# Earth-Venus-Earth Modem

*Operator's Guide*

Rev C - DRAFT

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DSES

October 2026

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# Earth-Venus-Earth Modem — Operator's Guide

| Document | DSES EVE Modem Operator's Guide |
|---|---|
| **Revision** | Rev C — DRAFT (program 1.0.21) |
| **Date** | 2026-10-23 |
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| **Funding** | Supported by a grant from Amateur Radio Digital Communications. |
| **Companion** | DSES EVE Modem Design Description and ICD (Rev C): the why behind every setting |
| **Where it lives** | This text is the application's Help → Operator's guide, and `docs/DSES_EVE_Modem_Operators_Guide.pdf` |

The waveform this program sends and receives is the Open Research Institute's Spiral #2, designed by Pete Wyckoff, KA3WCA, with the reference implementation by Michelle Thompson; the station software is DSES's. This guide is for the person at the keyboard at Haswell. It says what to connect, what to click, what to watch, and what to do when something is wrong. The design document explains the reasons; this one gives the steps.

## 1. What the program does

The DSES EVE modem sends an 11-symbol message (K0PRT K0PRT) as one tone at a time out of 4096 possible tones, bounces it off the Moon or Venus, and decides which tones came back. One symbol lasts 164.8 seconds (473 frames of 0.35 s); a whole message takes 30.2 minutes per pass, and several passes are added together before the decision. The program does all of it from one window:

- **Setup**: pick the kind of run, set the frequency, gains, message, and timing; preview the schedule; press Start.
- **Run**: watch the tones arrive, the decisions form, the chunks progress, the key line, the radio and the GPS clock.
- **Report**: read the session report when the run ends, re-decode an earlier one, or tick Compare to put two reports side by side.

The settings are remembered between runs, so the desktop icon opens the program ready for the last test. A run can be repeated, changed, and repeated again without restarting the program.

## 2. Before you start: the hardware checklist

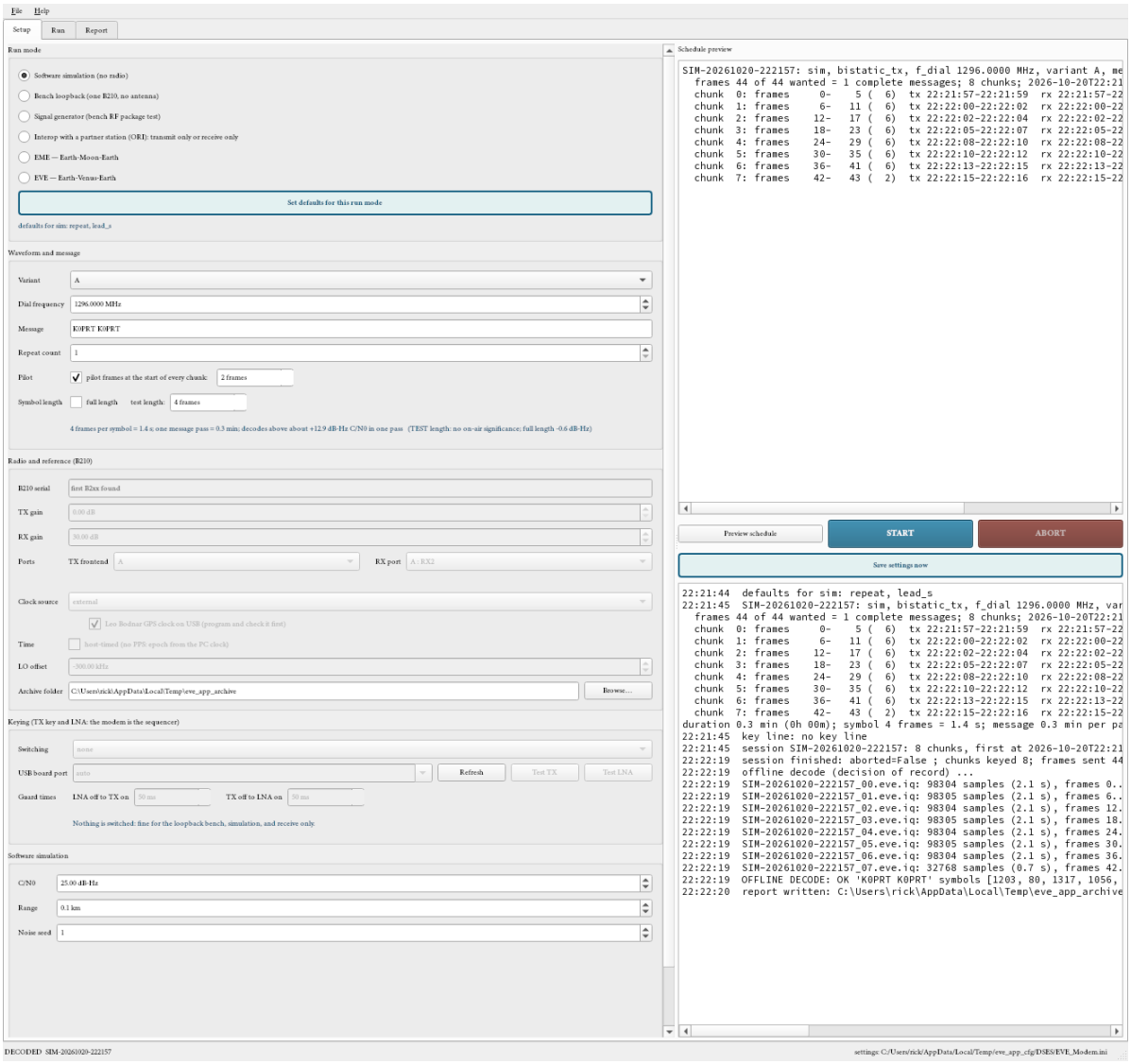
| Item | What to check |
|---|---|
| **B210** | On a USB 3 port of the PC (a direct rear port, not the powered extension cable). It appears in Device Manager under "USRPs". After a power event that leaves it unrecognized, unplug USB and the DC barrel for 15 s (a true cold start). |
| **GPS reference clock (Leo Bodnar)** | OUT1 to the B210 **REF IN** (10 MHz). OUT2 to the B210 **PPS IN** (with output 2 disabled the OUT2 connector carries the 1 PPS; the program sets this). USB to the PC. GPS antenna with a clear sky view. Both LEDs steady after a few minutes = locked. |
| **Switching (TX key and LNA)** | The modem is the sequencer: two signals, TX key and LNA control, timed in software. At DSES they go out on the **USB relay board** (DIUSTOU DSTUR-T20, `docs/hardware/diustou_dstur_t20.md`): relay 1 COM/NO = TX key (closed = transmit), relay 2 COM/NO = LNA control (closed = LNA off), on separate lines to the amplifier and to the LNA at the feed. Both released = receive, so an unplugged board or a dead PC leaves the feed receiving. The program also drives the same two signals on the **B210 J504** GPIO pins in parallel — **GPIO_0** = TX key (high = transmit), **GPIO_1** = LNA (high = LNA off), ground on pin 9 or 10, 3.3 V logic — for a station with its own external sequencer at the feed, as ORI has; DSES does not use them. (GPIO_0 alone can drive an external sequencer, DB6NT style, GPIO_1 then ignored. On the DSES clone the front-panel IO connector is a white 2x5 shrouded header, 2.54 mm pitch, 10-pin IDC ribbon socket or Dupont leads, whose legend gives the GPIO numbers: top row G 6 4 2 0, bottom row G 7 5 3 1. Never straight to a sequencer input without an isolating circuit.) |
| **Transmit** | B210 **TX/RX A** to the 20 W driver's input pad, in the control room; the driver feeds the LMR-600 run to the feed (about 10 dB loss), where 2 W drives the 1200 W SSPA's built-in pre-driver. The B210 gives at most +8 dBm; the driver decides the TX gain setting (Setup → TX gain). |
| **Receive** | LNA output (through the bandpass filter if fitted) to B210 **RX2 A**. Nothing on RX2 for the loopback bench. |
| **Sequencer** | None in the station: the modem sequences the LNA and the transmitter itself through the USB relay board (LNA off, guard, TX on; TX off, release, LNA on; abort takes the same way out, transmitter first). The amplifier's own interlocks stay armed; the 2 kW load only for the thermal test. |
| **PC clock** | The PC needs internet NTP (the second number of the PPS-edge time set comes from it). Windows: Settings → Time → Sync now. |
| **Pointing** | The dish tracks the target under System 1 (RA/Dec, J2000). The Run tab shows the target's azimuth and elevation from the ephemeris for a cross-check. |

