



# BHW Technologies (博泓微科技有限公司)



Advanced RF IC, Antenna, Filter, RF Front-End  
and Wireless System Solutions

## BHW AppNote #010

### Multi-Constellation GNSS Active Antenna Using BHWL161 Cascade and Single-Fed Dual-Band Antenna

Rev. 1.4

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# Background: Dual-Band is Next Mainstream for GNSS



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## Dual-Band Precision GNSS Market Moving from Insignificant to Billions in Less Than Five Years

Oyster Bay, New York - 06 Dec 2018

After many years of development at the fringe of the Global Navigation Satellite System (GNSS) industry, dual-frequency GNSS devices are finally ready to hit the mass market and will account for more than a billion chipset shipments in 2023, according to a new market data report by **ABI Research**, a market-foresight advisory firm providing strategic guidance on the most compelling transformative technologies. The report finds that the bulk of this growth will come from the adoption in the smartphone market with consumers hungry for better location accuracy.

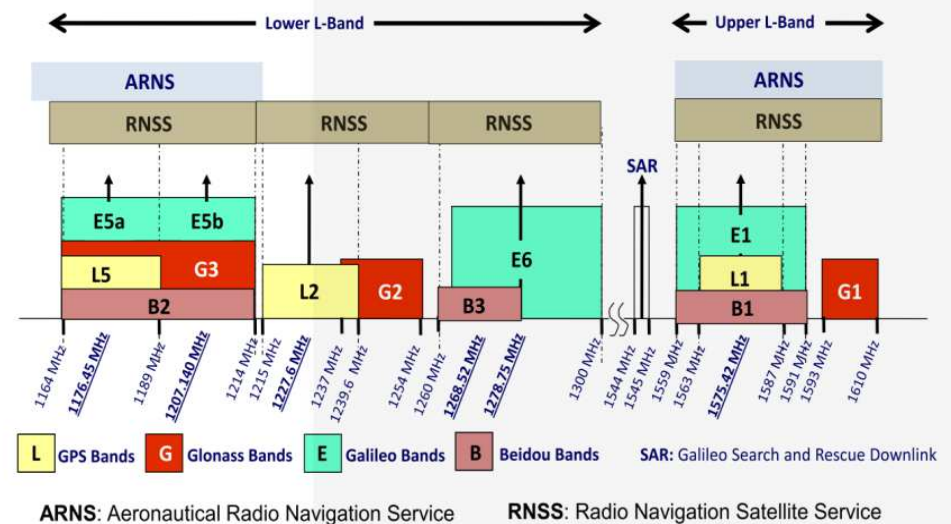
Dual-band GNSS can mitigate the so-called multipath interference effects which are especially present in areas with a high density of buildings, like urban canyons, and deliver significantly higher accuracy than single-frequency devices. However, there have been several obstacles preventing widespread adoption of dual-band GNSS until now, including insufficient satellite coverage of a second band, which could be L2 or L5/E5, high chipset prices, and challenges in fitting these integrated circuits and related antennas into small devices such as smartphones.

- 全球导航卫星系统正在经历从传统单频(L1/B1/E1/G1)到双频/三频 (L1/2/5, B1/2/3, E1/5/6) 的技术升级
- 定位精度由目前的3-6米大幅提升到30厘米-1米, 实现车道级别的精准定位导航
- 2018年后发射的大多数卫星具有多频功能, 下一代高精度卫星导航技术市场蓄势待发
- 多频GNSS将在5年内从微不足道发展到十亿级规模

### Technical Challenges for Dual/Multi-Band GNSS:

- New Dual/Multi/Wide-Band Antenna Technologies
- LNA with Low NF and Sufficient Gain over Wideband
- Resistant to RF Interference (Anti-Jamming/Spoofing)
- System Implementation and Optimization
- Delivering Best-Class Performance at Lowest BOM Cost

This AppNote describes design and test results of cascading two BHWL161 wideband GNSS LNAs to provide low-noise, high-IIP3 performance for all-band all-constellation GNSS active antennas and modules with best-class anti-RFI capability.

