PanCAT User Manual

Open Source Panadapter and CAT Control Web App for GuoheTec Q900 and PMR-171
Version 1.15 • Dafydd Gibbon, DJ0MZ • 22 January 2026

Official documentation based on the PanCAT v1.15 source code from dj0mz.darc.de.
Verify settings. Ensure the radio is connected to a dummy load or tuned antenna.

1. Preface

This document was generated by ChatGPT5.2 using three-shot prompts – (1) specification, (2) confirmation, (3) PanCAT HTML+CSS+JS code) and minimally post-edited.

This web app is experimental and still being tested and debugged. Bug reports (e.g. sensitivity to RFI during transmission, spectrum freezing, Bluetooth disconnect, CAT buttons freezing, ...) are welcome.

Initial prompt: specification

Please examine the following HTML, CSS and JS code carefully. It implements a web app called "PanCAT", by radio amateur Dafydd, DJ0MZ. The web app provides a panadapter and CAT operations for the GuoheTec radios Q900 and PMR-171. You are responsible for user-friendly documentation. I will present different document specifications, one after the other, in different prompts
Please describle the functionality, structure and operation of the PanCAT web app in a user-friendly way as a user manual, as a DOCX document using standard format styles, starting with "Title" for the title, and for the section headers "Heading 1", "Heading 2", etc. The document structure should be as follows:

1. Title page.
2. Table of Contents.
3. Introduction
   - brief description of the radios and what a panadapter and CAT control are; reasons for providing an external panadapter; reasons for choosing a client-based web app as opposed to a server-based application.
   - limitations of web apps, e.g. Chromium-based browser (Chromium, Chrome, Edge, etc.), WebSerial, WebBluetooth, need for a trusted host, usability on Linux, Mac and Windows and usability on PCs as opposed to mobile phones.
4. Quick Start
   - description of first use of PanCAT on PC and on mobile phone (Android),
   - description of user interface structure
5. Functionality
   -- Detailed description of the functionality of PanCAT (e.g. tuning, reception and transmission parameters)
6. Structure
   - workflow, dataflow of PanCATT
7. Related software
   - e.g. Hamlib, and other panadapter / CAT applications, and differences to PanCAT.
7. Glossary of terms
   - terms used in previous chapters

I will send the code in the next prompts. First, please summarise the task in your own words.

Software design and coding

The software specifications were developed over and ChatGPT5.1 and ChatGPT5.2 were used as coding assistants. The generated code matched the specifications closely but required some post-editing. The initial UI specification of PanCAT V1 was generated in a competition with Claude Sonnet, DeepSeek and ChatGPT4.1. The DeepSeek UI proposal was the most modern and ergonomic, and was therefore selected, inspected, post-edited, and expanded to contain the operational widgets.

2. Table of Contents

3. Introduction

What PanCAT is

PanCAT is a browser-based control panel that combines two functions for the GuoheTec Q900 and PMR-171 radios:

- A panadapter: a live spectrum and spectrogram (spectroscope and waterfall) display around the current receive frequency.
- CAT control: computer-aided transceiver commands for tuning and adjusting key RX/TX parameters.

PanCAT runs entirely in your web browser. It talks directly to the radio over a serial link (USB or Bluetooth Serial) using the Web Serial API. No additional software installation is required beyond a compatible browser.

The radios: GuoheTec Q900 and PMR-171

The GuoheTec Q900 and PMR-171 are compact transceivers that provide a CAT command interface. In addition to standard control commands (frequency, mode, gains, etc.), the radios can return spectrum data that PanCAT renders as a spectrum trace and waterfall.

Panadapter and CAT control in practice

A panadapter shows activity across a slice of spectrum around the tuned frequency. Compared to watching an S-meter and tuning blindly, a panadapter helps you:

- Find signals quickly (especially in crowded bands).
- See nearby activity while staying on-frequency.
- Check for interference and band noise at a glance.

CAT (Computer Aided Transceiver) control means the radio can be controlled from software. In PanCAT, CAT is used for tuning, selecting modes, adjusting receiver parameters, controlling the tuner, and reading back status such as TX/RX state, time, and S-meter information.

Why an external panadapter

Many radios have limited screen space or limited spectrum visualization. A separate panadapter view can provide:

- A larger, clearer spectrum and waterfall display.
- Touch or mouse-driven tuning directly on the spectrum.
- Convenient access to common controls without navigating radio menus.