| Item | What to check |
|---|---|
| **Archive folder** | A folder with room for the run: about 24 MB per 30-minute pass at the modem rate. |

## 3. Starting the program

Double-click the **DSES EVE Modem** desktop icon (created once with `install-shortcut.ps1`). The window opens on the Setup tab with the last settings. The status bar shows where the settings file is. If the program does not start, read the log: `%LOCALAPPDATA%\DSES\EVE_Modem\app.log` on Windows, `~/Library/Logs/DSES_EVE_Modem/app.log` on macOS, `~/.local/state/dses-eve-modem/app.log` on Linux. A hard crash leaves `fault.log` beside it.

**Updates.** Once a day at start-up, and whenever you choose Help → Check for updates…, the program asks gpstime whether a newer version is published. A newer one opens a window with the release notes; **Install Update** downloads it, checks its SHA-256 against the published sidecar, and installs it over this copy (a backup is kept) or as a new copy beside it, then offers a restart. Nothing is changed before the checksum matches, and nothing is installed while a run is in progress. Skip this version or Remind me later do what they say.


File Help
Setup Run Report
Run mode
Software simulation (no radio)
Bench loopback (one B210, no antenna)
Signal generator (bench RF package test)
Interop with a partner station (ORI): transmit only or receive only
EME — Earth-Moon-Earth
EVE — Earth-Venus-Earth
Set defaults for this run mode
defaults for sim: repeat, lead_s
Waveform and message
Variant A
Dial frequency 1296.0000 MHz
Message K0PRT K0PRT
Repeat count 1
Pilot pilot frames at the start of every chunk: 2 frames
Symbol length full length test length: 4 frames
4 frames per symbol = 1.4 s; one message pass = 0.3 min; decodes above about +12.9 dB-Hz C/N0 in one pass (TEST length: no on-air significance; full length -0.6 dB-Hz)
Radio and reference (B210)
B210 serial first B2xx found
TX gain 0.00 dB
RX gain 30.00 dB
Ports TX frontend A RX port A : RX2
Clock source external
Leo Bodnar GPS clock on USB (program and check it first)
Time host-timed (no PPS: epoch from the PC clock)
LO offset -300.00 kHz
Archive folder C:\Users\rick\AppData\Local\Temp\eve_app_archive
Browse...
Keying (TX key and LNA: the modem is the sequencer)
Switching none
USB board port auto
Refresh
Test TX
Test LNA
Guard times LNA off to TX on 50 ms TX off to LNA on 50 ms
Nothing is switched: fine for the loopback bench, simulation, and receive only
Software simulation
C/N0 25.00 dB-Hz
Range 0.1 km
Noise seed 1
Schedule preview
SIM-20261020-222157: sim, bistatic_tx, f_dial 1296.0000 MHz, variant A, me
frames 44 of 44 wanted = 1 complete messages; 8 chunks; 2026-10-20T22:21
chunk 0: frames 0- 5 ( 6) tx 22:21:57-22:21:59 rx 22:21:57-22
chunk 1: frames 6- 11 ( 6) tx 22:22:00-22:22:02 rx 22:22:00-22
chunk 2: frames 12- 17 ( 6) tx 22:22:02-22:22:04 rx 22:22:02-22
chunk 3: frames 18- 23 ( 6) tx 22:22:05-22:22:07 rx 22:22:05-22
chunk 4: frames 24- 29 ( 6) tx 22:22:08-22:22:10 rx 22:22:08-22
chunk 5: frames 30- 35 ( 6) tx 22:22:10-22:22:12 rx 22:22:10-22
chunk 6: frames 36- 41 ( 6) tx 22:22:13-22:22:15 rx 22:22:13-22
chunk 7: frames 42- 43 ( 2) tx 22:22:15-22:22:16 rx 22:22:15-22
Preview schedule
START
ABORT
Save settings now
22:21:44 defaults for sim: repeat, lead_s
22:21:45 SIM-20261020-222157: sim, bistatic_tx, f_dial 1296.0000 MHz, var
frames 44 of 44 wanted = 1 complete messages; 8 chunks; 2026-10-20T22:21
chunk 0: frames 0- 5 ( 6) tx 22:21:57-22:21:59 rx 22:21:57-22
chunk 1: frames 6- 11 ( 6) tx 22:22:00-22:22:02 rx 22:22:00-22
chunk 2: frames 12- 17 ( 6) tx 22:22:02-22:22:04 rx 22:22:02-22
chunk 3: frames 18- 23 ( 6) tx 22:22:05-22:22:07 rx 22:22:05-22
chunk 4: frames 24- 29 ( 6) tx 22:22:08-22:22:10 rx 22:22:08-22
chunk 5: frames 30- 35 ( 6) tx 22:22:10-22:22:12 rx 22:22:10-22
chunk 6: frames 36- 41 ( 6) tx 22:22:13-22:22:15 rx 22:22:13-22
chunk 7: frames 42- 43 ( 2) tx 22:22:15-22:22:16 rx 22:22:15-22
duration 0.3 min (0h 00m); symbol 4 frames = 1.4 s; message 0.3 min per pa
22:21:45 key line: no key line
22:21:45 session SIM-20261020-222157: 8 chunks, first at 2026-10-20T22:21
22:22:19 session finished: aborted=False ; chunks keyed 8; frames sent 44
22:22:19 offline decode (decision of record) ...
22:22:19 SIM-20261020-222157_00.eve.iq: 98304 samples (2.1 s), frames 0..
22:22:19 SIM-20261020-222157_01.eve.iq: 98305 samples (2.1 s), frames 6..
22:22:19 SIM-20261020-222157_02.eve.iq: 98304 samples (2.1 s), frames 12.
22:22:19 SIM-20261020-222157_03.eve.iq: 98305 samples (2.1 s), frames 18.
22:22:19 SIM-20261020-222157_04.eve.iq: 98304 samples (2.1 s), frames 24.
22:22:19 SIM-20261020-222157_05.eve.iq: 98305 samples (2.1 s), frames 30.
22:22:19 SIM-20261020-222157_06.eve.iq: 98304 samples (2.1 s), frames 36.
22:22:19 SIM-20261020-222157_07.eve.iq: 32768 samples (0.7 s), frames 42.
22:22:19 OFFLINE DECODE: OK 'K0PRT K0PRT' symbols [1203, 80, 1317, 1056,
22:22:20 report written: C:\Users\rick\AppData\Local\Temp\eve_app_archive
DECODED SIM-20261020-222157
settings C:/Users/rick/AppData/Local/Temp/eve_app_cfg/DSES/EVE_Modem.ini

