# ZumLink 900MHz Series Network Optimization

There are a number of important settings that impact the performance of a ZumLink network. This Application Note discusses radio settings to optimize RF Network Link Reliability and Data Throughput.

In some cases, the radio settings that improve RF link reliability may have an inverse effect on data throughput, and vice versa. The trade-off between RF Network Link Reliability and Data Throughput are presented in this document.

Included information:



 

# 1. ZumBoost Technology

ZumLink incorporates ZumBoost technology using four performance enhancing algorithms that can be used together or independently to improve throughput in the most demanding RF environments:

## Adaptive Spectrum Learning

- Learns which RF signals are part of the ZumLink network and which are not, reducing bad packets and retransmissions.
  - Standard on all ZumLink radios, the "Listen Before Talk" algorithm provides spectrum monitoring, delivering network intelligence and increasing throughputs in noisy environments.

## Forward Error Correction

- The **dataPath.fecRate** increases the reliability of the data transferred over the air at the cost of some transmission throughput.
  - Improves sensitivity by 3dB to maximize range and link range in noisy environments.
  - Adds redundant information to a data stream to detect packet errors and corrects them to avoid retransmission of the packet.

**Note**: Reduces throughput by 13%.

**FREEWAVE Recommends**: When viewing local diagnostics, if the **Radio Bad CRC** count is more than 15% of the total transmitted packets (the **Radio LL Tx** count), enabling the FEC setting is beneficial.

## Packet Aggregation

- The **dataPath.aggregateEnabled** setting increases throughput of small packets by combining multiple packets into a single packet minimizing the number of packets required for transmission.
  - Does NOT affect medium and large packets.

**Note**: Increases latency by 20msec and reduces poll rates.

## Packet Compression

- When the **dataPath.compressionEnabled** setting is enabled, the outgoing packets are analyzed and, if the data packet can be compressed, sent compressed to transmit fewer bits over the air.

**Note**: Increases latency by 10msec.

 

# 2. Optimizing RF Network Link Reliability

Adjust these radio settings to improve RF Network link reliability.

**Note**: See the respective ZumLink User Manual for detailed information about these settings.

### TX Power (Transmit Power)

- The **radioSettings.txPower** setting designates the RF output transmit power, in dB, for the radio.
  - Higher power level can be used to increase link performance.
  - Output power is limited to maximum of 30dBm or 1 Watt.

### Radio Hopping Mode

- The **radioSettings.radioHoppingMode** setting enables frequency hopping.
  - ZumLink can be configured to operate at a single frequency (RF data rate of 500kbps or higher only) or Frequency Hopping Spread Spectrum (FHSS) or hopping (all RF data rates).
    - For **rfDataRate** values of 115.2 and 250 kbps, the **radioSettings.radioHoppingMode** is forced **On** and CANNOT be set to `radiosettings.radioHoppingMode=Hopping_Off`
    - For **rfDataRate** values of 500 kbps, 1 Mbps, and 4 Mbps, the choice of the selected hopping mode is based on network frequency planning and channel conditions.
  - **Single Frequency**: Interference fixed at **multiple** frequencies within the spectrum can be avoided by operating at a single, less noisy frequency.
  - **Hopping Mode**: Interference at a **specific** frequency only affects the signal during that short interval.

### Max Fragment Size

- The **dataPath.otaMaxFragmentSize** setting designates the maximum fragment size, in bytes, sent over the air.
  - A **smaller Max Fragment Size** may increase RF link reliability in highly noisy environments.

**Note**: A **smaller Max Fragment Size** may reduce data throughput.

 

# 2.1. Hopping Mode - Optimizing RF Network Link Reliability

When **Hopping Mode** is **On**, adjust these radio settings to improve RF network link reliability.

> **Note**: See the respective ZumLink User Manual for detailed information about these settings.

### Beacon Interval

- The **radioSettings.beaconInterval** controls how often a Gateway radio sends out a beacon packet and changes to the next radio frequency in the hopping pattern.
  - A **shorter Beacon Interval** may improve the RF link reliability in noisy environments.

> **Note**: A **shorter Beacon Interval** may reduce data throughput.

### Beacon Burst Count

- The **radioSettings.beaconBurstCount** setting designates the number of consecutive beacons to send per **Beacon Interval** time.
  - **Increasing** the number of beacons may improve RF link reliability in noisy environments.

> **Note**: **Increasing** the number of beacons may reduce data throughput.

### Frequency Key

- The **radioSettings.frequencyKey** setting designates the number used as an index to select a hopping table.
  - Use a unique **Frequency Key** setting for each ZumLink network.
  - When using different hop patterns on each network, interference caused by neighboring ZumLink networks can be minimized.

