PandwaRF Marauder

User Guide

Contents

Warning

- This guide only covers features available in the PandwaRF Marauder Basic/Standard/Ultimate versions.
- This guide does NOT cover features available in the PandwaRF Rogue Gov or PandwaRF "regular" versions.
- Please refer to *PandwaRF Rogue Gov User Guide* for description of features of the PandwaRF Rogue Gov version.
- Please refer to *PandwaRF User Guide* for description of features of the PandwaRF "regular" or PandwaRF Rogue Pro versions.

Figures

Terms used in this document

- **Capture**: 1 second of RF data captured at a given time. Usually contains one press of a key fob. Captures are saved on sectors.
- **Sector**: the memory area where one capture is stored. Marauder contains 256 or 512 sectors depending on variant.
- **Slot**: same as sector
- **Fetch captures**: the action of retrieving captures summary
- **Download (all | sector) data**: the action of retrieving (all or specific sector) captured RF data
- **Data rate**: the speed at which target device sends RF data
- **Sampling rate**: the speed at which Marauder records RF data. Must be greater than Data rate

What is the PandwaRF Marauder

PandwaRF Marauder has been developed for activities requiring a discreet capture of RF data, typically keypress of keyfobs (alarms, cars, gate openers…).

The Marauder can be set up to automatically listen and record all RF data on pre-configured frequencies. Captured data is automatically demodulated and saved internally in the product's internal memory. RF data can be replayed when needed using the dedicated Android application.

Once started, the **Marauder is entirely autonomous.**

The PandwaRF Marauder system consists of two elements: the hardware device and the Android application.

PandwaRF can be connected to Android using Bluetooth Low Energy (BLE).

The USB port on PandwaRF Marauder is only used to charge the battery and cannot be used to control the RF as in PandwaRF "regular" or PandwaRF Rogue versions.

General Overview

PandwaRF is a RF recording tool used to:

Receive

- Capture any data in ASK/OOK/MSK/2-FSK/GFSK modulation from the frequency range: 300-348 MHz, 391-464 MHz and 782-928 MHz
- Save the captured data in internal memory and then to your smartphone
- Timestamp the captured data

Transmit

- Transmit previously captured data

Analyze

- Post process the captured data to find brand, model, rolling code
- Generate new rolling codes based on a captured rolling code

Possible applications include:

- Receive keyfobs transmission (car, alarm, gate opener, …)
- Replay captured transmission from keyfobs

Warning: PandwaRF Marauder is a test equipment for RF systems. It has not been tested for compliance with the regulations governing the transmission of radio signals. You are responsible for using your PandwaRF legally.

The intentional jamming of RF signals is ILLEGAL. PandwaRF is not designed for RF jamming and should only be used for testing the robustness of your own devices.

Internals

Below is a short explanation of the internal functioning of the Marauder.

- When started, Marauder continuously scan for signal on the configured frequencies
- When signal is detected, it is over-sampled at a predefined sampling rate (10/20/30 Kbits/s)
- Received signal is saved in memory in a 1 second unit (also called a 1s sector). All data on a given frequency received during 1 second is saved into the same sector.
- One sector can contain up to 3750 data bytes.
- If received data is longer than 1s, then it is split on multiple 1s sectors.
- Each 1s sector is timestamped with the capture date and time.
- To optimize memory space and transfer time, the received data can be compressed in real-time.
- Depending on the Marauder variant, up to 512x 1s sectors can be saved
- The Marauder has an internal battery allowing for a continuous 8 hours of recording, but a USB power bank can be connected to extend the recording time.

Memory usage

The Marauder records data in sectors of 1 second. Each 1s capture consume one sector, whatever the sampling rate is. If Marauder detects a transmission of more than 1s, it will keep storing data in memory sector for as long as the transmission lasts. For example a 3s transmission will consume 3 sectors and generate 3 timestamped captures of 1s each.

The Marauder Basic has 256 sectors, and the Standard and Ultimate variants have 512 sectors.

Most key fobs transmission do not last more than 1s, so generally 1 sector is enough for storing all the information of a keyfob button press.

The sampling rate has an impact on the speed at which the sectors are consumed. The higher the data rate, the more data is generated, the faster the sectors get filled.

This means a 1s capture at 20000 bits/s will generate twice more data than a 1s capture at 10000 bits/s.

What's in the box

If you ordered a **PandwaRF Marauder**, you should have:

- 1x PandwaRF Marauder (Basic or Standard or Ultimate)
- 1x Micro USB cable
- 1x 315MHz antenna
- 1x 433MHz antenna
- 1x 868MHz antenna
- 1x protective case

PandwaRF Marauder

Antennas

Using the proper antenna is critical to have good RF performance.

 Antennas are usually labelled with the first digit of their frequency band:

Here is how to identify each antenna:

3 for **3**15 MHz, 4 for **4**33 MHz, 8 for **8**68 MHz, 9 for **9**15 MHz

Note: Non-contractual pictures. The antennas might vary in number, shape and size based on the supplier we use at the moment.

Quick Start

Here are some quick steps to get you started with PandwaRF.

1. Download the PandwaRF Marauder Android application (https://play.google.com/store/apps/details?id=com.comthings.pandwarf.marauder).

Figure 1 Application QR code

2. Connect an antenna to the PandwaRF

3. If it is the first use after unpacking the device, you need to charge and wake up PandwaRF. To wake up:

   - **Preferred method**: Plug PandwaRF onto an USB power source (the Orange & Blue lights will blink slowly to indicate charging & BLE advertising), or
   - **Alternative method**: Open the plastic enclosure and press any button (the Blue light will blink slowly to indicate BLE advertising).

3. Check that your Android phone has GPS enabled. See why in next chapter.

4. Start the PandwaRF Marauder Android app. If Android pops up a dialog to request for location and storage permission, you need to grant access. (Cf. Android Application permissions)

5. From the **Scan** tab, all the nearby PandwaRF devices will be searched automatically. PandwaRF can be used while charging.

6. Choose the PandwaRF Marauder to connect to by clicking on it. The blue LED on PandwaRF device will stop blinking and remain ON. The app screen will change to the **Bus Service** tab, showing you the device information (MAC address, battery level, RSSI level, enabled features etc.).

7. The status in **BUS Service** tab should be *Ready* and link icon should be green.

8. Navigate to the **Config** or **Captured data** pages to start having fun...

9. When you are done having fun, you can disconnect from the device using the **Disconnect** button.

You will find many more details in our wiki: https://github.com/ComThings/PandwaRF/wiki

Android Application permissions

The PandwaRF application uses 2 types of permissions:

Storage

Storage permission is used to read/write files (JavaScript, saved sessions, captured data, …) onto the device.

Location

On Android version 6.0 Bluetooth Low Energy (BLE) scanning will only work if Location services are enabled on the device. This is a requirement from Google. If you don't grant location permission to the app, the scan may not find any BLE device. We are aware that this is not a convenient situation and we are working on an alternate solution that does not require users to grant Location permission to the app.

Hardware

Opening the enclosure

PandwaRF can be easily opened as the top enclosure part is not stuck to the bottom enclosure part.

You can use a coin to open the enclosure.

Figure 2 Opening the enclosure

Using the internal buttons

On some very particular occasions, you need to press a button.

These occasions are:

- If you want to link/pair your PandwaRF to your phone and prevent any other phone to connect to it
- Manually shutdown the PandwaRF
- Reset the PandwaRF if it becomes unstable
- FW update failed and red LED remains ON
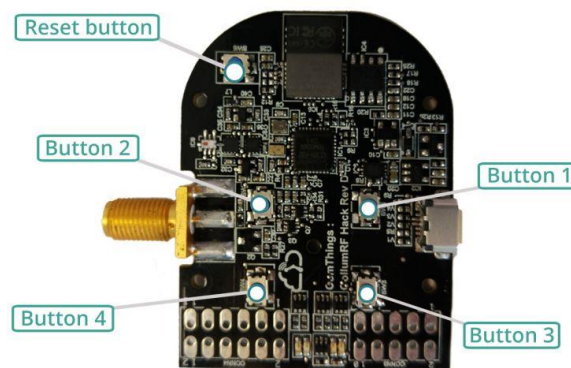
Button position

Figure 3 Button position

Button	Short press	Long press (>2s)
SW1		Shutdown PandwaRF
SW2		Whitelist bypass mode
SW3		Delete all bonding information
SW4		
SW5	Reset	

Whitelist bypass mode

Temporarily turn off usage of the whitelist until the next connection. Pressing *SW2* for 2s allows connecting to a phone which is not in the whitelist. This is valid for a single connection. To be granted access to PandwaRF permanently, this phone must then bond.