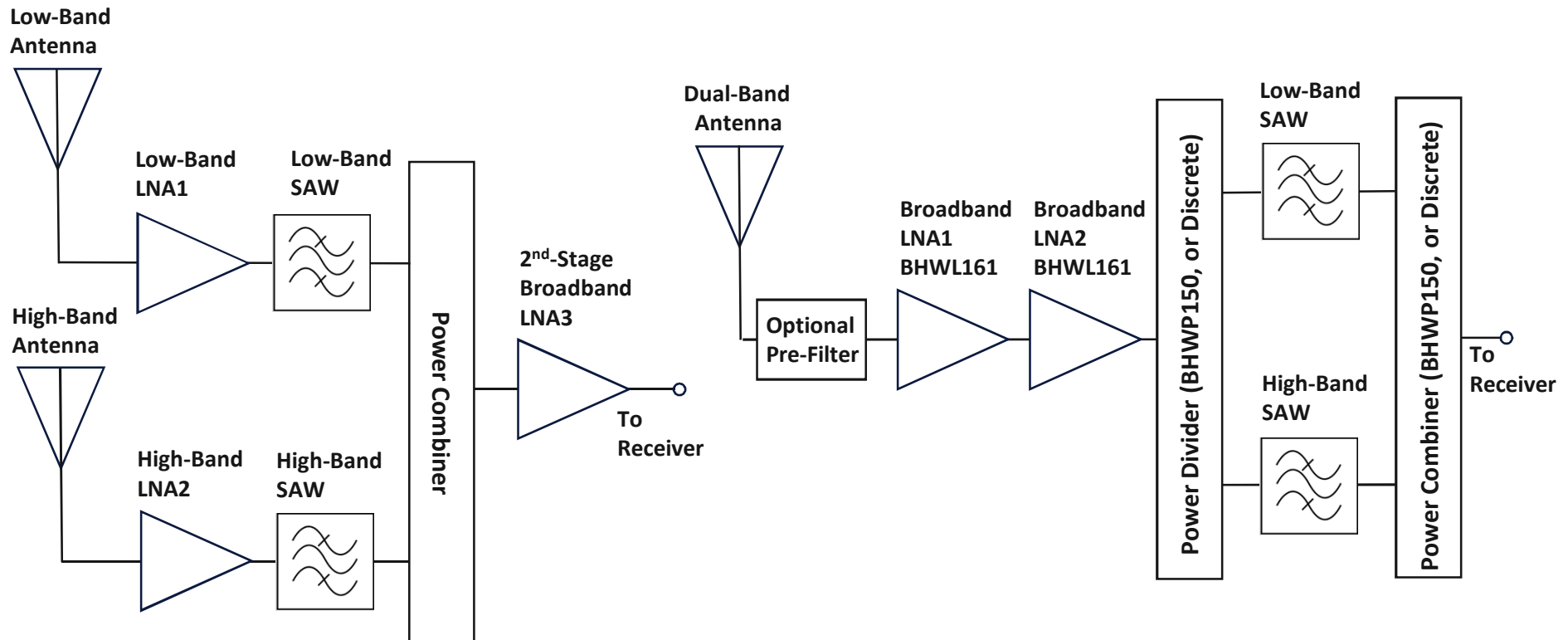


# LNB Topologies for Dual-Band GNSS



**Conventional Topology A**  
**Dual-Antenna/Dual-LNA**

**BHW Proposal Topology B**  
**Single-Antenna/Broadband-LNA**



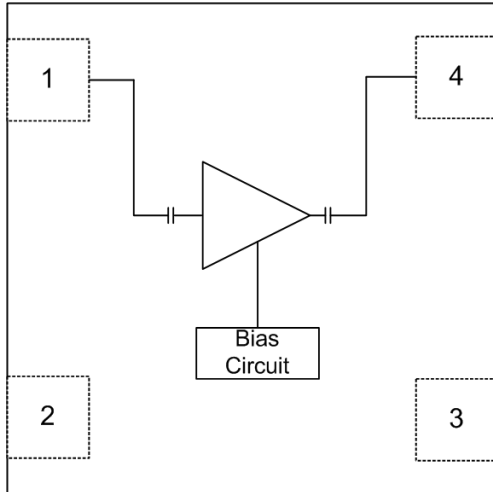
**Notes:**

- Most current dual-band GNSS designs use Topology A, based on separate antennas and LNAs for low and high band
- Dual/Multi-Band GNSS receiver with broadband antenna and LNA (Topology B) has huge size and cost advantages over dual-antenna/ dual-LNA based topology
- Full-band all-constellation LNAs with state-of-art RF performance are available today, such as BHWL161
- Concerns over potential interference/desensitization for broadband design is address by high input P1dB/IIP3 of the LNA
