APPENDIX A

ModVibe 2.0 Register Map

Public Modbus RTU interface

Appendix contents

This document defines the customer-accessible holding-register interface for ModVibe 2.0 application firmware. It covers device identity, temperature and health, waveform capture, paged data transfer, and an optional baud-rate boost for faster waveform downloads.

⚠ Contract-first integration

This register map defines the exact application firmware 1.03 tuple: identity 2, map 3, capture 5, data window 3, and FIR catalog 3. Require `APP_VERSION 0x00000103` and those contract values together. Reject mixed tuples and do not infer compatibility from a later firmware version.

Document scope

- Application-mode Modbus holding registers
- Zero-based protocol addresses
- Access type, data format, units, and value definitions
- Capture control and paged waveform retrieval
- Error and status codes

Unlisted addresses are reserved. Service, provisioning, calibration-write, bootloader access, FIR coefficients and catalog slot details, test fault-injection, and raw debug interfaces are outside this public register map. Contact iQunet for bootloader entry or unit-ID commissioning.

Addressing convention

Register addresses in this document are PDU addresses as transmitted on the wire. Some PLC tools display holding register 0 as 40001. Configure that translation in the tool, not in the device protocol.

First integration target

Implement and verify the direct-capture path before adding the baud-rate boost. Follow the quick-start sequence in the right column; advanced workflows are documented in their dedicated sections.

Public address blocks

Start	End	Function
0	13	Identity and firmware versions
32	36	System status and unit ID
38	38	Restart command (write-only)
48	54	Sensor temperatures
55	63	Temperature-calibration readback
100	110	Health supervision
200	229	Capture control and status
500	514	Fast-transfer status and recovery evidence
520	526	Fast-transfer command
1000	1124	Waveform data window
1200	1200	FIR catalog compatibility header

Quick start: direct capture

1. Connect using Modbus RTU at 115,200 bit/s, 8-N-1, and the assigned unit ID.
2. Read registers 0–13 and require identity contract 2, application version 0x00000103, and register-map contract 3.
3. Read registers 200–201 together and register 1200 separately. Require capture contract 5, data-window contract 3, and FIR catalog contract 3.
4. Write one complete capture configuration.
5. Write START to register 204 and poll `CAPTURE_STATUS` (202).
6. When READY, page through registers 1000–1124 using the explicit offset at registers 228–229.

Optional faster download

For the baud-rate boost and recovery procedure, see Sections A.9 and A.10.

A.1 Protocol conventions

A.1.1 Serial and framing

Parameter	Value
Physical layer	Two-wire RS-485
Normal baud rate	115,200 bit/s
Character format	8 data, no parity, 1 stop
Unit ID	Printed on device label
Valid unit-ID range	1–247
Read Holding Registers	FC03
Write Single Register	FC06
Write Multiple Registers	FC16
Read limit	125 registers
Multiple-write limit	123 registers

Modbus CRC-16 is transmitted low byte first. Values inside the Modbus PDU use the normal big-endian byte order.

Broadcast START at register 204 requests near-simultaneous direct captures. Modbus devices do not respond to broadcast requests, so poll each device afterward and verify status, error, and waveform ID before downloading data.

A.1.2 Word and integer order

Every register is one unsigned 16-bit protocol word. Signed 16-bit values use two's complement. A 32-bit value occupies consecutive `HI` and `LO` registers:

```
value = (HI « 16) | LO
```

Read related multiword values as one coherent block in a single FC03 (Read Holding Registers) transaction.

A.1.3 Access notation

Mark	Meaning
R	Read-only
R/W	Read/write
W	Write-only command; cannot be read back

- Unsupported function code: exception 01 (illegal function).
- Unsupported address: exception 02 (illegal data address).
- Invalid value: exception 03 (illegal data value), unless the relevant feature contract defines a more specific in-band error or status result.

A.1.4 Atomic capture configuration

Use function 16 (Write Multiple Registers) for capture-configuration block writes and for all 32-bit register pairs. Any configuration change immediately invalidates previously ready output. Complete the capture configuration before writing START.

> **⚠ Modbus TCP-to-RTU and client ownership**
>
> Capture configuration, waveform ID, window offset, and returned data pages form one transaction. Serialize access per device, especially through a Modbus TCP-to-RTU gateway, to prevent another client from replacing the configuration or seeking the shared window.

A.1.5 Retry after a timeout

After a write timeout, safely repeat configuration and seek writes with the same values. Before repeating START, read status and waveform ID to determine whether the capture started. A repeated START clears the current output and begins a new capture.

A.2 Identity and version registers

Addr.	Name	Access	Format	Description
0	`ID_MAGIC_HIGH`	**R**	u16	Fixed `0x4649`
1	`ID_MAGIC_LOW`	**R**	u16	Fixed `0x5642`
2	`ID_CONTRACT`	**R**	u16	Identity contract; current `0x02`
3	`MAP_CONTRACT`	**R**	u16	Register-map contract; current `0x03`
4	`HW_GENERATION`	**R**	u16	Hardware generation; current `0x01` (revision A)
5	`FEATURE_FLAGS`	**R**	bits	Identity feature flags; current `0x0000` (none)
6–8	`DEVICE_ID`	**R**	3 × u16	Provisioned 48-bit MAC address, high word first
9–10	`APP_VERSION`	**R**	u32	Application version, HI then LO
11–12	`BOOT_VERSION`	**R**	u32	Bootloader version, HI then LO
13	`BOOT_CONTRACT`	**R**	u16	Boot contract version

- `ID_MAGIC`: Identifies ModVibe during automatic device discovery and Modbus bus scans.
- `ID_CONTRACT`: Verify before interpreting identity registers 0–13.
- `MAP_CONTRACT`: Versions the public register map; reject unsupported values.
- `FEATURE_FLAGS`: Reserved for future identity capabilities; current firmware reports `0x0000`. Reject unsupported bits.

