

### BHW Technologies (博泓微科技有限公司)



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

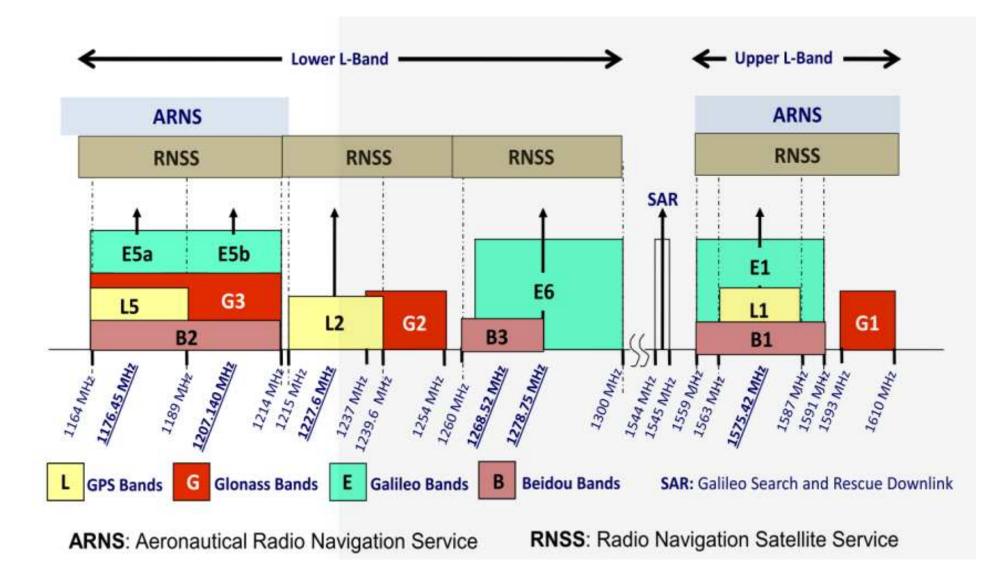
## BHW AppNote #013

### **GNSS Noise Floor vs Receiver Architecture**

**Rev. 1.1** 

www.bhw-tech.com

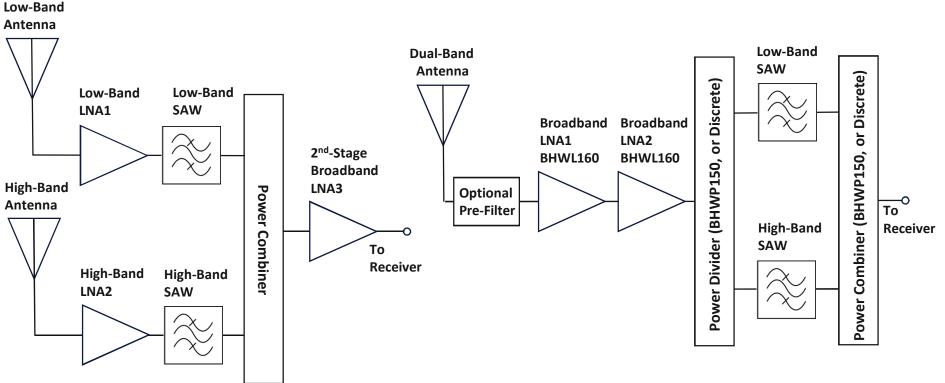




# **Receiver Topologies for Dual/Multi-Band GNSS**

#### **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 BHWL160/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 BHWL160/BHWL161's broadband, low-NF, moderate gain and outstanding IIP3 to enable multi-band GNSS LNBs (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

**BHW Technologies Confidential** 

### **GPS L1 Noise Floor vs Receiver Architecture**



#### Noise Floor with GPS L1 Antenna followed by BHWL160 and SAW Filter In-Band Noise Floor ~ -141dBm/Hz at ~1575MHz OOB Noise Floor ~ -149dBm/Hz at ~1612MHz

