

PLXDigi (v1.04)

APRS STANDALONE DIGIPEATER
MULTIPATH DSP APRS DECODING ALGORITHM
WEATHER STATION SUPPORT
EXTERNAL TELEMETRY MODULE SUPPORT
INPUT VOLTAGE MEASUREMENT
SERIAL CONSOLE FOR ADMINISTRATION
EASY USB-HID CONFIGURATION AND FIRMWARE UPDATE

Instruction manual
Configuration software manual



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1. Technical parameters

| | |
|-----------------------------------|------------------------|
| Dimensions | 94x50x25 mm |
| Weight | 70g |
| Supply voltage | 12VDC typ. (9 - 16VDC) |
| Power consumption | 50mA |
| Operation temperature | -30 °C / +70 °C |
| Humidity | 95% max. |
| PC connector | Mini USB-B |
| Power, radio, telemetry connector | DB-9 male |
| Serial ports connector | Mini DIN 6-pin female |

2. Device features

2.1. MultiPath APRS packets decoding

In PLXDigi device we resigned from hardware packet decoding method. MultiPath APRS packet decoding algorithm is a digital signal processing based method utilizing features of modern 32-bit microcontrollers used in our devices.

MultiPath decoding allows to decode received packets simultaneously by two decoding algorithms, with different digital filters applied to both paths. Packets distorted by low-frequency components or with imbalanced 1200/2200Hz tones are prefiltered which increases the probability of correct packet decoding.

2.2. APRS client

PLXDigi allows you to generate APRS data packets with information field defined by user and send them in a specified interval. In this way, it is possible to send beacons, objects, weather and telemetry data.

2.3. APRS digipeater

The main purpose of the device is receiving and sending APRS data packets via amateur radio transceiver. PLXDigi is capable of receiving an APRS packet, decoding the sender, recipient, path and information field. Then actions are performed in accordance with the options configured by user:

- Packet is digipeated via the APRS network,
- Packet is ignored if it was corrupted.

Device firmware implements the following mechanisms:

- Checksum Verification - packets with errors are ignored,
- Anti-flood - packets repeated in a short time interval are not forwarded,
- Path checking - a decision whether to digipeat a packet or not is made using a filter stored in configuration data of the device. User defines whether to forward WIDE1-1, WIDEn-N, SPn-N, or local path packets and the maximum value of N (so called New-N paradigm),
- Callsign filter - a simple callsign filter allows you to add stations to black list (these stations will be ignored) or white list (only these stations will be digipeated).

2.4. Weather station support

PLXDigi allows you to receive weather data from compatible weather stations over RS-232 serial interface. Currently supported stations are:

- LaCrosse/Technoline WS-2300,
- LaCrosse/Technoline WS-2350,
- Peet Bros Ultimeter 100,
- Peet Bros Ultimeter 800,
- Peet Bros Ultimeter 2000,
- Peet Bros Ultimeter 2100,
- Davis Vantage Pro (with RS-232 datalogger),
- Davis Vantage Pro2 (with RS-232 datalogger),

- Davis Vantage Pro Plus (with RS-232 datalogger),
- Davis Vantage Pro2 Plus (with RS-232 datalogger),

2.5. Telemetry reports

Device allows you to send telemetry reports to APRS network. Possible telemetry channels are:

- input voltage,
- received APRS packets in 1 hour or 10 minutes window,
- digipeated APRS packets in 1 hour or 10 minutes window,
- packet decoding efficiency in 1 hour window or in the whole range from device power-up,

2.6. WXTelemetry module support (analog channels)

You can get more telemetry report options when using external WXTelemetry module. With WXTelemetry module you can measure and send following values:

- two current measurement inputs,
- two voltage measurement inputs,
- DS18B20 digital thermometer input.

2.7. WXTelemetry module support (analog channels)

You can use an additional WXBits module for reporting of digital input channels and administration of output channels. WXBits is a module which includes:

- 4 optocoupler digital inputs,
- 4 mosfet transistor open-collector outputs.

States of both inputs and outputs can be reported in APRS telemetry reports and outputs can also be controlled via serial port console.

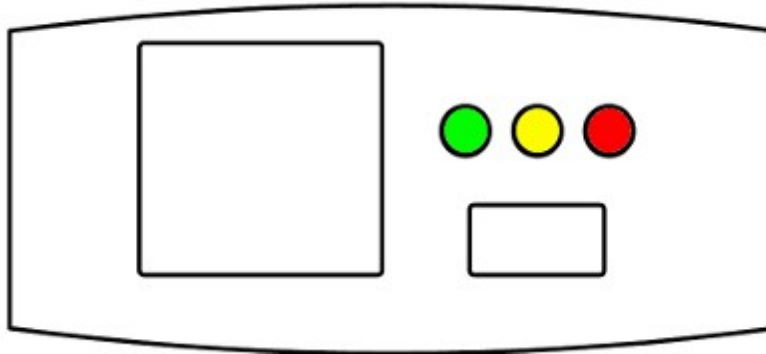
2.8. Firmware and configuration updates

In PLXDigi you can do all firmware and configuration updates over an USB cable connection from your PC using a simple Configurator application.

3. Connectors and device status leds

3.1. Front panel

There are 3 leds on the front panel that show the status of device operation. The following image shows the location of front panel LEDs and connectors.



Leds:

- **Green LED** - illuminates when receiving a signal from the radio (indicates the channel is busy),
- **Yellow LED** - lights during transmission, when the device sends an APRS data packet,
- **Red LED** - blinking is dependent on current device state:
 - one short blink (0.1 second) per 1.6 seconds - in idle state,
 - two short blinks (0.1 second each) per 1.6 seconds - when a weather report is received from weather station,
 - one long blink (1 second) per 1.6 seconds - APRS packet was properly received.

Connectors:

- **Mini DIN 6-pin** - two RS-232 serial data interfaces,
- **Mini USB** - a mini USB socket, used to connect to a computer for configuration,

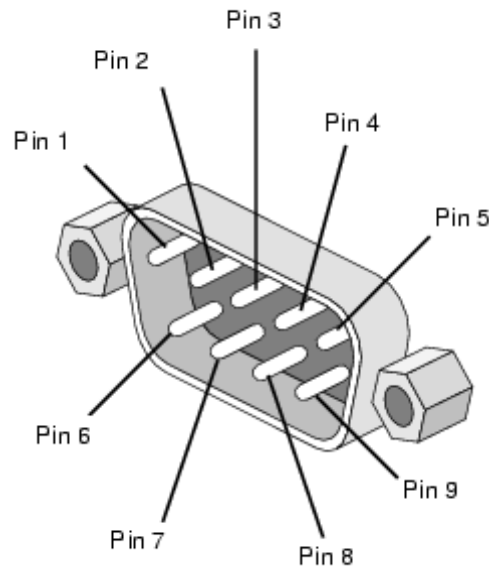
3.2. Rear panel

Connectors:

- **DB9 male connector** - used for connection of supply voltage, radio, and RS-485 telemetry module.

4. Power, radio, RS-485 connector

DB-9 male connector is used for supply voltage input, audio in, audio out, PTT, and RS-485 bus for telemetry.



DB9 connector pins description:

- Pin 1 - PTT output, open collector, if the external PTT output is selected in device configuration, this pin is shorted to ground while broadcasting,
- Pin 2 - GND,
- Pin 3 - GND,
- Pin 4 - APRS audio input from radio to PLXDigi,
- Pin 5 - GND,
- Pin 6 - RS-485 A+ positive differential input/output,
- Pin 7 - RS-485 B- negative differential input/output,
- Pin 8 - APRS audio output from the device to the microphone input of the radio. This output also acts as a PTT by shorting pin to ground through a 2k2 resistor - an option for portable radios that do not have a separate PTT input (selectable in configuration software, 2k2 resistor is built-in),
- Pin 9 - supply voltage input.

For handheld radios which use 2k2 resistor on microphone input line you don't need to use any external resistor or external PTT (pin 6) output. Connect pins: 2 (audio output), 4 (audio input), 5 (ground) and set "PTT:" to "2k2 resistor" in device configuration. 2k2 resistor is located inside of the device.