A.3 System status and restart

Addr.	Name	Access	Format	Description
32	`RESERVED`	**R**	u16	Unused; reads 0
33	`SYSTEM_STATUS`	**R**	enum	System-command result: 1 completed; 2 in progress; 3 failed
34	`LAST_COMMAND`	**R**	u16	Last system command value
35	`ACTIVE_UNIT_ID`	**R**	u16	Active Modbus unit ID
36	`UNIT_ID_MIRROR`	**R**	u16	Runtime configuration mirror
37	`RESERVED`	–	–	Not readable or writable
38	`RESTART_COMMAND`	**W**	enum	`0x5201` restarts the application

> **ⓘ System and capture status**
>
> `SYSTEM_STATUS` and `LAST_COMMAND` report service-command results; they do not indicate device health or capture progress. Use `HEALTH_STATUS` (101) or `CAPTURE_STATUS` (202) instead.

A.3.1 Unit ID commissioning and block reads

The factory-assigned Modbus unit ID is printed on the device label and lies in the range 1–247. `ACTIVE_UNIT_ID` (35) and `UNIT_ID_MIRROR` (36) are runtime values and normally match; register 36 is not persistent-storage readback. A controlled commissioning interface can change the runtime unit ID or persist a new assignment for later application starts. Contact iQunet for access.

For block reads, stop at register 36. Registers 37 and 38 are not readable and must not be included in that FC03 request.

A.3.2 Application restart

Write `0x5201` to register 38 only with FC06 and never broadcast the command. The device sends the write response before restarting. The Modbus link then disappears; reconnect at 115,200 bit/s using the assigned unit ID and repeat the identity and contract checks before continuing.

A.4 Temperature

A.4.1 Temperature registers (48–54)

Addr.	Name	A	Format	Description
48	TEMP_ADXL380	R	i16	0.1 °C/count
49	TEMP_ADXL382	R	i16	0.1 °C/count
50	TEMP_ADXL380_RAW	R	i16	Sign-extended 12-bit code
51	TEMP_ADXL382_RAW	R	i16	Sign-extended 12-bit code
52	TEMP_STATUS	R	bits	Validity/calibration flags; see Section A.4.2
53	TEMP_ADXL380_AGE	R	u16	Seconds since refresh
54	TEMP_ADXL382_AGE	R	u16	Seconds since refresh

TEMP_ADXL380 (48) and **TEMP_ADXL382** (49) report each accelerometer's internal temperature at 0.1 °C per count.

These values do not represent exact machine-surface or ambient-air temperatures. The IP67/IP68-rated enclosure and sensor packages introduce thermal delay, and internal power dissipation can add a temperature offset. See Section 3.1 of the main datasheet for details.

TEMP_ADXL380_RAW (50) and **TEMP_ADXL382_RAW** (51) expose sign-extended, uncalibrated 12-bit temperature codes. See the Analog Devices ADXL380 data sheet and ADXL382 data sheet for encoding and conversion details.

TEMP_STATUS (52) contains the validity, freshness, and calibration flags defined in Section A.4.2.

TEMP_ADXL380_AGE (53) and **TEMP_ADXL382_AGE** (54) report the elapsed seconds since the corresponding reading was refreshed.

A.4.2 Temperature status bits (register 52)

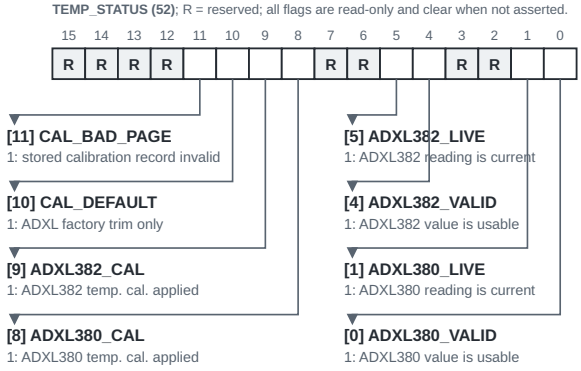


Figure 1: **TEMP_STATUS** (52) bit definitions, repeated for reference.

ADXL380_VALID (52.0) and **ADXL382_VALID** (52.4) indicate that a usable temperature is stored for the corresponding sensor. Require the corresponding VALID flag before using the temperature.

ADXL380_LIVE (52.1) and **ADXL382_LIVE** (52.5) indicate that the latest asynchronous refresh succeeded for the corresponding sensor. LIVE alone does not guarantee a recent reading. Use **TEMP_ADXL380_AGE** (53) or **TEMP_ADXL382_AGE** (54) to apply the application's freshness limit. If VALID is set while LIVE is clear, the snapshot contains the last usable stored value and the AGE register gives its age.

ADXL380_CAL (52.8) and **ADXL382_CAL** (52.9) indicate that device-specific temperature calibration was applied to the corresponding temperature value. **CAL_DEFAULT** (52.10) indicates that only the accelerometer's factory trim is in use. **CAL_BAD_PAGE** (52.11) indicates that the stored calibration is invalid.

> **Temperature polling**
>
> Read 48–54 as one coherent cached snapshot. A read returns immediately. A missing or stale snapshot queues one asynchronous refresh after the Modbus response; no sensor I2C occurs inline. Physical captures also request a refresh. Without temperature reads or physical captures, the cache can remain stale indefinitely. A failed refresh preserves the last VALID value and age but clears the affected LIVE bit.

