User Manual

WaveFlex Picocell Gateway Radio

WaveFlex WPGR - Version 1.2

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1. Introduction

1.1 Product Description

The WaveFlex Picocell Gateway Radio (WPGR) provides a quick and easy solution for your LoRa® Sensor Monitoring needs. The WPGR has a USB Type-A Male connector that is designed to plug into a standard USB Type-A Female Host Port for Power and to connect to a Linux Host Gateway Data Interface. When the WPGR is plugged into a USB Port it appears on the Linux Host Gateway PC as a USB CDC Virtual Serial Port. Semtech has provided Open Source Software at https://github.com/LoRa®-net that will allow you to create your own Picocell Gateway or you can purchase a WaveFlex Gateway Base Station (WaveFlex-GBS) which is a complete turnkey LoRa® Picocell GW Base Station solution. Please refer to the "WaveFlex-GBS" User's Manual for more information.

RX-Receive LED

TX-Transmit LED

Host Interface
USB 2.0 Type A
Male Connector

Antenna Interface
Reverse Polarity
SMA Connector

Top View

Reset Button
Boot Button
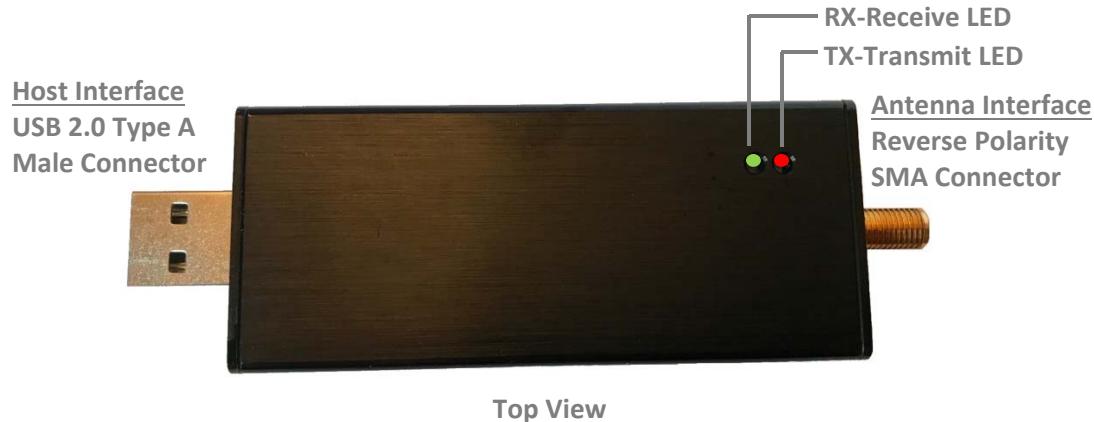
Bottom View
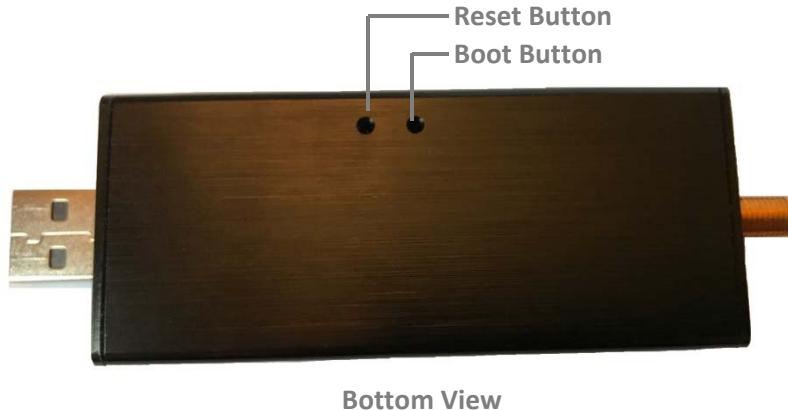
Figure 1 – WaveFlex-WPGR Overview