Image: Search Delta       -100.000 dBm *         Peak Search Delta       -100.000 dBm *         Peak Search Delta       -100.000 dBm *         Image: Trace One Delta       -100.000 dBm *         Start 1.555000 GHz       Center 1.585000 GHz       Stop 1.615000 GHz         Stop 1.615000 GHz       Stop 1.615000 GHz       Stop 1.615000 GHz         Stop 1.615000 GHz       Stop 1.615000 GHz       Stop 1.615000 GHz         Stop 1.615000 GHz       Stop 1.615000 GHz       Stop 1.615000 GHz         Stop 1.615000 GHz       Stop 1.615000 GHz       Stop 1.615000 GHz         Stop 1.615000 GHz       Stop 1.615000 GHz       Stop 1.615000 GHz	Normality       New Normality		Spike: Signal Hound Spectrum Analyzer Softwa File Edit Presets Settings Analysis Mor											- 0 ×
			Spectrogram Disabled *	Persistence Intensity						→ Single	C+ Auto	Rec	al	Preset
		FR								VBW 1	0.000000 kHz			
			Type Max Hold *	2		Burne Looks	2014 Laboratoria (1994)		Mkr 2	1.559997 GH	z, -94.73 dBm	Span 🔺		60.000000 MHz
			Color Update V	and the property of the second s		an a						Stop Step	100	1.615000 GHz 20.000000 MHz
		SEC.	Export Clear									<ul> <li>Amplitude</li> </ul>		
		120 HE	Type Normal *	-130.00								Div Gain Au	rto Gain	10.0 dB *
		1 1	Set Freq 1.575170 GHz	-150.00								Preamp Au		•
Image: Description of the part light of the part ligh	Pak Barch       Data         D Catelor       D Catelor         D Catelor       D Catelor       D Catelor		Pk Tracking  Pk Threshold -100.000 dBm *									RBW	* ¥	* 10.000000 kHz 10.000000 kHz
Image: Display of the Display of th	Image: Conception of the conception	46 H H H H H H H H H H H H H H H H H H H	Peak Search Delta To Center To Ref	-170.00								Auto RBW	]	
Image: Trace One       9000         None Power       9000         Statt Logging       1         Other Power       1         Statt Logging       1	Image: Trace One       9000         None Power       9000         Statt Logging       1         Other Power       1         Statt Logging       1		Occupied Bandwidth	-190.00 Start 1 555000 GHz			Center 1 58500	20 GHz		Stop	1 615000 GHz	Video Units F		
Norme Control       State       Offset       Eandwidth       Lower (dBm)       Upper (dBm)       Upper (dBm)         Norme Power       NA       1       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA         State       Offset       Eandwidth       Lower (dBm)       Upper (dBm)       NA       NA         Power       NA       20.00000 MHz       20.00000 MHz       20.00000 MHz       NA       NA       NA         State       Offset       Eandwidth       Lower (dBM)       Upper (dBM)       NA       NA         Obsabled       20.00000 MHz       20.00000 MHz       20.00000 MHz       NA       NA       NA         Statt Logging       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA         Disabled       20.00000 MHz       20.00000 MHz       20.00000 MHz       NA       NA       NA         Statt Logging       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA         Chamme Power       Sweep Recording       Peak Table         Disabled       20.00000 MHz       NA       NA	Norme Control       State       Offset       Eandwidth       Lower (dBm)       Upper (dBm)       Upper (dBm)         Norme Power       NA       1       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA         State       Offset       Eandwidth       Lower (dBm)       Upper (dBm)       NA       NA         Power       NA       20.00000 MHz       20.00000 MHz       20.00000 MHz       NA       NA       NA         State       Offset       Eandwidth       Lower (dBM)       Upper (dBM)       NA       NA         Obsabled       20.00000 MHz       20.00000 MHz       20.00000 MHz       NA       NA       NA         Statt Logging       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA         Disabled       20.00000 MHz       20.00000 MHz       20.00000 MHz       NA       NA       NA         Statt Logging       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA         Chamme Power       Sweep Recording       Peak Table         Disabled       20.00000 MHz       NA       NA		Target Trace One 👻				Span 60.00000	DO MHz		Swp Time 54	13ms (30k pts)	Swp Time		1.000 ms 0.0 s