Why PanCAT is client-based (browser app) instead of server-based

PanCAT is designed to run locally in the browser, connecting directly to the radio. This approach has several benefits:

- Simple setup: no server installation, no background services, no drivers beyond what your OS already provides.
- Privacy: radio control and spectrum data stay on your device; there is no cloud component.
- Portability: one HTML file can be hosted on any trusted site or saved for offline use.
- Cross-platform potential: works on Windows, macOS, and Linux when using a compatible Chromium-based browser.

A server-based solution can be useful for remote operation, sharing a receiver over the network, or supporting older browsers, but it also adds complexity (server configuration, security, and network troubleshooting).

Limitations and requirements of web apps

Because PanCAT uses modern browser hardware APIs, there are a few practical constraints:

- Browser: Web Serial is typically available in Chromium-based browsers (for example: Chromium, Chrome, Edge). Other browsers may not support it.
- Secure context: browsers normally require a trusted origin (HTTPS) or localhost to access Web Serial.
- Permissions: you must explicitly grant access when selecting the serial port/device.
- Operating systems: usability is generally good on Windows, macOS, and Linux on a desktop or laptop.

- Mobile: support varies by platform. Android with Chrome is the most practical mobile option; iOS browsers generally do not offer Web Serial.

In addition, a web app cannot automatically connect to devices without user interaction each session, and access to local hardware is intentionally restricted for security.

4. Quick Start

First use on a PC (Windows, macOS, Linux)

1. Open PanCAT in a compatible Chromium-based browser.
2. Power on the radio and connect it to your computer (USB serial adapter/cable, or a Bluetooth serial connection if available).
3. Click “Port: …” and select the correct serial device when the browser prompts you.
4. Click “📡 Connect”. The CAT status should change to Connected, and the spectrum should start streaming.
5. Verify the correct band and mode, then tune by clicking a band button, using the Tune buttons, or dragging on the spectrum.

If you do not see spectrum activity, check cabling/pairing, verify the radio is set to the expected serial settings, and confirm that the browser has permission to use the selected port.

First use on Android (mobile)

6. Use a Chromium-based browser on Android (typically Chrome).
7. Pair the radio’s Bluetooth serial interface with the phone, or connect a USB serial adapter via OTG (if supported).
8. Open PanCAT, then tap “Port: …” and select the serial device offered by the browser.
9. Tap “📡 Connect” to start CAT and spectrum streaming.

Mobile operation is best for monitoring and quick tuning. For extended operating sessions and for detailed control, a desktop or laptop provides a larger display and more comfortable interaction.

User interface overview

PanCAT is laid out in three main areas:

- Top bar: connection controls and live indicators (TX/RX, SWR, UTC clocks, logging, and memory reset).
- Visualization: Spectrum and Waterfall canvases (panadapter display).
- Control panels: tuning, VFO/memory, band/mode selection, RX/TX controls, and a status/log panel.

Top bar controls and indicators

- Port: selects the serial connection (USB Serial or Bluetooth Serial, depending on what the browser offers).
- 📡 Connect / Disconnect: opens or closes the serial link and starts/stops the CAT + spectrum loops.
- TX indicator: shows Standby (RX) or On Air (TX) based on radio status.
- SWR indicator: shows “SWR” when not transmitting; while transmitting it displays an approximate SWR-like value derived from the radio’s meter data.
- System (UTC) and Radio time: system clock in UTC, plus radio UTC time read from CAT status.
- System → Radio: copies the system UTC time to the radio (if supported by the radio configuration).
- CAT log: toggles detailed CAT traffic logging.
- DELETE MEMORIES: clears stored settings and memories in the browser and reloads the page.

Spectrum and Waterfall area

- Spectrum: a line plot of the received spectrum around the current center frequency.
- Waterfall: a scrolling history view; newer lines appear at the top, older lines below.
- Frequency labels: the horizontal axis is labeled in MHz and reflects the selected span.

Main control panel at a glance

- Row Avg: controls spectrum averaging (smoother trace at the cost of responsiveness).
- Floor/Ceil: sets the spectrum display scaling (visual only).
- Span: selects how wide the displayed spectrum is (48 kHz down to 1.5 kHz).
- Step + Tune: selects tuning step and provides left/right step tuning.

