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FlexPort[®]

Mobile Backhaul Platform

***Backhaul Evolved*[™]**

The Evolution of Backhaul

The evolution from 2G/3G mobile networks to 4G creates challenges for operators that go well beyond the adoption of new handset air-interface technologies. 4G Long Term Evolution (LTE) and WiMAX capacity translate into aggregate base station capacities that grow from the tens of megabits per second common today to hundreds. This in turn places demands on backhaul networks that drive a transition from copper and low-capacity microwave links to fiber and new gigabit wireless backhaul solutions. This growth in capacity is primarily driven by data services; therefore, operators also look to transition from circuit to packet-based architectures in order to more efficiently adapt to the new data-centric world. In order to realize the efficiency gains promised by packet architectures, robust traffic and network management tools are required to optimally address a high mix of application traffic with widely varying Quality of Service (QoS) requirements. While operators look towards a new data-driven future, incumbent operators will still rely on their legacy of 2G/3G networks for years to come. Backhaul solutions that look forward to 4G must also support existing access technologies, without imposing substantial cost or complexity on operators.

The FlexPort® Platform

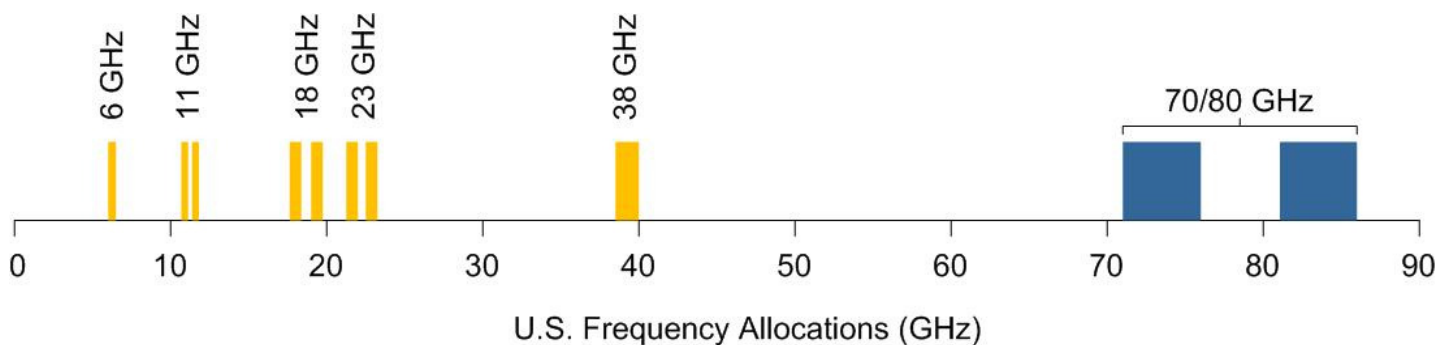
Traditional 2G/3G wireless backhaul products have become highly standardized and commoditized over time; however, the 4G transition creates a discontinuity in backhaul requirements, due to exponential capacity growth and a traffic mix transition from traditional voice to packet data, video and VoIP. BridgeWave's FlexPort platform is the first multi-gigabit wireless backhaul solution designed from the bottom up to enable the migration to 4G networks. Products based on the FlexPort platform provide mobile operators with the tools to eliminate today's and tomorrow's backhaul bottlenecks while simplifying the evolution from circuit to packet-based network infrastructures. BridgeWave's FlexPort platform:

- Delivers future-proof, non-blocking backhaul capacity of up to 1.2 Gbps per second, with the investment protection of software-key capacity upgrades.
- Transports native-mode IP packet and native-mode time-division multiplexing (TDM) circuit traffic to support the coexistence of 2G/3G/4G access technologies and facilitate a graceful migration of services from circuit to packet domains.
- Supports efficient RF channel assignments across the entire new 70/80 GHz band, enabling high-density deployments and simplifying RF spectrum planning by utilizing an unprecedented 10 GHz of allocated spectrum.
- Provides a rich set of packet prioritization capabilities to flexibly provision the capacity to address strict operator QoS requirements.
- Maximizes clear-sky link capacity and ensures highly available rain-fade operation by employing BridgeWave's Adaptive Rate and Modulation (ARM) capability that features both traditional adaptive modulation coupled with unique adaptive bandwidth technology.
- Features physical and packet layer device configuration and monitoring through HTTP/HTTPS and SNMP interfaces, and provides support for Ethernet OAM (IEEE 802.1ag, 802.3ah, and Y.1731) end-to-end management and monitoring.
- Advanced security solutions offer controlled system access and line-rate encryption for data streams with 256 AES encryption.