A.4.3 Temperature-calibration readback

Addr.	Name	A	Format	Content
55	CAL_STATUS	R	bits	Active calibration state
56	CAL_VERSION	R	u16	Current schema version 0x01
57–58	CAL_GENERATION	R	u32	Commit count, HI/LO
59	ADXL380_OFFSET	R	i16	Offset, 0.1 °C/count
60	ADXL382_OFFSET	R	i16	Offset, 0.1 °C/count
61	CAL_REFERENCE	R	i16	Reference, 0.1 °C/count
62	ADXL380_CAL_RAW	R	i16	Raw code at calibration
63	ADXL382_CAL_RAW	R	i16	Raw code at calibration

CAL_STATUS (55) summarizes the active calibration record. Its flags show whether the record is valid, which sensor corrections are applied, whether factory defaults are in use, and whether an invalid stored page was detected.

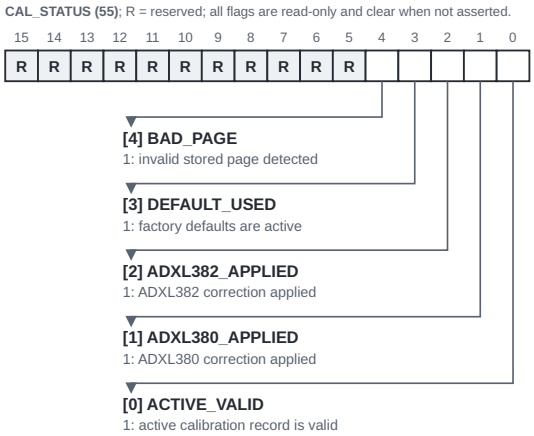


Figure 2: **CAL_STATUS** (55) bit definitions.

CAL_VERSION (56) identifies the format of the active calibration record. The current schema is 0x01; the register is zero when no valid stored record is active.

CAL_GENERATION (57–58) is a 32-bit counter, high word first. It increments after each successful calibration commit. Firmware stores two redundant calibration pages and uses this counter to select the newest valid record at startup.

ADXL380_OFFSET (59) and **ADXL382_OFFSET** (60) contain signed corrections. Under schema 0x01, firmware first converts the raw sensor code to an uncalibrated temperature and then applies the corresponding offset:

$$T_{\mathrm{cal}} = T_{\mathrm{uncal}} + T_{\mathrm{offset}}.$$

- T_{cal} is **TEMP_ADXL380** (48) or **TEMP_ADXL382** (49).
- T_{uncal} is obtained by converting the corresponding **TEMP_ADXL380_RAW** (50) or **TEMP_ADXL382_RAW** (51) value as specified in its ADXL data sheet.
- T_{offset} is **ADXL380_OFFSET** (59) or **ADXL382_OFFSET** (60).

All three formula terms use 0.1 °C units.

CAL_REFERENCE (61) records the reference temperature used for the calibration. **ADXL380_CAL_RAW** (62) and **ADXL382_CAL_RAW** (63) record the corresponding sign-extended raw sensor codes captured at that calibration point.

A.5 Health

Registers 100–110 expose one coherent health-supervisor snapshot. The “live” fields describe the latest completed supervisor cycle; retained fields preserve the most recent failed check and the firmware response.

Health diagnostics identify inconsistent internal firmware state. They are not a comprehensive hardware self-test. They do not report the outcome of a specific capture. Use each feature’s own status and error registers for that purpose.

A.5.1 Health registers (100–110)

Addr.	Name	A	Format	Description
100	HEALTH_CONTRACT	R	u16	This contract: 0x01
101	HEALTH_STATUS	R	enum	Latest cycle: 0 OK; 1 FAULT
102–103	RUN_COUNT	R	u32	Supervisor cycles, HI/LO
104–105	FAULT_COUNT	R	u32	Failed checks, HI/LO
106	FAULT_BITS	R	bits	Latest-cycle fault mask
107	LAST_OWNER	R	enum	Service subsystem code
108	LAST_VALIDATOR	R	enum	Service check code
109	LAST_ACTION	R	enum	Retained response
110	LAST_FAULT_BITS	R	bits	Retained fault mask

HEALTH_CONTRACT (100) versions the layout and semantics of registers 101–110. Require 0x01 before interpreting the remaining fields.

The supervisor runs every 100 ms. It checks the protected states used for Modbus communication, capture, and fast transfer. Depending on the failed check, firmware takes one of three actions:

- repairs the state;
- stops the affected operation in a safe error state; or
- records the fault condition without changing the state.

A.5.2 Current status and counters

HEALTH_STATUS (101) reports whether the latest supervisor cycle found a fault. FAULT_BITS (106) identifies every subsystem that failed in that cycle. Both are recalculated each cycle and clear after a healthy cycle.

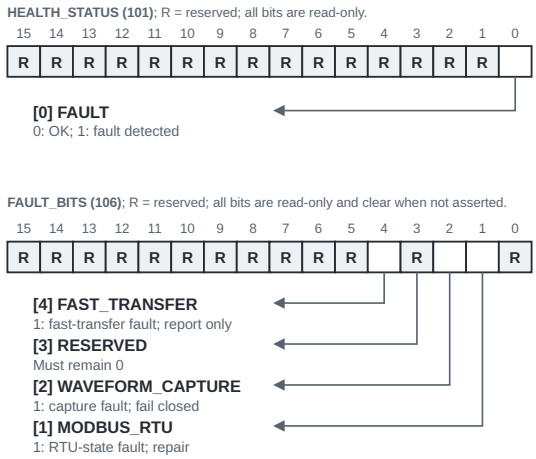


Figure 3: HEALTH_STATUS (101), FAULT_BITS (106), and firmware responses, repeated for reference.

RUN_COUNT (102–103) is a 32-bit counter, high word first, that increments once per completed supervisor cycle. A change between reads confirms that supervision is running.