If you are going to use both WXTelemetry and WXBits external telemetry modules, you should connect them in a chained style: A+ and B- pair go from PLXDigi to first telemetry module, and then from first telemetry module to the second one. From a schematic point of view, both modules must be connected in parallel (A+ from PLXDigi goes to A+ of the first module, and then to A+ of the second, similarly with B-). Never connect A+ to B-.

4.1. Audio output level regulation

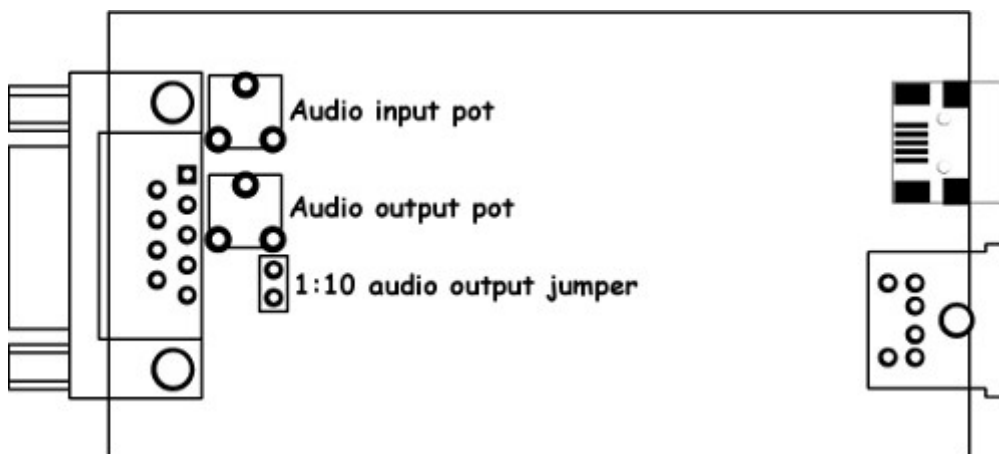
There is 1kOhm potentiometer on the device audio output. Clockwise turn increases audio output level, counter-clockwise decreases. Audio output level is regulated after production to some default value. The most suitable value is dependent on the radio used, because of various input impedance of different radios (for example, most Motorola GM-300/GM-350 radios have a strong DC voltage bias on the front audio input connector, so the output driver should be set to drive a stronger signal on the output to overcome this bias voltage). If you need to adjust output level, you can use a potentiometer located inside the device. To do that, you will need to open the case and gain access to the PCB of the device. Output signal should be set to achieve the desired modulation depth at the RF output of the radio.

Some radios with dedicated “DATA” connector demand a very low signal level on the input (for example 40mV) for proper modulation depth. In these situations you should remove 1:10 divider jumper (to enable divider) and also regulate potentiometer output carefully for best results.

4.2. Audio input level

Audio input level should be regulated for proper packet decoding. In most cases the default potentiometer setting should work but it can be trimmed to get the best results. After every received packet you can observe reported signal level via serial console connection to your device (with “debug ax25 on” command applied). The best results are obtained with reported signal level above 40% and below 70%.

~~There is a 1kOhm potentiometer on the input~~ (starting with September 2013 we replaced 1kOhm resistor with 10kOhm for better interfacing with weak signals from “DATA” connector of some radios). Clockwise turn increases audio output level, counter-clockwise decreases. The best method for first try is to set it to a neutral center position. Audio input after the potentiometer should not exceed about 400mV (to avoid signal clipping) and should not be below 50mV. So on device input you should provide audio level of around 100-800mV (for potentiometer in neutral position).

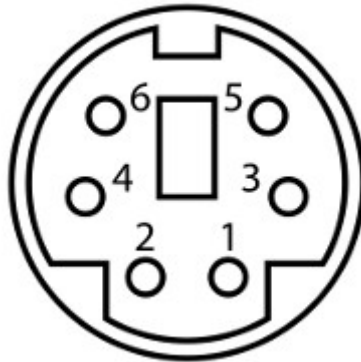


The level of input and output should be individualized in such a way that packets are decoded correctly. Audio levels can be regulated using potentiometers placed on a PCB inside of the device.

Our tests revealed that decoding works fine for wide range of audio input levels. Packets were decoded properly even with audio input over-driven with high-level audio signal from speaker outputs. Similarly packets were decoded even with signal level as low as 5% of the ADC conversion range

5. Serial ports connector

In PLXDigi the MINI DIN 6pin female connector is used for RS-232 serial ports and 5V voltage output.



MINI DIN 6pin connector pins description:

- Pin 6 - RS-232 Port 1 RXD,
- Pin 4 - RS-232 Port 2 TXD,
- Pin 2 - GND,
- Pin 1 - 5V output, do not short-circuit, max. current 100mA,
- Pin 3 - RS-232 Port 1 TXD,
- Pin 5 - RS-232 Port 2 RXD.

RS-232 Port 1 and Port 2 functions are selectable in software.

6. Connecting the weather station

6.1. LaCrosse/Technoline WS-2300, WS-2350 stations

These stations are somehow problematic when you try to use them with RS-232 interfaces other than personal computer serial ports.

WS-23XX stations need an additional polarization positive and negative voltage on pin 4 and pin 7 of DB9 connector. For that purpose we can use our 5V voltage output, but we will also need to use the second RS-232 port's TXD line for negative voltage polarization. If you want to use WS-23XX weather stations, you will not be able to use your second RS-232 port for any other purpose (so both ports are used by WS-23XX weather stations).

For WS-23XX weather stations you can use our prebuilt cable: "CAB02 - PLXDigi serial interface cable (for WS-23XX)".

6.2. Peet Bros Ultimeter stations

For Peet Bros Ultimeter weather stations, you need to use RXD, TXD, and GND lines of PLXDigi serial interface. Stations must then be manually switched to "data logger" mode. According to the manufacturer's instructions, you should press CLEAR + WIND SPEED buttons for 3 seconds to activate the "data logger".

For Peet Bros weather stations you can use our prebuilt cable: "CAB01 - PLXDigi serial interface cable".

6.3. Davis Vantage stations

To connect PLXDigi to Davis weather stations you need to use an additional RS-232 "datalogger" interface available from the manufacturer. Device part number is 06510SER. You need to use RXD, TXD and GND lines of PLXDigi serial interface.

For Davis weather stations you can use our prebuilt cable: "CAB01 - PLXDigi serial interface cable".

Davis stations datalogger interface comes in two kinds: "standard" datalogger or "APRS" datalogger. According to my current knowledge, both types work fine with PLXDigi (it doesn't use an "APRS" feature of datalogger but "APRS" datalogger has also the same communication options like "standard" one).

7. Connecting to PC

Configuration of PLXDigi can be done via USB interface with PLXDigi Configurator software.