Backhaul without Bottlenecks

Within the FlexPort® product family, FlexPort80 starts at 240 Mbps capacity to support the initial needs of 4G base stations, and can deliver up to 1200 Mbps capacity. This allows for sufficient headroom to cover anticipated capacity growth over the lifetime of a 4G base station. Use of the new 70/80 GHz wireless frequency band, with a massive 10 GHz of allocated spectrum, enables FlexPort80 to deliver multi-gigabit data rates, coupled with ultra-low latency, serving as a true fiber alternative wherever fiber is unavailable or cost-prohibitive to install or lease. This makes FlexPort ideal for serving single base station sites, as well as provides wireless aggregation connections for multiple base stations in branching or ring backhaul networks. The entire multi-gigabit capacity can be deployed from the start, or operators can start as low as 240 Mbps and incrementally grow to capacity through software-key upgrades.



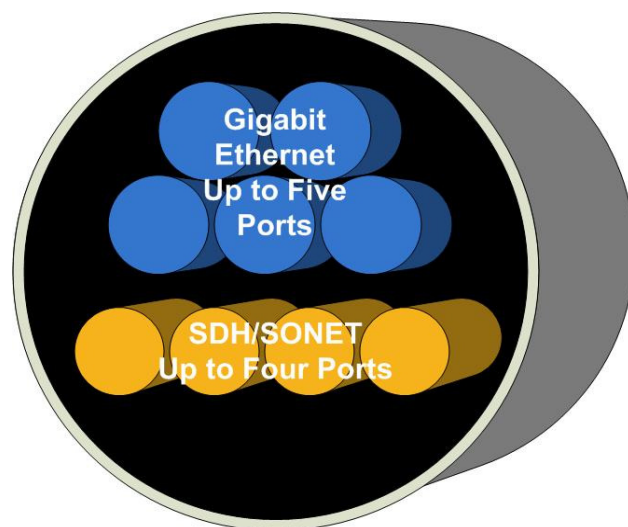
Lower-frequency (6-38 GHz) microwave radio solutions are limited to capacities of around 350 Mbps per RF channel, due to limited spectrum allocations and narrow channel bandwidth limits. The only way to reach gigabit capacities using these links is to combine multiple RF channels and radio transceivers, multiplying link cost and making it increasingly difficult to obtain needed spectrum licenses in dense urban settings. The costs of RF licenses vary across the world; however, 70/80 GHz spectrum is typically much less expensive to license than lower-frequency spectrum, providing 70/80 GHz links with a substantial total cost of ownership advantage – especially when multiple lower-frequency licenses are needed to meet capacity requirements. Lower-frequency solutions will continue to play a key role in 4G networks; however, operators will increasingly move to the new 70/80 GHz band, especially for dense, urban, high capacity base station scenarios.

Removing backhaul as a network performance bottleneck means that network subscribers will experience the full potential of 4G access solutions – and that network operators can grow their 4G site capacity over time, without having to re-engineer their backhaul infrastructure.

Migrate at Your Own Pace

Both LTE and WiMAX 4G standards are based on Ethernet packet transport through the backhaul and core networks. While 'greenfield' operators have the luxury of installing Ethernet-only networks, incumbent operators are generally planning on overlaying 4G services on top of existing 2G/3G services that use TDM (wired or wireless) circuits for backhaul. Backhaul is one of the operators' greatest costs and deployment challenges, so there is a strong economic and logistical need to provision a single backhaul connection to transport both legacy 2G/3G traffic and new 4G traffic.

The FlexPort® platform addresses these needs head-on by offering operators both Ethernet packet and SONET/SDH circuit interfaces native on the platform, with the flexibility of eight user-pluggable -SFP interfaces. This avoids the complexities of moving existing TDM traffic to pseudowire TDM-over-Ethernet solutions, or the inefficiencies involved with running Ethernet packet traffic over TDM circuits. Of course, the FlexPort platform also fully supports these latter approaches when operators choose these as part of their 4G migration strategies. Indeed, FlexPort products offer operators total flexibility to manage their introduction and long-term migration to packet networks as they see fit. FlexPort products can be software reconfigured to reallocate backhaul capacity between TDM and Ethernet interfaces in any mix throughout the packet migration process, and with multi-gigabit capacity TDM and Ethernet backhaul can easily be run in parallel for as long as is needed to ensure a smooth network transition.