Delete all bonding information

- Pressing *SW3* for 2s or
- Pressing *SW3* and press/release *SW5* reset at the same time to clear all bonding information. This allows any phone to connect to PandwaRF.

Shutdown

Pressing *SW1* for 2s will force PandwaRF to power off until either a button is pressed again, or a USB cable is plugged-in.

Signification of the LEDs

For an explanation on the LEDs' meaning, check the LEDs Indication States page in our wiki: https://github.com/ComThings/PandwaRF/wiki/Hardware-LEDs-Indication-State

Eye	Color	Used for
Right	🟠 Orange	USB Charging status
Right	🔵 Blue	BLE state
Left	🟢 Green	RX
Left	🔴 Red	Blink: TX, On: Error

Power Management

PandwaRF Marauder low power mode

When not plugged onto USB and not connected in BLE

- If Marauder has not been configured for recording:
  - o Marauder enters low power mode
  - o Marauder only advertises to allow BLE connection
  - o In this mode the Blue LED blinks every 5s.
- If Marauder has been configured for recording:
  - o Marauder does NOT enters low power mode
  - o PandwaRF only advertises to allow BLE connection if Stealth BLE advertising has been disabled (Marauder Ultimate only)
  - o The Blue LED blinks every 5s.

When plugged onto USB

- The Orange LED blinks every 1s while charging
- The Orange LED stays on when charge is complete.

When connected in BLE

- The Blue LED stays on

PandwaRF shutdown

In case you need to shut down PandwaRF completely, there are 2 methods:

- open the enclosure and press any of the 4 buttons (not the reset button) for 2s

- when connected to your PandwaRF, go to **Bus Service** page and click on **Power Off**

PandwaRF will shut down completely and will stop advertising.

Pressing any of the 5 buttons or providing USB power will wake up the PandwaRF.

Warning: in this mode, your smartphone will not be able to discover or connect to your PandwaRF.

Battery charging

PandwaRF has an integrated Battery Gas Gauge, allowing to precisely measure the remaining battery capacity. For the measurement to be precise, PandwaRF needs to be fully charged at least once. It will then initialize its coulomb counter to 100%. Once unplugged from the power source, it will start monitoring its own consumption.

- When charging, PandwaRF's Orange LED blinks once per second.
- When fully charged, PandwaRF's Orange LED remains ON.

Typical operation flow

1. Configure frequency and other RF parameters to capture
2. Start Marauder
   - Disconnect Bluetooth between app and Marauder
   - **Marauder starts recording**
3. Place Marauder near target
   - Battery duration up to 8h with internal battery
   - Use USB power bank if longer capture time needed
4. Come back later to retrieve captured data
5. Analyze captured data
   - Fetch captures to have a short summary of what was captured
   - Locate a sector containing an interesting capture and expand this sector
   - Replay capture and check if replay has performed the expected action (gate opened, alarm de-activated, ...)
     - In case of success, **Download** sector data to transfer sector captured data to phone
     - If not, try another sector

Using the Android application

Scanning and connecting

1. In the **Scan** page, press the **Scan** button
2. The app will search for all PandwaRF in range. Use the MAC address to tell the difference between several PandwaRF devices.
3. The received signal level (RSSI) is displayed, in dBm negative value (the higher the RSSI, the closer the device is)
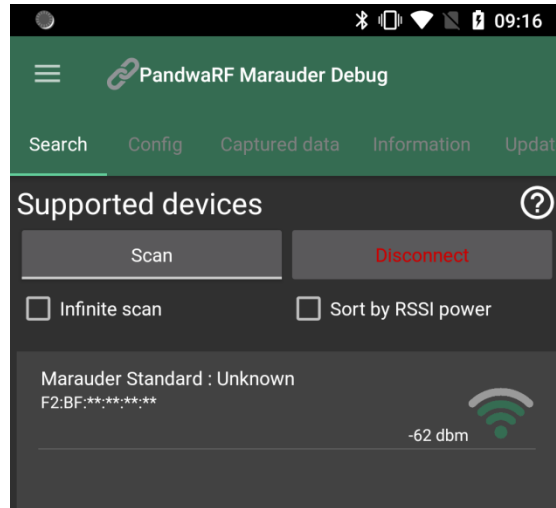

Figure 4 Scanning

4. Click on the device to connect
5. Status will change to *Connected*, then *Ready*
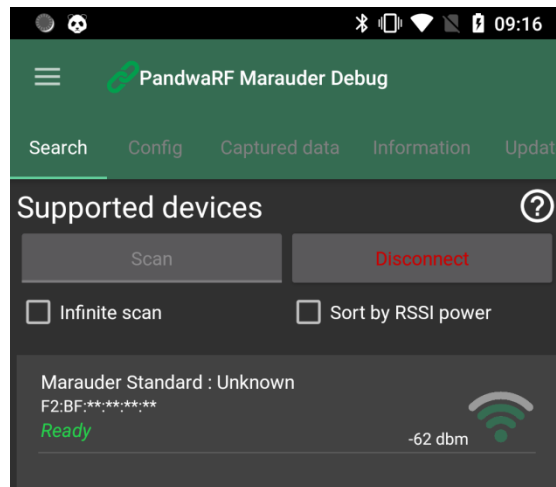6. Device cannot operate until status is *Ready*

Figure 5 Connected

7. Once device is *Ready*, the **BUS Service** page is displayed. It gives you information about your PandwaRF model, FW versions, battery level etc.

Configure the capture

Frequency/band

Configure the frequency of the target (keyfob, …) to capture

o Always try to know the center frequency onto which the keyfob is transmitting (!).
o Setting the correct frequency has an impact on RX data quality (of course). The more you know the exact frequency, the more you get a chance to capture the keyfob signal.
o For example 433 MHz is not precise information, you need to know if it is 433.42 MHz, 433.92 MHz, etc...

Note on frequency support per variant:

o The Marauder Basic only supports scanning/recording on a single frequency.
o The Marauder Standard supports scanning/recording on 2 frequencies.
o The Marauder Ultimate:
   • supports scanning/recording on 2 frequencies
   • can also be configured to scan a frequency band of 500 KHz bandwidth instead of a single frequency.

Note: when configured to scan 2 frequencies or a band, the Marauder Standard/Ultimate alternatively scans (very fast) the different frequencies. If it detects a signal then Marauder starts recording. So there is a small chance to miss the capture if the data is being transmitted while Marauder is busy scanning another frequency.

Note: You can measure the exact frequency by using the Spectrum analyzer available in the PandwaRF, PandwaRF Rogue Pro, or PandwaRF Rogue Gov.

Setting the frequency can be done using a predefined setting or entering custom value.