- Topology B takes full advantage of BHWL161's broadband, low-NF, moderate gain and outstanding IIP3 to enable multi-band GNSS LNAs (Low Noise Block) with best system NF and IIP3 at minimal device count, power, and BOM cost
- An optional double-notch pre-filter can be added between the antenna and LNA to further improve anti-jamming capability of the GNSS system significantly, while causing only very minor degradation in C/N0 and TTFF from cold start

# BHWL161 Wideband GaAs Low Noise Amplifier

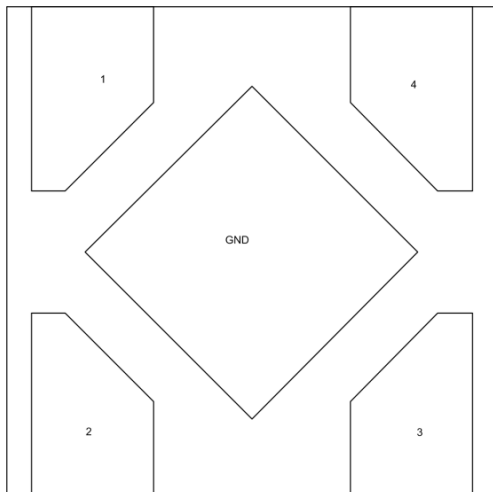


## Functional Block Diagram

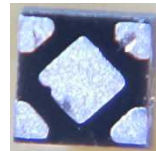


## Package Pin-Out

(Top "See-Through" View)