*Setup tab*

## 4. The Setup tab

Every control has a tooltip: hover over it or its label. The essentials:

### 4.1 Run mode

| Mode | When to use it |
|---|---|
| **Software simulation** | No radio. Proves the decoder and the display at a chosen signal-to-noise. Run it first on any new PC. |
| **Bench loopback** | One B210, nothing on the antenna ports. Transmits at low gain, receives its own internal leakage. Proves the radio, the reference, the archive, and the decoder before anything goes on the air. |
| **Signal generator** | The B210 as a bench source for the RF package: CW, two tones, or the EVE waveform at the dial frequency, running until you stop it. You key and unkey through the sequencer as often as you like, and change the signal, the TX gain, and a digital scale while it runs, or step the gain on a timer. For power-out, compression, and tuning measurements on the 23 cm and 13 cm packages, and for checking the station's wiring to the relays with no RF at all. See section 4.6. |
| **Interop with a partner station** | Compatibility test with ORI's own hardware and software, on the bench through a cable and attenuator or across the room: transmit only (their receiver decodes us) or receive only (their generator transmits, we archive and decode). No Doppler, no round trip, no amplifier limits. See section 7.1. |
| **EME** | Moon bounce. Ephemeris from JPL Horizons, Doppler pre-compensated, transmit 2.4 s then listen for the 2.5 s echo, repeat. The rehearsal before Venus. |
| **EVE** | Venus bounce. 240 s transmit chunks against the 272 s round trip. A full message is 30.2 minutes per pass; plan seven passes, 8 hours above 10 degrees (the 2026-10-20 operating schedule at 600 W; five suffice at the full 1200 W). |

**Set defaults for this run mode** puts every setting the mode cares about back to the design value: variant, frequency, repeat count, symbol length, gains, chunking, timing, Doppler, and for the Moon, Venus and the signal generator the switching (the USB relay board and B210 GPIO sequencer). The status line lists what changed. Changing the run mode, the variant, the symbol length, or the interop direction also applies a few consistency rules (a sky session gets an external clock; Venus and interop get full-length symbols, Venus 1299.5 MHz and the amplifier limits; interop pins Variant A; EME starts at test length; a bench or interop chunk grows to hold the pilot, and on the Moon or Venus the pilot is capped to what the chunk holds; receive-only interop drops the pilot) and says so in the teal line under the run modes.

### 4.2 Waveform and message

- **Variant** B (1.5 Hz bins, 247 frames of 0.667 s) is the DSES 23 cm monostatic waveform and the default for Venus, the Moon and the bench: 1.1 dB more sensitive than A, matched to the 1.5 Hz spread at 1299.5 MHz (design D13, 6.1.1), and the waveform every published link margin assumes. B also halves

the radio sample rate (786 kS/s against A's 1.5 MS/s): **the Raspberry Pi 5 station PC generates B in real time but not A**. On A the Pi's transmitter underruns, the chunks go out late or empty, and only the first symbol decodes (found 2026-10-20); the program now says so (below). A is the ORI air interface (2.87 Hz bins, 473 frames); use A whenever another station must decode us, never on the Pi. The interop mode pins A: no ORI receiver decodes B.

- **Dial frequency**: 1299.5 MHz for Venus 2026 with the 23 cm package; 1296 on the bench. The comb sits 25 to 48.5 kHz above the dial.
- **Message**: K0PRT K0PRT, the club call. Up to 11 characters.
- **Repeat count**: passes of the message. The receiver adds them; seven for Venus (the operating schedule: about 8 hours, Venus above 10 degrees), five at the full 1200 W.
- **Pilot**: a known tone for the first N frames of **every chunk**; the receiver measures the frequency offset on it and confirms the signal is there. The design value is 40 frames (14 s) on the 240 s Venus chunk. Every chunk must hold the pilot plus two data frames, so the Moon's 2.4 s chunk allows four at most on Variant A (six frames) and one on Variant B (three frames); the program caps the setting and says so. The EME defaults use one frame on Variant B; use 2 on the bench. One or two frames are a decisive check at EME strength, and every pilot frame on the Moon displaces a data frame (a one-frame pilot on Variant B makes a full-length Moon pass half again as long).
- **Symbol length**: **full length** (473 frames of Variant A or 247 of Variant B, 164.8 s per symbol either way) is the air interface. The **test length** (6 frames, 2.1 s on A, 4 s on B) makes a whole message pass in under a minute for bench work. The program asks before sending a test-length signal on the air and says what to do: on the Moon the test length is the recommended first run (answer Yes, then full length once it decodes); for Venus and interop it recommends No and full length. **A short symbol is a deaf symbol.** The waveform reaches 0 dB-Hz only by adding up the frames of a full symbol; the blue line under the setting shows the C/N0 a one-pass decode needs (design 2.4 model, 10 % message error rate), and it rises 6.5 dB for every factor of ten fewer frames:

| Frames per symbol | Symbol | Needs C/N0 above |
|---|---|---|
| **473 (full, Variant A)** | 164.8 s | −0.6 dB-Hz |
| **247 (full, Variant B)** | 164.7 s | −1.7 dB-Hz |
| **118** | 41 s | +3.0 dB-Hz |
| **47** | 16 s | +5.4 dB-Hz |
| **12** | 4.2 s | +9.5 dB-Hz |
| **6 (bench default)** | 2.1 s | +11.7 dB-Hz |

So a software simulation at 2 dB-Hz with the 6-frame test length fails as it should; test sensitivity with full length (a 30 minute pass), or set the simulation C/N0 at least 3 dB above the line for the length in use. Repeat count helps: each doubling of passes buys about 3 dB.