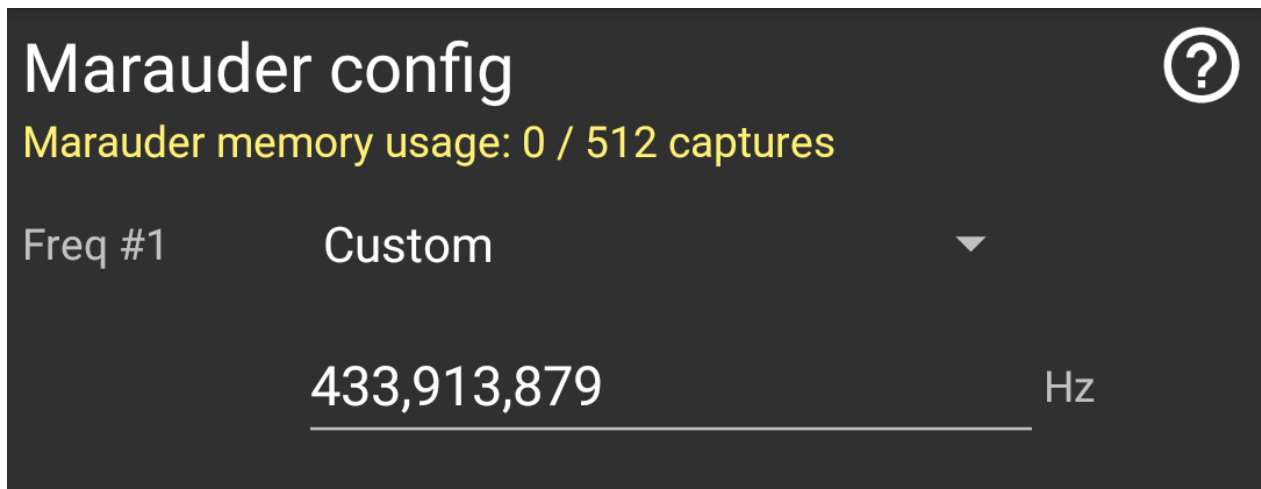o You can set a custom frequency value in Hz: the range is [300000000, 928000000] Hz:

Figure 6 Setting a custom frequency

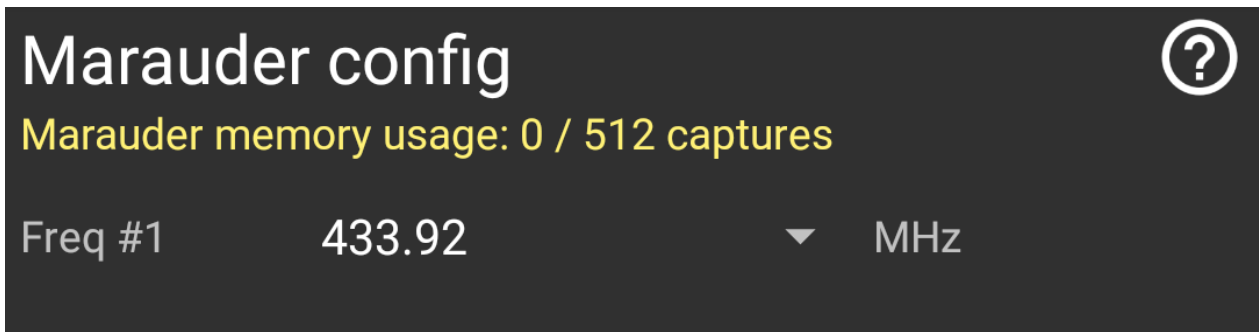o You can choose one the predefined frequencies (433.92, 868.8, etc...):

Marauder config

Marauder memory usage: 0 / 512 captures

| Freq #1 | 433.92 | ▼ | MHz |

Figure 7 Setting a predefined frequency

o You can choose one the predefined frequencies (433.92, 868.8, etc...):

| Freq #2 | N/A | ▼ |

Figure 8 Setting frequency 2 as not used (N/A)

Modulation

You also need to know what the used modulation is. Keyfobs are mostly OOK, but we have also seen PSK or 2-FSK for some keyfobs. 2-FSK, GFSK, MSK, ASK, and OOK modulation formats are supported.

Deviation

When FSK/GFSK modulation is used the DEVIATN register specifies the expected frequency deviation of incoming signal in RX and should be the same as the TX deviation for demodulation to be performed reliably and robustly.

Sampling rate

When recording a signal, the Marauder samples the input data at the specified sampling rate. The higher the sampling rate, the more precise the captured data is, but the bigger the memory space used. We recommend using the default value of 30.000 bits/s.

RX compression

If the sampling rate is much higher than data rate of incoming signal, the captured data will contain redundant information and more data bits than required. This additional bits will fill the 1s slot faster than when sampling rate and data rate are the same. Using RX compression can reduce the amount of data to be saved in the 1s slot.

PandwaRF Marauder can compress the data in real-time before saving it to memory. This allows for more data to be stored in a 1-second capture sector. But the compression is only effective if the sampling rate is very high versus the data rate of the keyfob.

RX compression can be enabled without problem, because this condition is almost always satisfied:

o Typical keyfobs transmit at a data rate between 2000 bits/s to 5000 bits/s
o default sampling rate is 30.000 bits/s

However to capture data transmitted at a higher data rate (eg. 15000 bits/s), RX compression needs to be disabled.

If you enable RX compression while sampling at the same rate as transmission data rate, PandwaRF will generate more data than without RX frame compression. Recommendation is to enable RX frame compression when sampling more than 10x times faster **than data rate of incoming transmission**.

RF power amplifiers

PandwaRF Marauder contains internal RX and TX RF amplifiers.

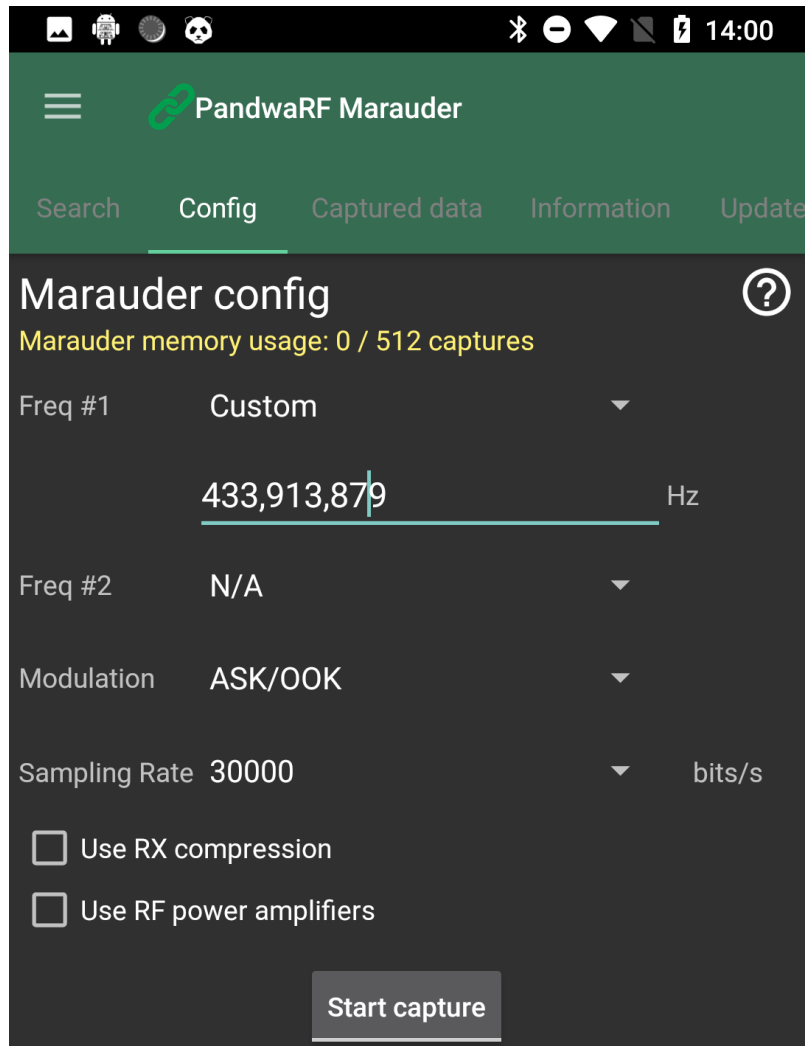Depending on the distance to the target, amplifiers need to be enabled.

Figure 9 Configuration page

Stealth BLE advertising (Ultimate)

To be even more discreet, Marauder Ultimate includes the possibility to de-activate the Bluetooth Low Energy advertising. This makes the Marauder Ultimate completely invisible to a Bluetooth scan from a smartphone.

In this mode, the Marauder Ultimate operates with Bluetooth Low Energy advertising is de-activated. So you will not be able to reconnect with the app unless BLE Advertising Stealth mode is disabled.

Once activated, disabling BLE Advertising Stealth mode can only be disabled with a physical access to the Marauder.

To disable BLE Advertising Stealth mode:

- open the Marauder enclosure
- press any button
- open the Android application and re-scan.