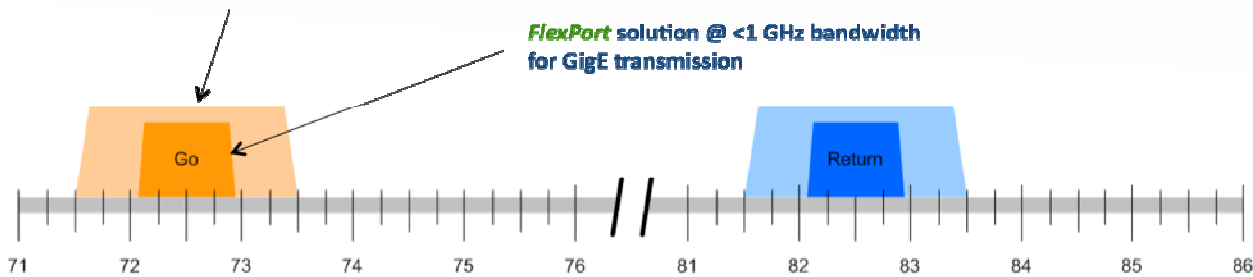
Efficient Spectrum Utilization

The new 70/80 GHz frequency band offers five times more allocated spectrum than in any other licensed frequency band. However, operators are looking for solutions in this band that provide up to ten times more backhaul capacity than can be provided using the lower frequency bands. In many places where microwave backhaul has been extensively deployed (such as in many major European cities), operators are already facing shortages of licensable channels, and without the use of 70/80 spectrum, the situation is likely to become untenable. Looking forward, it is clear that the 70/80 spectrum must be used efficiently in order to ensure that wireless backhaul solutions will be available in dense urban environments for decades to come.

FlexPort80 address this need for efficiency in multiple ways. First, by operating in the high frequency 70/80 GHz band, even small antennas naturally produce narrow beam width signals. A one-foot (30cm) antenna produces about a one-degree beam – a quarter of a comparable 18 GHz antenna. This creates very high spatial re-use efficiencies, where collocated radios can often re-use the same RF channel if they are oriented even a few degrees away from one another.

Other vendor solution @ 1.5 – 2 GHz bandwidth for GigE transmission

FlexPort solution @ <1 GHz bandwidth for GigE transmission

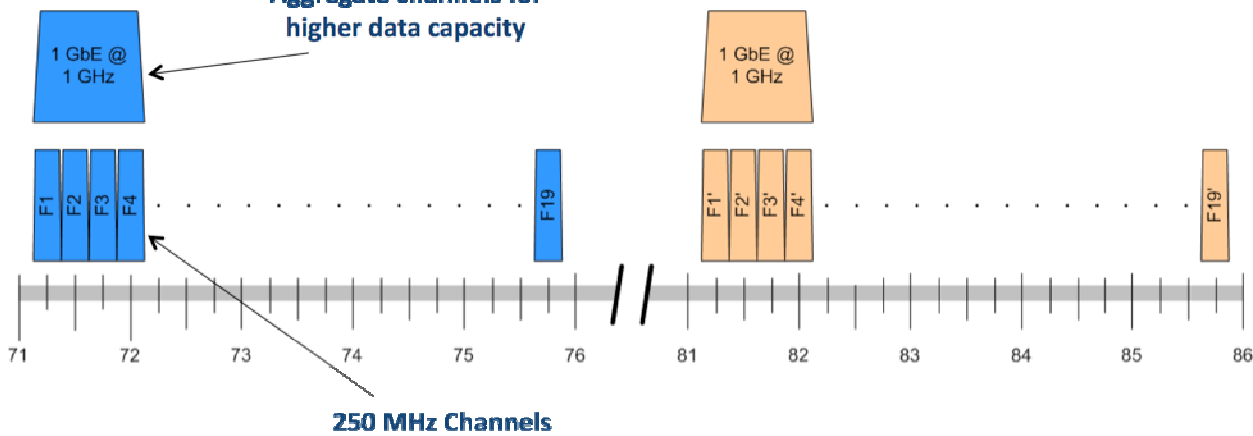


FlexPort80 features the use of highly efficient quadrature phase-shift keying (QPSK) modulation coupled with strong forward error correction (FEC). QPSK modulation requires less than 1 GHz of radio spectrum to be used to transmit more than 1 Gbps of user traffic. Furthermore the use of QPSK and strong FEC make the links highly tolerant of co-channel interference; this allows re-use of the same RF spectrum at much shorter distance intervals than would be possible using higher-order modulation schemes. The net result is that much denser deployments of gigabit 70/80 GHz links are possible than compared with using high-order modulation (e.g. 350 Mbps using 256 QAM) lower-frequency microwave solutions – even if the total spectrum allocations were comparable!