FAULT_COUNT (104–105) is a 32-bit counter, high word first, that increments once for each failed check. A persistent fault can add one count every 100 ms, and several failed checks can add several counts in one cycle. Within one application run, a counter increase reveals intermittent faults that cleared before polling.

A.5.3 Fault diagnosis and recovery

When a check fails, firmware updates registers 107–110 as one retained record. Healthy cycles leave this record unchanged. If several checks fail during one cycle, it describes the last check processed. A nonzero retained value therefore does not by itself indicate an active fault. The health block is volatile and cleared on every application start, including a commanded restart, watchdog recovery, or power cycle. Save the snapshot first.

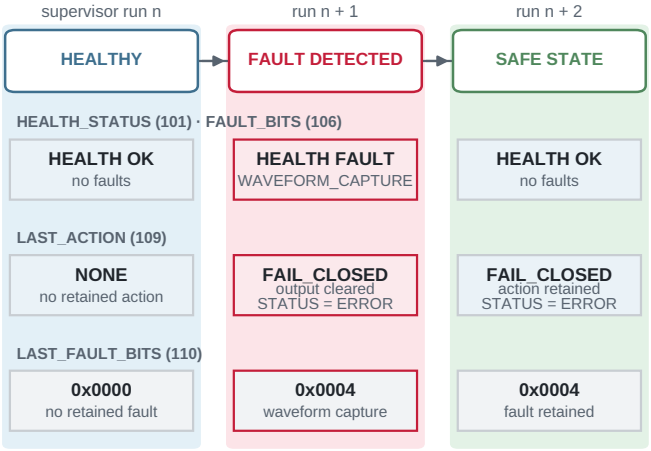


Figure 4: Latest-cycle faults clear; the retained record preserves the latest fault and response.

LAST_FAULT_BITS (110) identifies the most recently retained fault using the same bit definitions as FAULT_BITS (106) and selects the corresponding table row. LAST_ACTION (109) records the firmware response; verify that it matches the listed response.

Apply the listed next step only when diagnosing a newly observed fault. An older retained record does not require the recovery action to be repeated.

Fault mask	Area	Response (109)	Next step
0x0000	None	0, NONE	No retained fault
0x0001	Reserved	N/A	N/A
0x0002	Modbus RTU	3, REPAIR	Verify SYSTEM_STATUS (33) is valid and mirrors 35–36 match the assigned ID
0x0004	Waveform capture	2, FAIL_CLOSED	Discard result; reconfigure and retry
0x0008	Reserved	N/A	N/A
0x0010	Fast transfer	1, REPORT_ONLY	Stop requests; follow Section A.10.2

Implementation workflow.

1. On connection, read 100–110 in one FC03 transaction and require HEALTH_CONTRACT=0x0001. Store the snapshot as the baseline. A retained fault is historical unless its live bit is set.
2. Within one application run, use HEALTH_STATUS and FAULT_BITS for active faults. A changed FAULT_COUNT proves that at least one check failed since the previous poll; it is not an event count.
3. For each set FAULT_BITS bit, use the table to identify the area. If the live mask is clear, LAST_FAULT_BITS identifies the most recent area. For detail, read 33–36 (Modbus RTU), 200–229 (capture), or 500–514 (fast transfer).
4. Use feature-specific status and error registers to determine success and retry. A cleared health bit confirms only internal consistency.

LAST_OWNER (107) and LAST_VALIDATOR (108) are opaque service-diagnostic codes.

A.6 Configure a waveform capture

Use Sections 1 and 2 of the main datasheet to choose the sensor, range, output rate, and record length. The tables below show how to encode those choices in the capture request. Section A.7 explains how to start and monitor the request; Section A.8 explains how waveform data is paged for Modbus download.

All capture-block addresses from 200 through 229 are readable. Only fields marked **R/W** are writable. Registers 205–213 form the capture request, and register 204 is the command register.

A.6.1 Contracts and capture request

Require `CAPTURE_CONTRACT`=`0x0005` before interpreting registers 202–227. Section 1.6 of the main datasheet explains the waveform configuration.

Addr.	Name	A	Format	Description
200	`CAPTURE_CONTRACT`	R	u16	Require `0x0005`
201	`WINDOW_CONTRACT`	R	u16	Require `0x0003`
202	`CAPTURE_STATUS`	R	enum	Lifecycle; see Section A.7
203	`ERROR`	R	enum	Result/error; see Section A.7
204	`CONTROL`	R/W	enum	0 IDLE; 1 START
205	`SOURCE`	R/W	enum	2 ADXL380; 3 ADXL382
206	`CHANNEL_MASK`	R/W	bits	Require `0x0007`: X/Y/Z
207	`OUTPUT_RATE_HZ`	R/W	u16	Per-axis values: **ADXL380**: 125, 250, 500, 1000, 2000, 4000, 8000 S/s; **ADXL382**: 125, 250, 500, 1000, 2000, 4000, 8000, 16000 S/s
208–209	`SAMPLES_PER_CHANNEL`	R/W	u32	HI/LO; 64, 128, 256, 512, 1024, 2048, 4096, or 8192
210	`FILTER_PROFILE`	R/W	enum	Require `0x0003`
211	`DOWNLOAD_POLICY`	R/W	enum	Require 1
212	`MAX_DOWNLOAD_MS`	R/W	u16	Require 30000 ms
213	`FULL_SCALE_G`	R/W	u16	ADXL380: 4, 8, or 16 g; ADXL382: 15, 30, or 60 g

Filter profile 3 applies FIR decimation at reduced rates and full-rate bypass at 8 kS/s for ADXL380 or 16 kS/s for ADXL382.

A.6.2 Result, capability, and paging registers

Require `WINDOW_CONTRACT`=`0x0003` before using registers 228–229 or the waveform-data window.