More information can be found here: https://github.com/ComThings/PandwaRF/wiki/Android-Marauder-Fragment-Config

Start Marauder

- Once all parameters have been set up, press the **Start capture** button
    o The Marauder starts scanning/recording RF data and the green LED blinks slowly (every 2s)
- You can now disconnect Marauder from the App by:
    o Pressing **Disconnect** button in the Search page, or
    o Sending the app in background
- The blue LED will switch from continuously on to blinking approx. every 5s
- <u>Note:</u> once disconnected, the Marauder will restart BLE advertising, making it visible to a Bluetooth scan. To disable BLE advertising (Marauder Ultimate only), cf. **Configure the capture**
- The Marauder will start scanning and capturing any incoming transmission

Marauder scan & capture

When in capture mode, the Marauder doesn't need any phone connection to record data.

If Marauder is powered off and on again, it will resume to its previous state and restart data recording.

Marauder will continue scanning & recording until battery is empty or memory is full.

Summary of captures

To retrieve captured data from Marauder:

- Reconnect to Marauder (cf. Scanning and connecting)
- Switch to the **Captured data** page
- Press **Fetch captures** button to start downloading a short summary of Marauder memory content. A pop-up dialog will be displayed indicating how many captures need to be download from Marauder to app
    o Press **Restart** to download all sectors from 0 to the last used sector
    o Press **Resume** to download only new sectors
    o If a fetch was made previously and there are already some sectors displayed in the app, the **Resume** button will be enabled to allow user to not re-download all data from zero.
- The app will start retrieving information about each capture. The captured data is not yet downloaded at this step.
- This will not download the full Marauder memory, which can be quite long (from few seconds to few minutes), but will only display the following information:

- o   number of sector used
- o   data and time of capture
- o   number of bytes used for each capture (one sector equals one capture)

Note: If you want to automatically fetch memory status upon BLE connection, enable the *Auto fetch* option from *Settings* menu.
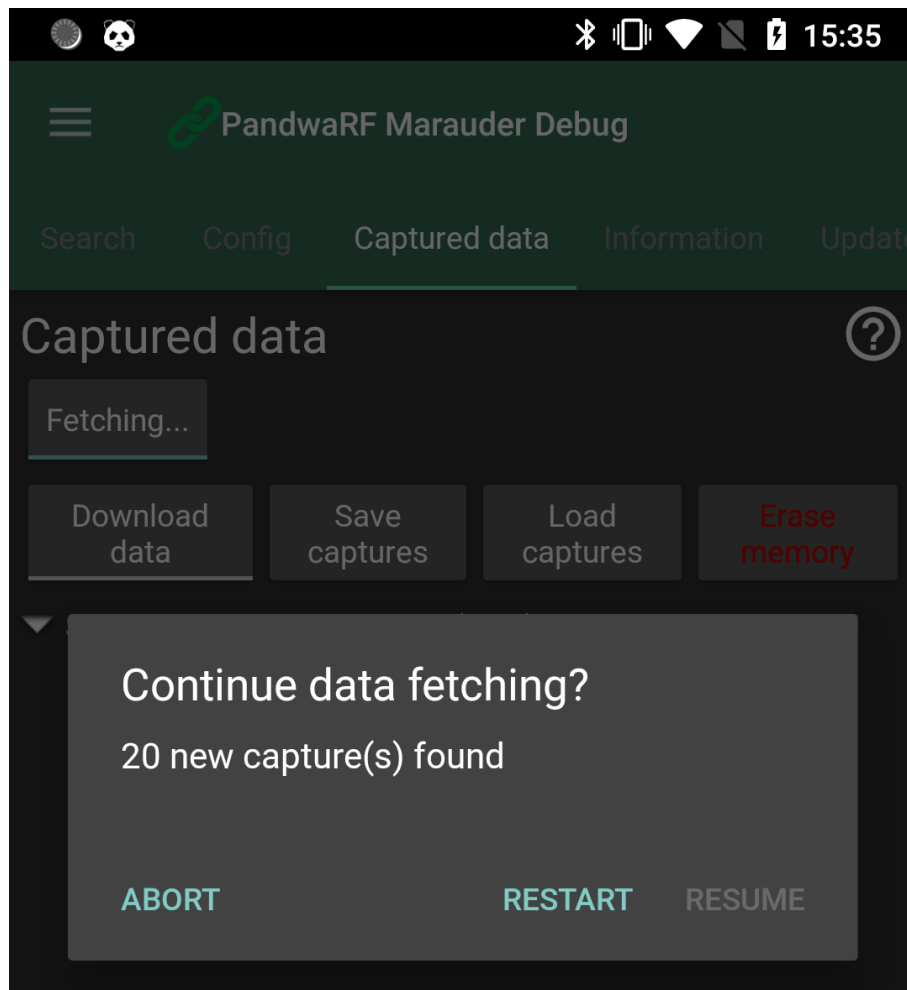

Figure 10 Fetching a summary of captures

Press **Restart** to start fetching data from sector 0. If a fetch was made previously and there are already some sectors displayed in the app, the **Resume** button will be enabled to allow user to not re-download all data from zero.

Note: you can always choose to restart the full download from 0 without losing any data, the transfer will only be a few seconds longer.
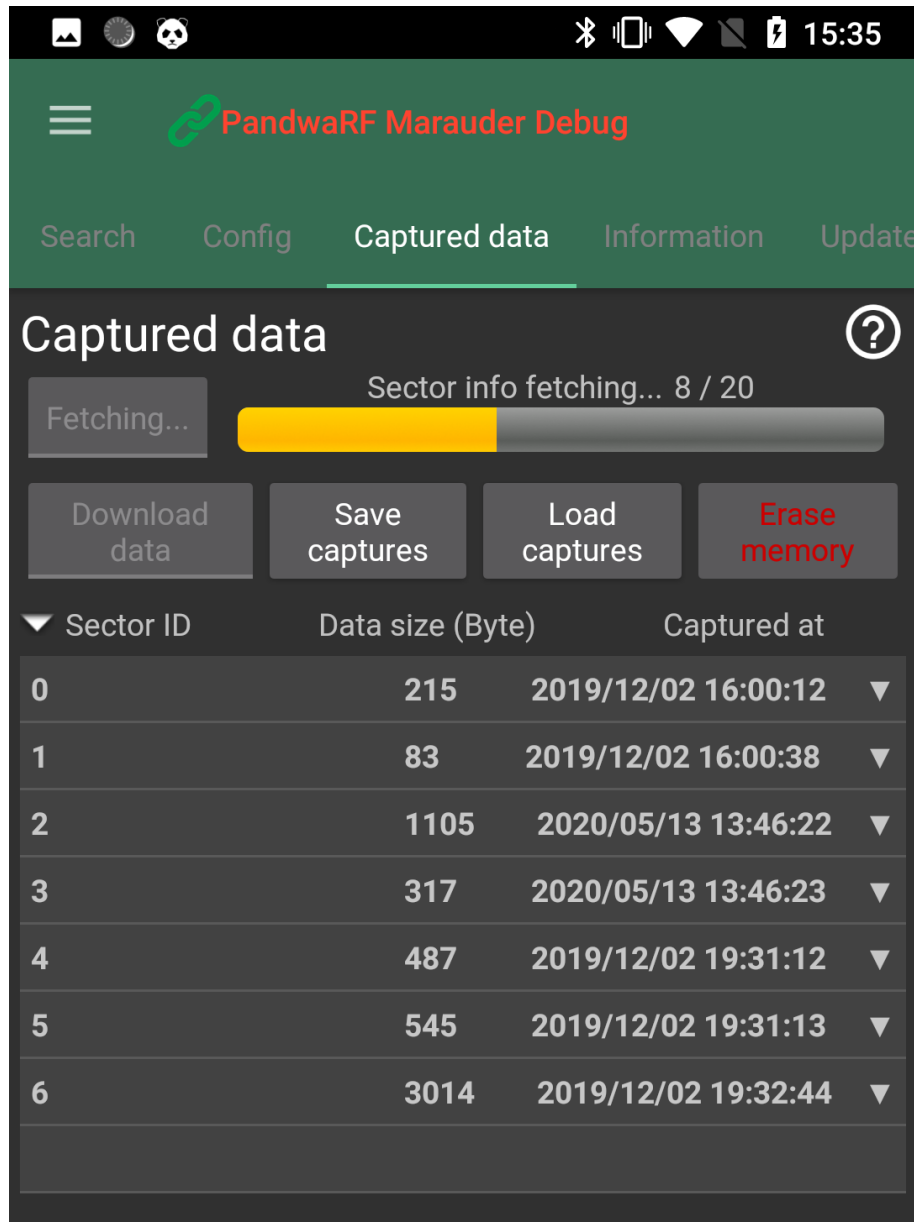
According to your phone model (all models have different BLE performances) and number of sector used, fetching a memory summary from Marauder shall not last more than 60s.