Tunable RF Channel Capabilities

FlexPort80 is software configured to operate at center frequencies spanning the entire 70/80 GHz band, consistent with both U.S. FCC rules and European (CEPT) channelization recommendations (in accordance with ECC REC 05/07). As a result of these combined features, FlexPort80 supports the highest possible deployment densities, simplify spectrum planning, and make the most efficient use possible of the 70/80 GHz spectrum allocation.

Aggregate channels for higher data capacity



Built-In Quality of Service

In the TDM circuit-switched world, circuit capacity is constant and guaranteed – optimized for constant-rate voice communications at the expense of high burst packet data traffic. The move to packet transmission enables improved data carrying and aggregation efficiencies, but requires that Quality of Service (QoS) mechanisms be provided to prioritize voice traffic and flexibly allocate capacity among video, high-priority, and best-effort data applications. FlexPort80 leverages its built-in Ethernet switch to allow flexible allocation of capacity across multiple TDM and packet interfaces, and multiple weighted round-robin and strict-priority queues for packet data. This provides operators with the means to take advantage of the data performance benefits of packet networks, while maintaining the quality of voice and priority services for their subscribers.



The screenshot shows the BridgeWave web interface for QoS Classifier Configuration. At the top, there is a status bar with system information:

- RSL(dBm):** -35.0/-39.0
- Link Rate:** 1200 Mbps
- Uptime:** 12 Days 2 Hrs 41 Mins 6 Secs
- FEH:** 44.2 °C
- Band:** High(Tx:6, Rx:6)
- Serial:** BGWVBW10140056
- Logout:** admin
- IP:** 172.21.2.102
- MAC:** 00:03:5b:01:20:10

The main configuration area is titled "QoS Classifier Configuration" and is divided into "Classifier" and "Scheduler" tabs. Under the "Classifier" tab, there is an "Ingress Classifier" section with the following options:

- Port Based
- VLAN P-bits Based (802.1p)
- Diffserv Based
- Diffserv & 802.1p Based

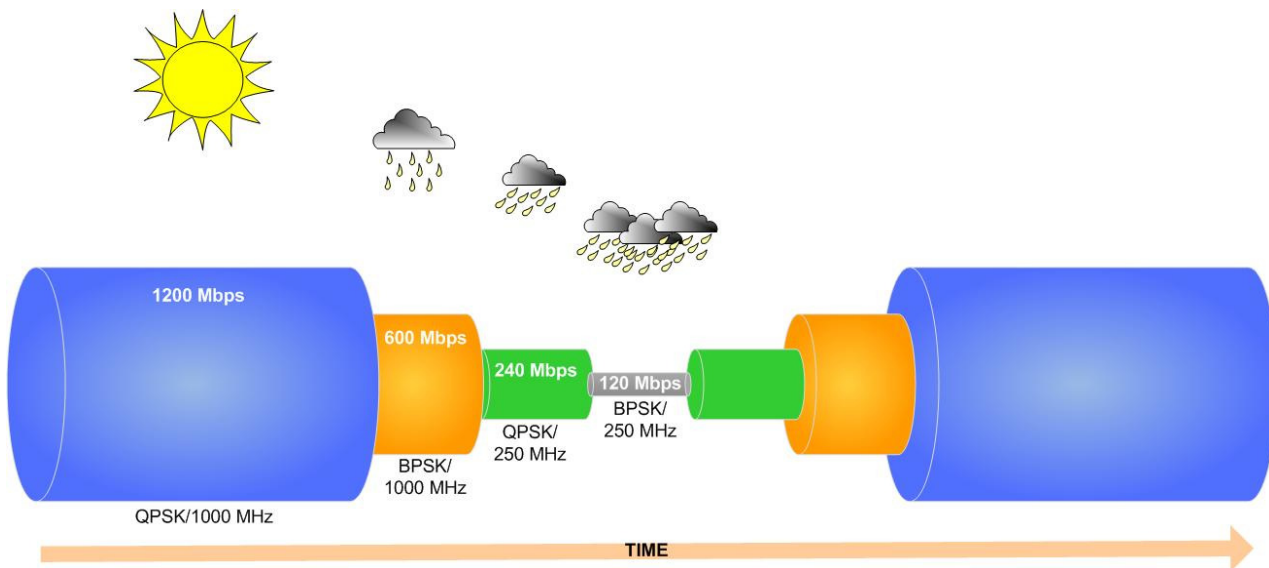
Below these options are "Submit" and "Reset" buttons. To the right, there is a "Port Classifier" table:

Port	Traffic Class
Radio(Pri)	0
Radio(Sec)	0
Port#5	0
Port#6	0
Port#7	0
Port#8	0
Copper#9	0

A left-hand navigation menu includes links for ShowAll, Hide, Status, Configuration (IP, Time, SNMP, AES, Ports, VLAN, Radio Link, ARM, ECFM, EOAM, QoS), Security, Statistics, History, Charts, Tools, and Contacts.