Addr.	Name	A	Format	Description
214–215	`OUTPUT_WORDS`	R	u32	3 × samples/axis
216–217	`CHUNK_COUNT`	R	u32	$\lceil$`OUTPUT_WORDS`$/122\rceil$
218–219	`EST_DOWNLOAD_MS`	R	u32	Paging estimate at 115,200 bit/s
220	`WAVEFORM_ID`	R	u16	Nonzero ID when READY
221–222	`MAX_OUTPUT_WORDS`	R	u32	Buffer capacity
223	`CHUNK_PAYLOAD_WORDS`	R	u16	= 122 payload words/page
224	`CHUNK_HEADER_WORDS`	R	u16	= 3 header words/page
225	`SUPPORTED_SOURCE_MASK`	R	bits	Bits 1/2: ADXL380/ADXL382; = `0x0006`
226	`SUPPORTED_CHANNEL_MASK`	R	bits	Bits 0/1/2: X/Y/Z; = `0x0007`
227	`NORMAL_MAX_DOWNLOAD_MS`	R	u16	Maximum download budget: 30,000 ms
228–229	`WINDOW_OFFSET`	R/W	u32	Payload offset; see Section A.8

Use registers 214–220 only while status is READY. Read them together before paging. Capability registers 221–227 do not expand the released combinations in Section A.6.1. `MAX_OUTPUT_WORDS` is buffer capacity, not an accepted request size; the largest released request is 24,576 words (3 axes × 8,192 samples/axis).

A.7 Write, run, and monitor a capture

Refer to Section 2.1 of the main datasheet for the complete capture and polling workflow.

A.7.1 Write the configuration

Write registers 205–213 together with FC16 (Write Multiple Registers) to store one complete capture configuration. START validates the configuration and its transfer budget before acquisition begins.

> **⚠ Configuration writes invalidate READY output**
>
> Any write to 205–213 stops the current request, invalidates a READY waveform, clears its metadata, sets `WAVEFORM_ID` (220) to `0x0000`, and sets status to CONFIGURED. Complete an active download before rewriting the request.

A.7.2 Status and control values

Value	Name	Meaning
`CAPTURE_STATUS` (202) enum		
0	IDLE	No active request
1	CONFIGURED	Stored; not started
2	ACQUIRING	Acquiring samples into SRAM
3	PROCESSING	Processing captured samples
4	READY	Output is valid
5	ERROR	Read `ERROR` (203)
`CONTROL` (204) enum		
0	IDLE	Cancel; clear output, error, and ID
1	START	Validate and begin acquisition

Values from 6 through 65535 are not valid `CAPTURE_STATUS` values. An aborted capture reports status ERROR (5) with `ERROR` (203) set to ABORTED (12). A client must treat any status value above 5 as an incompatible firmware state.

A.7.3 Start, poll, and retry

Before START. Read 202–220 together. Require status (202) = CONFIGURED, error (203) = NONE, waveform ID (220) = `0x0000`, and request block 205–213 to match the requested configuration.
Normal polling. Write START=1 to `CONTROL` (204) with FC06. After the expected record duration, read 202–203 with FC03 at one-second intervals. Status 2 or 3 with error NONE means capture is in progress. On READY, read 202–220 together; require status READY, error NONE, and a nonzero ID in that snapshot. IDs range from `0x1` to `0xffff` and wrap to `0x1`. ERROR is terminal; other combinations restart the identity and configuration sequence.
Unconfirmed START. After configuring several devices, broadcast START to request near-simultaneous captures on one RS-485 bus. Broadcast requests have no response, so poll 202–220 together on each device at the normal interval. Apply the normal outcomes above, except that a device remaining CONFIGURED with error NONE, ID `0x0000`, and matching 205–213 did not receive a valid broadcast START; retry START once by unicast.

A.7.4 Capture error values (register 203)

Value	Name	Meaning
0	NONE	No capture error
1	BAD_CONFIG	Invalid field or combination
2	UNSUPPORTED_SOURCE	Source not available
3	UNSUPPORTED_CHANNEL_MASK	Requested channel mask unsupported
4	UNSUPPORTED_RATE	Output rate not available
5	UNSUPPORTED_FILTER	Filter profile not available
6	OUTPUT_TOO_LARGE	Output exceeds device capacity
7	DOWNLOAD_BUDGET_EXCEEDED	Transfer exceeds policy
8	SENSOR_NOT_READY	Source cannot start
9	SENSOR_FAULT	Source reported a fault
10	PROCESS_OVERRUN	Processing did not keep pace
11	BUFFER_BUSY	Required buffer is unavailable
12	ABORTED	Capture aborted
13	INTERNAL_ERROR	Fail-closed internal error

A.8 Paged waveform data window

The data block at addresses 1000–1124 is always 125 registers: a three-word header followed by 122 signed payload words. The host selects a payload offset by writing the 32-bit `WINDOW_OFFSET` at 228–229, then reads all 125 data registers in one function-03 transaction.

Data address	Access	Format	Description
1000	**R**	u16	Waveform ID
1001	**R**	u16	Offset high word
1002	**R**	u16	Offset low word
1003–1124	**R**	i16	Payload; zero-padded at end

A.8.1 Random-access seek rules

- Offset 0 is always permitted.
- A nonzero offset must be less than `OUTPUT_WORDS`.
- A nonzero offset must be a multiple of 122 words.
- Write both offset words together with function 16.
- Reading a page does not auto-advance the offset.

Because reads do not mutate cursor state, the same page can be read again after a timeout or CRC failure. The returned header proves which waveform ID and offset the payload belongs to.