- VFO A / VFO B: two VFOs with direct frequency entry, A=B copy, and Split/Simplex toggle.
- Memories: 10 browser-stored memories for VFO A, VFO B, and mode.
- Bands: quick band selection; toggle between CW and SSB target frequencies.
- Mode: select operating mode (USB/LSB/CW/AM/FM variants).
- RX Controls: speaker volume, filter/bandwidth index, NR, NB, gains, AGC, squelch, preamp.
- TX Controls: CW key type, speed, sidetone settings, practice mode, and TX power.
- Status panel: CAT/spectrum status, peak/center readings, sync buttons, and the CAT log window.

5. Functionality

Connecting to the radio

Connecting is a two-step process: select a port, then connect.

- Select port: “Port: …” opens a browser dialog where you choose the serial device. This is required by browser security rules.
- Connect: “📡 Connect” opens the port at 115200 baud and starts periodic status polling and spectrum requests.

Safety feature: on connection, PanCAT sends a short burst of “PTT release” commands to reduce the chance of the radio remaining keyed after a reconnect.

Panadapter display: spectrum

The spectrum shows signal levels across the selected span centered on the active VFO frequency.

- Peak freq: the strongest bin in the spectrum is converted into an approximate peak frequency and shown in the status panel.
- Peak level: the maximum bin value is shown as a numeric level (relative, not calibrated in dBm).
- Row Avg: averages 1 to 11 spectrum frames to smooth the trace.

Floor and Ceil sliders adjust the visible range of the spectrum trace. They do not change radio receiver gain.

Waterfall display

The waterfall is a time history of the spectrum. Each new spectrum frame becomes one horizontal line. Colors represent relative strength (brighter/warmer colors correspond to stronger signals).

Tuning methods

PanCAT supports several tuning workflows:

- Step tuning: select 10 Hz, 100 Hz, 1 kHz, or 10 kHz, then use ← Tune / Tune →.
- Direct entry: type a frequency into the active VFO and click ENTER FREQUENCY (or press Enter).
- Band buttons: tap/click a band to jump to a preset frequency for that band (CW or SSB depending on the Bands toggle).
- Drag tuning: click/touch and drag on the spectrum to tune smoothly across the span.

Drag tuning is rate-limited so the radio is not flooded with frequency updates. When you release the pointer, PanCAT commits the final frequency.

Frequency entry format

The VFO input boxes accept multiple formats:

- Single number (e.g., “14.285”): interpreted as MHz.
- Two groups (e.g., “14.285000” or “14.285”): interpreted as MHz with decimals.
- Three groups (e.g., “14.285.000”): interpreted as MHz.kHz.Hz in the displayed format.

VFO A/B and Split

- VFO A / VFO B: selects which VFO is active for tuning and mode changes.
- A = B: copies VFO A frequency to VFO B.
- Simplex / Split ON: enables or disables split operation. When split is ON, VFO A and VFO B can represent RX and TX frequencies depending on radio behavior.

PanCAT always sends both VFO A and VFO B frequencies when setting frequency, ensuring the radio stays synchronized with the on-screen values.

Band presets and CW/SSB toggle

The Bands button toggles between two sets of preset frequencies:

- Bands: SSB uses SSB-oriented center frequencies (where defined).

- Bands: CW uses CW-oriented center frequencies.

Some bands may intentionally have no SSB preset (for example, 60 m and 30 m). In that case the preset label is blank and tapping the band does nothing in SSB mode.

Mode selection

Mode buttons set the operating mode for the active VFO:

- USB / LSB: single-sideband modes.
- CWR / CWL: CW receive sideband selection.
- AM: amplitude modulation.
- NFM / WFM: narrow/wide FM (availability depends on the radio and band).

Span and spectrum scaling

- Span selects the bandwidth of the panadapter view (48.0, 24.0, 12.0, 6.0, 3.0, or 1.5 kHz).
- Floor and Ceil adjust how the spectrum values are mapped to the display (visual only).
- CW sidetone guide lines: when the CW Tone Hz slider is set, vertical guide lines are drawn at ± sidetone frequency around center to help with CW tuning.

Tuner control

- Tuner: OFF / ON toggles the tuner state.
- Tuner Scan starts an automatic scan cycle (if supported by the radio).