Optimized Performance – Rain or Shine

Traditional microwave links employ adaptive modulation techniques in order to maximize link capacity during clear-air conditions, while maintaining reliable link connectivity (at or above base capacity levels) during rain fades. The FlexPort® platform incorporates BridgeWave's Adaptive Rate and Modulation (ARM) technology, which combines traditional adaptive modulation with BridgeWave's adaptive bandwidth technology. ARM is especially effective for use with high bandwidth QPSK systems, where the link capacity/availability gains from the combination of these techniques far exceed what is possible using adaptive modulation alone. The ARM solution also works proactively, gradually switching data rates to increase link margins before data losses occur, unlike many lower-frequency product adaptive modulation systems that only react after transmission errors occur.



Beyond Adaptive Rate and Modulation, the FlexPort platform also provides AdaptPath™ alternate path switching. The AdaptPath capability allows operators to provision an alternate path using a technology immune to rain fading that enables continuous base capacity connectivity during even the most extreme rain events.

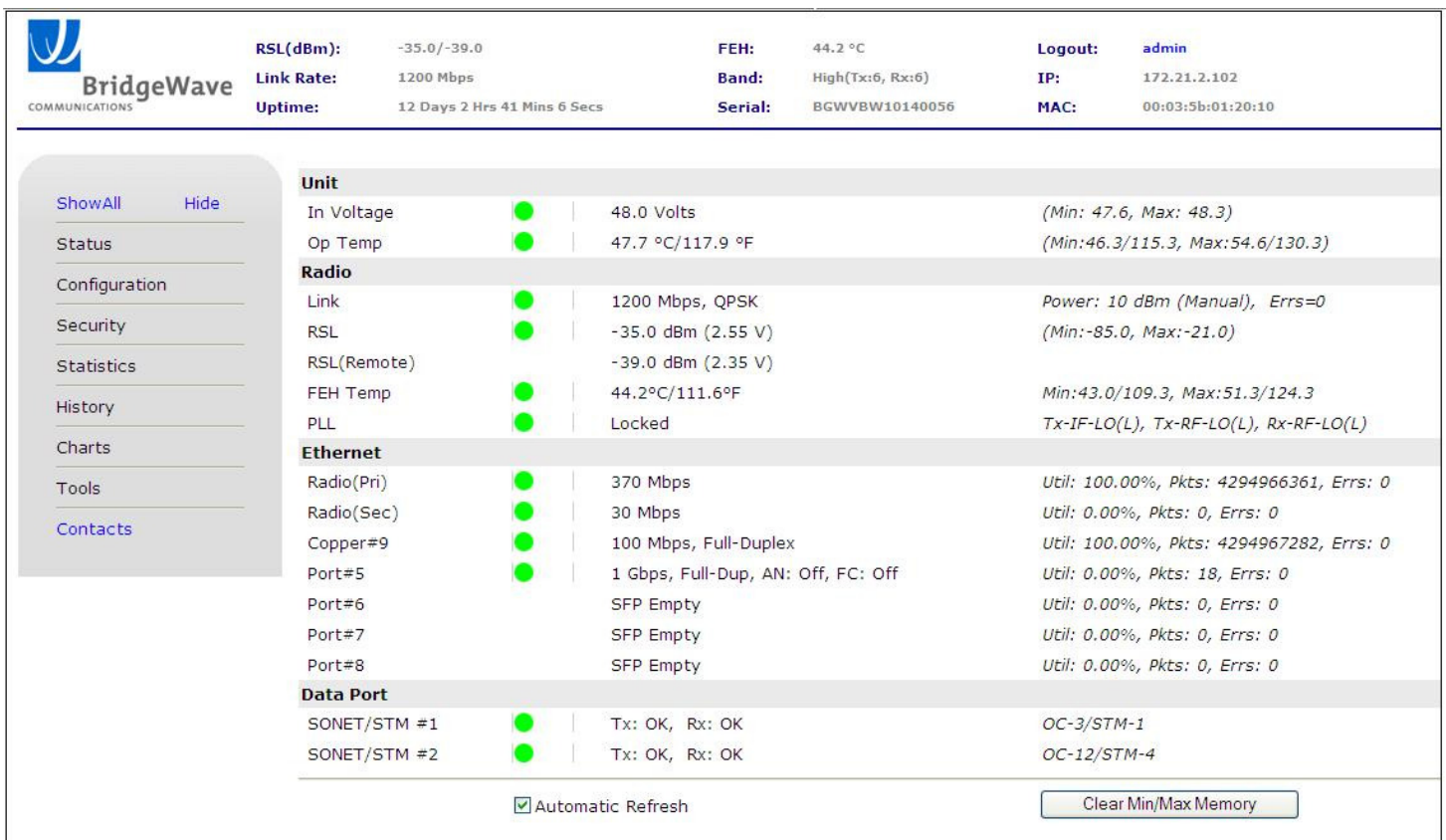
These link performance optimization techniques work hand-in-hand with FlexPort QoS controls, ensuring uninterrupted transmission of high-priority traffic during severe rain events and maximum link transmission capacity in clear air.

