: Helix
- Gain: L1 > 1.5 dBi; L6 > 2.0 dBi
- Polarization: RHCP
- LNA gain: 31dB typ.
- Noise Figure: < 2dB
- Output SWR: < 2
- Output Impedance: 50 Ohm
- Out-band rejection: In-Band +/- 80Mhz (>35dB)
- Support Voltage: 3~5 V
- Power consumption: < 40mA (3.3V typ.)

**Mechanicals**
- Size: D27.5 x H58.6mm
- Interface: SMA-J

(2019.06.01 Hong Kong)
# Low Cost L1 / L5 Passive Patch Antennas

<table>
<thead>
<tr>
<th>GNSS Reception</th>
<th>GPS/QZS L1 L5, BDS B1 B2a, GLO L1OF, GAL E1 E5a, NAVIC, SBAS</th>
</tr>
</thead>
</table>
| Specifications | **Architecture:** Single Feed Stack  
|                 | **Axial Ratio:** L1 < 4dB; L5 < 13dB  
|                 | **Gain:** 3~5dBi  
|                 | **Polarization:** RHCP  
|                 | **Output SWR:** < 2  
|                 | **Output Impedance:** 50 Ohm |
| Mechanicals    | **Size:** Type A (35x35mm + 25x25mm)  
|                 | Type B (25x25mm + 15x15mm) |
Low Cost L1 / L5 Band Linear antenna

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Peak Gain (dB)</th>
<th>Average gain (dBi)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1176.45MHz</td>
<td>1.65</td>
<td>-3.15</td>
<td>48.45%</td>
</tr>
<tr>
<td>1227MHz</td>
<td>2.28</td>
<td>-1.87</td>
<td>64.98%</td>
</tr>
<tr>
<td>1575.42MHz</td>
<td>3.48</td>
<td>-1.31</td>
<td>73.94%</td>
</tr>
</tbody>
</table>
Allystar is glad to boost the location and Internet of Things (IoT) applications with the latest multi-frequency GNSS SoC (system on chip) technology.
L1 / L5 band design applications

JS-A2518M

JS-H410M

LYNO N32
Realizing in smart phone

The latest Lenovo smart phone offers dual-frequency GNSS capable of tracking GPS L1, L5, BDS B1, B2a, GAL E1, E5a, GLO L1OF, IRNSS (HD8041D only), the Z6 SE, using an Allystar chipset.