Target       Trace One       1       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA         Widh       20.00000 MHz       20.00000 MHz       20.00000 MHz       NA       NA       NA       NA         Power       NA       3       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA         StartLooping       4       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA         Change Directory       1       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA	Target       Trace One       1       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA         Widh       20.00000 MHz       20.00000 MHz       20.00000 MHz       NA       NA       NA       NA         Power       NA       3       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA         StartLooping       4       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA         Change Directory       1       Disabled       20.00000 MHz       20.00000 MHz       NA       NA       NA		39.00			State	Office	Pandwidth Lawss (dPa	) Lours (dPm)	Upper (dRs)	Linner (dRm)	1		
NA         2         Disabled         2         2000000 MHz         2000000 MHz         NA         NA         NA         NA           Vidit         2000000 MHz         2000000 MHz         2000000 MHz         2000000 MHz         NA         NA         NA         NA           StartLopping         Glasited         2000000 MHz         2000000 MHz         NA         NA         NA         NA           Change Directory         5         Disabled         2000000 MHz         2000000 MHz         NA         NA         NA           Change Directory         5         Disabled         2000000 MHz         2000000 MHz         NA         NA         NA	NA         2         Disabled         2         2000000 MHz         2000000 MHz         NA         NA         NA         NA           Vidit         2000000 MHz         2000000 MHz         2000000 MHz         2000000 MHz         NA         NA         NA         NA           StartLopping         Glasited         2000000 MHz         2000000 MHz         NA         NA         NA         NA           Change Directory         5         Disabled         2000000 MHz         2000000 MHz         NA         NA         NA           Change Directory         5         Disabled         2000000 MHz         2000000 MHz         NA         NA         NA				- 1 D									
NA         3         Disabled         -         20.00000 MHz         NA         NA         NA           StatLooping         -         20.00000 MHz         20.00000 MHz         NA         NA         NA         NA           Change Directory         5         Disabled         -         20.00000 MHz         NA         NA         NA         NA           Change Directory         5         Disabled         -         20.00000 MHz         NA         NA         NA	NA         3         Disabled         -         20.00000 MHz         NA         NA         NA           StatLooping         -         20.00000 MHz         20.00000 MHz         NA         NA         NA         NA           Change Directory         5         Disabled         -         20.00000 MHz         NA         NA         NA         NA           Change Directory         5         Disabled         -         20.00000 MHz         NA         NA         NA	An approximate the second seco			20.000000 MHz 2 D	Disabled +	20.000000 MHz	20.000000 MHz N/A	N/A	N/A	N/A			
StartLogging     4     Disabled     ~     20.00000 MHz     N/A     N/A     N/A       Change Directory     5     Disabled     ~     20.00000 MHz     20.00000 MHz     N/A     N/A     N/A	StartLogging     4     Disabled     ~     20.00000 MHz     N/A     N/A     N/A       Change Directory     5     Disabled     ~     20.00000 MHz     20.00000 MHz     N/A     N/A     N/A					Disabled -	20.000000 MHz	20.000000 MHz N/A	N/A	N/A	N/A			
Channel Power Sweep Playback Sweep Recording Peak Table	Channel Power Sweep Playback Sweep Recording Peak Table	25 00 🧲		and the second sec	aging 4 D	Disabled +	20.000000 MHz	20.000000 MHz N/A	N/A	N/A	N/A			
Channel Power Sweep Playback Sweep Playback Sweep Playback	Channel Power Sweep Playback Sweep Playback Sweep Playback	ADE: SOC				Disabled *	20.000000 MHz	20.000000 MHz N/A	N/A	N/A	N/A			
				Channel Rower Sween Blackack	Swaan Recording Rock Table									
		S -		Citaminel Power Sweep Playback	oweep Recording Peak Table				SA44B   INT REF	S/N - 19358749 F/W	Version 2.12 28.00	C - 4.78 V	New Software	Version Available
		1 Hz to leasuri												
er/ Measuri	easuri	t 4 GHz												