2. Hardware Overview

The WPGR is an FCC Certified LoRa®-Enabled multi-channel high performance transceiver that is based on the Semtech Rev 2b Reference Design. This design incorporates the Semtech SX1308 Digital Baseband IC and two Semtech SX1257 Radio Transceiver IC's which are capable of operating over the 902 to 928 MHz North American/Australian, and 867.1-868.5MHz European ISM license-exempt frequency bands. The RF Front End is capable of receiving data simultaneously on 8 LoRa® Channels and is terminated with a Reverse Polarity SMA connector for connecting an FCC approved 2.0 dBi maximum gain antenna. The WPGR is designed to plug into a standard USB 2.0 Type A Female Host Port for Power and LoRaWAN Gateway Communications support.

2.1 WaveFlex-WPGR RF Block Diagram

- The SX1308 Digital Baseband IC provides a powerful DSP Engine which integrates the LoRa® Concentrator IP

- The two SX1257 transceivers provide a robust RF front-end that is capable of receiving data on 8 LoRa® 200 kHz channels simultaneously.
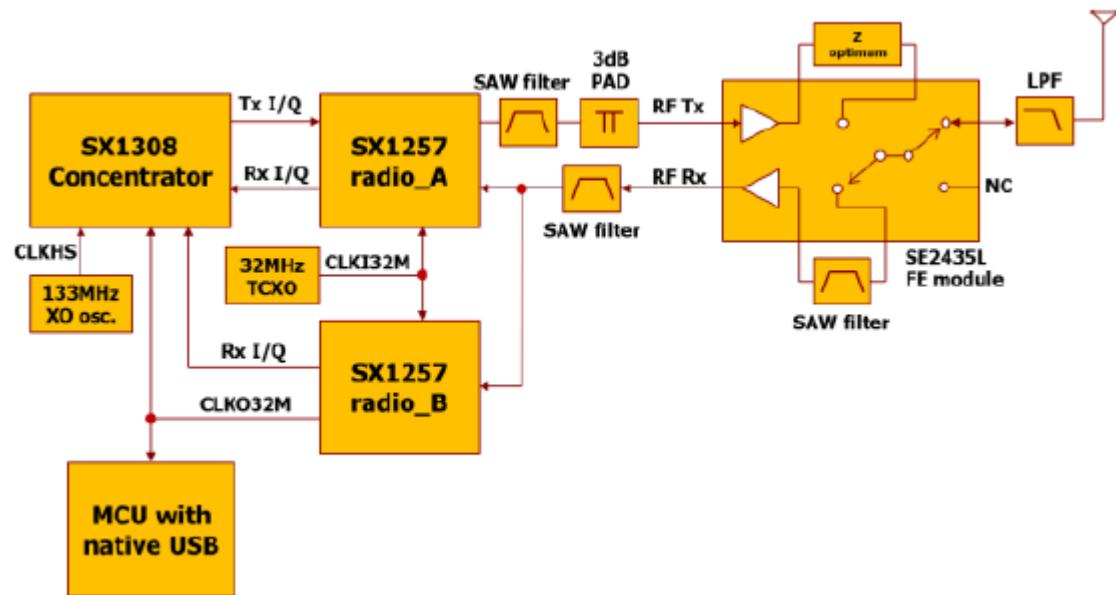
Figure 2 – WaveFlex Picocell Gateway RF Block Diagram

3. Software Overview

The WPGR uses software that was written by Semtech to provide their customers with an Open Source solution for their LoRa® based products. The Picocell GW software uses a layered architecture which consists of the Hardware Layer "picoGW_mcu", the Hardware Abstraction Layer "picoGW_hal" and the Application Layer "packet_forwarder".