In the example above, we have fetched the summary of 20 sectors in about 5s (Nexus 5X, Android 8.1.0).

More information can be found here: https://github.com/ComThings/PandwaRF/wiki/Android-Marauder-Fragment-Captured-Data

Analyzing the captured data

Once the information about each capture has been downloaded to the app, user needs to analyze and filter the captured data.

You can scroll through all captured sectors to find the one of interest to you.

Note: at this step, the sector data has not yet been downloaded yet.

There are 2 options to retrieve sector data:

- The easiest way is to download all sectors data at once by pressing **Download data** button. This may takes a few minutes depending on sector usage and BLE connection.

- The other way is to expand each sector and only download the data of the sector you want. For this:

  - Expand sector with the ▼

  - Press **Download**

Sector content

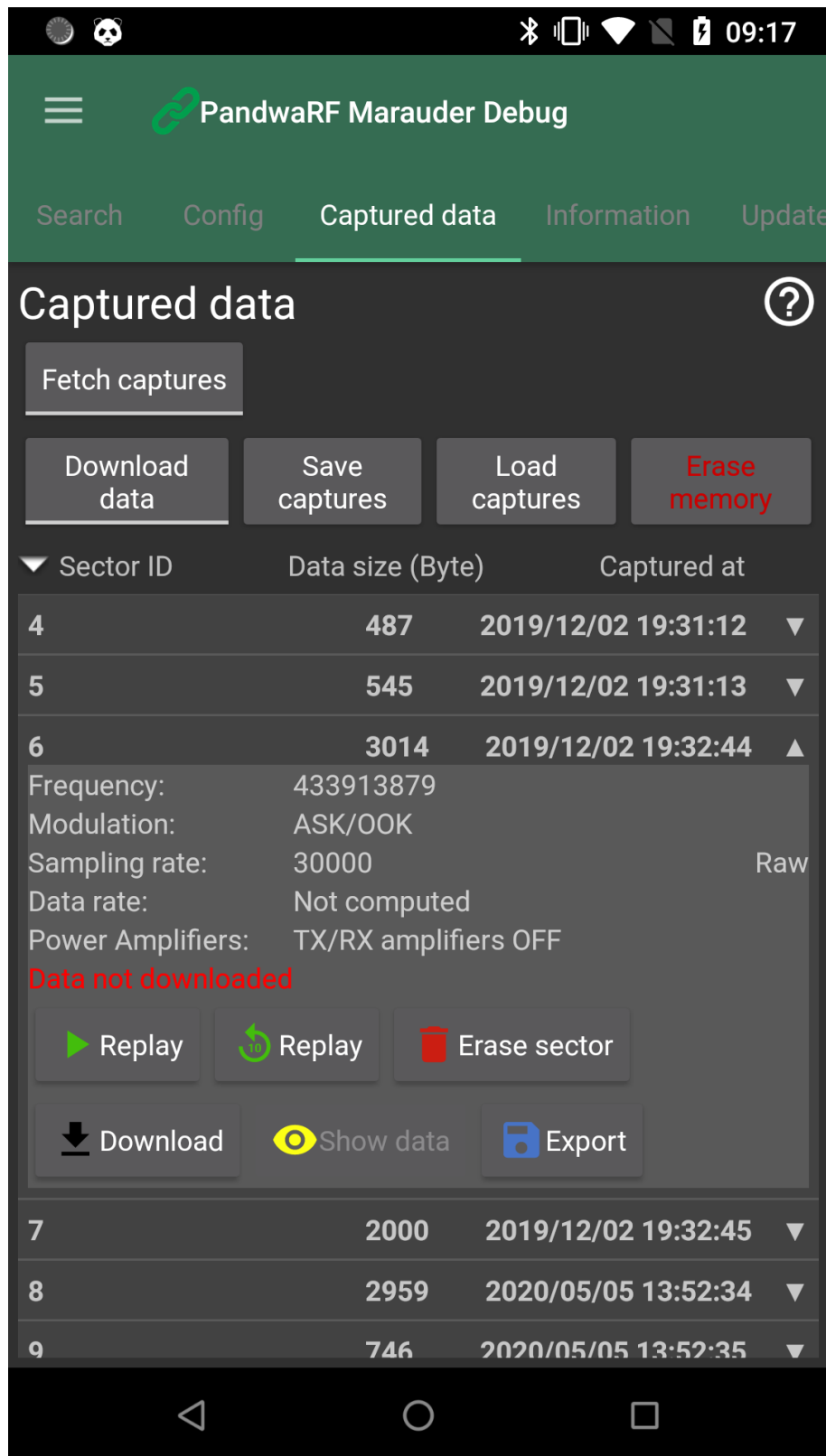To display more details about a specific sector, just expand the sector with the ▼.

Figure 12 Sector content

Detailed sector information contains:

- Capture frequency, in Hz

- Modulation: (OOK/FSK, ...)

- Sampling rate used to capture the data

- Data compression mode:

    o Raw: data was captured and stored uncompressed

    o Compressed: data was captured and stored compressed

- Data rate: data rate is computed automatically once data is downloaded (Cf. Download single sector data)

- Power amplifier usage

- Sector data download status: Downloaded/Not downloaded

A set of actions to perform on this sector data is now available:

- **Replay once** : Send captured sector data once (as captured)

- **Replay 10x**: Send the same sector data 10 times, in case capture was too short

- **Erase sector**: Erase a sector from Marauder memory. Cf. Erase sector data

- **Download**: Transfer sector data from Marauder to app

- **Show Data**: Display captured data in JSON format. Requires **Download** first.

- **Export data**: Save sector data to disk in JSON format. JSON file is saved in `/sdcard/Documents/Gollum/Marauder/Captures`

When testing sector data, it is recommended to replay once and check if there is any reaction of the target system. If replaying the data once didn't work, try **Replay 10x**.