## 4.3 Radio and reference

- **TX gain** 0 dB on the bench; 55 dB is the Moon and Venus default. It can be turned while a run is going, in any mode: the new gain is applied at once, logged with its time and written to the session JSON, so the drive the amplifier saw is on record. The driver's input pad decides the final figure; the signal generator mode (4.6) measures it.
- **RX gain**: set so the background of the tone strip is visible but not saturated; like the TX gain it can be turned while a run is going (applied at once, logged, in the session JSON) (30 dB on the bench, 40 to 50 dB behind the LNA).
- **Ports**: the B210 has two frontends, A and B, each with a TX/RX and an RX2 port. The station is wired TX on **A** (TX/RX A to the driver) and RX on **A : RX2** (the LNA), and those are the defaults. Change them for a board with a bad side, or to compare ports on the bench: TX on B, RX on B : RX2, or RX on the TX/RX port of the frontend that is not transmitting. The same frontend's TX/RX for both directions is refused. The line under the setting says when the choice differs from the station wiring. **Port isolation is not equal on the two sides.** Measured on two B210s (Workbench bench, 2026-09-14): with the receiver on frontend A, the unselected port leaks into the selected one at only about 5 dB (TX/RX state) to 17 dB (RX2 state); on frontend B it is about 26 dB, and between the two frontends it is best of all. So a loopback bench through side A shows a very strong signal (margins near 40 dB) and one through side B a weak one (a few dB): both are normal. For the station this favours transmitting on A and receiving on B : RX2 when the cabling allows; to be revisited.
- **Clock source** external (the GPS clock on REF IN and PPS IN). The run refuses to start unless the B210 reports lock.
- **Time**: leave host-timed unticked when the PPS is connected. Tick it only if there is no PPS; the epoch then comes from the PC clock, still inside the tolerance.
- **Clock source** has a sub-item: tick "the external reference is the Leo Bodnar GPS clock on USB" when that clock is the reference; the program then sets it to the station setting and waits for lock before opening the radio. With the HP5065A rubidium (plus a PPS source) back in service, untick it; the B210's own lock check still runs.
- **Archive folder**: where the run's files go.
- **Keying**: the modem is the station's sequencer (design 7.2, D24). *none* switches nothing (bench, simulation, receive only). Otherwise two signals go out: **TX key** (relay 1 of the USB board; energized = transmit) and **LNA** (relay 2; energized = LNA off). Both released is receive. The same two signals appear on B210 GPIO_0 and GPIO_1 in parallel, for a station with an external sequencer at the feed; DSES does not use them. The USB board's port is *auto*: the program finds the board wherever it is today. If no board answers, the run goes ahead on the GPIO lines alone and tells you so in a box, the status bar, and the log; at DSES that keys nothing, so find the board before transmitting. **Test TX** and **Test LNA** click the relays for a second without touching the radio. The two guard times are the gaps between switching the LNA

off and keying the transmitter, and between unkeying and switching the LNA back on; the RF starts 200 ms after the key as before. The switching runs in **every** mode, the software simulation and the loopback bench included, so the relays can be watched and timed with nothing on the air (in the simulation the GPIO lines are recorded rather than driven). It needs 1.5 s of silence between chunks; the program raises the minimum off time to that when the switching is on. **Set defaults** selects the switching for the Moon, Venus and the signal generator; choosing none afterwards for an EME or Venus run is allowed but the teal line warns.

## 4.4 Mode settings

The group under the radio settings changes with the mode. For EME and Venus the sky session group adds the start, the stop, the minimum elevation, the ephemeris source (Horizons, astropy fallback), the station mode (monostatic, or transmit-only for a partner receiver), and the Doppler handling. The defaults are the design values; change them only for a reason you can write in the log.

**Start** is one of three: *now* + the lead time after START; *at UTC* the time beside it (a planned session window; a time in the past is refused); or *when the target rises*, the first minute the Moon or Venus is above the minimum elevation. With the last one you can press START hours ahead: the program opens the radio, fetches the ephemeris, builds the schedule and waits, with the badge saying when the first chunk is due. That is the Venus default.

**Stop** bounds the run. *After the passes* ends it when the repeat count has been sent;

*at UTC* ends it no later than the time beside it. Either way the run also ends when the target drops below the **minimum elevation** (10 degrees, the operating schedule's floor: below it the ground fills the beam and a pass adds little). The schedule plans no chunk whose echo would arrive after the stop, so the preview shows exactly what will be sent, and the report says how many passes were complete. A run that is going well can be ended early with STOP (section 4.5).

## 4.5 Preview, Operations schedule, Start, Stop, Abort

**Preview schedule** builds the schedule without touching the radio and lists every chunk with its times, frames, round trip, elevation, and Doppler, then the total duration. For a sky session this fetches the ephemeris, which takes a few seconds. Check the elevation and the duration before Start. If the Moon or Venus is below the horizon at the start time, the preview warns and shows the next viable schedule instead, from the minute the target reaches 10 degrees; set that start time (untick *start now*) before Start, which still refuses a target below the horizon. For a sky session the preview begins with an OPERATIONS block: the day's window above the minimum elevation, the highest elevation, the start and the stop with their reasons, and how many of the passes fit before the stop.

**Operations schedule** (EME and Venus) shows the next two weeks in the preview box from one ephemeris: for each day the window above the minimum elevation in UTC and Mountain time, the highest elevation, how many of the repeat count's passes fit with the current chunking, the last echo, the range and its loss against the best day, and the Doppler at rise. Nothing is run. The same table comes from `tools/eve_ops_schedule.py` for the field log and for planning emails.

**START** saves the settings, programs the GPS clock, opens the radio, builds the schedule, and switches to the Run tab. The first chunk starts after the lead time, at the UTC time, or when the target rises, as the Start setting says.

**STOP after chunk** ends a run cleanly: the chunk being transmitted finishes and its echo is received, no further chunk is keyed, and the offline decode and the report follow as after a complete run, with the passes in hand. Use it when the window is closing or the passes received are enough. The same button is on the Run tab.

**ABORT** releases the key line at once, stops the streams, closes the archive, and writes the log. Use it for any fault. The same button is on the Run tab.