SA: Signal Hound USB-SA44B, Range 1555-1615MHz RBM=VBW=10KHz, MaxHold

**BHW Technologies Confidential** 

### **GPS L1 Noise Floor vs Receiver Architecture**



### Noise Floor with GPS L1 Antenna followed by SAW then BHWL160 In-Band Noise Floor ~ -143dBm/Hz at ~1575MHz OOB Noise Floor ~ -149dBm/Hz at ~1612MHz

Image: Second	Spectrogram Disabled   Messurements	Persistence Intensity			a sona de Aven-		→ Single	C Auto	Re Sweep Settings	tecal	Preset
		Ref -90.00 dBm Div 10.0		RBW 10.0000 Atten Au	000 kHz Ito		VBW 1	0.000000 kHz			
Micro       Micro <td< td=""><td>Trace One -</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Center</td><td>• •</td><td>1.585000 GH</td></td<>	Trace One -								Center	• •	1.585000 GH
Molecular       1000         Interest interes	Type Max Hold 👻		A						Span	* ¥	60.000000 MH
Undig       Image: manual manua manual manual manua manual manual manual m	Avg Count 10	فالمحمد والمحمد والمحمل المحاصل المحاصل المتحمل المحمد المحمد المحمد والمحمل والمحاص	و مالا مسرد الداد الأساد م	محافاته بعرجعته سأمانيا	يتبع فالمسير على فيساغر وبعادات كمانغا ماقته			-100.50 ubm	Start		1.555000 GH
Hoi       Image: Clear       Image: C		And the second	the day of the second second lines of		annu an sa sh hadalaraa						
Egot       Gear         More:       Image: Status         Piece On       Trace One         Piece One       Trace One<		-110.00								1	
Image: set of the set of									Full	Span	Zero Span
Marker       Tree one       13000       Image: Instance	Export Clear								🔺 Amplitude		
warm       image       image <td< td=""><td><ul> <li>Markers</li> </ul></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>RefLevel</td><td>* ¥</td><td>-90.000 dBm -</td></td<>	<ul> <li>Markers</li> </ul>								RefLevel	* ¥	-90.000 dBm -
Place On       Tace One       Image: Construction of the	Marker Three -	-130.00							Div		10.0 d
Ser Freq       1575170 GHz         Update	Type Normal 👻								Gain	Auto Gain	
Ubdale	Place On Trace One *								Atten	Auto Atten	
Adhe									Preamp	Auto	
Pk Tracking       -100.003 (dmmm)		-150.00							Bandwidth	_	
Pit Raching       -100.00       (dim + brieshold)       -100.00       (dim + brieshold)       -100.00       (dim + brieshold)       -100.00       -100.00       (dim + brieshold)       -100.00									PRW Shane	FlatTan	
Print mesting       -100.00 dbing         Peak Search       Defa         0 center       To Ref         Peak Left       Peak Right         -100.00       Start 1.555000 GHz         Start 1.555000 GHz       Center 1.585000 GHz         Start 1.555000 GHz       Start 1.555000 GHz         Start									and the second second		10.000000 kH
In Lucia       0.000 mL         Peak Search       Delta         To Center       To Ref         Peak Left       Peak Right         I - 190.00       Start 1.555000 GHz         Start 1.555000 GHz       Center 1.585000 GHz         Start 1.555000 GHz       Stop 1.615000 GHz         Start 1.555000 GHz       Start 1.555000 GHz         Start 1.555000 GH											10.000000 kHz
To Center       To Ref         Peak.Left       Peak.Right         - focored faceduction       -190.00         Target       Tace One         Start 1.555000 GHz       Center 1.585000 GHz       Storp 1.615000 GHz         Storp 1.615000 GHz       Storp 1.615000 GHz       Storp 1.615000 GHz         Non       NA       NA         Non       NA       NA       NA         Non       NA       NA       NA		-170.00							Auto RBW		
Peak Left       Peak Right       A control of the second of the s									Auto VBW		
I cocceld Bundle         I cocceld Bundle<											
Target       Target       Target       Target       Target       Target       Span 60.00000 MHz       Span 60.00000 MHz       Swp Time 545ms (30k pt)       Swp Time       1000 mHz       10000 mHz       1000 mHz       1		-190.00									
Notice         Notice         State         Offset         Bandwidth         Lower(dBc)         Upper(dBc)         <		Start 1.555000 GHz					Stop	1.615000 GHz		Average	1.000 m
Enable         Enable         State         Offset         Bandwidth         Lower (dBr.)         Upper (dBr.)         Upper (dBr.)           Target         Tarce One         1         Disabled         *         20.000000 MHz         20.000000 MHz         NA         NA         NA           Vidth         Tarce One         1         Disabled         *         20.000000 MHz         20.00000 MHz         NA         NA         NA           Vidth         One         0         Disabled         *         20.00000 MHz         20.00000 MHz         NA         NA         NA           Power         NA         Disabled         *         20.00000 MHz         20.00000 MHz         NA         NA         NA           Gistart Logging         4         Disabled         *         20.00000 MHz         NA         NA         NA		Channel Damos		Span 60.0000			Swp Time 5	sins (sok pis)	_		
Target         Target One         1         Disable         4         20.00000 MHz         20.00000 MHz         N/A         N/A         N/A           Vidm         Q.000000 MHz         2         Disable         4         20.00000 MHz         20.00000 MHz         N/A         N/A         N/A           Prever         NA         StartLogging         4         Disable         4         20.00000 MHz         20.00000 MHz         N/A         N/A         N/A			0.0	011-11	0 4 1 Miles (40 4	Lener (JDer)	11(40)	Harry (JD-1)	1		
With         20.000000 MHz         2         Disabled         20.000000 MHz         20.000000 MHz         N/A         N/A         N/A           Power         N/A         N/A         3         Disabled         20.000000 MHz         20.000000 MHz         N/A         N/A         N/A           StartLogging         4         Disabled         20.000000 MHz         20.000000 MHz         N/A         N/A         N/A			S								
Power         NA         3         Disabled         *         20.00000 MHz         V/A         N/A         N/A           Start Logging         4         Disabled         *         20.00000 MHz         N/A         N/A         N/A											
					20.000000 MHz N/A		N/A	N/A			
Change Directory 5 Disabled * 20.00000 MHz V/A N/A N/A N/A		Start Logging	4 Disabled -	20.000000 MHz	20.000000 MHz N/A	N/A	N/A	N/A			
		Change Directory	5 Disabled 👻	20.000000 MHz	20.000000 MHz N/A	N/A	N/A	N/A			
		Channel Power Sweep Playback Sweep Recording Peak		_		4B I INTREE S	S/N - 19358749 _ F/W	Version 2.12 28.00	C - 4.78 V	New Softwar	re Version Available
Channel Power Sweep Playback Sweep Recording Peak Table								20.00		A CHI CLEAN AND	