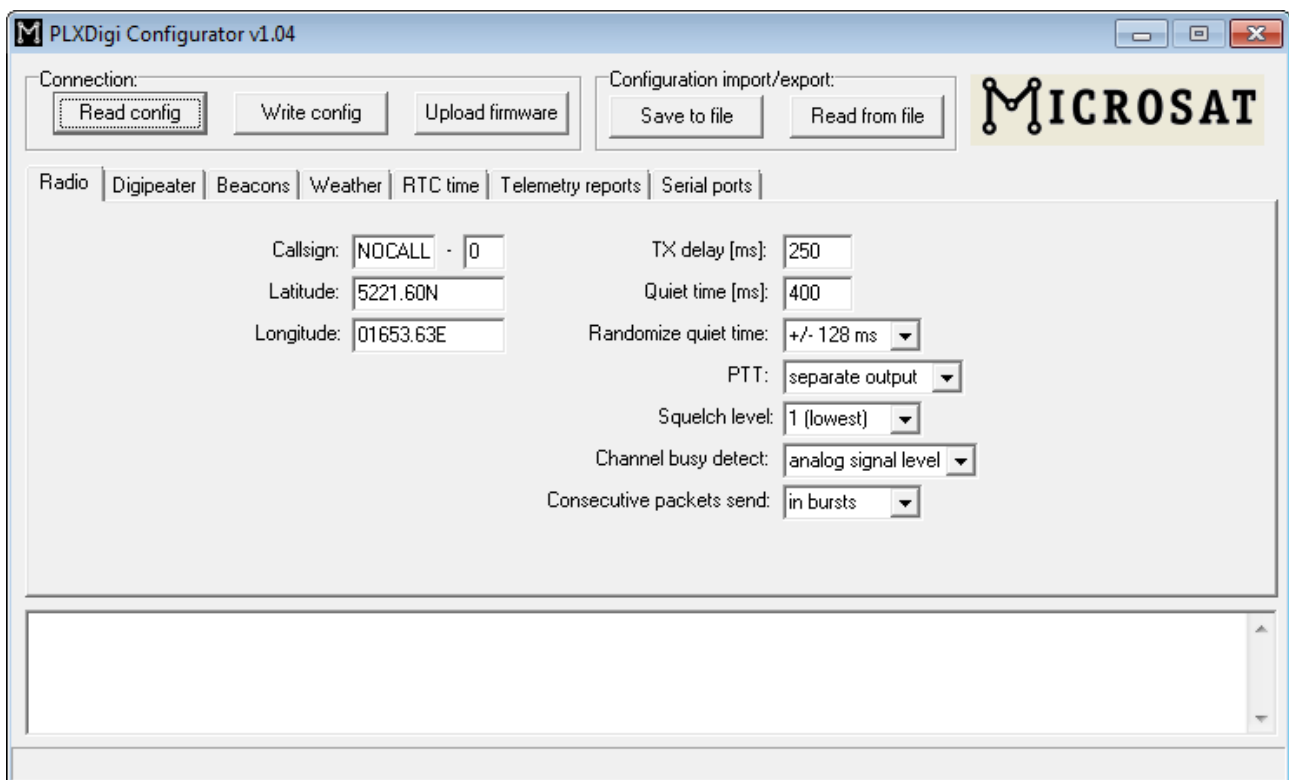
PLXDigi enters into configuration mode only when USB cable is detected while powering up and it is indicated by Red LED blinking.

To connect to your computer, follow these steps:

- Disconnect PLXDigi DB-9 cable, device should be unpowered,
- Connect the USB cable from your computer to PLXDigi, Red LED should start to blink (device is now powered from USB),
- Now you can use PLXDigi Configurator for device configuration read/write or firmware update.

PLXDigi device appears as USB-HID device in Windows operating system, and should be detected automatically. Therefore you don't need to install any device drivers for PLXDigi.

Now you can simply use PLXDigi Configurator application to read, modify, write configuration to the device. The following image shows the application window.



7. Description of configuration software

In this chapter we will discuss all the Configurator application settings and describe its influence on the device operation.

7.1. Reading configuration from the device

To read the configuration from the device you must use the **“Read config”** button. After this action, the program will download current configuration values from PLXDigi internal memory.

7.2. Writing configuration to the device

After entering configuration values in Configurator application, choose **“Write config”** to upload current configuration to PLXDigi internal memory.

7.3. Firmware update

If there is a new software update, you should upload the new firmware attached to PLXDigi Configurator software package. For this purpose, click on the **“Upload firmware”** button, this operation will open a file selection window. From PLXDigi Configurator folder please select the firmware file `plxdigi_firmware_vXXX.hash` (where XXX is the next version of the firmware). Then wait for the update to complete.

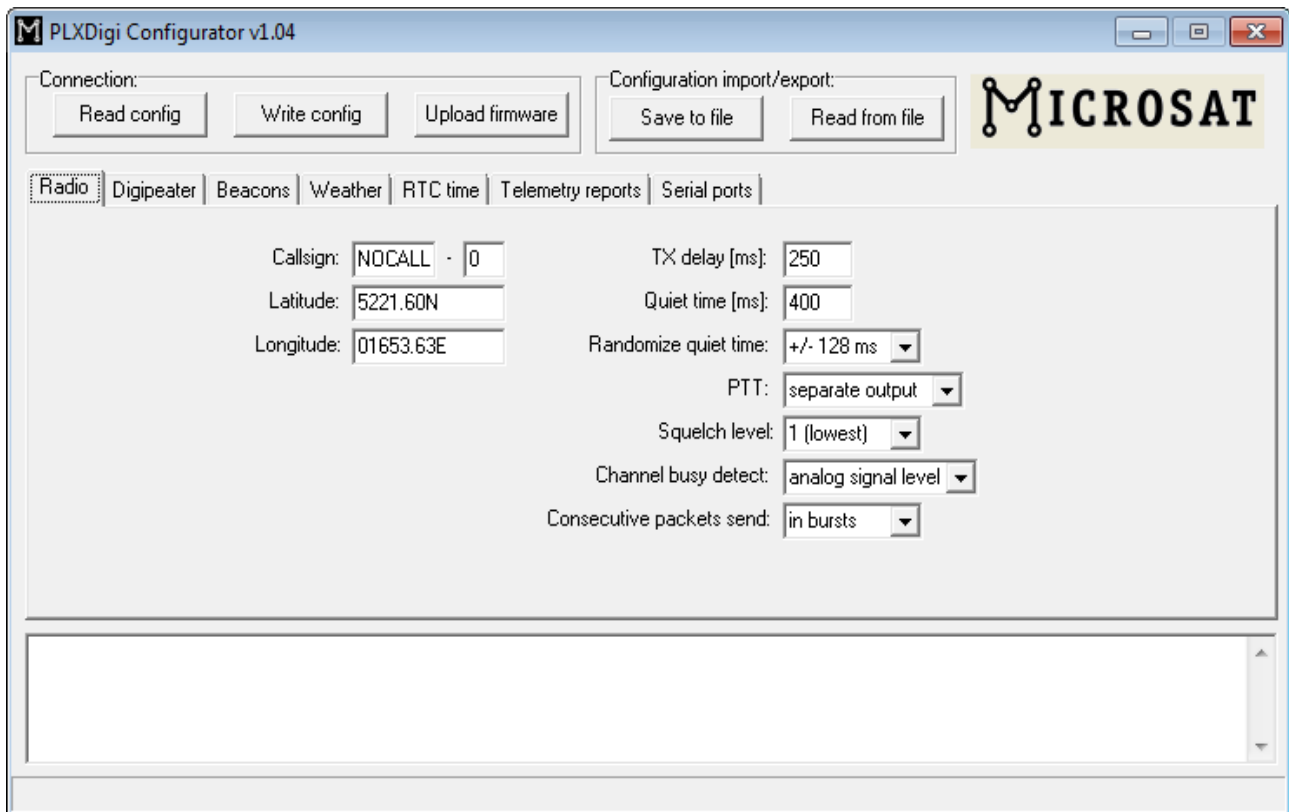
Don't worry, it is not possible to “brick” or damage the device with this operation. If anything goes bad, you will simply need to try again with firmware update function.

Please remember that you should update your device with the same Configurator and firmware version numbers. It is also always necessary to upload new configuration after flashing the device with new firmware versions. The device will not start if configuration and firmware versions do not match. If your device simply blinks all the leds when powered up, it means that your configuration version does not match firmware version.

7.4. Configuration import/export

With **“Save to file”** button you can export your current configuration from PLXDigi Configurator window to a file on your PC's disk drive. Similarly with **“Read from file”** button you can import configuration from a file to your PLXDigi Configurator application. These functions can be used to save your device's configuration and to transfer your device's configuration to recent Configurator and firmware versions.

7.5. Radio Tab



- **“Callsign”** - The callsign of your station with SSID extension. This field can be up to 6 characters long. The default SSID is 0 and allowed SSID's are between 0 and 15,
- **“Latitude”** - north-south position of your radio station,
- **“Longitude”** - east-west position of your radio station.

For APRS beacons latitude is encoded as “XXYY.ZZD” where XX are degrees, YY are seconds (1/60 of a degree), ZZ are hundredths of seconds (1/100), D can be N for north or S for south.

Longitude is encoded as “XXXYY.ZZD” where XXX are degrees, YY are seconds (1/60 of a degree), ZZ are hundredths of seconds (1/100), D can be E for east or W for west.