Receiver controls (RX Controls)

The RX Controls panel sends CAT commands to adjust receiver behavior:

- Spkr Vol: speaker/audio volume (0–30).
- IF/BW: selects an IF filter/bandwidth preset by index.
- NR: noise reduction level (0–5).
- NB: noise blanker level (0–5).
- RF Gain: front-end gain (0–100).
- IF Gain: IF gain (0–80).
- AGC: automatic gain control mode (OFF, FAST, MID, SLOW, SSLOW, AUTO).
- Squelch: opens/closes audio based on signal level (0–20).
- Preamp: toggles the preamplifier on/off.

Changes are sent to the radio when you release a slider (on change), which keeps the UI responsive while dragging.

Transmitter and CW controls (TX Controls)

- CW Key: selects keying type (Straight, Paddle L, Paddle R).
- WPM: CW speed (5–48).
- Tone Hz: CW sidetone frequency (400–800 Hz).
- Tone Vol: CW sidetone volume (0–15).
- CW Pract.: enables practice mode so you can monitor keying without transmitting (behavior depends on radio firmware).
- TX Power: toggles between low and high power.

Status indicators

The right-hand status panel summarizes live information:

- CAT status: connected/disconnected state.
- Spectrum status: idle, starting, or streaming.
- RF Center: center frequency (active VFO).
- Span: current span value.
- Peak freq and Peak level: strongest signal in the current spectrum frame.
- S-meter: value reported by the radio status frame.

TX and SWR indicators

The TX pill in the top bar shows whether the radio is in RX (Standby) or TX (On Air). During TX, the SWR pill changes color from green toward red as the radio's meter value rises, and displays an approximate SWR-like number. Treat this as a quick indicator; it is not a calibrated antenna analyzer.

Time display and time sync

PanCAT shows two clocks:

- System (UTC): your computer/phone's UTC time.
- Radio: the radio's UTC time as reported in the CAT status frame.

The "System → Radio" button sends the current system UTC date/time to the radio. If the radio reports that a GPS or LoRa time source is present, PanCAT hides this button to avoid conflicting time sources.

Local memories and persistence

PanCAT stores some settings in your browser using local storage. This means settings survive page reloads on the same device/browser.

- VFO memories (M1–M10): store VFO A frequency, VFO B frequency, and the selected mode.
- Last span, tuning step, band-mode (CW/SSB), and spectrum averaging setting.
- Last selected port label (for convenience; you still must grant permission when selecting the port).

DELETE MEMORIES clears all stored data for PanCAT in the browser and reloads the app.

Sync buttons in the status panel

- Sync ← Radio: requests a fresh status frame from the radio (useful after changing settings on the radio itself).
- Recall Local: reloads locally stored settings from the browser.
- Push → Radio: sends the local span and VFO frequencies to the radio to re-synchronize.

CAT log

When CAT log is ON, PanCAT records sent and received CAT activity in the log window. Because detailed logging can be very chatty during spectrum streaming, logging is OFF by default.

6. Structure

High-level architecture

PanCAT is implemented as a single HTML page with embedded CSS and JavaScript. Internally it is organized into a few clear layers:

- UI layer: buttons, sliders, and canvases; collects user input and updates visible indicators.
- Model layer: stores the current state (VFOs, modes, span, meters, spectrum bins).
- Protocol layer: sends CAT commands and manages periodic status and spectrum requests.
- Transport layer: manages the Web Serial connection and raw byte I/O.

Event-driven workflow

Components communicate through an internal event bus. This keeps rendering, device I/O, and UI logic decoupled.

10. A UI action (button/slider/drag) emits an event (for example: setFrequencyHz).
11. The protocol controller translates that event into one or more CAT commands and sends them over the serial transport.
12. Incoming bytes from the radio are framed and validated, then decoded into status updates or spectrum bins.
13. The model is updated and emits a change event.
14. Renderers update the spectrum and waterfall, and the UI controller updates labels and button highlights.

Dataflow: status versus spectrum

PanCAT handles two main streams of data:

- Status (CAT command 0x0B): polled roughly twice per second to update VFO state, active VFO, span index, S-meter, TX/RX state, and radio time.
- Spectrum (CAT command 0x39): requested repeatedly to drive the panadapter. Each spectrum response contains a fixed number of bins that represent the current span.

Frame format and integrity checks

Radio communication uses framed binary messages with a CRC-16 (CCITT-FALSE) checksum. PanCAT validates checksums to protect against misaligned or corrupted data and automatically resynchronizes when needed.