Management and Security on Your Terms

Network management in a circuit switched TDM world is primarily a physical layer matter. Moving to the packet world, not only is the physical layer important, but packet layer information also becomes key to understanding network performance, congestion, and connectivity as packets pass through Ethernet switch points. FlexPort® products provide physical layer plus network layer configuration, monitoring and alarm capabilities, including full Ethernet frame capacity and error performance visibility. Management data and link

configuration is fully accessible through SNMP and secure HTTP/HTTPS web interfaces, and management interfaces can be flexibly configured for in-band or out-of-band access. The heart of the packet management capabilities is an Ethernet switch embedded within the FlexPort engine. This provides operations staff with the same comprehensive view of Ethernet traffic as is found in typical wire-line Ethernet switches, and provides end-to-end OAM and CFM capabilities and SLA monitoring. The switch also offers Ethernet VLAN, link aggregation, and jumbo frame support.

FlexPort products offer advanced security solutions, both for management system access as well as for network data transmissions. Encryption solutions are available for both traffic types, including the industry's first full multi-gigabit line rate 256-bit AES wireless transmission solution. The FlexPort management system also offers flexible access policies, including RADIUS authentication to seamlessly integrate with existing operations access systems. FlexPort is unique in the industry as it is the first millimeter wave radio to provide Syslog support. The picture below, of a single snapshot view of the radio's health, is an example of the FlexPort's powerful, intuitive, and user friendly GUI.



The screenshot displays the BridgeWave management interface for a radio unit. At the top, there is a header with the BridgeWave logo and several status metrics:

- RSL(dBm):** -35.0/-39.0
- Link Rate:** 1200 Mbps
- Uptime:** 12 Days 2 Hrs 41 Mins 6 Secs
- FEH:** 44.2 °C
- Band:** High(Tx:6, Rx:6)
- Serial:** BGWVBW10140056
- Logout:** admin
- IP:** 172.21.2.102
- MAC:** 00:03:5b:01:20:10

On the left side, there is a navigation menu with options: ShowAll, Hide, Status, Configuration, Security, Statistics, History, Charts, Tools, and Contacts.