### Frequency Masks

- The **radioSettings.frequencyMasks** setting designates specific frequencies or a set of frequencies in the hopping pattern to be removed from usage.
  - When **Frequency Masks** is enabled, interference fixed at certain frequencies within the spectrum can be avoided by the transmitter.

 

# 3. Optimizing Data Throughput

Adjust these radio settings to improve Data Throughput.

**Note**: See the respective ZumLink User Manual for detailed information about these settings.

### Max Fragment Size

- The **dataPath.otaMaxFragmentSize** setting designates the maximum fragment size, in bytes, sent over the air.
  - A **larger Max Fragment Size** may increase data throughput.

**Note**: A **larger Max Fragment Size** may reduce RF link reliability in noisy environments.

### Netmask Filter

- The **network.netmaskFilterEnabled** enables a bridge firewall to restrict network communication to current IPv4 subnet.
  - Enabling **Netmask Filter** can prevent non-radio Ethernet traffic from adversely affecting the performance and capacity of the radio network.

### TX Queue Length

- The **network.txqueuelen** setting designates the Ethernet transmit packet queue length by designating how many Ethernet packets to hold in the transmit queue before sending them over the radio link.
  - If the queue size is too small in an Ethernet network with a high rate of small packets, then packets could be lost.
    - **Increasing TX Queue Length** may increase throughput if there is a lot of network chatter that causes packets to be lost at the network layer.

**Note**: **Increasing TX Queue Length** can increase latency if the packets are arriving at the Ethernet interface at an average rate that is above the capacity of the radio link.

 

# 3.1. Hopping Mode - Optimizing Data Throughput

When **Hopping Mode** is **On**, adjust these radio settings to improve Data Throughput.

> **Note**: See the respective ZumLink User Manual for detailed information about these settings.

### Beacon Interval

- The **radioSettings.beaconInterval** controls how often a Gateway radio sends out a beacon packet and changes to the next radio frequency in the hopping pattern.
  - A **longer Beacon Interval** may improve throughput in environments where interference is minimal.

> **Note**: A **longer Beacon Interval** may degrade RF link reliability in noisy environments.

### Beacon Burst Count

- The **radioSettings.beaconBurstCount** setting designates the number of consecutive beacons to send per **Beacon Interval** time.
  - **Decreasing** the number of beacons may improve throughput in environments where interference is minimal.

> **Note**: **Decreasing** the number of beacons may degrade RF link reliability in noisy environments.

ZumLink contains a number of radio settings that can optimize network performance. Certain radio settings present a trade-off between optimizing RF Link reliability and data throughput. These tradeoffs should be accounted for during network setup.

 

# 4. Summary: ZumLink Settings for Network Optimization



**Note**: See the respective ZumLink User Manual for detailed information about these settings.

## 4.1. ZumBoost

| ZumBoost | | | | |
|---|---|---|---|---|
| **Setting** | **Description** | **Optimizing RF Link Reliability** | **Optimizing Data Throughput** | **Notes** |
| Forward Error Correction | The **dataPath.fecRate** increases the reliability of the data transferred over the air at the cost of some transmission throughput. | Enable | Disable | • Adds redundant information to a data stream to detect packet errors and corrects them to avoid retransmission of the packet.<br>• Reduces throughput by 13%.<br>• Increases latency by 10msec.<br>**FREEWAVE Recommends**: When viewing local diagnostics, if the **Radio Bad CRC** count is more than 15% of the total transmitted packets (the **Radio LL Tx** count), enabling the FEC setting is beneficial. (15% > BadCRC / (BadCRC +LL RX)) |
| Packet Aggregation | The **dataPath.aggregateEnabled** setting increases throughput of small packets by combining multiple packets into a single packet minimizing the number of packets required for transmission. | Disable | Enable | • Does NOT affect medium and large packets.<br>• Increases latency by 20msec and reduces poll rates. |
| Packet Compression | When the **dataPath.compressionEnabled** setting is enabled, the outgoing packets are analyzed and, if the data packet can be compressed, sent compressed to transmit fewer bits over the air. | N/A | Enable | • When enabled, the **Packet Compression** setting increases latency by a maximum of 10msec.<br>• Net throughput may increase due to sending more data in each packet.<br>• All radios have the ability to de-compress received packets regardless of their compression setting.<br>• This setting does NOT need to match on all radios. |