## 4.6 Signal generator

The **Signal generator** run mode turns the B210 into the bench source for integrating the RF package: the 20 W driver, the amplifier at the feed, filters, feed, and the relay wiring. It behaves like a bench instrument, not a timed session. **START** brings it up with the key up and it stays up until you press **STOP generator** on the Run tab. Nothing is received or decoded.

On the Run tab, above the operator panel, the **Signal generator** bar holds the controls you use while it runs:

| Control | What it does |
|---|---|
| **KEY** | Keys the transmitter through the sequencer: LNA off, guard, TX key (relay 1), then the RF after the key lead. The key lamp turns red. |
| **UNKEY** | Releases it: RF off, key lag, TX key off, release, LNA on. The generator stays up; press **KEY** again whenever you are ready. |
| **Sweep** | Runs the timed TX-gain sweep now (the key must be down and **Sweep** ticked on the Setup tab). |
| **STOP generator** | Ends the run cleanly: the key is released, the radio closed, the report written. **ABORT** does the same and marks the run aborted. |

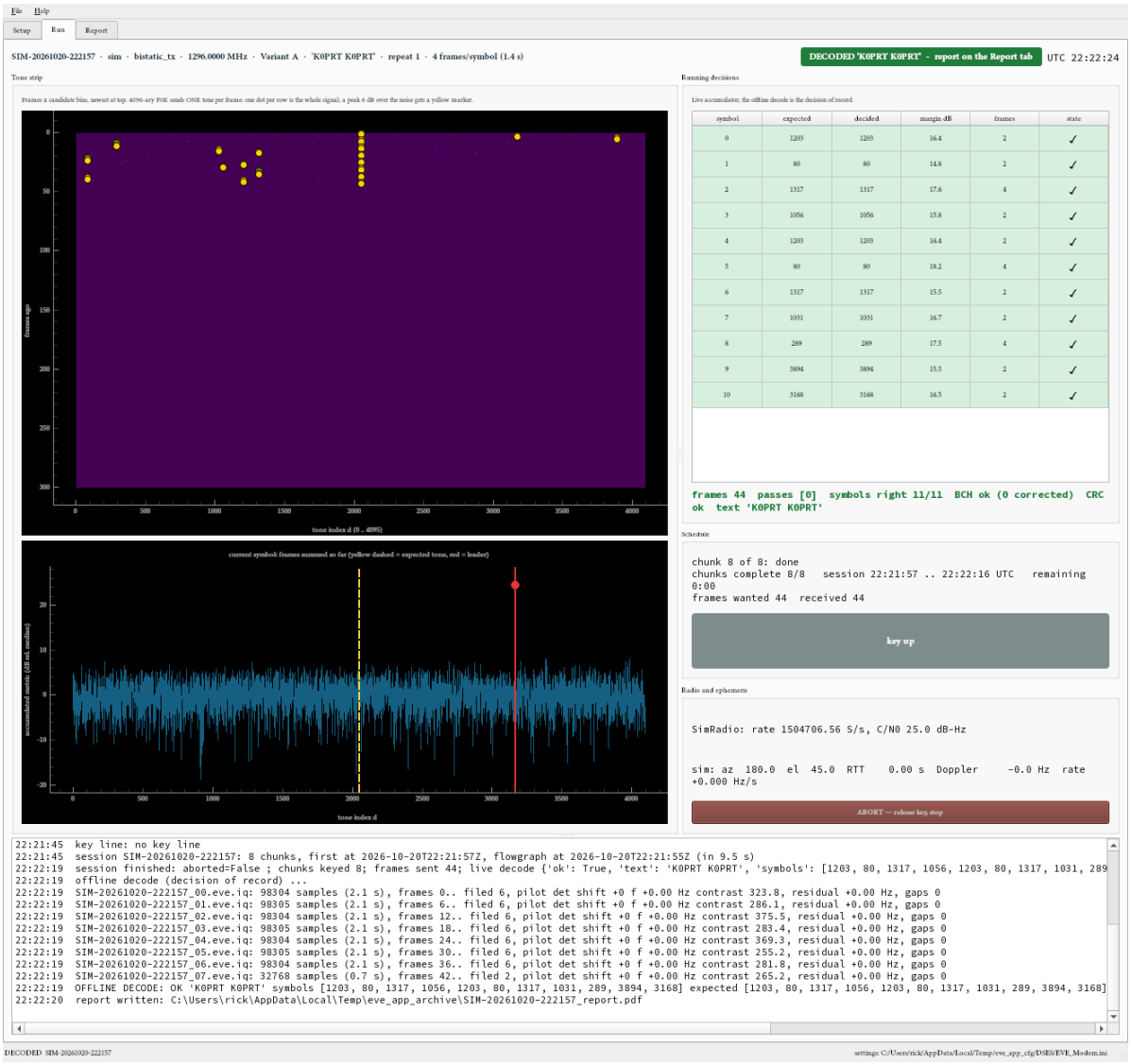
The settings in the **Signal generator** group on the Setup tab all apply at once while the generator runs, keyed or not:

| Setting | What it does |
|---|---|
| **Signal** | **CW**: one tone at the dial frequency plus the offset. **Two-tone**: two equal tones centered on the offset and spaced as set; the two-tone test shows an amplifier's intermodulation and the onset of compression. **EVE waveform**: the real 4096-FSK message, pilot first, cycling for as long as the key is down: exactly the comb the amplifier sees in a session. Changing it takes effect within a fraction of a second. |
| **Offset** | Where the tone sits relative to the dial frequency (0 puts it on the dial; the modem's own IF comb sits 25 kHz above). |
| **Spacing** | Two-tone only: the distance between the two tones. |
| **Digital scale** | The fine level: dB below full scale. Combine with **TX gain** in the Radio group (coarse, 0 to 89.75 dB in 0.25 dB steps). Every change is logged with its time and goes into the report. |
| **PA** | Enforce the amplifier duty limits on each key-down: the key is released after 300 s, and **KEY** is refused until 240 s have passed (the Run tab counts it down). Tick whenever an amplifier is in the chain, even into a load. |
| **Dry run** | Run on the simulated radio, no B210: the sequencer (relay board and simulated GPIO), the key controls, the level controls, the sweep, and the report all work as they would on the air. Use it to check the station's wiring to the relays before the first real transmission, without risking a kilowatt. |
| **Sweep** | Step the TX gain from the start to the stop level by the step, holding each level for the hold time: automatically on the first key-down, and again whenever you press **Sweep**. Unkeying stops it; the gain stays at the last level reached. A compression curve in one run: note the meter reading at each step against the times in the log, or read them off the report. |

The Run tab's radio box shows the generator line: the signal, the current TX gain and scale, the key state with its on-time (and, with **PA** ticked, the cooling countdown), and the sweep. A watchdog releases the transmitter if the program stops responding while keyed. The report is a single page: the settings and every key event, level step, and signal change with its UTC time; it lands in the archive folder.