DFN-4L 1.0x1.0x0.45mm



## Product Overview:

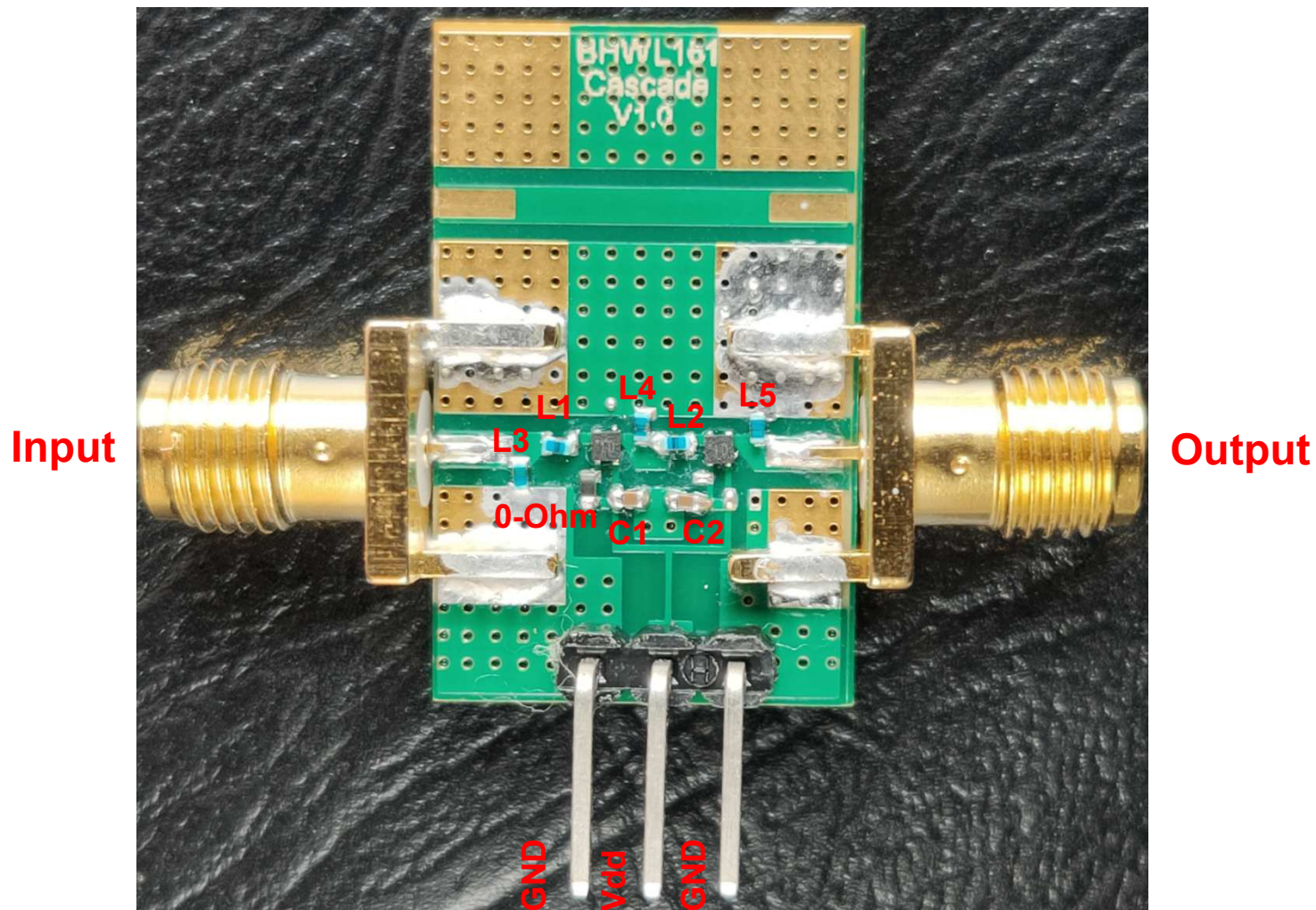
- Advanced GaAs E/D-pHEMT Process
- Ultra-Wideband 700MHz~2.5GHz Operational
- Support Full-Band GNSS 1165~1610MHz
- Ultra-Low 0.45/0.4dB EVB/De-Embedded NF at L1
- Record-Low 0.3dB NF at L1 with Optimal Matching
- NF <0.7dB at L1/L5; <0.8dB over Full GNSS Bands
- Gain: 15.5/17dB (High/Low Band)
- High Input P1dB: -3/-4dBm at 3.3/2.8V at 1575MHz
- IIP3: ~+5dBm at Vdd=3.3V at 1575MHz
- Adjustable Current: 2~9mA at 1.2~3.6V
- ESD at All I/O Ports: 1kV HBM, >2KV CDM
- Ultra-Compact 1.0x1.0mm DFN-4L Package
- Relaxed Pin Pitch 0.65mm for Easy PCB Assembly

## Applications:

- GNSS for Smartphones, Smart Watches, Wearables
- GNSS for PNDs, UAVs and Drones
- GNSS for Vehicles, ADS Systems
- GNSS for Shared Rides, Asset Tracking
- Active GNSS Antennas & Modules
- UHF 600/700/868/915MHz Products
- 2.4GHz Angle-of-Arrival Systems
- 2.4GHz Remote Controls
- Other Generic Radios from Sub-GHz to 2.5GHz