## 4.2. General Settings

**Note**: See the respective ZumLink User Manual for detailed information about these settings.

| General Settings | | | | |
|---|---|---|---|---|
| **Setting** | **Description** | **Optimizing RF Link Reliability** | **Optimizing Data Throughput** | **Notes** |
| TX Power | The **radioSettings.txPower** setting designates the RF output transmit power, in dB, for the radio. | Increase Power | N/A | • Higher power level can be used to increase link performance.<br>• Output power is limited to maximum of 30dBm or 1 Watt. |
| Single Frequency | A single frequency is designated when `radiosettings.radioHoppingMode=Hopping_Off`. | Enable | N/A | ***__Single Frequency__: Interference fixed at **multiple** frequencies within the spectrum can be avoided by operating at a single, less noisy frequency. |
| Hopping Mode | The **radioSettings.radioHoppingMode** setting enables frequency hopping. | Enable | N/A | ***__Hopping Mode__: Interference at a **specific** frequency only affects the signal during that short interval. |
| Max Fragment Size | The **dataPath.otaMaxFragmentSize** setting designates the maximum fragment size, in bytes, sent over the air. | Decrease Fragment Size | Increase Fragment Size | • A **smaller Max Fragment Size** may increase RF link reliability in highly noisy environments.<br>  • A **smaller Max Fragment Size** may reduce data throughput.<br>• A **larger Max Fragment Size** may increase data throughput.<br>  • A **larger Max Fragment Size** may reduce RF link reliability in noisy environments. |
| Netmask Filter | The **network.netmaskFilterEnabled** enables a bridge firewall to restrict network communication to current IPv4 subnet. | N/A | Enable | Enabling **Netmask Filter** can prevent non-radio Ethernet traffic from adversely affecting the performance and capacity of the radio network. |
| TX Queue Length | The **network.txqueuelen** setting designates the Ethernet transmit packet queue length by designating how many Ethernet packets to hold in the transmit queue before sending them over the radio link. | N/A | Increase | • If the queue size is too small in an Ethernet network with a high rate of small packets, then packets could be lost.<br>• **Increasing TX Queue Length** may increase throughput if there is a lot of network chatter that causes packets to be lost at the network layer.<br>• **Increasing TX Queue Length** can increase latency if the packets are arriving at the Ethernet interface at an average rate that is above the capacity of the radio link. |

***ZumLink radios can only operate in either single frequency or hopping mode.

# 4.3. Hopping Mode Settings

**Note**: See the respective ZumLink User Manual for detailed information about these settings.

| Hopping Mode Settings | | | | |
|---|---|---|---|---|
| **Setting** | **Description** | **Optimizing RF Link Reliability** | **Optimizing Data Throughput** | **Notes** |
| Beacon Burst Count | The **radioSettings.beaconBurstCount** setting designates the number of consecutive beacons to send per **Beacon Interval** time. | Increase the number of beacons | Decrease the number of beacons | • **Increasing** the number of beacons may improve RF link reliability in noisy environments.<br>  • **Increasing** the number of beacons may reduce data throughput.<br>• **Decreasing** the number of beacons may improve throughput in environments where interference is minimal.<br>  • **Decreasing** the number of beacons may degrade RF link reliability in noisy environments. |
| Beacon Interval | The **radioSettings.beaconInterval** controls how often a Gateway radio sends out a beacon packet and changes to the next radio frequency in the hopping pattern. | Decrease Interval | Increase Interval | • A **shorter Beacon Interval** may improve the RF link reliability in noisy environments.<br>  • A **shorter Beacon Interval** may reduce data throughput.<br>• A **longer Beacon Interval** may improve throughput in environments where interference is minimal.<br>  • A **longer Beacon Interval** may degrade RF link reliability in noisy environments. |
| Frequency Key | The **radioSettings.frequencyKey** setting designates the number used as an index to select a hopping table. | Use a unique **Frequency Key** setting for each ZumLink network. | N/A | When using different hop patterns on each network, interference caused by neighboring ZumLink networks can be minimized. |
| Frequency Masks | The **radioSettings.frequencyMasks** setting designates specific frequencies or a set of frequencies in the hopping pattern to be removed from usage. | Enable | N/A | When **Frequency Masks** is enabled, interference fixed at certain frequencies within the spectrum can be avoided by the transmitter. |

 

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For additional product information about the Z9-P / Z9-PE, visit http://support.freewave.com/.

For additional assistance, contact a local reseller, or contact FreeWave Technologies, Inc. at 303.381.9200 or 1.866.923.6168, or by email at moreinfo@freewave.com.

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The ZumLink 900MHz Series complies with FCC Part 15 rules. Operation is subject to the following two conditions: 1) This device may not cause harmful interference and 2) this device must accept any interference received, including interference that may cause undesired operation.

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