A typical bench session: a **Dry run** first to hear the relays click in the right order; then the B210 into the driver through an attenuator, with the power meter on the output, at **TX gain** 0 and **Digital scale** -20 dB; **KEY**, raise the gain until the meter reads the driver's rated 20 W, **UNKEY**; then **KEY** with **Sweep** set across the last 20 dB in 1 dB steps to find the 1 dB compression point. Know the driver's maximum input before you raise the gain: the B210 can deliver about +10 dBm, far more than a high-gain driver needs. Never run the generator into an amplifier without the load or the antenna connected, and keep **PA** ticked whenever the amplifier is in the chain.

## 5. The Run tab: what to watch

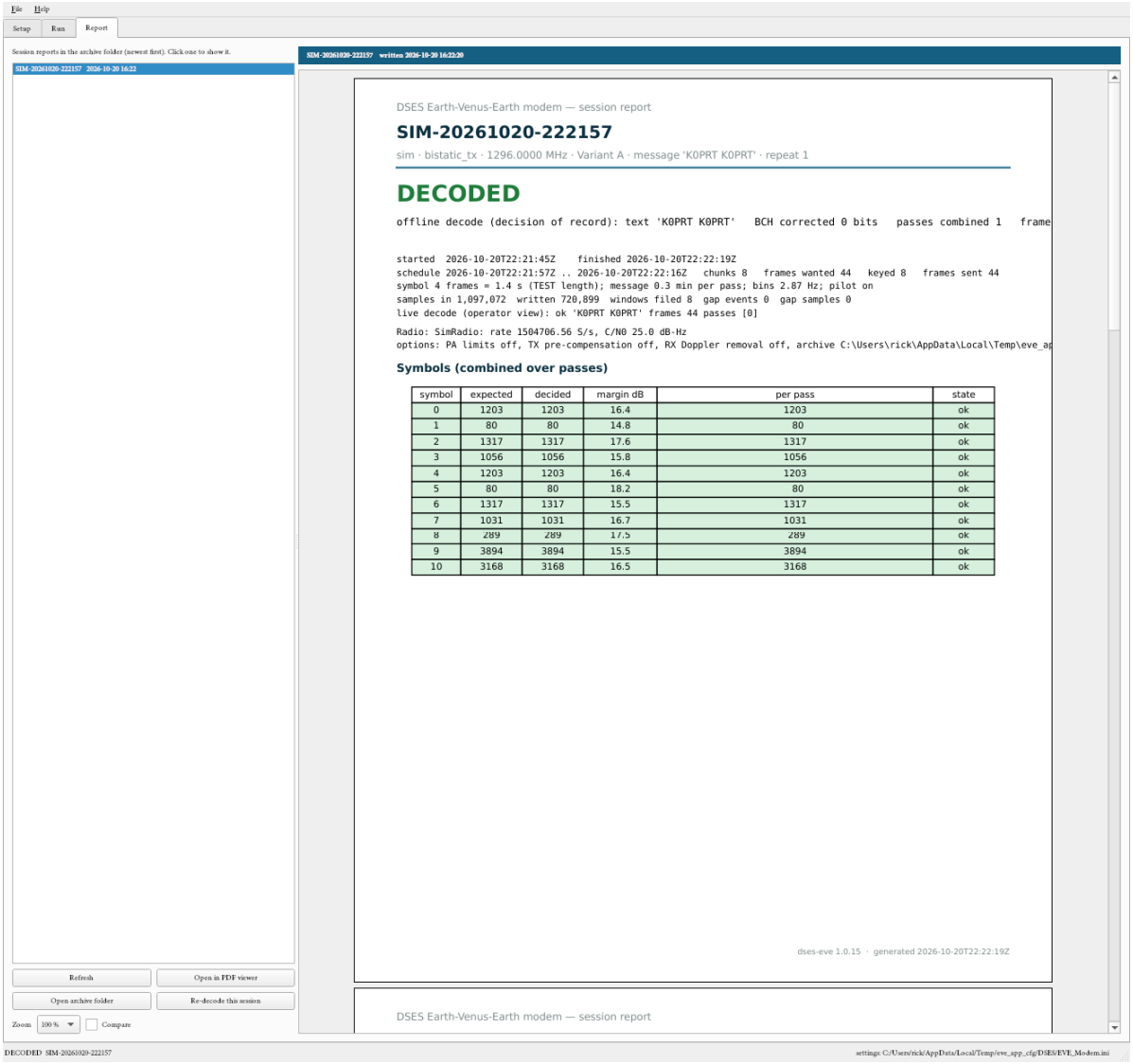



*Run tab*

| Panel | What a healthy run looks like |
|---|---|
| **Phase badge (top right)** | Colored by state. Amber while the program is busy before the session (opening the radio, GPS clock, ephemeris, schedule) and after it (draining and closing the archive, closing the radio, offline decode window n of N, writing the report). Teal during the session: waiting (a timed start, with the first chunk's time) → armed → TX chunk n of N → listening for chunk n → … → stopping after chunk n (after STOP). Green DECODED or red NOT DECODED / ABORTED / FAILED at the end, and it stays there while the Report tab shows the result. If the badge is amber, the program is working; give the decode a few seconds per window. |
| **STOP and ABORT** | STOP after this chunk (amber) lets the chunk in progress finish and its echo arrive, keys no more, and goes on to the decode and the report. ABORT (red) releases the key at once and stops everything; use it for a fault. |
| **Clocks** | UTC (PC) and device time agree to milliseconds when the time was set on a PPS. |
| **Tone strip** | One bright dot per row (one tone per frame) that steps to a new column at each symbol boundary; a steady column during the pilot. The background is receiver noise. A blank strip means no signal, wrong RX gain, or the receive window is closed (between chunks). At Venus strength single frames show nothing: that is expected. |
| **Current symbol** | The sum over the frames of the symbol in progress. The yellow dashed line is the tone we sent; the solid red line with a dot on its peak is the leader. On the bench they coincide from the first frame; on Venus the peak climbs out of the noise as frames add up. |
| **Running decisions** | One row per symbol: expected, decided, margin in dB, frames summed. Green rows agree with what we sent. The line under the table shows the message the live accumulators would decode now. |
| **Schedule** | The countdown first: what the station is doing now and how long it lasts, big and colored (red TRANSMITTING with the seconds left in the chunk; teal LISTENING / RECEIVING ECHO until the echo window closes; slate NEXT TX or WAITING FOR START until the next key-down, in hours:minutes:seconds for a timed start; amber STOPPING after STOP). Under it the chunk in progress, chunks complete, session start and end, time remaining, frames wanted vs received. |
| **Key lamp** | Red while the transmitter is keyed; the line beside it reads TX and LNA state and names the outputs in use (the USB relay board, the B210 GPIO lines, or both), with any fault (a board that stopped answering). The transmitter is keyed 200 ms before the RF and released 100 ms after; the LNA switches off a guard time before that and back on a release time after. |
| **Radio and ephemeris** | LOCKED must be shown on the air. LO offset ok in both directions. GPS clock: sat LOCK, PLL LOCK. Target azimuth, elevation, round trip, Doppler, and rate. |
| **Log** | Every step the program took, keying events, radio messages, decode results. |

The live decisions are a view for the operator; the decision of record is the offline decode of the archived windows that runs when the session ends and appears in the report.