A.8.2 Payload layout

Vibration samples are signed 16-bit acceleration counts. Each X, Y, and Z block contains N consecutive time samples. The three blocks appear in this order:

```
X0 ... X(N-1), Y0 ... Y(N-1), Z0 ... Z(N-1)
```

A.8.3 Nominal waveform scaling

`SOURCE` (205)	`FULL_SCALE_G` (213)	Nominal LSB/g
2 (ADXL380)	4 (±4 g)	7500
2 (ADXL380)	8 (±8 g)	3750
2 (ADXL380)	16 (±16 g)	1875
3 (ADXL382)	15 (±15 g)	2000
3 (ADXL382)	30 (±30 g)	1000
3 (ADXL382)	60 (±60 g)	500

Convert waveform words from payload registers 1003–1124 to signed 16-bit two's-complement values. Divide each value by the applicable nominal LSB/g to obtain acceleration in g. This scale comes from the sensor data sheets; it is not a shaker-certified amplitude calibration.

A.8.4 Minimal page loop

1. Save `WAVEFORM_ID` (220) and `OUTPUT_WORDS` (214–215).
2. Set `WINDOW_OFFSET` (228–229) to 0 with FC16.
3. Read 125 registers from address 1000 with FC03.
4. Verify header: waveform ID (1000) and offset (1001–1002).
5. Append payload 1003–1124; stop at saved `OUTPUT_WORDS`.
6. If data remains, increment `WINDOW_OFFSET` (228–229) by 122 with FC16; repeat step 3.

> **Retry safety**
>
> On a timeout or CRC error, retry the same seek and page read. Never append a page unless its header matches the expected waveform ID and offset. This prevents stale, duplicated, or reordered data from entering a waveform.

A.8.5 FIR catalog compatibility header

Register 1200, `FIR_CATALOG`, is a read-only u16 compatibility header. Application firmware 1.03 reports `0x0003`. Clients shall use it only as part of the exact release tuple; FIR coefficient and catalog slot details are not part of this public interface.

A.9 Baud-rate boost

Fast transfer changes one ModVibe from 115,200 bit/s to 230,400 or 460,800 bit/s and requires exclusive ownership of the RTU bus until that device returns to 115,200 bit/s. These optional rates are ModVibe-specific, not standard Modbus defaults. Clients must implement the rate-change and recovery procedure before selecting them.

The lease is the maximum permitted interval between valid requests handled by the selected ModVibe while FAST_ACTIVE. Each request restarts the timer; traffic to another device does not. The lease limits the gap between requests, not the total session duration. Clients without boost remain fully compatible at 115,200 bit/s.

A.9.1 Fast-transfer status block (500–514)

Read registers 500–514 together with FC03 as one status snapshot.

Addr.	Name	A	Format	Description
500	`FAST_CONTRACT`	**R**	u16	Current `0x0002`
501	`FAST_STATUS`	**R**	enum	Current lifecycle
502	`FAST_ERROR`	**R**	enum	Error/fallback cause
503	`SUPPORTED_BAUD_MASK`	**R**	bits	Supported rate codes
504	`DEFAULT_BAUD_CODE`	**R**	enum	Nominal rate code
505	`ACTIVE_BAUD_CODE`	**R**	enum	Current rate code
506	`MAX_LEASE_MS`	**R**	u16	Maximum request gap
507	`GUARD_MS`	**R**	u16	Minimum switch guard
508	`CONFIRM_TIMEOUT_MS`	**R**	u16	Confirmation deadline
509–510	`ACTIVE_NONCE`	**R**	u32	Current session nonce
511	`SESSION_COUNTER`	**R**	u16	Accepted sessions
512	`FALLBACK_COUNTER`	**R**	u16	Fallback attempts
513	`RECOVERY_ACTION`	**R**	enum	Retained recovery action
514	`RECOVERY_ERROR`	**R**	enum	Retained recovery cause

Contract and state. `FAST_CONTRACT` (500) versions the block; require `0x0002`. `FAST_STATUS` (501) is the authoritative session state and is interpreted together with `FAST_ERROR` (502).

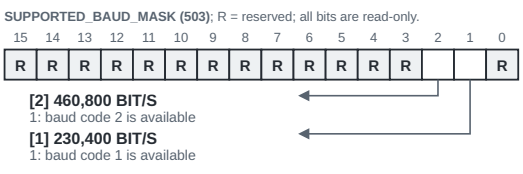
Value	`FAST_STATUS` (501)	Meaning
0	IDLE	Link uses the default rate
1	SWITCH_PENDING	Rate switch scheduled
2	FAST_PENDING_CONFIRM	Awaiting confirmation
3	FAST_ACTIVE	Boost lease is active
4	REVERT_PENDING	Return scheduled
5	FAILED	Internal rate-change failure

`FAST_ERROR` (502) gives the cause of a rejected command or automatic fallback and can remain nonzero after status returns to IDLE.

Table 1. `FAST_ERROR` **(502) values.**

Value	`FAST_ERROR` (502)	Meaning
0	NONE	No fast-transfer error
1	UNSUPPORTED_BAUD	Select an advertised code
2	BUSY	Reread status before retrying
3	BAD_NONCE	New nonce for START; active nonce thereafter
4	LEASE_ERROR	Correct lease, or recover after expiry
5	NOT_EXCLUSIVE	Do not use boost on this link
6	CONFIRM_TIMEOUT	Reconnect after the recovery wait
7	INTERNAL	Stop boost requests and recover

`SUPPORTED_BAUD_MASK` (503) advertises the boost codes accepted by START_TEMPORARY; firmware 1.03 reports `0x0006`. `DEFAULT_BAUD_CODE` (504) is 0 for the nominal 115,200 bit/s rate and is not part of the boost mask.



A.9.2 Boost session, timing, and counters (505–512)

ACTIVE_BAUD_CODE (505) reports the current link rate using the enum below.