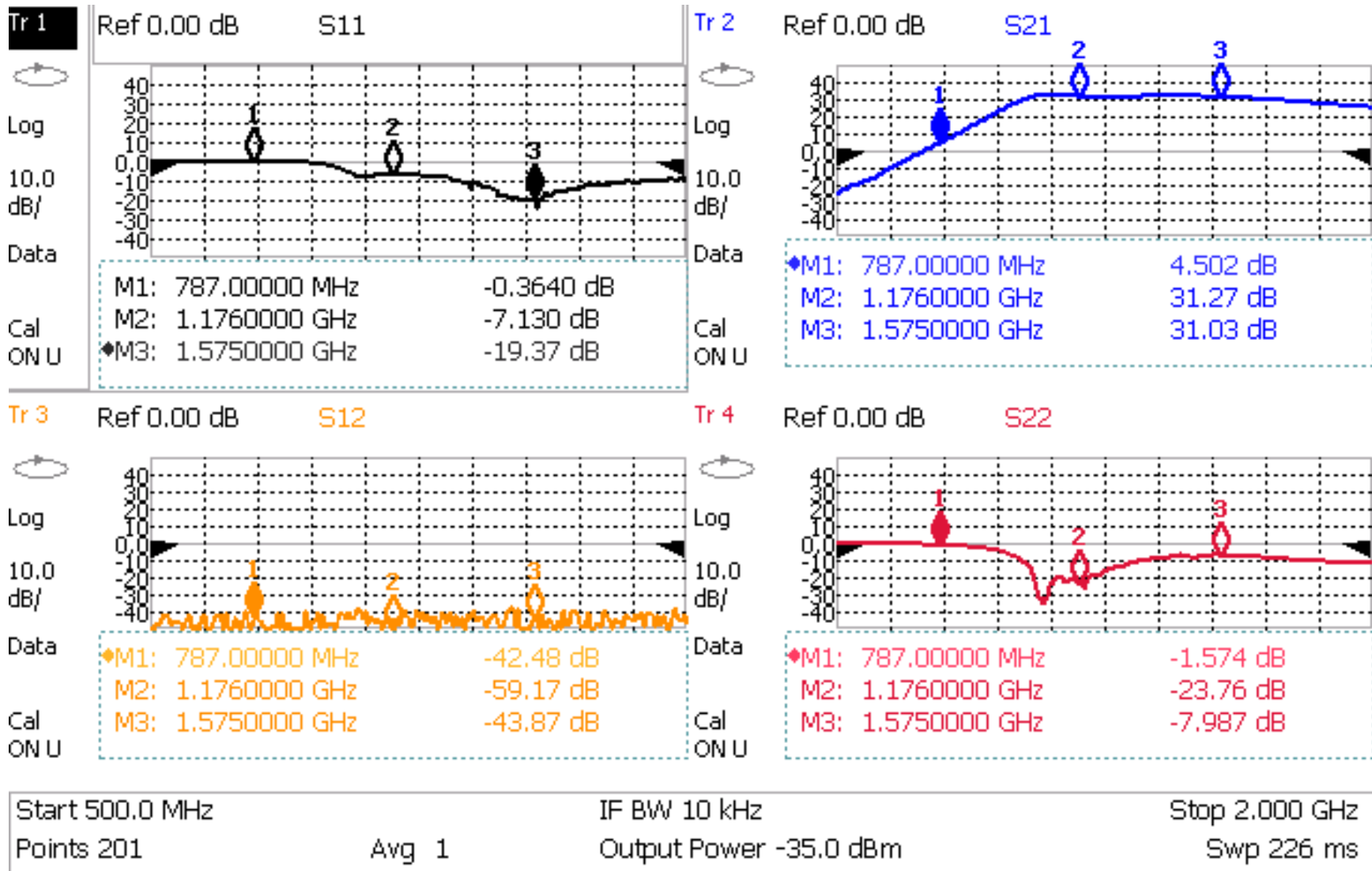
# BHWL161 Cascade EVB for Full-Band GNSS



## Nominal BOM for Full-Band GNSS (1165-1610MHz):

- $L1=L2=7.5\text{nH}$ ,  $L3=9.1\text{nH}$ ,  $L4=3.6\text{nH}$ ,  $L5=9.1\text{nH}$  (Murata LQW15A Recommended),  $C1=C2=1\mu\text{F}$
- Inductor values may need minor adjustment to achieve optimal performance on customer's specific PCB
- Optional resistors can be added to control line to reduce current for specific applications. See BHWL161 AppNote for details.
- Nominal bias:  $V_{dd}=V_{en}=3.3\text{V}$ ,  $I_{dq}\sim 13\text{mA}$  total for the two LNAs.