Please refer to the following web link for access to the Software and Documentation.
https://github.com/LoRa®-net

3.1 Hardware Layer – picoGW_mcu

The "picoGW_mcu" is a low level Embedded Firmware MCU driver for the Gateway Concentrator PCB. It handles the power management of the SX1308 during the downlink to keep within the 500 mA maximum power limit of the USB Host interface. This Firmware also implements the USB CDC protocol to bridge commands from the Host to the SX1308 SPI Interface.

3.2 Hardware Abstraction Layer – picoGW_hal

The "picoGW_hal" is a Host Driver which runs on the Linux Host PC and provides the communications interface to the Concentrator PCB via the USB Serial Interface.

3.3 Application Layer – packet_forwarder

The "packet_forwarder" is an Application Program that runs on the Linux Host PC and communicates with the Picocell GW via the USB Serial Interface. The program forwards RF packets that are received by the Concentrator PCB to the LoRa® Server through an IP/UDP Link. This program also sends data from the Lora® Server to the Picocell GW that will be transmitted to End Nodes Devices via LoRa® RF packets.
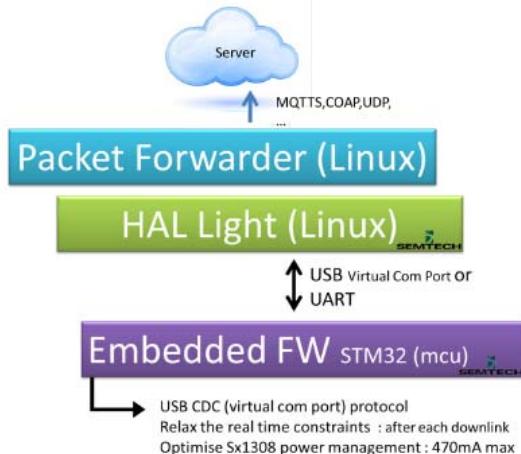
4. Software Installation – LoRa® Gateway Support Software

Please follow the steps below to download the Semtech LoRa® Gateway Software Package from GitHub and install this on a Raspberry Pi3. Once this software is installed and running on the RPi3 and the WPGR is plugged into the RPi3 USB Port, you will have a fully functional LoRa® Picocell Gateway System.

4.1 Install Semtech LoRa® Gateway Software Package into RPi3

- $ mkdir lora-net

- $ cd lora-net

- $ sudo apt-get update

- $ sudo apt-get install git

- $ git clone https://github.com/Lora-net/picoGW_packet_forwarder.git

- $ git clone https://github.com/Lora-net/picoGW_mcu.git

- $ git clone https://github.com/Lora-net/picoGW_hal.git

4.2 Install Device Firmware Upgrade Utilities (dfu-util) into RPi3.
This tool is used to program the firmware into the WaveFlex Picocell Gateway Radio.

- $ cd ~/lora-net/

- $ sudo apt-get install autoconf

- $ git clone https://git.code.sf.net/p/dfu-util/dfu-util

- $ cd dfu-util

- $ ./autogen.sh

- $ sudo apt-get install libusb-1.0-0-dev

- $ ./configure

- $ make

- $ sudo make install

5. Firmware Installation for WaveFlex-WPGR

This section covers loading the LoRa® Picocell Bootloader and Firmware into the WPGR.

5.1   Initial Factory Installation of Bootloader into the WPGR.

(Note: These steps are already completed in the Factory before the unit is shipped)

1. Press the "BOOT0" Button on the back of the WPGR PCB while plugging it into a USB Port on the RPi3 Unit.
2. On the RPi3, load the binary image into the WPGR PCB by entering the following command in the Data Terminal view on the RPi3:

$ sudo /usr/local/bin/dfu-util -a 0 -D ~/lora-net/picoGW_mcu/bin/pgw_fw_usb.dfu

5.2   Field Installation of the Bootloader into the WPGR.

1. Plug the WPGR into the USB Port on the RPi3 Unit that is powered-up.
2. Go to the Data Terminal view on the RPi3.
3. Enter the following command to verify USB communications: $ lsusb
4. One of the Response Lines should end in: "STMicroelectronics STM32F407" is the RPi3 recognizes the WPGR.
5. Enter the following command to identify which COM Serial Port is used:
   $ dmesg
6. The Hardware Configuration of the RPi3 is displayed and in this you should be able to find the following lines displayed:
   usb Product: SEMTECH Corp Virtual ComPort
   usb Manufacturer: SEMTECH
   usb SerialNumber:
   cdc_acm : ttyACM0: USB ACM device (Note: This may use ttyACM1 as well)
7. In the Data Terminal type in:
   a. $ cd ~/lora-net/picoGW_hal/util_boot
   b. $ make
   c. $ ./util_boot –d /dev/ttyACM0   (Note: or "ttyACM1")
   d. $ lsusb   (Enter this command to check that "STM Device is in DFU Mode"
   e. Enter command below to load the binary image into the WPGR.
   $ sudo /usr/local/bin/dfu-util -a 0 -D ~/lora-net/picoGW_mcu/bin/pgw_fw_usb.dfu
   f. To Exit DFU (Device Firmware Update) mode remove and re-insert WPGR device into the USB Port on the RPi3.

6. Packet Forwarder Application Program for RPi3 Picocell Gateway Host

The LoRa® Packet Forwarder is an application program that runs on the RPi3 Picocell Gateway Host. This program forwards RF packets received by the WPGR from the End-Node-Devices to the LoRa® Server through an IP/UDP Link. The Packet Forwarder also forwards data that is sent by the LoRa® Server to the End-Node-Devices on the Network via the WPGR.

6.1 Compile Semtech HAL and Packet Forwarder on the RPi3

- $ cd ~/lora-net/picoGW_hal

- $ make clean all

- $ cd ~/lora-net/picoGW_packet_forwarder

- $ make clean al

6.2 Run USB Communications Stress Test between RPi3 Host and WPGR

Running this test will test the USB to Serial communications link between the RPi3 Host and the WPGR. This test should run continuously and dump data to the Terminal on the RPi3 until it is stopped.

- $ cd ~/lora-net/picoGW_hal/util_com_stress

- $ ./util_com_stress -t 4 -d /dev/ttyACM0

- Press Ctrl+C and then Enter Key to Exit the Test.

6.3 Get the unique Gateway ID from the WPGR

Run the commands below to access the Gateway ID from the WPGR. This value should be used in the "global_conf.json" file as the "Gateway ID".

- $ cd ~/lora-net/picoGW_hal/util_chip_id

- $ ./util_chip_id -d /dev/ttyACM0   (Note: may need to use "ttyACM1")

6.4 Running the Packet Forwarder on the RPi3

a. Run Packet Forwarder on RPi3 – Enter the command strings below:

$ cd ~/lora-net/picoGW_packet_forwarder/lora_pkt_fwd/

$ ./lora_pkt_fwd -d /dev/ttyACM0   (Note: may need to use "ttyACM1")

b. The Packet Forwarder should begin running and will start displaying the data that is transferred. The Payload Data displayed is encrypted so it cannot be read.

c. The LoRa® Packet Forwarder program, "lora_pkt_fwd", loads the "global_conf.json" configuration file at start-up. This file is used to configure the RF and Communications Parameters that are used by the WPGR Radio and the Packet Forwarder program.