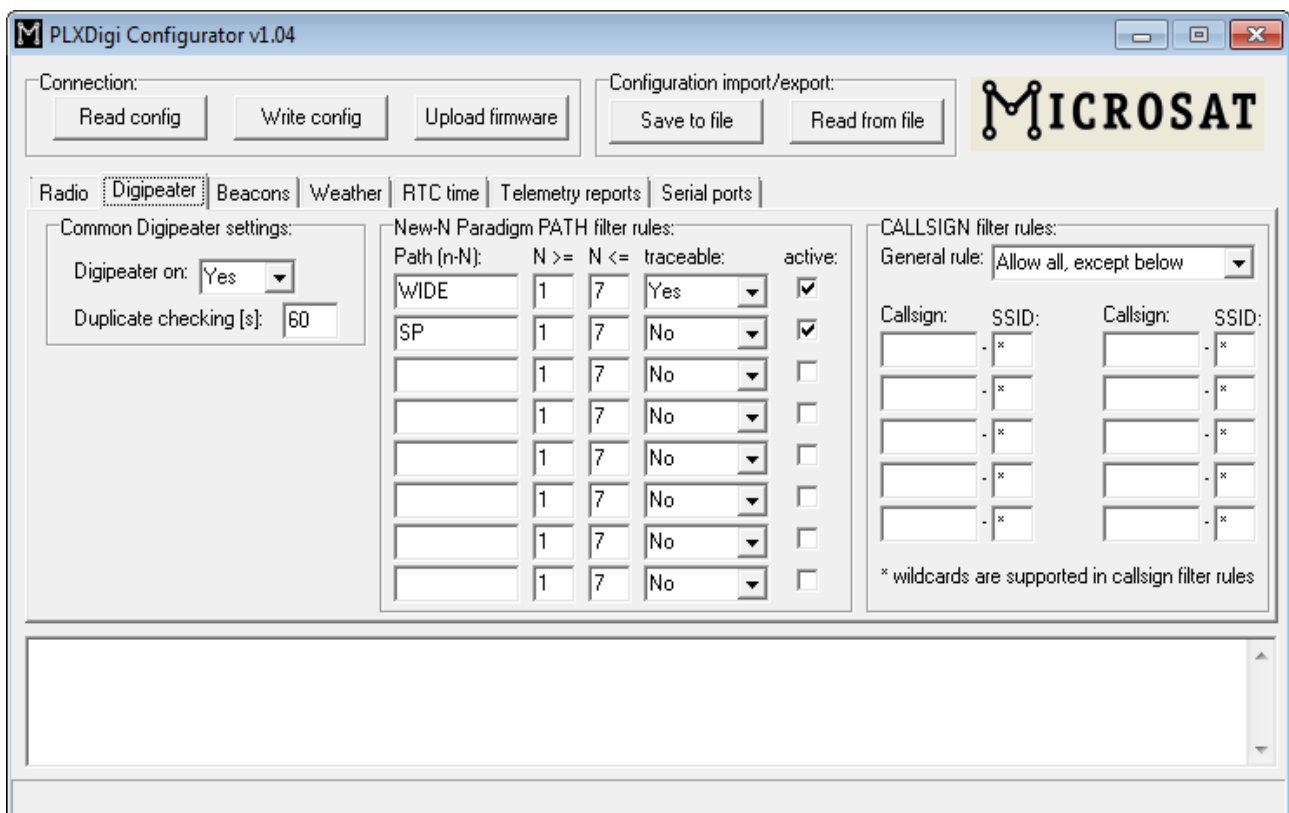
You can easily find your coordinates in APRS format on aprs.fi map, they are displayed in upper-left corner of the screen.

- **“TX delay (ms)”** - Delay time in milliseconds for sending an APRS packet. It is the length of preamble sent before packet and necessary for radio receivers to synchronize with our packet. The recommended value is not less than 250ms,
- **“Quiet time (ms)”** - Minimum time off after the radio channel is busy. After this time next packet can be sent from the transmit buffer,
- **“Randomize quiet time”** - this option adds some randomization to Quiet time value which changes every packet sent with a range selected in this box,
- **“PTT”** - push-to-talk output selection, we can choose between two options:
 - **“separate output”** - PTT output pin is shorted to ground while broadcasting,

- “2k2 resistor” - audio output is shorted to ground via 2k2 Ohm resistor, function used in some handheld radios for transmission enable,
- “Squelch level” - this a squelch level selection, with lower values usable signal will be detected with lower signal amplitude. Default value of 1 should be the best option,
- “Channel busy detect” - This option selects if channel busy is detected by input signal amplitude (“analog signal level”) or with proper packet start detection (“digital detect”). The second option allows to work with open-squelch on the radio, but it can lead to some packet collisions. The first option is default and should be used in most cases,
- “Consecutive packet send” - this option will make your device send all the packets from TX queue one after another without any delays (“in bursts”), or with TX delay, Quiet time, and channel busy detection between every packet (“separately”). The first one is default and used by most APRS devices.

If you are new to APRS or if you are running the device for the first time, you should change Callsign, Latitude and Longitude field to proper values for your station. These fields are important. You should also change PTT option to be compatible with your radio connection. Other options can be left unchanged as default values should work fine.

7.6. Digipeater Tab



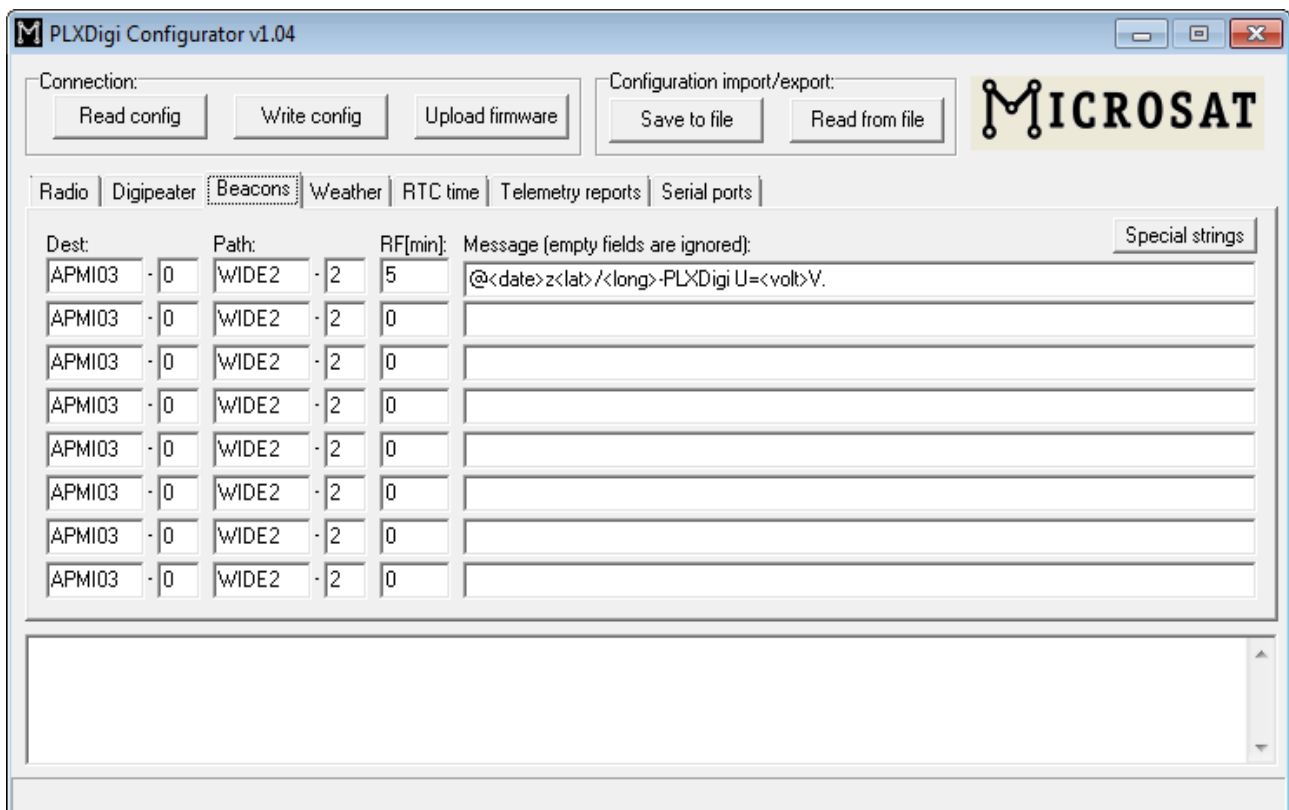
- “Digipeater on” - Enables or disables a function of RF APRS packets digipeating,
- “Duplicate checking (s)” - Time in seconds after which the next packet will be forwarded, if it has the same content as the previous one. This function allows you to ignore stations, which are flooding the network and also to ignore packets

which were heard a while before and are heard again after being digipeated by other stations,