Download single sector data

Once you have found a sector of interest and replayed the data successfully, you can download the complete sector data from Marauder to the app by pressing the **Download** button.
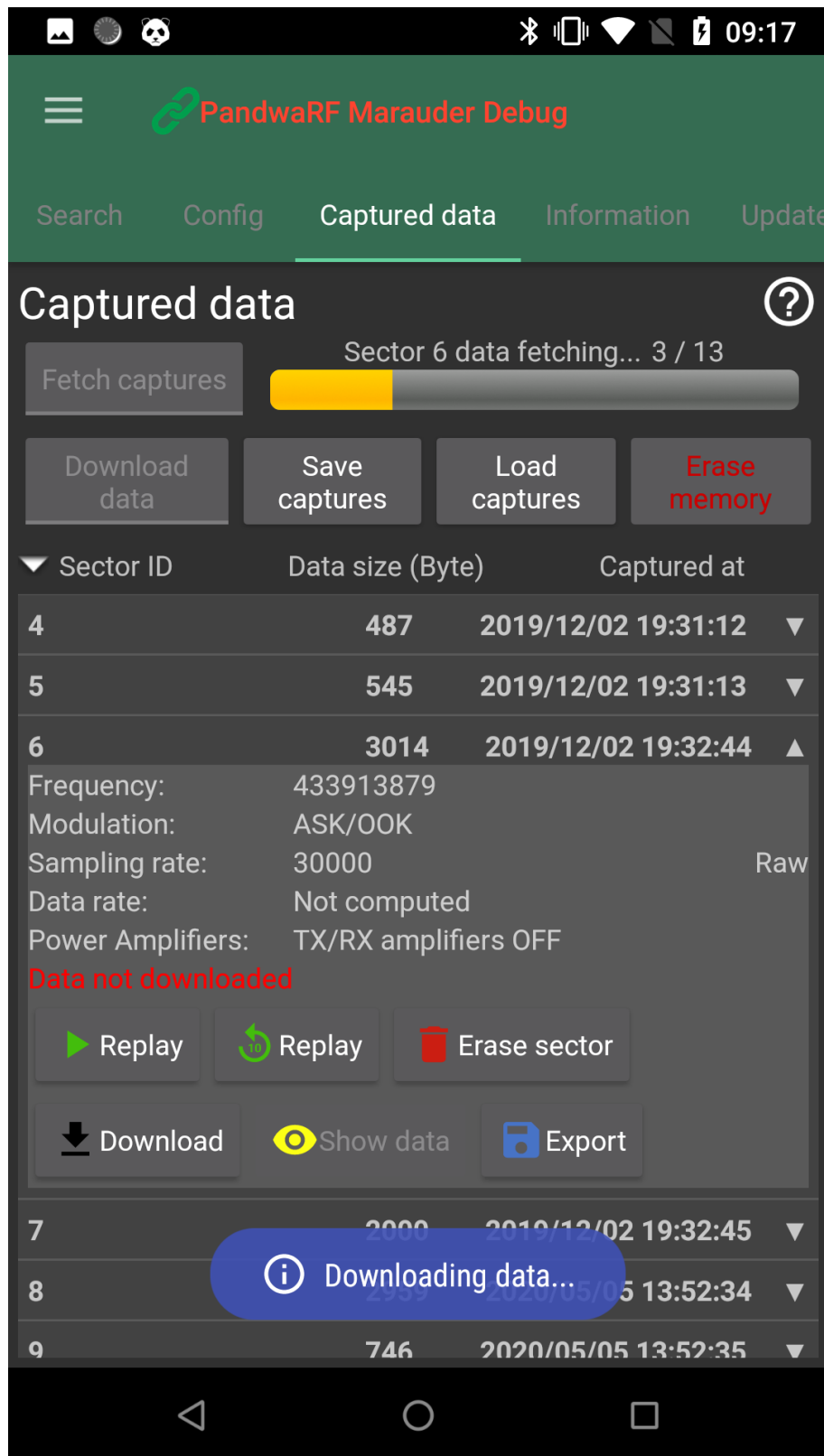
Figure 13 Downloading single sector data

Once sector data has been downloaded:

- the **Show data** button is enabled and you can display the captured data in JSON format.

- the download icon is displayed in the sector status bar to remind the user this sector data has already been downloaded.

Note: the sector data has not yet been saved to a file. Press **Export** to save data for this specific sector to a JSON file.

Note: you can also save data from all sectors at the same time by pressing **Save captures** button at the top of the screen.
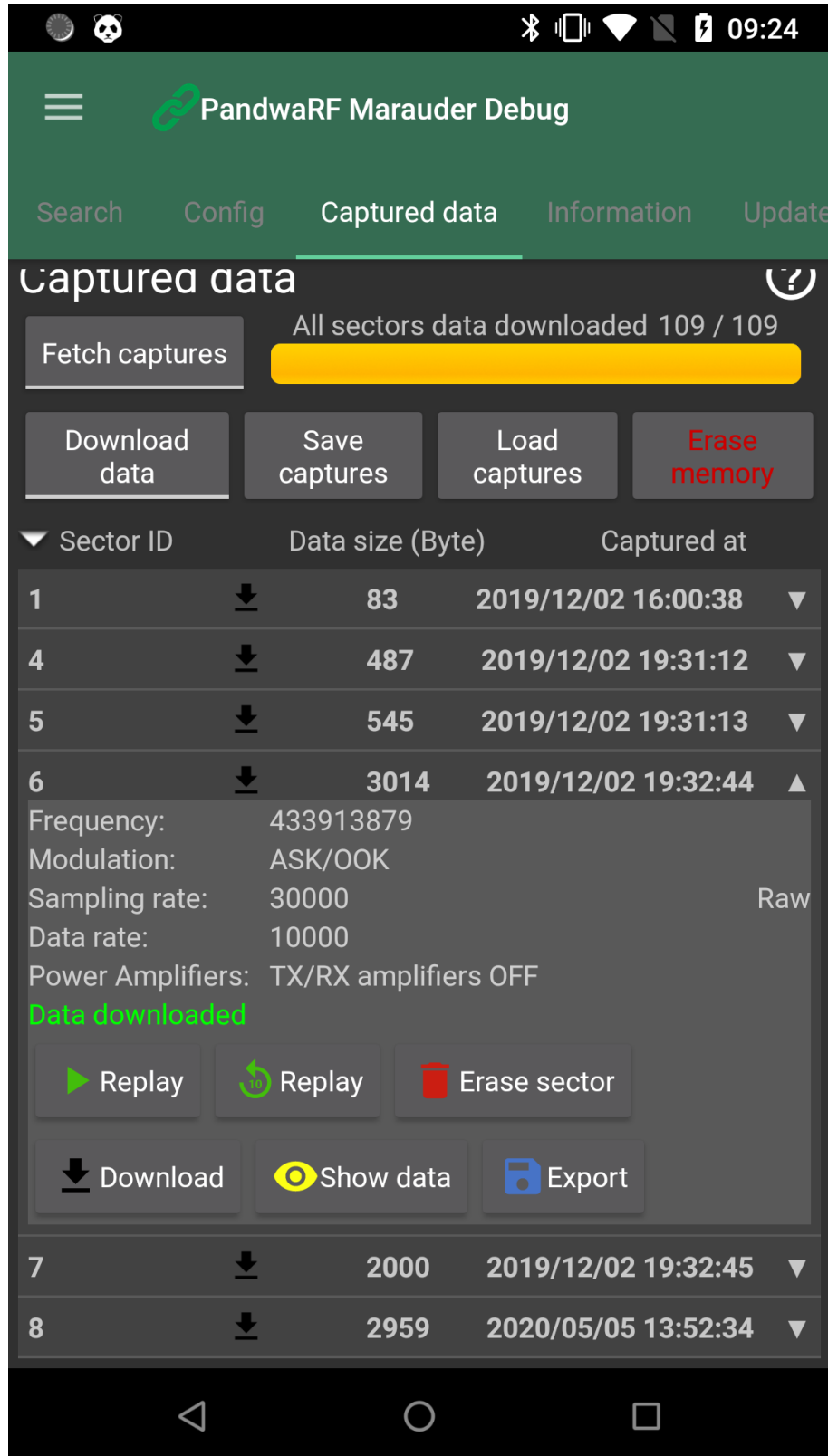

Figure 14 Sector data downloaded

Download all sectors data

At any time you can choose to save information from all sectors at the same time by pressing **Save captures** button at the top of the screen. This will allow you to make a quick backup into a JSON file
in `/sdcard/Documents/Gollum/Marauder/Captures`.
Note: the JSON file will only contain what is known from the app at the moment of the capture. If data has not been downloaded from a sector, this data is not saved into the JSON.

Note: Saving to JSON doesn't erase the data on the Marauder.