Code	Rate
0	115,200 bit/s
1	230,400 bit/s
2	460,800 bit/s

Timing fields. Registers 506–508 use milliseconds.

MAX_LEASE_MS (506) is the longest permitted interval between valid Modbus requests during a boosted session; firmware 1.03 reports 5,000 ms. Firmware 1.03 accepts LEASE_MS values from 1,000 ms through this limit.

GUARD_MS (507) is the minimum silence after the complete START or REVERT response. Change the host UART, then wait this interval plus its switching margin before transmitting at the new rate.

CONFIRM_TIMEOUT_MS (508) is the confirmation deadline. It starts when the device accepts START_TEMPORARY. Before it expires, the device must accept CONFIRM_FAST at the boosted rate. Firmware 1.03 reports 250 ms. On expiry, the device returns to 115,200 bit/s.

Session. ACTIVE_NONCE (509–510) reports the client-selected nonce from START_TEMPORARY. Reuse it in CONFIRM_FAST and REVERT. It remains available until IDLE, then reads zero.

Counters. SESSION_COUNTER (511) counts accepted boost sessions. FALLBACK_COUNTER (512) counts automatic fallback attempts after a missing confirmation or lease expiry. Both are volatile: they wrap from 0xFFFF to 0x0000 and clear at application start. Command value 4 (CLEAR_RECOVERY) does not change them.

A.9.3 Baud-rate recovery record (513–514)

RECOVERY_ACTION (513) identifies the recovery method.

Value	RECOVERY_ACTION (513)	Meaning
0	NONE	No abnormal recovery retained
4	RESTORE_NOMINAL_BAUD	Baud rate restored; no reset
5	SOFTWARE_RESET_RECOVERY	Application reset restored 115,200 bit/s

RECOVERY_ERROR (514) uses the enum in Table 1. Explicit REVERT creates no retained recovery record.

A later abnormal recovery atomically replaces both fields. They survive software and watchdog resets until CLEAR_RECOVERY is issued or power is lost.

A.9.4 Baud-rate command block and values (520–526)

Write all seven write-only registers together with FC16. COMMAND_MAGIC and FLAGS have fixed values; each command defines the remaining field constraints.

Addr.	Name	A	Format	Value/role
520	COMMAND_MAGIC	W	u16	Intent marker: 0xF157
521–522	COMMAND_NONCE	W	u32	Client session token
523	BAUD_CODE	W	enum	Rate code; see A.9.2
524	LEASE_MS	W	u16	Requested gap limit, ms
525	FLAGS	W	bits	Reserved; require 0
526	COMMAND	W	enum	Operation code below

Value	COMMAND (526)	Required fields
1	START_TEMPORARY	New nonzero nonce; BAUD_CODE 1 or 2; LEASE_MS: 1,000 to MAX_LEASE_MS
2	CONFIRM_FAST	Active nonce from START_TEMPORARY; BAUD_CODE and LEASE_MS both 0
3	REVERT	Active nonce from START_TEMPORARY; BAUD_CODE and LEASE_MS both 0
4	CLEAR_RECOVERY	Nonce, BAUD_CODE, and LEASE_MS all 0

A.10 Use and recover the baud-rate boost

A.10.1 Boost and return sequence

Use the Section A.9.4 command fields. Boost only a READY waveform: complete the capture and save WAVEFORM_ID (220) first. Otherwise, capture time can consume the lease before downloading begins.

1. At 115,200 bit/s, read 500–514. Require contract version 2 and target-rate support; otherwise do not use boost. Require status IDLE, active baud code 0, nonce 0, and RECOVERY_ACTION (513) = 0. If communication or any state or record check fails, follow Section A.10.2. Save 506–508.
2. Send START_TEMPORARY (1) at 115,200 bit/s with a new nonce and normally a 1,000 ms lease. Increase the lease only for a longer expected request gap plus transfer and scheduling margin; do not exceed MAX_LEASE_MS (506). After the complete response, switch to the target rate, then wait GUARD_MS (507) plus the host switching margin before transmitting.
3. At the target rate, send CONFIRM_FAST with the same nonce. Require FAST_STATUS (501) = FAST_ACTIVE, FAST_ERROR (502) = NONE, the target code in ACTIVE_BAUD_CODE (505), and the nonce in ACTIVE_NONCE (509–510).
4. Download the READY waveform. Keep the interval between valid Modbus transactions shorter than the requested lease.
5. At the target rate, send REVERT with the same nonce and receive the complete response. Set the host to 115,200 bit/s, then wait GUARD_MS (507) plus the host switching margin. Read 500–514 together and require FAST_STATUS (501) = IDLE, FAST_ERROR (502) = NONE, and both ACTIVE_BAUD_CODE (505) and ACTIVE_NONCE (509–510) = 0.

REVERT is also accepted from FAST_PENDING_CONFIRM to cancel the boost before confirmation.

A.10.2 Recovery after an uncertain rate change

If one coherent FC03 read of 500–514 at 115,200 bit/s already shows contract version 2, status IDLE, active baud code 0, and nonce 0, communication is restored; continue at **Retained record**.

Recover communication

1. **Stop traffic.** Stop Modbus requests, set the host UART to 115,200 bit/s, and do not scan rates or transmit during the wait.
2. **Wait.** From when traffic stopped, wait at least 5,100 ms. For firmware 1.03, this covers the latest normal fallback deadline plus GUARD_MS (507).
3. **Reconnect.** At 115,200 bit/s, retry coherent FC03 reads of 500–514 for at least 5,000 ms. Require one snapshot with contract version 2, status IDLE, active baud code 0, and nonce 0. Otherwise stop and report recovery failure.