- **“New-N Paradigm PATH filter rules”** - here you can insert New-N Paradigm paths to be handled by PLXDigi digipeater function:
 - **“Path (n-N)”** - path name, WIDE, SP, etc.
 - **“N>=”** and **“N<=”** - minimum and maximum N for path to be forwarded, for example WIDEn-N with N>=1 and N<=3 will forward paths: WIDE3-3, WIDE3-2, WIDE3-1, WIDE2-2, WIDE2-1, WIDE1-1,
 - **“traceable”** - if Yes, PLXDigi will add its own callsign to the path, if No, it will not do that,
 - **“active”** - if not checked, current row will not be active.
- **“CALLSIGN filter rules”** - here you can define “black list” (“General rule:” set to **“Allow all, except below”** - all callsigns will be digipeated except listed below), or “white list” (“General rule:” set to **“Deny all, except below”** - only callsigns listed below will be digipeated).

If you are new to APRS or if you are running the device for the first time, you can leave all the options as default. By default, the device will digipeat all packets with WIDEn-N string in path and also local Polish SPn-N string (if you are not from Poland you can remove SP from the second row, it is placed here as an example of a local New-N path).

7.7. Beacons Tab



- **“Dest”** - destination field of a beacon packet. It would be best to leave it default which will allow your device to be recognized as PLXDigi (and added to working stations callsign list on my webpage),

- **“Path”** - APRS path (default value of WIDE2-2 will allow your device to be digipeated by most nearby digipeaters), if you leave this field empty, beacon will be sent without path,
- **“RF[min]“** - beacon transmit rate to RF (expressed in minutes), beacon will not be sent if this field is set to 0,
- **“Message“** - APRS packet information field content. Beacon will not be sent if this field is left empty.

To properly generate a message field structure, please read the information on the APRS packet format. I recommend the website of the Polish APRS Group's founder Andrew Bartosz SP3LYR, where all is nicely described (in Polish): <http://www.aprs.pl>.

Example beacon packet:

```
@<date>z<lat>/<long>-PLXDigi U=<volt>V
```

- @ - APRS data ID,
- <date>z - time and date in the format DDHHMM (day/hour/minute),
- <lat>/<long> - station latitude and longitude,
- „-“ - together with “/” sign between <lat> and <long> defines a station symbol (House in this example), please refer to the table of symbols at <http://aprs.pl/ikony.htm>,
- PLXDigi U=<volt>V - beacon information field, <volt> will be replaced with input voltage reading.

As you can see in the above example, PLXDigi allows to use some special strings, which are automatically replaced with corresponding values:

- <date> - inserts current date in DDHHMM (day/hour/minute) format,
- <lat> - inserts your stations latitude defined in “Radio” Tab,
- <long> inserts your stations longitude defined in “Radio” Tab,
- <volt> inserts your current input voltage read by the device.

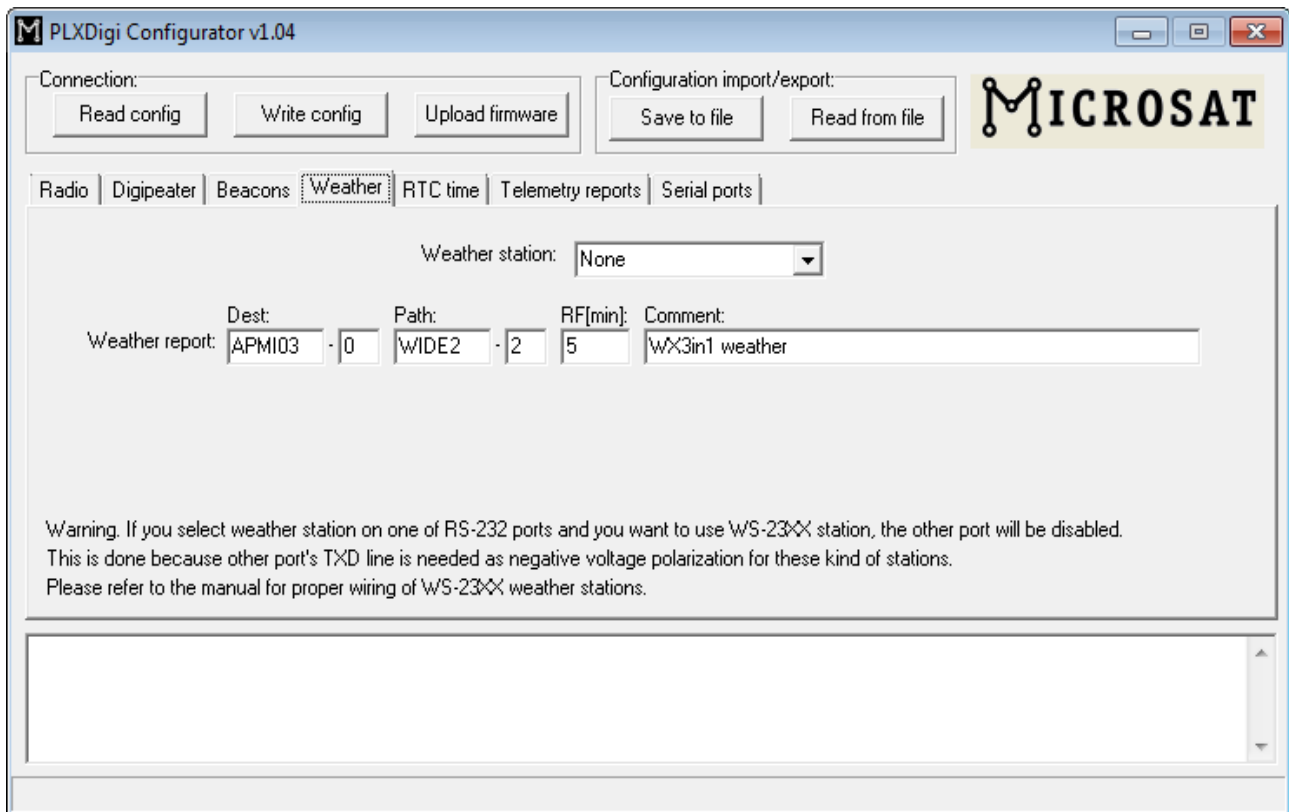
After inserting corresponding values example beacon packet will look for example like that:

```
@100214z5221.60N/01653.63E-PLXDigi U=12.1V
```

Important note: I sometimes see that users try to replace special <date>, <lat>, <long>, <volt> strings with direct values. You don't need to do that. If you set for example “<date>” string in your beacon, current date will be placed instead of this string. The same for “<lat>”, “<long>”, and “<volt>”.