Show sector data

Once a sector data has been downloaded (either globally with **Download data** or individually with **Download**), the **Show data** button is enabled and you can view the resulting JSON file in a text viewer.
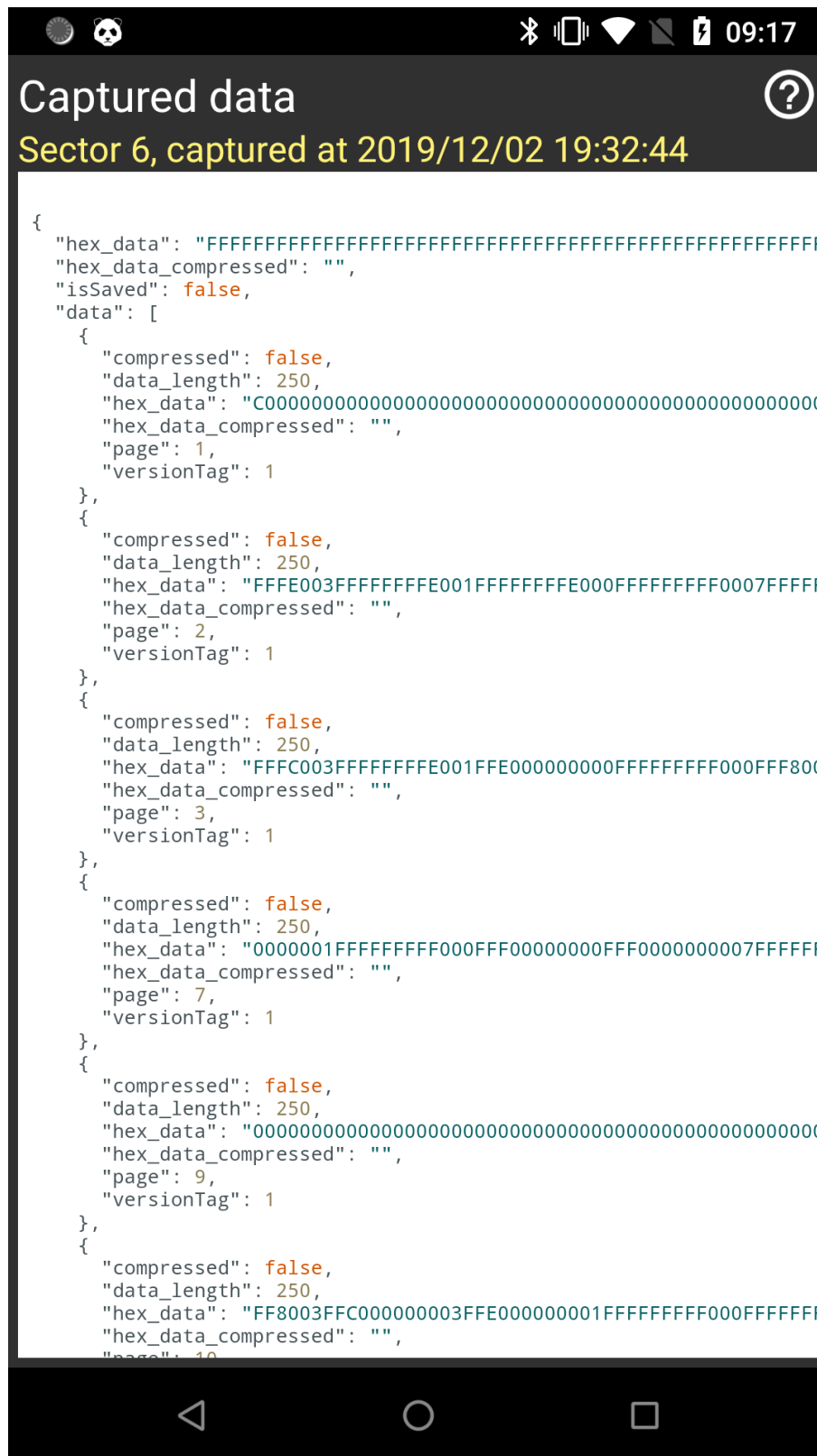
Figure 15 Viewing the captured data in JSON

Once a data has been viewed once, the icon is displayed in the sector status bar to remind the user this sector data has already been viewed. This is to ease sector triage and classification.

Cf. Triage and classification

Erase sector data

After sector analysis, user can decide to remove a sector which contains useless data.

Usually, sectors with few data (less than 50 bytes) are garbage from previous transmissions or false detection that can be removed.
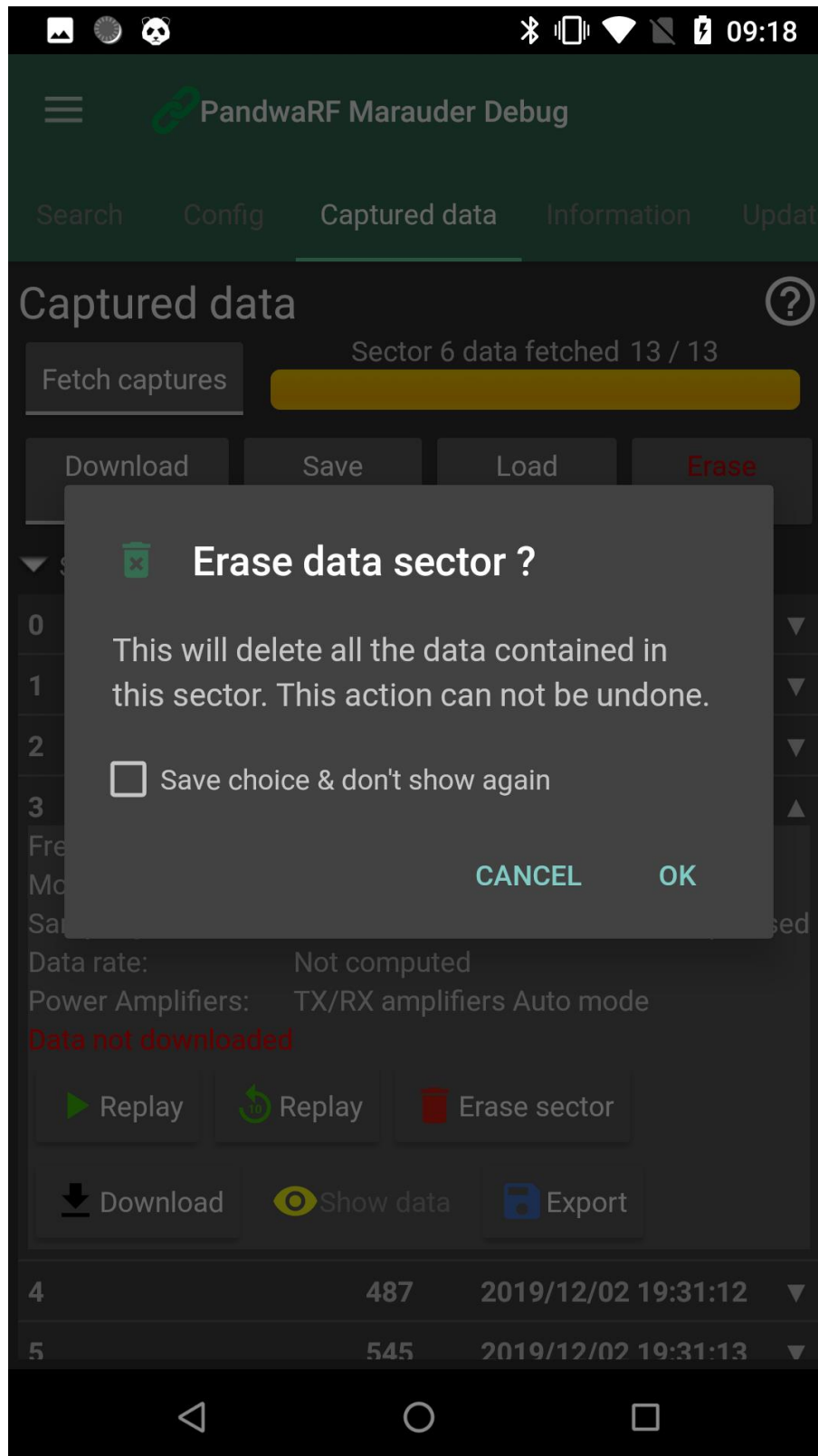

Figure 16 Erasing a sector

Removing a sector make it available for storing data in a subsequent capture.