7. WaveFlex Picocell Gateway Radio - Specifications

7.1 WPGR – Specifications

Item	Description	Specification
Voltage Input	USB ® A Male Connector	5VDC (± 10%)
Power	Current Draw	8 Rx Channels ON TX OFF (330 mA)
		8 Rx Channels OFF TX ON (230 mA)
		Maximum Current Draw (468 mA)
Physical Parameters	Case Dimensions	78 x 33 x 13 mm (L x W x H)
	USB Connector Dimensions	13 x 11 x 4 mm (L x W x H)
	SMA Connector Dimensions	10 x 5 mm (L x Diameter)
	Total Weight	43 g
Operating Range	Operating Temperature	0 °C to 70 °C
Radio Design	Semtech Radio IC's	1 - SX1308, 2 – SX1257
	Semtech Reference Design	Based on Semtech Rev 2b
RF Characteristics	Maximum RF Input Level	-10 dBm
	Maximum RF Output Level for US/CAN/AS-NZ	+27.8dBm
	Maximum RF Output Level for EU	+20 dBm
	Receiver Sensitivity	-139 dBm at SF12 BW 125 kHz
		-125 dBm at SF7 BW 125 kHz
	Freq. Range – US/Australia	915 ISM Band (902 MHz to 928 MHz)
	Freq. Range – Europe	868 ISM Band (867.1-868.5MHz)
	Max ERP	24.9mW at 867.1MHz at 0 degrees C.
Agency Approval	Certifications	FCC/IC/CE

Figure 3 – WaveFlex Picocell Gateway Radio - Specifications

8. WaveFlex Picocell Gateway Radio - Maintenance

The WaveFlex LoRa® Picocell Gateway Radio is not designed to be waterproof, so it must never be immersed in any type of liquid. The enclosure is designed for indoor use only. If the Picocell GW is used outdoors it must be placed in an appropriate enclosure to protect it completely from the elements.

Please refer to the "WaveFlex Gateway Base Station User's Manual" for more details on the installation and operation of the complete sensor system.

9. WaveFlex Picocell Gateway Radio - Regulatory Statements

9.1 FCC

Changes or modifications not expressly approved by WaveFlex, Inc. could void the user's authority to operate the equipment.

This device complies with Part 15 of FCC 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.2

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

—Reorient or relocate the receiving antenna.
—Increase the separation between the equipment and receiver.
—Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
—Consult the dealer or an experienced radio/TV technician for help.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

9.2 IC

This radio transmitter, IC: 24956-1001003, has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Le présent émetteur radio, IC: 24956-1001003, a été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué pour tout type figurant sur la liste, sont strictement interdits pour l'exploitation de l'émetteur.

9.3 Approved Antennas

Model	RFA-ZW-C55-U-B70-1
Frequency	865-928 MHz
Peak Gain	2.2 dBi
Average Gain	0.2 dBi
VSWR	3.0 : 1 Max
Polarization	Linear, vertical
Connector	RP-SMA PLUG
Dimensions	137mm

9.4 RF Exposure Warning

WARNING: The Federal Communications Commission warns that changes or modifications of the radio module within this device not expressly approved by WaveFlex, Inc. could void the user's authority to operate the equipment.

The minimum safe distance for people from this module has been determined by conservative calculation to be 20 cm for all allowable antenna types. The end product User's Guide must include the following statement in a prominent location: (Note for modules with RF output power <10mW, this statement is likely not required).

To comply with FCC's RF radiation exposure requirements, the antenna(s) used for this transmitter must be installed such that a minimum separation distance of 20 cm is maintained

between the radiating element (antenna) & any user's or bystander at all times and must not be co-located or operating in conjunction with any other antenna or transmitter.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

9.5 RSS Gen 8.4

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:
1. This device may not cause interference.
2. This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :
1. L'appareil ne doit pas produire de brouillage;
2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement

10. Labels and Markings

10.1 Labeling Instruction

When installing the Picocell Gateway Radio inside a host product in accordance with Single Modular Approved radio rules, the following sticker must be permanently placed on the exterior of the host product.

Contains FCCID:2ASYA-1001003
Contains IC: 24956-1001003

10.2 Markings

11. Contact

Company Name:	WaveFlex, Inc.
Contact Name:	Shawn S. Flannery
Contact Title:	President
Company Address:	5480 Roesland Dr. Galena OH, 43021
Telephone No:	614-682-5293
Facsimile No:	740-549-4640
Email Address:	sflannery@wave-flex.com