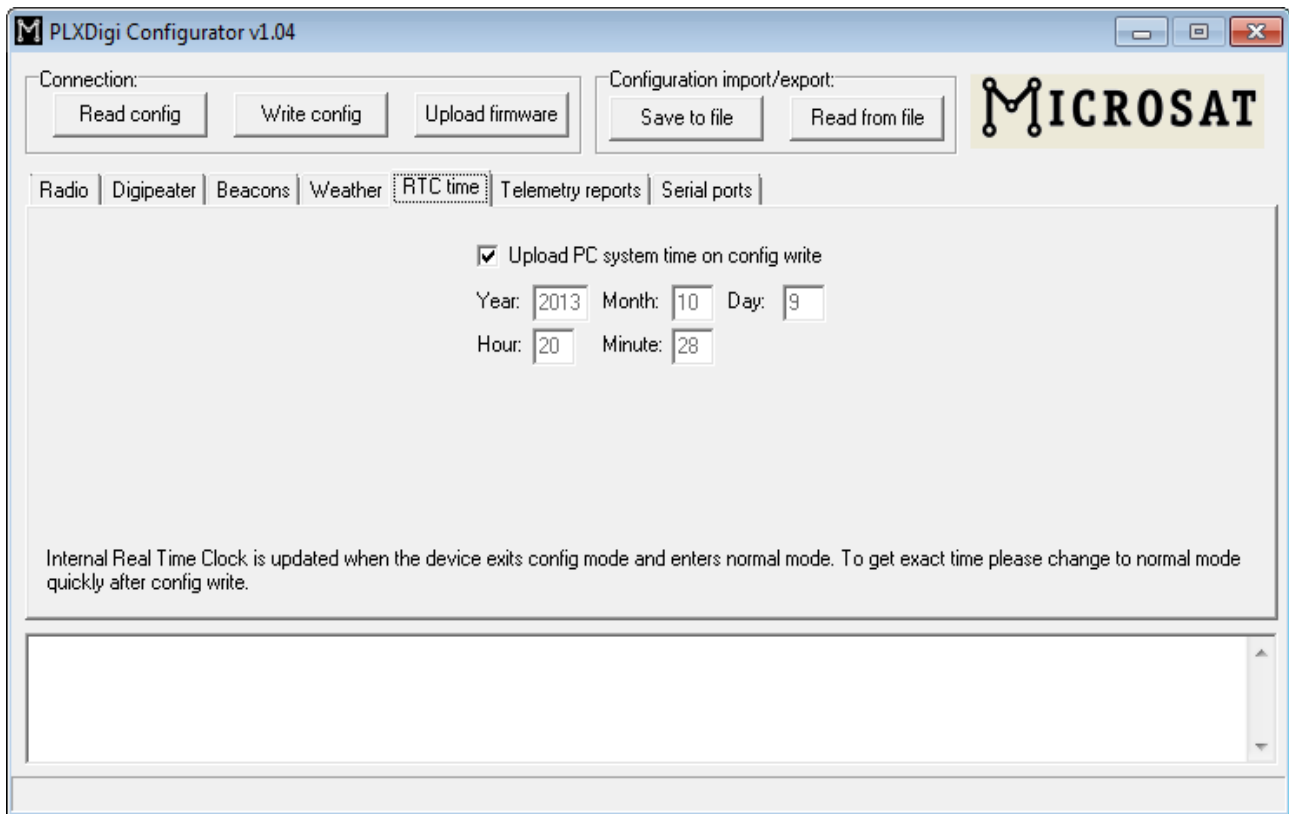
If you are new to APRS or if you are running the device for the first time, you can leave all the options as default. By default, the device will send standard beacon packet with time, latitude, longitude and current voltage reading both to RF every 5 minutes. It should make your station appear on the map on aprs.fi.

7.8. Weather Tab



- **“Weather station”** - weather station type selection box,
- **“Dest”** - destination field of a weather report.
- **“Path”** - APRS path (default value of WIDE2-2 will allow your device to be digipeated by most nearby digipeaters), if you leave this field empty, weather report will be sent without path,
- **“RF[min]”** - weather report transmit rate to RF (expressed in minutes), report will not be sent if this field is set to 0,
- **“Comment”** - This is a short comment which will be appended at the end of weather report.

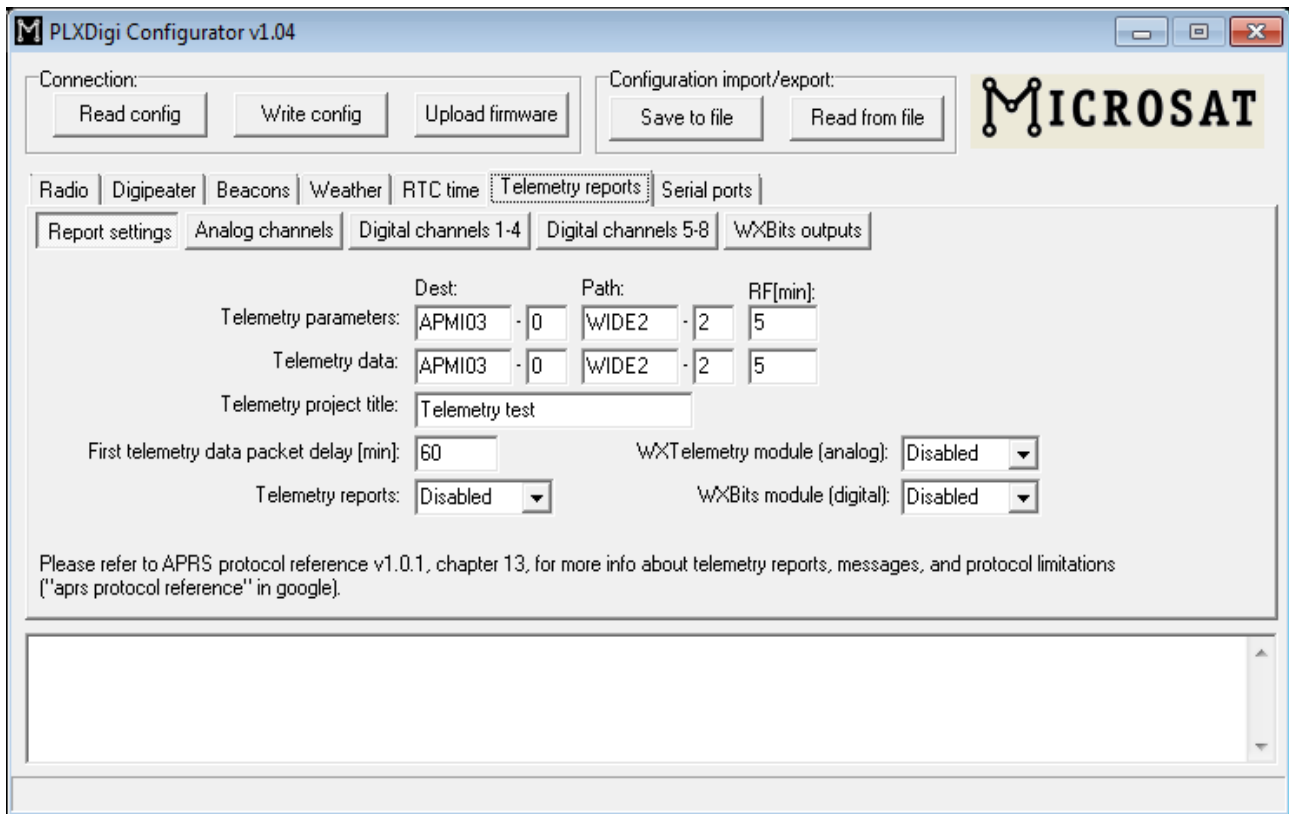
7.9. RTC time Tab



- **“Upload PC system time on config write”** - if this option is selected, application will ignore date and time fields visible below and will upload your PC system time on configuration write,
- **“Year”, “Month”, “Day”, “Hour”, “Minute”** - user-defined date and time for PLXDigi,

Internal Real Time Clock is updated when the device exits config mode and enters normal mode. To get exact time please reboot your unit to normal mode quickly after config write.