Note: you have the option to hide empty sectors from the **Settings** menu. Uncheck *Show empty sectors* if you want to hide empty sectors.
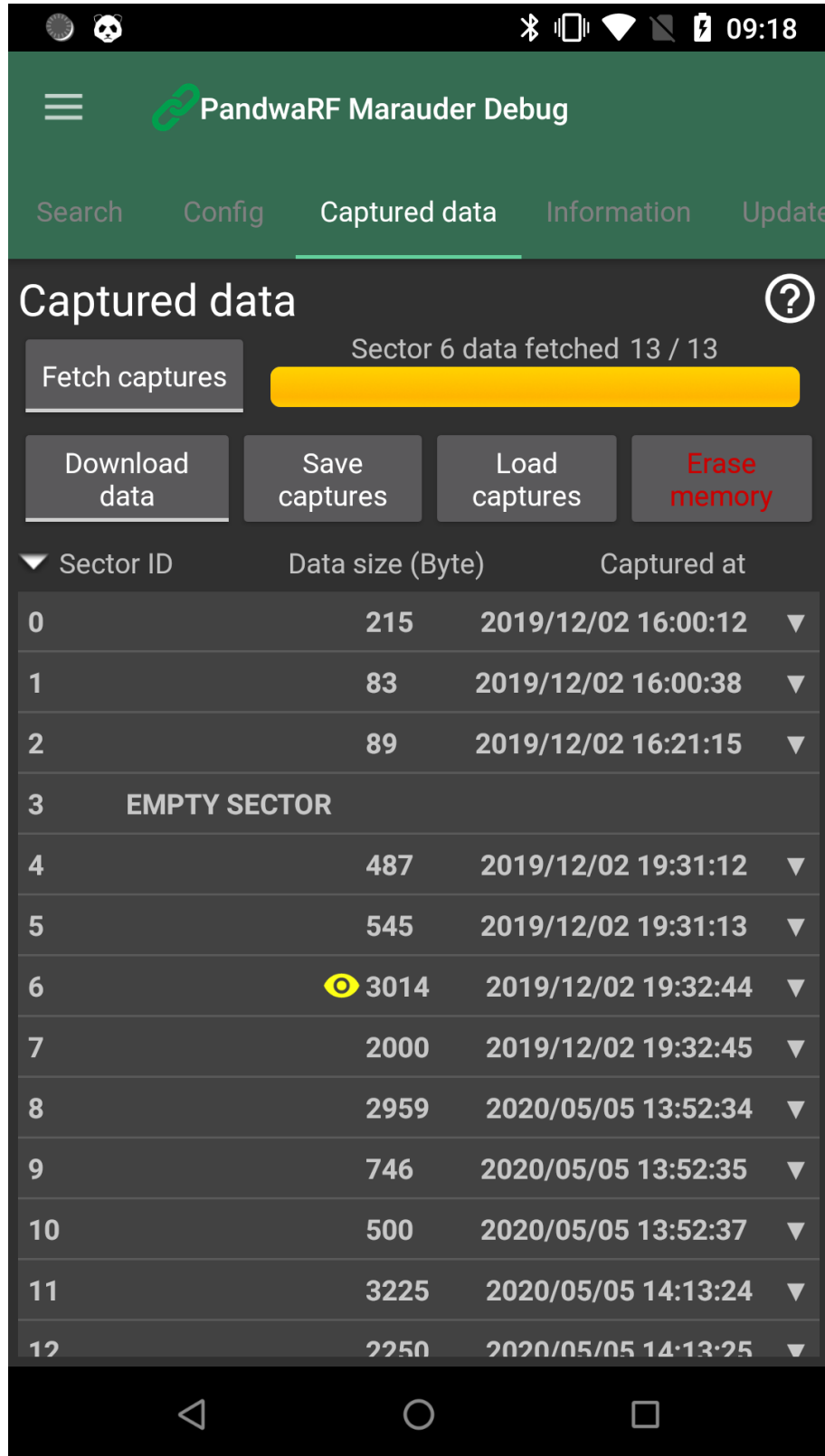
Triage and classification

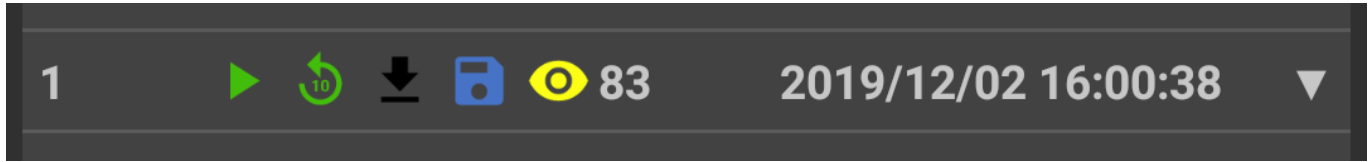Each time you perform an action on a sector for the first time, an icon is displayed in the sector status bar

- Capture has been played at least once

- Capture has been played in 10x repeat mode at least once

- Capture data has been downloaded to phone

- Capture data has been saved to file

- Capture JSON data has been viewed at least once

Settings

You can control some default behavior of the application.

Marauder

Auto fetch

- Automatically fetch data from Marauder at each connection
- Keep sectors with errors

Auto sector reset on BLE errors

Automatically reset sector on reception error

Show empty sectors

- Show all sectors, including empty sectors
- Only show sectors that contain valid data

Bluetooth Connectivity

Auto scan devices when app starts

- Automatic BLE scan when application is launched or resumed.
- Do not start automatic BLE scan when application is launched or resumed. Manual scan only.

Device scan

This setting is used to switch to alternative scanning mode.

- Use BLE scan. Requires GPS location enabled. This is default scanning mode required by Android.
- Use BT scan (Classic Bluetooth scan). Does not require GPS location enabled. This scan will consume more battery than the BLE scan.

Only available on Marauder Ultimate.

Auto reconnect when app starts

Automatically reconnect to the last successfully connected PandwaRF when the application is launched.

Auto reconnect when app resumes

Automatically reconnect to the last successfully connected PandwaRF when the application is resumed from background and becomes visible.

Auto reconnect on BLE error

Automatically attempt a BLE reconnection to the last successfully connected PandwaRF when there is an unexpected BLE disconnection (GATT error, reset, tsunami...)

Auto bonding

Automatically bond PandwaRF upon connection.

Network Connectivity

Error reporting

Report PandwaRF Nordic FW errors. No personal data is sent.

Note: you cannot change this setting.

Radio settings

FSK Deviation

Display all supported values of FSK deviation, or only display commonly used values.

Features

Developer Mode

- Only the basic features: Scan/Configure/Captured data/FW update…
- Enable experimental and dangerous features: BLE throughput measurement, CC1111 RF registers access, BLE errors, Self-test, BUS service, BLE Parameters, Log.

Display

Tab names in view pager

- Do not display page name in the tab located on top of the screen. Saves space on small screens.
- Display page name in the tab located on top of the screen. This is redundant with menu drawer, so uncheck this option if you have a small screen.

Display tab names in alternate view pager (Tablet only)

- Do not display page name in the tab located on top right of the screen. Saves space on small screens.
- Display page name in the tab located on top right of the screen. Uncheck this option if you have a small screen.

Force split mode

- One page fits the entire screen.
- Split UI in 2 parts: left page with Core features, right page with settings. Uncheck this option if you have a small screen. Changes will take effect only after restarting the app.

Changes will take effect only after restarting the app.

Tip of the Day

- Do not show Tips on Startup.
- Show Tips on Startup.

MAC address hiding

- Display all MAC addresses completely.
- Hide lower bytes of all MAC addresses displayed in the app (for privacy).

Tweaking

BLE TX enqueue mode

- Normal mode: Enqueue all TX packets into a FIFO queue. Faster, but can freeze sometimes.
- Fallback mode: Send one BLE packet at a time, waiting for the previous packet to be sent before queuing the new one. Safer but slower. Use this mode if you experience issues with the BLE connection.

Changes will be effective at the next connection.

Periodic RSSI measurement of the connected PandwaRF

- RSSI is measured every 1s. Can cause disconnect issues on some phones (Samsung Galaxy S5, …)
- RSSI is not measured when PandwaRF is connected.

Reset

Clear user input history

Clear all user input data. Eg. frequency, data rate.

Reset settings

This will reset the application settings to default values. All preferences regarding showing or hiding pop-up dialogs are cleared, and all pop-up dialogs will now be displayed until user's choice.

More Information

1. PandwaRF website (https://pandwarf.com/)
2. Wiki (https://github.com/ComThings/PandwaRF/wiki)
3. Chat (https://gitter.im/ComThings/Lobby)
4. Forum (http://pandwarf.boards.net/)
5. Demo videos (https://www.youtube.com/c/comthings/)

Note: You can find the solution to the most common issues in our wiki. Make sure to also check the PandwaRF forum and our Gitter chat room. If you still have the issue after doing so, please report it using our tracking system (https://github.com/ComThings/PandwaRF/issues)**.**

Still have questions? Feel free to contact us at pandwarf@comthings.com.

Happy hacking! :)

Document Revision History

Revision	Date	Status and Description
0.1	2020-09-10	Initial version.
0.2	2020-09-11	Add Stealth BLE advertising