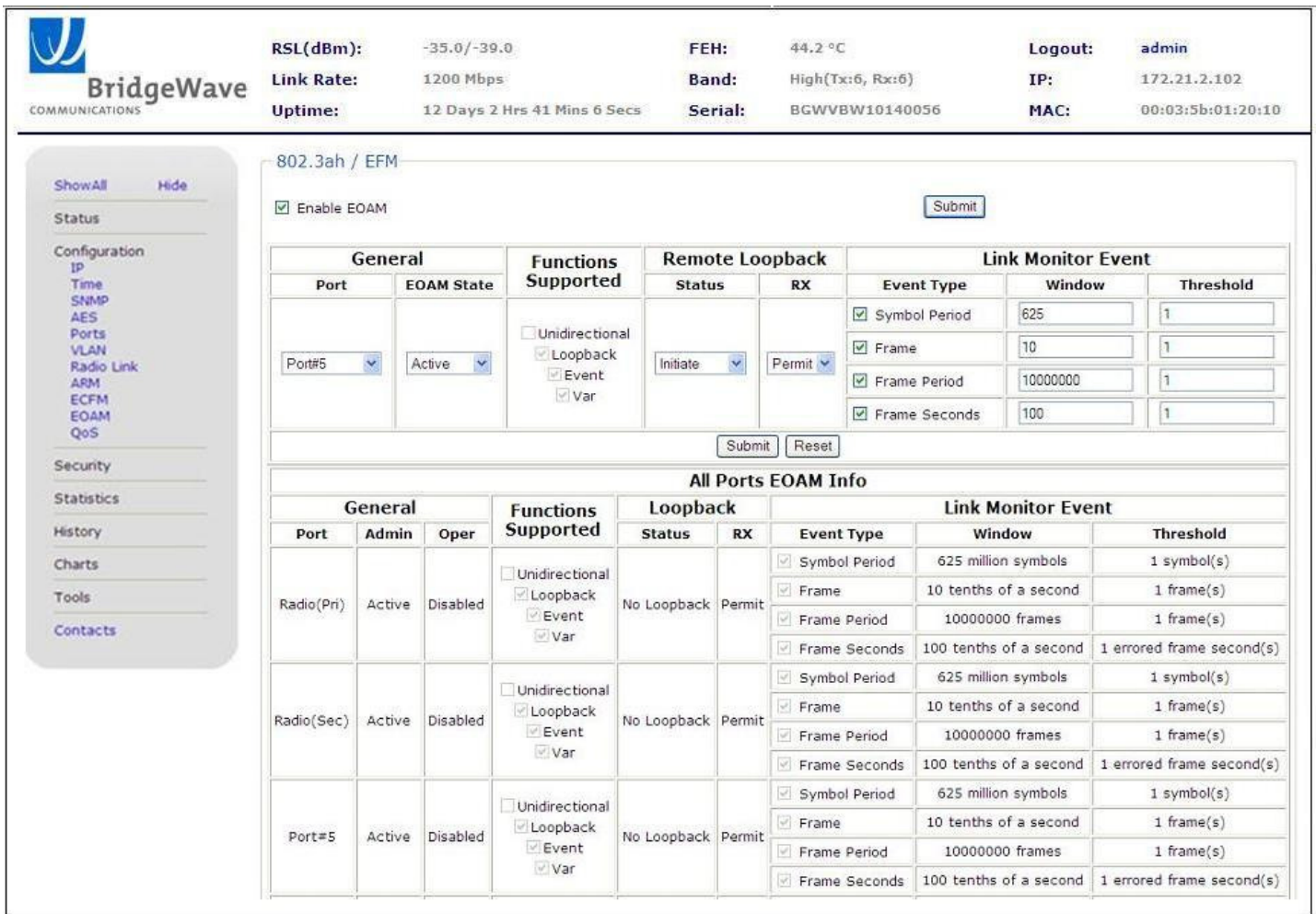
The main content area is divided into several sections, each with a status indicator (green dot) and detailed information:

- Unit:**
 - In Voltage: 48.0 Volts (Min: 47.6, Max: 48.3)
 - Op Temp: 47.7 °C/117.9 °F (Min:46.3/115.3, Max:54.6/130.3)
- Radio:**
 - Link: 1200 Mbps, QPSK (Power: 10 dBm (Manual), Errs=0)
 - RSL: -35.0 dBm (2.55 V) (Min:-85.0, Max:-21.0)
 - RSL(Remote): -39.0 dBm (2.35 V)
 - FEH Temp: 44.2°C/111.6°F (Min:43.0/109.3, Max:51.3/124.3)
 - PLL: Locked (Tx-IF-LO(L), Tx-RF-LO(L), Rx-RF-LO(L))
- Ethernet:**
 - Radio(Pri): 370 Mbps (Util: 100.00%, Pkts: 4294966361, Errs: 0)
 - Radio(Sec): 30 Mbps (Util: 0.00%, Pkts: 0, Errs: 0)
 - Copper#9: 100 Mbps, Full-Duplex (Util: 100.00%, Pkts: 4294967282, Errs: 0)
 - Port#5: 1 Gbps, Full-Dup, AN: Off, FC: Off (Util: 0.00%, Pkts: 18, Errs: 0)
 - Port#6: SFP Empty (Util: 0.00%, Pkts: 0, Errs: 0)
 - Port#7: SFP Empty (Util: 0.00%, Pkts: 0, Errs: 0)
 - Port#8: SFP Empty (Util: 0.00%, Pkts: 0, Errs: 0)
- Data Port:**
 - SONET/STM #1: Tx: OK, Rx: OK (OC-3/STM-1)
 - SONET/STM #2: Tx: OK, Rx: OK (OC-12/STM-4)

At the bottom of the interface, there are two buttons: Automatic Refresh and Clear Min/Max Memory.