7.10. Telemetry reports Tab



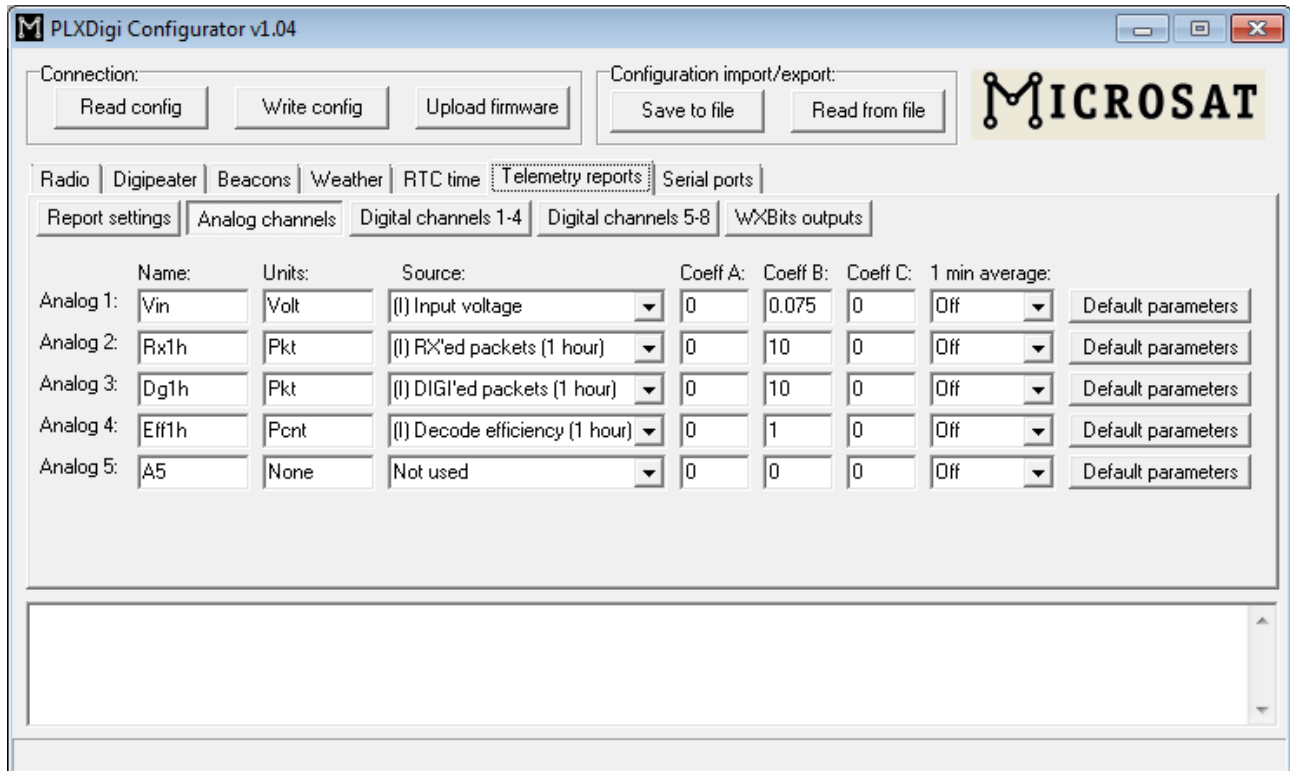
“Report settings” Tab:

- **“Telemetry parameters”** - this group of fields defines settings of PARM, UNIT, EQNS, and BITS parameter packets which describe the telemetry data sent by the device,
 - **“Dest”** - destination field of a telemetry parameters packet.
 - **“Path”** - APRS path (default value of WIDE2-2 will allow your device to be digipeated by most nearby digipeaters), if you leave this field empty, packet will be sent without path,
 - **“RF[min]“** - telemetry parameters packet transmit rate to RF (expressed in minutes), packet will not be sent if this field is set to 0,
- **“Telemetry data”** - this group of fields defines settings telemetry data reports,
 - **“Dest”** - destination field of a telemetry data packet.
 - **“Path”** - APRS path (default value of WIDE2-2 will allow your device to be digipeated by most nearby digipeaters), if you leave this field empty, packet will be sent without path,
 - **“RF[min]“** - telemetry data packet transmit rate to RF (expressed in minutes), packet will not be sent if this field is set to 0,
- **“Telemetry project title”** - this is a project name associated with the telemetry station, sent in BITS message,
- **“First telemetry data packet delay [min]”** - delay for the first telemetry data packet, it allows to gather data (especially for 10-min and 60-min report) after device power-up.
- **“Telemetry reports”** - if disabled, no telemetry description messages or telemetry data will be sent,

- “WXTelemetry module (analog)” - this box enables or disables WXTelemetry module support,
- “WXBits module (digital)” - this box enables or disables WXBits module support.

You can find more useful information about telemetry reports format in APRS specification: <http://aprs.org/doc/APRS101.PDF>, page 68.

Analog channels:



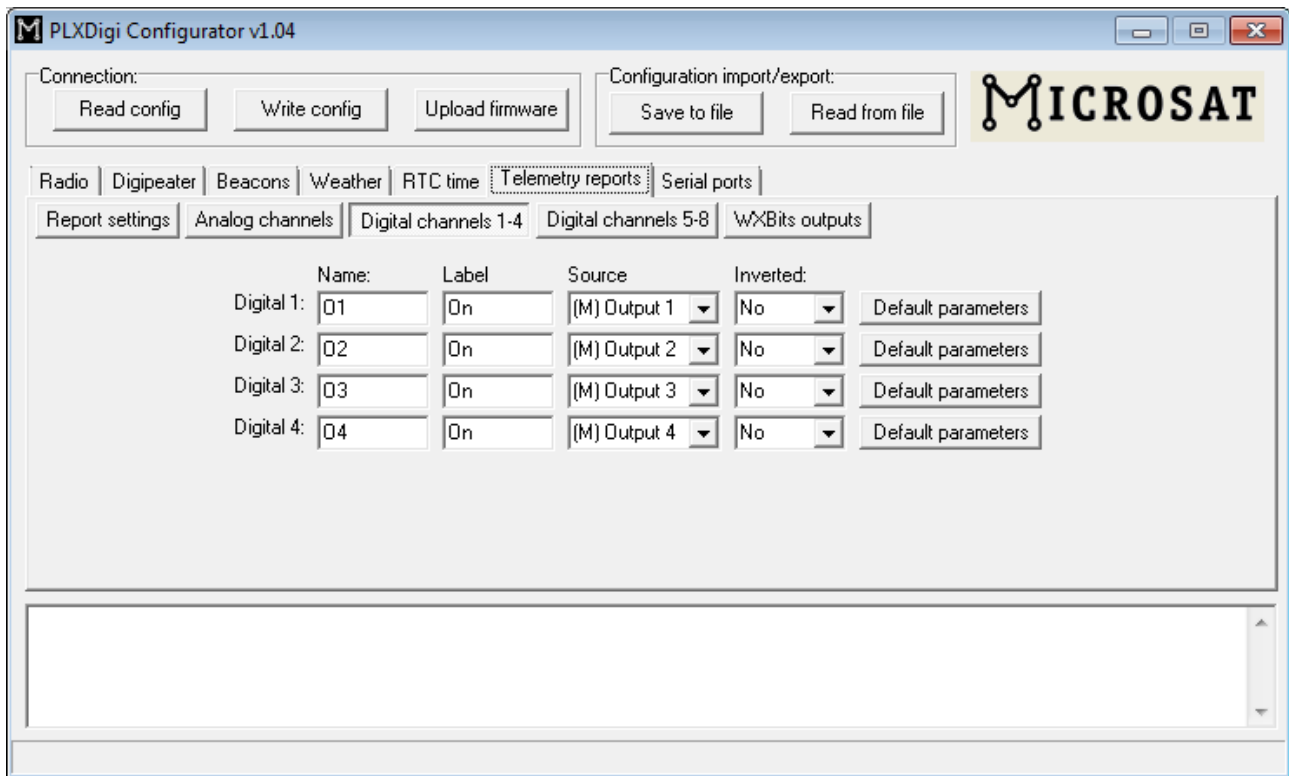
“Analog channels” Tab - defines 5 analog channels available in APRS telemetry reports. You can select many different sources for channels data, including external telemetry module data (M) and internal data (I),

- “Name” - short name for the channel, length is limited by APRS standard and is different for different channel numbers,
- “Units” - short name for units of data for the channel, length is limited by APRS standard and is different for different channel numbers,
- “Source” - most important field, specifies what data will be send for particular channel, (M) sources are associated with WXTelemetry module and (I) sources are associated with device's internal statistics and measurements,
- “Coeff A”, “Coeff B”, “Coeff C” - these coefficients tell recipients of the telemetry reports how to decode analog value in following form:

$$\text{value} = A * \text{data} * \text{data} + B * \text{data} + C,$$
- “1 min average” - only functional for external telemetry module data (M), defines if reported values are averaged or not,
- “Default parameters” - you should click this button after you change data source for the channel. It loads default coefficient values and name/units for a channel.

Important note: If you change “Source” field for a channel, you also need to change “Name”, “Units”, and “Coeffs” fields. Otherwise everyone else who receive your data (including web services like aprs.fi) will not be able do decode your reports properly. Every source has its own coefficients, names and units. With USB Configurator you can get default settings by clicking on “Default parameters” button. When changing configuration via WWW you need to set these fields manually (you can always write them down from USB Configurator application).