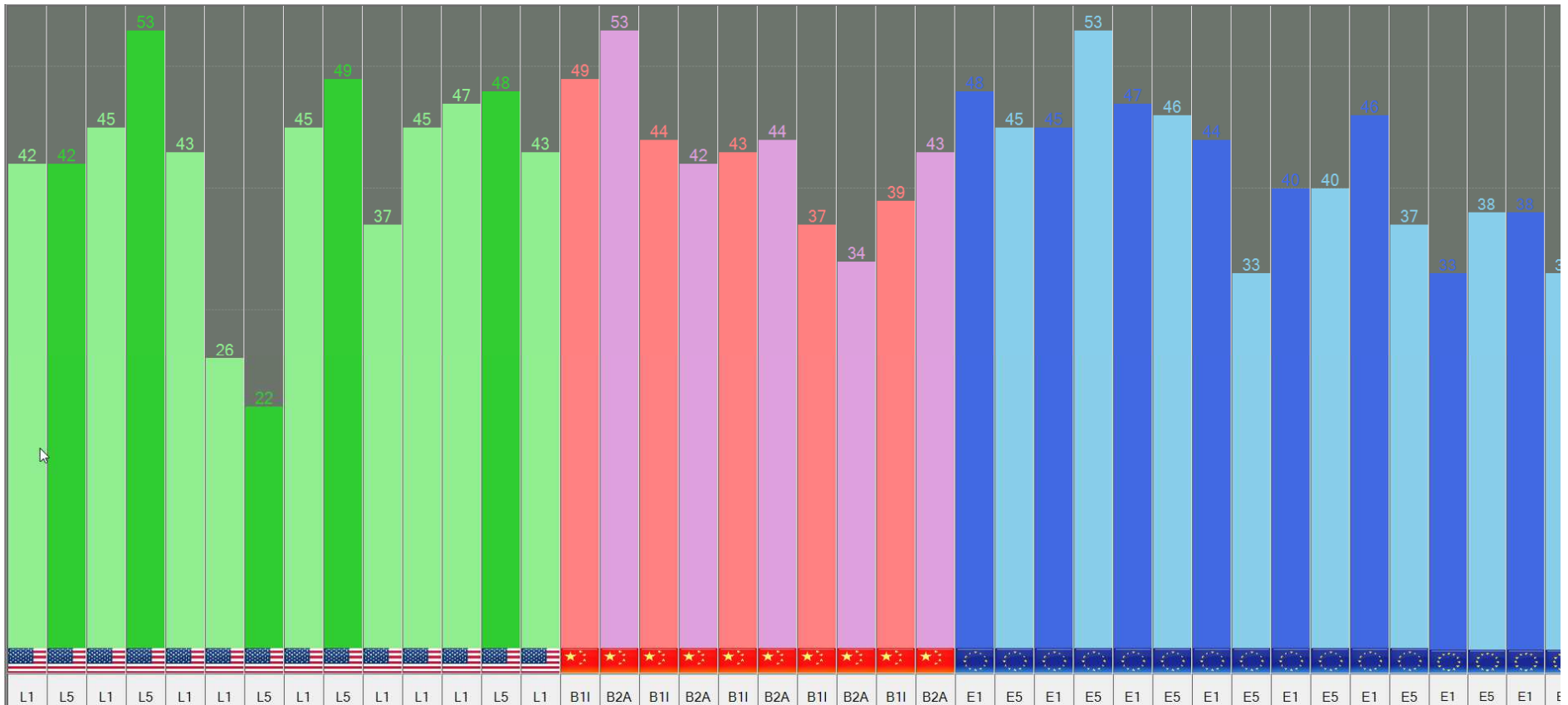
# BHWL161 Cascade for Full-Band GNSS : S-Parameters



**Notes:**

- DC Bias: Vdd=Ven=3.3V, Idq~13mA total
- Measured S21 includes EVB trace and SMA connector losses (~0.2dB)

# BHWL161 Cascade Breadboard: C/N0 Test Results



## Comments:

- Maximum C/N0 of 49~53dB was measured in L1, B1, L5, B2, E5 bands.
- C/N0 test results depends on several factors including sky clearance and satellite positions.
- This preliminary breadboard test verified the feasibility of the proposed dual-band LNB architecture, with best system NF and sufficient system IIP3 for most applications.