OAM Management

As 4G next generation networks migrate to Ethernet based systems, the ability to fully manage these Ethernet services will play a critical role in allowing operators to offer service level agreements (SLAs) and generate new revenues. FlexPort® incorporates Ethernet Operation, Administration, and Maintenance (OAM) functionality as described in the IEEE 802.3ah, 802.1ag, and ITU-T Y.1731 specifications in the form of Link OAM and Service OAM. This provides network operators with automated end-to-end management and the ability to validate connections to help monitor their networks, detect faults and alarms, perform loopbacks, and monitor link performance. Further, FlexPort's advanced Ethernet OAM capabilities enable service providers to measure QoS parameters and make decisions proactively, before the network is affected. FlexPort's Ethernet OAM (EOAM) facilitates efficient fault isolation and circuit restoration, reducing expensive truck rolls and lowering maintenance costs.



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802.3ah / EFM

Enable EOAM

General		Functions Supported	Remote Loopback		Link Monitor Event		
Port	EOAM State		Status	RX	Event Type	Window	Threshold
Port#5	Active	<input type="checkbox"/> Unidirectional <input checked="" type="checkbox"/> Loopback <input checked="" type="checkbox"/> Event <input checked="" type="checkbox"/> Var	Initiate	Permit	<input checked="" type="checkbox"/> Symbol Period	625	1
					<input checked="" type="checkbox"/> Frame	10	1
					<input checked="" type="checkbox"/> Frame Period	10000000	1
					<input checked="" type="checkbox"/> Frame Seconds	100	1

All Ports EOAM Info

General			Functions Supported	Loopback		Link Monitor Event		
Port	Admin	Oper		Status	RX	Event Type	Window	Threshold
Radio(Pri)	Active	Disabled	<input type="checkbox"/> Unidirectional <input checked="" type="checkbox"/> Loopback <input checked="" type="checkbox"/> Event <input checked="" type="checkbox"/> Var	No Loopback	Permit	<input checked="" type="checkbox"/> Symbol Period	625 million symbols	1 symbol(s)
						<input checked="" type="checkbox"/> Frame	10 tenths of a second	1 frame(s)
						<input checked="" type="checkbox"/> Frame Period	10000000 frames	1 frame(s)
						<input checked="" type="checkbox"/> Frame Seconds	100 tenths of a second	1 errored frame second(s)
Radio(Sec)	Active	Disabled	<input type="checkbox"/> Unidirectional <input checked="" type="checkbox"/> Loopback <input checked="" type="checkbox"/> Event <input checked="" type="checkbox"/> Var	No Loopback	Permit	<input checked="" type="checkbox"/> Symbol Period	625 million symbols	1 symbol(s)
						<input checked="" type="checkbox"/> Frame	10 tenths of a second	1 frame(s)
						<input checked="" type="checkbox"/> Frame Period	10000000 frames	1 frame(s)
						<input checked="" type="checkbox"/> Frame Seconds	100 tenths of a second	1 errored frame second(s)
Port#5	Active	Disabled	<input type="checkbox"/> Unidirectional <input checked="" type="checkbox"/> Loopback <input checked="" type="checkbox"/> Event <input checked="" type="checkbox"/> Var	No Loopback	Permit	<input checked="" type="checkbox"/> Symbol Period	625 million symbols	1 symbol(s)
						<input checked="" type="checkbox"/> Frame	10 tenths of a second	1 frame(s)
						<input checked="" type="checkbox"/> Frame Period	10000000 frames	1 frame(s)
						<input checked="" type="checkbox"/> Frame Seconds	100 tenths of a second	1 errored frame second(s)



Backhaul Evolved

4G deployments offer the promise of a step-function in subscriber performance experience, but come with the costs of major architecture and capacity upgrades for operators. BridgeWave's FlexPort® platform sets the new standard for 4G wireless backhaul solutions, delivering future-proof multi-gigabit capacity and the tools that mobile operators need to bridge the circuit and packet worlds.

About BridgeWave Communications

Founded in 1999, BridgeWave Communications is the leading supplier of outdoor Gigabit wireless connectivity solutions. The company's exclusive AdaptRate™ and AdaptPath™ technologies combined with its advanced Forward Error Correction capability deliver the highest availability at the longest distances for full-rate gigabit links. BridgeWave's point-to-point wireless solutions are widely deployed in mainstream enterprise and service provider network applications and are poised to play a key role in the migration to 4G mobile network backhaul. With the introduction of FlexPort®, carriers and mobile operators have a true future-proof solution providing migration from TDM-based networks to next generation IP-based networks with up to 1.2Gbps capacity and carrier-class Ethernet capabilities. With the largest installed base of GigE radios worldwide, BridgeWave delivers the highest levels of product quality and reliability. For more information, visit www.bridgewave.com.



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