#### SA: Signal Hound USB-SA44B, Range 1555-1615MHz RBM=VBW=10KHz, MaxHold

**BHW Technologies Confidential** 



### Summary

➢GPS receiver architecture with SAW preceding LNA has slightly lower in-band noise floor but much higher noise figure (~1.5dB including ~1dB/SAW and ~0.5dB/LNA)

➢GPS receiver architecture with LNA preceding SAW has slightly higher in-band and similar OOB noise floor, but much lower NF (~0.5dB for BHWL160)

➢GPS receiver architecture with SAW preceding LNA is much more complicated and expensive since low/high-band selection/filtering has to be implemented before lownoise amplification, resulting in higher system NF and lower C/N0

➢GPS dual/multi-band receiver architecture with single-fed antenna, single broadband LNA (BHWL160/L161) can greatly relief the burden on SAW selection, providing the most cost-effective solution while achieving best-class performance at the same time

➢GPS dual/multi-band receivers based on BHWL160/L161 has consistently delivered maximum C/N0 of 52~53dB in both L5 and L1 bands, beating industry's state-of-theart performance (50dB or lower for dual-band receivers)

# **BHW RF Front-End AppNote Library**



This is an abridged version of BHW AppNote #013. 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 CN0 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

Contact <a href="mailto:support@bhwtechnologies.com">support@bhwtechnologies.com</a> or BHW distributors/representatives for your copy of the above and new up-coming documents.