- CAT commands: start with four 0xA5 bytes, then a length byte, command byte, data, and a 16-bit CRC.
- Spectrum frames: contain metadata and 512 spectrum bins (plus CRC). Some radios may also provide a shorter 0x7E-framed spectrum format.

Timing, pacing, and throttling

To keep the connection stable, PanCAT paces requests and limits how fast it sends updates:

- Spectrum loop is RX-paced: after receiving a spectrum frame, PanCAT schedules the next request with a minimum gap (~120 ms).
- A watchdog timer retries if a spectrum frame does not arrive within a short timeout.
- Frequency changes during drag are throttled (~120 ms minimum gap). A final “commit” is sent when you release the pointer.

Local storage (browser persistence)

PanCAT saves user-facing state under a single local-storage key. The stored information includes:

- Last tuned frequency (active VFO at the time of saving).
- Span selection and tuning step.
- Band-mode (CW or SSB) and spectrum averaging value.
- Ten VFO memories (A frequency, B frequency, mode).

This storage is per browser and per device. If you open PanCAT on another device, it starts with default values until you store settings there.

7. Related software

Hamlib and CAT libraries

Hamlib is a widely used open-source library that provides a common API for controlling many different radios over CAT. It is often used by logging programs, digital-mode applications, and custom control tools.
PanCAT differs from Hamlib-based applications in that it talks directly to the Q900/PMR-171 protocol from inside the browser, without a separate installed library or background daemon.

Other panadapter and CAT applications

Many transceivers and SDR receivers are supported by desktop programs that combine CAT control with spectrum displays. Examples include SDR front-ends, transceiver control suites, and digital-mode programs that integrate frequency control.
Key differences compared to PanCAT:

- PanCAT is a client-side web app: it runs locally in the browser and does not require a server component.
- PanCAT is specialized for the Q900/PMR-171 protocol and uses spectrum data produced by the radio (not raw IQ streaming).
- PanCAT focuses on essential controls and a responsive touch-friendly UI rather than advanced DSP or remote networking features.

When you might prefer other tools

- If you need full remote operation over a network, a server-based solution or dedicated remote-control software may be more appropriate.
- If you need advanced DSP features, recording, or wideband IQ streaming, an SDR-oriented application may be a better fit.
- If you need integration with logging or contest software across many radio models, Hamlib-based tools can provide broader compatibility.

8. Glossary of terms

The following terms are used throughout this manual:

Term	Meaning
AGC	Automatic Gain Control. A receiver function that automatically adjusts gain to keep audio levels more consistent.
Band	A range of frequencies allocated for a particular radio service (for example, 20 m amateur band).
CAT	Computer Aided Transceiver. A command interface used to control a radio from external software.
Center frequency	The frequency at the middle of the displayed spectrum span (here: the active VFO frequency).
CRC	Cyclic Redundancy Check. A checksum used to detect corrupted or misaligned data frames.
CW	Continuous Wave (Morse code). Often used with narrow filters and a sidetone.
CWL / CWR	CW receive sideband selection (lower/upper) which affects the audio offset direction.
IF	Intermediate Frequency. Many radios apply filters and gain control in IF stages.
IF/BW	In PanCAT: an index selecting an IF filter/bandwidth preset on the radio.
NB	Noise Blanker. A receiver feature that reduces impulse noise.
NR	Noise Reduction. A receiver feature that reduces background noise (often DSP-based).
Panadapter	A spectrum display centered around the tuned frequency, showing signals across a selectable span.
Preamp	Preamplifier. Adds receiver gain before later stages; can help weak signals but may increase overload risk.
S-meter	A relative signal strength meter reported by the receiver.
Span	The width of spectrum displayed around

	the center frequency (for example, 12 kHz).
Split	Operating mode where transmit and receive frequencies differ (typically VFO A and VFO B).
Squelch	A control that mutes audio until the received signal exceeds a threshold.
SWR	Standing Wave Ratio. A measure related to antenna match during transmit; high values may indicate mismatch.
Sidetone	An audio tone generated during CW keying to help the operator hear their own keying.
VFO	Variable Frequency Oscillator. In practice: an independent frequency register (VFO A and VFO B).
Waterfall	A scrolling time history of the spectrum where each row represents one spectrum snapshot.
Web Serial	A browser API that allows a web app to access serial devices, subject to user permissions and secure-context rules.
WPM	Words Per Minute. A measure of CW sending speed.