# BHW RF Front-End AppNote Library



*This is an abridged version of BHW AppNote #010. Please contact BHW Support or your local sales rep/distributor for a complete copy of the document and other related information.*



# BHW RF Front-End Solutions AppNote Library



In addition to standard datasheets and EVB/BOM info, BHW publishes an AppNote series that address various topics on RF front-end design and performance over a wide frequency range from 300MHz to 6GHz, as an effort to assist customers in developing cutting-edge, cost-competitive products:

- BHW AppNote #001 - Cross-Over Cascade of BHWM253 to Boost Tx Power and Rx Sensitivity of 2.4GHz Systems
- BHW AppNote #002 - Accurate Benchmark of GNSS CNO Using the Power-Splitter Method
- BHW AppNote #003 - Boosting Wi-Fi Tx Power and Rx Sensitivity with BHWA251 and BHWM252
- BHW AppNote #004 - UHF 900MHz RF Front-End Solution Using BHWA251 Half-Watt PA and BHWL160 Sub-1dB-NF LNA
- BHW AppNote #005 - Sub-1GHz Applications of BHWA350 2-in-1 Wideband Fully Matched Amplifier
- BHW AppNote #006 - Low-Noise High-IIP3 LNB Architecture for Dual-Band High-Precision GNSS Using Cascade of BHWL160
- BHW AppNote #007 - UWB RF Front-End Solution Using BHWA350 and BHWM552
- BHW AppNote #008 - High-Power 5.8GHz RF Front-End Solution Using BHWA555 and BHWM552 for ETC, V2X and Wireless Video
- BHW AppNote #009 - 5.8GHz RF Front-End Using BHWA350 and BHWM552 for Wireless Audio
- BHW AppNote #010 - Multi-Constellation GNSS Active Antenna Using BHWL161 Cascade and Single-Fed Dual-Band Antenna
- BHW AppNote #011 - BHWL161 Super-Compact Low-Power Low Noise Amplifier for Range Extension of 2.4GHz RC and IoT
- BHW AppNote #012 - Enabling Cost-Effective High-Precision GNSS Using BHWL161 and Linear-Polarization PCB Antenna
- BHW AppNote #013 - GNSS Noise Floor vs Receiver Architecture
- BHW AppNote #014 - Designing Ultra Low-Power High-Performance GNSS Products Using BHWL160 GaAs PHEMT LNA
- BHW AppNote #015 - BHWL161 GNSS Full-Band High-Performance LNA in Super-Compact 1x1mm DFN with Relaxed Pin Pitch
- BHW AppNote #016 - Improving GNSS NF Measurement Accuracy Using Broadband LNA BHWL161 as Pre-Amp
- BHW AppNote #017 - High-Efficiency, Low-NF 2.4GHz Front-End Solution for IoT Using BHWA251 and BHWM252
- BHW AppNote #018 - Optimizing BHWA555 Wideband One-Watt PA for Long-Range 5.8GHz Transmitter Applications
- BHW AppNote #019 - Miniature 2.4GHz RF Front-End with Integrated Chip Antenna and BHWM253 for TWS and IoT
- BHW AppNote #020 - Multiplying the Range for 2.4GHz Music Streaming with BHWR250L Active Integrated Antenna (AiA)
- BHW AppNote #021 - Range Extension for 2.4GHz Wireless Systems with BHWR250M Active Integrated Antenna (AiA)
- BHW AppNote #022 - Enabling Long-Range Angle-of-Arrival for High-Precision Indoor Positioning with BHWR250N RF AiA
- BHW AppNote #023 - Extend the Range for 5.8GHz Audio/Video Streaming with BHWR580M Active Integrated Antenna (AiA)
- BHW AppNote #024 - Improving 5.8GHz Radio Link Budget with BHWR580L Active Integrated Antenna (AiA)
- BHW AppNote #025 - Improving Range and Throughput of 2.4GHz Wi-Fi with BHWR250 Array Antenna
- BHW AppNote #026 - Improving Range and Throughput of 5GHz Wi-Fi with BHWR550 Array Antenna
- BHW AppNote #027 - Multi-Band High-Accuracy GNSS Solutions Using BHWP150 DFN1x1 Ultra-Compact Power Divider & Combiner
- BHW AppNote #028 - Use BHWM252 Cascade to Extend Range of 2.4GHz Wireless Systems with Single-Port SoCs
- BHW AppNote #029 - Improving Range of 2.4GHz Wireless Microphones and Audio Systems with BHWR250A Active Integrated Antenna (AiA)
- BHW AppNote #030 - Simultaneous Improvement in Range and Battery Life of 2.4GHz Wireless Systems with BHWR250M AiA

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