## 6. The Report tab




*Report tab*

When a run ends the program decodes the archive, writes `<session>_report.pdf` beside the session log, and shows it here: the verdict, the decisions with margins per pass, the chunk timeline with key events, the per-window synchronization (pilot offset, tracker residual, sample gaps), and the key-event list.

- **Open in PDF viewer** for printing or sending.
- **Open archive folder** to reach the raw files.

- **Re-decode this session** runs the offline decode again on the archived windows and rebuilds the report (after a software fix, or to try without the pilot).
- Earlier reports in the same folder are listed; click one to view it. The teal bar over the pages names the report shown.
- **Compare** opens a second pane with its own chooser, so two runs sit side by side (Zoom 50 % fits both on a laptop screen).

## 7. The test sequence at the site

1. **Software simulation** at C/N0 20 dB-Hz, test-length symbols: proves the program on the site PC. One minute.
2. **Bench loopback**, Variant B (the default; on the Raspberry Pi never A), test length, TX gain 0, GPS clock ticked, clock source external: proves the B210, the reference lock, the PPS time set, the archive, the decode. About two minutes. Both passes should decode at 20 dB or more of margin.
3. **Bench loopback, full length, one pass** (34 minutes): proves the long streams with no underruns and the amplifier-limit chunking at real length. Run it once per PC.
4. **EME**, test length first, then full length, Variant B, pilot 1 frame (the EME defaults), with the dish on the Moon: the echo path, the Doppler pre-compensation, the sequencer, the LNA, and the gains. Expect the echo in the receive windows 2.5 s after each chunk.
5. **Venus**: press *Set defaults* in EVE mode (full length, seven passes, start *when the target rises, minimum elevation 10 degrees), check the day with* Operations schedule *and* Preview schedule*, and press START any time before Venus reaches 10 degrees (about 14:20 UTC on 24 October): the program waits with the radio open, sends the passes, and stops by itself when they are done or when Venus drops below 10 degrees (about 22:27 UTC). STOP after chunk ends the day early with the passes in hand.

After every run, read the report before deciding the next step. Keep the archive folder; the raw windows can be decoded again later.

### 7.1 The interop test with ORI

Both ends agree on four things beforehand: Variant A with full-length symbols, the dial frequency, the message (K0PRT K0PRT), and the UTC start of the transmission. In the program choose **Interop with a partner station**, tick **full length**, and set the start either as "now + lead" (tell the partner the time the preview shows) or as the agreed UTC time.

- **Transmit only**: we send the message; the partner's receiver decodes it. Their result is the test result. Our report shows what left the radio.
- **Receive only**: the partner transmits from their generator, which has no pilot: **untick Pilot**. We send no RF and key nothing. After the run the decoder searches for their actual start within the **start search range** (30 frames = ±10 s around the agreed time; widen it if their start is looser) and the report says by how many frames they were off and whether the message decoded.

Cable and attenuator: the B210 puts out up to +8 dBm, and its receiver wants no more than about −20 dBm at RX2, so 30 to 40 dB of attenuation between two radios on the bench.

## 8. When something is wrong

| Symptom | What it means and what to do |
|---|---|
| **"GPS clock not locked; refusing to start"** | The Leo Bodnar clock has no satellite or PLL lock. Check the antenna's sky view and the LEDs; wait a few minutes after power-up; after reprogramming the PLL drops for a few seconds and relocks within 20 s. |
| **"reference not locked (external)"** | No 10 MHz at REF IN, or the clock is not locked. Check the OUT1 cable and the clock's LEDs. |
| **"USRP time did not take on the PPS edge"** | No PPS at PPS IN. Check OUT2 to PPS IN (output 2 must be disabled: the program does that). As a fallback tick host-timed. |
| **"PPS verify False" in the log** | Same as above: no second PPS edge was seen. |
| **A storm of 'L' or LATE_COMMAND in the log at the start** | The radio was not armed in time. Increase the lead time (15 s or more) and close other programs. |

| Symptom | What it means and what to do |
|---|---|
| **"TRANSMITTER UNDERRAN" in red on the Run tab's radio line, in a notice box and in the report; a 'U' then a burst of 'L' in app.log** | The host could not generate the transmit samples in time (an underflow). From 1.0.17 the stream re-times itself: the log says "TX RESYNC n: the transmit stream was x s behind ... skipped ahead", the frames in those seconds are lost (the chunk in progress is named), and the rest of the run goes out on time; the warning counts the resyncs. Before 1.0.17 every packet after the underflow was late and dropped and nothing reached the air for the rest of the run (Haswell, 20 and 23 October). Causes: Variant A's 1.5 MS/s on the Raspberry Pi 5 (use Variant B, the default), the Pi running hot (it throttles its clock near 80 C: give it air, read `vcgencmd get_throttled`, 0x0 is clean), a remote-desktop streamer or other programs on the CPU, a USB hub instead of a direct USB 3 port. Repeated resyncs mean the host cannot keep up at all: stop and fix the cause. The counts (underflows, late packets, resyncs) are in the session JSON under `tx_events`. |
| **'O' or overflows in the log** | The PC dropped receive samples. One short overflow at start-up is known and padded; repeated ones mean the PC is too busy: close other programs, use a direct USB 3 port. The archive records every gap. |
| **Blank tone strip during a receive window** | No signal or wrong RX gain. On the bench check TX gain 0 and nothing on the antenna ports; on the air check the LNA and the sequencer. |
| **Decisions wrong on the bench** | Reference unlocked (frequency off), or the LO offset fell back (the radio line says so). Do not go on the air until the bench decodes. |
| **"a chunk of N frames cannot hold the pilot frames plus data"** | The chunk is too short for the pilot. Bench and interop chunks are raised by the program; on the Moon the 2.4 s chunk holds six Variant A frames (three of Variant B), so the pilot is capped at four (one), and a chunk shortened afterwards may need the pilot set again. Variant B on the bench: use a chunk of 4 s or more (the message says the minimum). |
| **The Keying group's Switching reads "none" after the program was restarted or updated** | Before 1.0.20 the saved choice was lost on every start, and a run then keyed neither the PA nor the LNA (the key lamp still shows the timing). From 1.0.20 the choice is kept; a Moon or Venus START with Switching at "none" asks "Start anyway, without keying?". Check the Keying group once after any update. |