Digital channels:

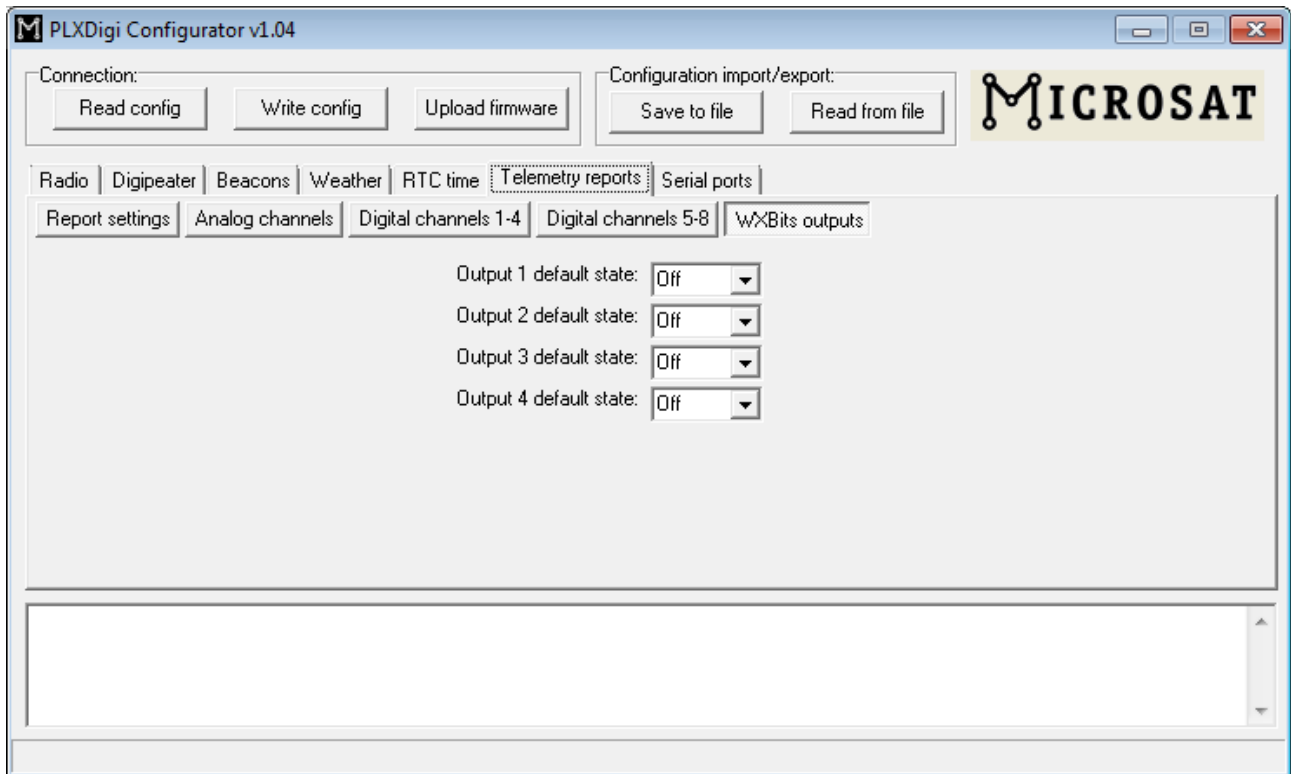


“Digital channels 1-4” and “Digital channels 5-8” Tabs - define 8 digital channels available in APRS telemetry reports. These tabs should be used when WXBits module is connected,

- “Name” - short name for the channel, length is limited by APRS standard and is different for different channel numbers,
- “Label” - short label for the channel, length is limited by APRS standard and is different for different channel numbers,
- “Source” - most important field, specifies what data will be send for particular channel, (M) sources are associated with WXBits module,
- “Inverted” - defines if channels should be reported as inverted in BITS telemetry message,
- “Default parameters” - you should click this button after you change data source for the channel. It loads default coefficient values and name/units for a channel.

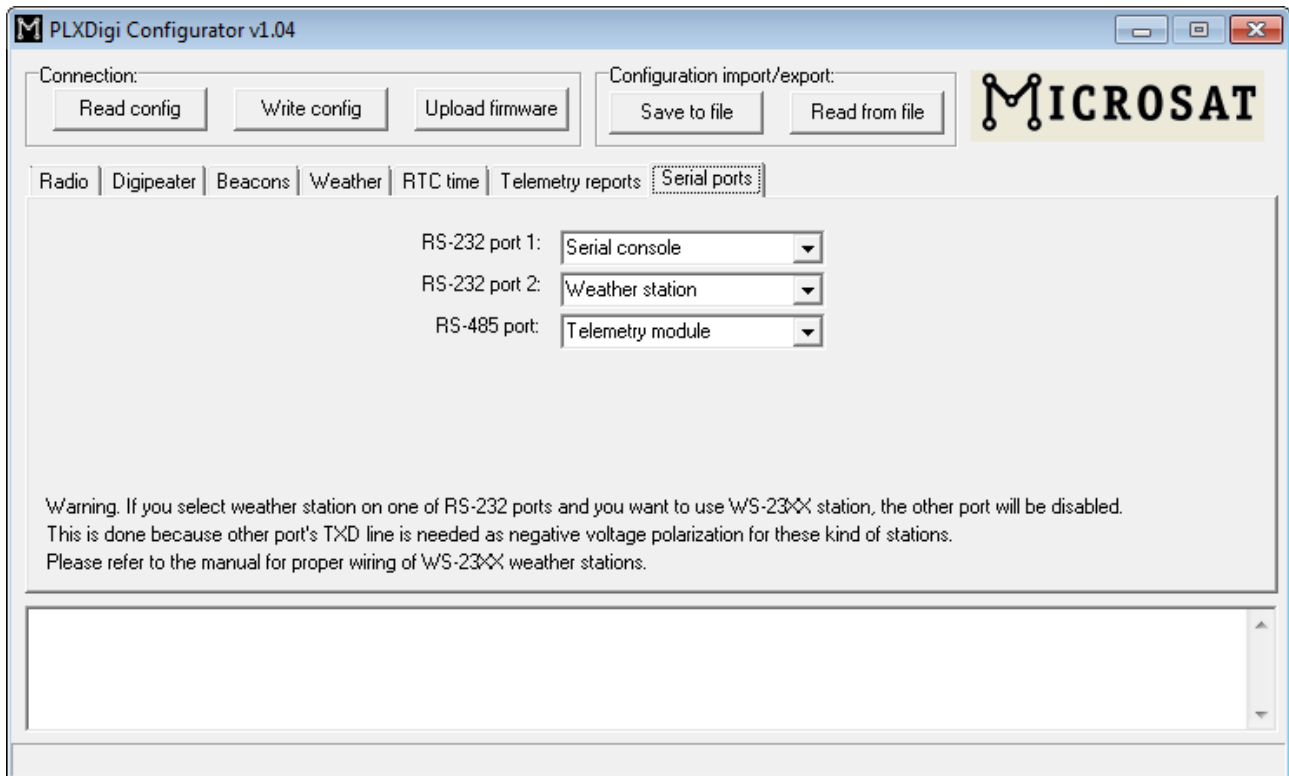
Important note: If you change “Source” field for a channel, you also need to change “Name”, “Label”, and “Inverted” fields. Otherwise everyone else who receive your data (including web services like aprs.fi) will not be able do decode your reports properly.

Wxbits outputs (default state after power-up):



“WXBits outputs” - this Tab defines what should be the default states for WXBits output channels. After power-up PLXDigi will constantly try to set outputs to the defined states, unless changed by the user.

7.11. Serial ports Tab



- “RS-232 port 1” - allows to select function of serial port 1,
- “RS-232 port 2” - allows to select function of serial port 2,
- “RS-485 port” - allows to select function of RS-485 port.

If you select weather station on one of RS-232 ports and you want to use WS-23XX station, the other port will be disabled. This done because other port's TXD line is needed as negative voltage polarization for these kind of stations. Therefore if you connect WS-23XX weather station, you lose ability to use the other RS-232 port for any other purpose.