| Symptom | What it means and what to do |
|---|---|
| **"the run worker stopped without a result"** | The run process ended without reporting. Read the last lines of `app.log` before it (section 3 names the log folder). Before 1.0.10 a full-length sky schedule could trip a timestamp rounding fault in the program itself (one timestamp in a thousand written a second early; fixed), and the message appeared while the worker was in fact still running. |
| **"chunk would hold no frames"** | The chunk settings leave no room between the round trip and the guard. Restore the mode's defaults. |
| **"the stop ... is not after the start" or "no chunk fits between the start ... and the stop"** | The stop (the UTC stop, or the target setting below the minimum elevation) comes before a chunk and its echo could complete. Start earlier, stop later, or lower the minimum elevation; the preview's OPERATIONS block shows the day's window. |
| **"does not reach 10 deg within two days"** | Start *when the target rises* was chosen but the target stays below the minimum elevation for two days from now. Check the target (Moon or Venus) and the minimum elevation, or set a UTC start. |
| **Horizons unreachable** | The ephemeris source falls back to astropy with the local DE440s. The Doppler differs by up to 10 Hz at 13 cm; acceptable, but note it in the log. |
| **"the run worker died while opening the radio ... retrying"** | Every run lives in its own worker process, and opening the B210 faults about one time in seven on Windows (a UHD fault, not the radio). The program retries the open up to three times by itself; the log shows each try. If all three fail, power-cycle the B210 (USB and DC off for 15 s) and Start again. The window never closes because of it. |
| **The program closes by itself** | A native library crashed. Two files in the log folder (section 3) tell the story: `app.log` (everything the program printed) and `fault.log` (the traceback of a hard crash). Send both. If the B210 was left streaming by a program that was killed, power-cycle it (USB and DC off for 15 s) before the next try. |
| **A PDF (report or guide) opens in LibreOffice Draw with text spilling over the right margin (Linux)** | Draw imports the PDF for editing with substitute fonts; the file is fine (the Report tab renders it with its embedded fonts). The program now opens PDFs in a viewer (Evince, Okular, Firefox) when one is installed; to fix the desktop default: `xdg-mime default org.gnome.Evince.desktop application/pdf`. |
| **Help → Check for updates says "urlopen error timed out"** | The server sometimes takes 10-15 s to accept the first connection and is instant after that. Try again; the second check goes through. (From 1.0.5 the check waits 30 s and tries twice by itself.) |
| **The program will not start from the icon** | Read `app.log` in the log folder (section 3). The project environment must exist in `.conda` next to the program. |

## 9. Files a run produces

In the archive folder, all named by the session id (mode and UTC start):

- `<session>.json` — the schedule (the contract with any partner station).
- `<session>_<target>_haswell.csv` — the ephemeris table used (sky sessions).
- `<session>_NN.eve.iq` + `.json` — one receive window per chunk, complex float samples at the modem rate with a sidecar (start time, first frame, gaps).
- `<session>_session.json` — the session log (times, keying, radio, live decode).
- `<session>_report.pdf` — the report.

## 10. Installing on another computer

The program is a zip, `eve-modem-<version>.zip`, from `https://gpstime.com/sw_distribution/eve-modem/` (the folder also holds this guide and the design document). It carries no Python: it runs on a conda environment with GNU Radio, UHD, PySide6, and a few pip packages, the same radioconda base the DSES Workbench uses. Windows, macOS, and Linux (including a Raspberry Pi 5 with the aarch64 radioconda) use the same zip.

1. Install radioconda (https://github.com/ryanvolz/radioconda) or any conda with the

   conda-forge channel.

2. Unzip the release; it makes one folder `eve-modem-<version>`.
3. In that folder create the program's environment from the included file:

```
conda env create --prefix .conda -f environment.yml
```

   (about 3 GB; ten minutes). This installs gnuradio, uhd, numpy, scipy, astropy, jplephem, pyside6, pyqtgraph, matplotlib, pytest, and the pip extras galois, sigmf, hidapi, pymupdf, pyserial. On Linux the USB HID clock and the CH340 relay need the usual udev permissions (a rule for USB 1dd2:2210, membership of `dialout`).

   **One-command version of steps 1-4 for a Mac or Linux machine that already has radioconda** (adds the extras, downloads and verifies the zip, unzips into `~/Applications`, starts the program, shows the log if it dies):

```
curl -fsSL https://gpstime.com/sw_distribution/eve-modem/mac_first_run.sh | bash
```

**Lighter alternative** if the machine already runs the DSES Workbench from radioconda: skip the new environment and add the extras to radioconda instead, then the launcher finds it by itself:

```
~/radioconda/bin/pip install galois sigmf hidapi pymupdf pyserial astropy jplephem
```

(Windows: `C:\ProgramData\radioconda\Scripts\pip.exe install ...` with the same list; the launcher finds radioconda in `C:\ProgramData` or your profile by itself, or set `EVE_PYTHON` to a `python.exe`. If an extra is missing the launcher says which one and how to add it.)

**Linux: install a PDF viewer** if the desktop has none (Ubuntu with LibreOffice opens PDFs in Draw, which re-flows them with substitute fonts). Evince is the one to have:

```
sudo apt install evince
```

4. Start it: Windows `launcher.bat` (or `install-shortcut.ps1` once for a desktop icon); macOS `launcher.command` (or `install-shortcut.command` once for an app on the Desktop); Linux `bash launcher.sh` (or `install-shortcut.command` once for a menu entry). The launchers use `.conda` beside the program if it exists, else `EVE_PYTHON`, `RADIOCONDA_ROOT`, `CONDA_PREFIX`, or `~/radioconda`.
5. First run: choose **Software simulation**, press Start, and watch a message decode with no hardware at all. Then the bench loopback with a B210.

Updates arrive through Help → Check for updates (section 3). The B210 needs the UHD FPGA images (`uhd_images_downloader` in radioconda) the first time it is opened.

## 11. Command-line equivalents

The window drives the same code as the tools in `tools/`: `eve_session.py plan | run | sim`, `eve_bench.py`, `eve_decode.py`, `eve_txcw.py` (one comb tone into the lab counter), `eve_ops_schedule.py` (the operating schedule table for any span of days), and `python -m eve.gpsdo status | config | preflight` for the GPS clock. Use them for scripted tests and for the field log; the design document section 5.1 lists their options.