Retained record

4. **Interpret the outcome.** Read RECOVERY_ACTION (513):
   - NONE (0): no abnormal recovery record;
   - RESTORE_NOMINAL_BAUD (4): nominal rate restored without reset;
   - SOFTWARE_RESET_RECOVERY (5): application reset restored the nominal rate.

   With NONE, FAST_ERROR (502) may still identify a routine confirmation timeout or lease expiry. Log it and FALLBACK_COUNTER (512) if useful; do not clear. For either abnormal action, first save 100–110 and 500–514. The cause is in RECOVERY_ERROR (514).
5. **Clear abnormal evidence.** For either abnormal action, send CLEAR_RECOVERY at 115,200 bit/s while IDLE with the fields defined in Section A.9.4. It is retry-safe and clears only the retained record. Reread RECOVERY_ACTION (513) and RECOVERY_ERROR (514); require NONE in both.

APPENDIX B

Capturing a ModVibe Waveform

Minimal Modbus RTU application note

This application note performs one complete triaxial capture from the ModVibe 2.0 precision sensor. The example returns 1,024 samples per axis at 1 kS/s and converts the signed waveform words to acceleration in g.

Example result

Sensor: ADXL380 precision sensor
Axes: X, Y, Z
Range: ±8 g
Output rate: 1,000 samples/s per axis
Returned duration: 1.024 s
Output: 3,072 signed words

What the host must provide

- FTDI-based USB-to-RS-485 converter
- Modbus RTU functions 03, 06, and 16
- Read and write access to zero-based holding-register addresses
- A receive buffer for 125 registers per data page

The complete transaction

1. **Connect.** Use 115,200 bit/s, 8-N-1, and the ModVibe unit ID shown on the device label.
2. **Identify.** Verify the device identity and capture contracts.
3. **Configure.** Write the nine-word capture request at address 205 with FC16.
4. **Start.** Write START=1 to `CONTROL` (204) with FC06.
5. **Monitor.** Poll `CAPTURE_STATUS` (202) and `ERROR` (203) until READY or ERROR.
6. **Read metadata.** Read `WAVEFORM_ID` (220) and `OUTPUT_WORDS` (214–215).
7. **Download.** Seek and read fixed 125-register waveform pages.
8. **Validate.** Verify every page header before appending its payload.
9. **Separate axes.** Split the output into 1,024 X, 1,024 Y, and 1,024 Z samples.
10. **Scale.** Divide the signed ±8 g samples by 3,750 LSB/g.

Waveform duration excludes transfer time

The returned sample duration is 1,024 / 1,000 = 1.024 s. Communication time is additional and depends on baud rate, page count, host latency, and retries.

Related document

The Appendix A defines every register, state, error, scale, and optional baud-rate-boost command. The example in Section B.5 does not use baud-rate boost.

B.1 Connection and protocol setup

B.1.1 Power and RS-485 connections

Connect the fixed cable as follows:

Color	Signal	Host connection
Red	V+	12–30 VDC supply; 24 VDC nominal
Black	0 V	Supply return and Modbus Common
Blue	D1+	Modbus positive line
White	D0−	Modbus negative line
Bare	Drain	Cable-shield access

The bare drain has no internal connection and must not carry return current. Follow Section 5.4 of the main datasheet for shield bonding and bus-topology guidance.

B.1.2 Modbus operations and response checks

FC	Operation	Used for
03	Read holding registers	Status, metadata, data page
06	Write single register	START command
16	Write multiple registers	Config and 32-bit seek

Before using a response, require a valid CRC and verify that it matches the outstanding request:

- FC03: unit ID, function code, and expected byte count;
- FC06: unit ID, function code, register address, and written value;
- FC16: unit ID, function code, start address, and register count.

A function code with bit 7 set is an exception response. Stop and report its exception code. Ignore unrelated or malformed frames. If this example times out, report the failed operation and stop.

B.1.3 Identity check

Read registers 0–13 as one identity block and require the common identity fields:

Addr.	Register	Required
0	`ID_MAGIC_HIGH`	`0x4649`
1	`ID_MAGIC_LOW`	`0x5642`
2	`ID_CONTRACT`	`0x0002`

Read registers 200–201 together and register 1200 separately. Accept only one complete release tuple from the following table:

Addr.	Register	Firmware 1.02	Firmware 1.03
9–10	`APP_VERSION`	`0x00000102`	`0x00000103`
3	`MAP_CONTRACT`	`0x0002`	`0x0003`
200	`CAPTURE_CONTRACT`	`0x0004`	`0x0005`
201	`WINDOW_CONTRACT`	`0x0003`	`0x0003`
1200	`FIR_CATALOG`	`0x0002`	`0x0003`

Stop with a clear compatibility error for a mixed tuple or any unknown value. This prevents a client from interpreting one contract with another release's register semantics.

The fixed example uses ADXL380 at 1 kS/s and is supported by both tuples. Firmware 1.02 does not support reduced-rate ADXL382 capture; use the exact firmware 1.03 tuple for that path.

Address notation

This note uses the zero-based address transmitted in the Modbus PDU. A PLC package may display address 0 as holding register 40001. Apply that offset once in the PLC configuration; do not add it to wire-level requests.

B.2 Known-good capture configuration

Registers 205–213 form one coherent capture request. This example selects the ADXL380, all three axes, 1 kS/s per axis, 1,024 samples per axis, FIR decimation, and a ±8 g range. Write the complete nine-register block in one FC16 transaction.

Addr.	Field	Value	Meaning
205	SOURCE	2	ADXL380 precision sensor
206	CHANNEL_MASK	0x0007	X, Y, Z
207	OUTPUT_RATE_HZ	1,000	1 kS/s per axis
208	SAMPLE_COUNT_HI	0	32-bit high word
209	SAMPLE_COUNT_LO	1,024	1,024 samples/axis
210	FILTER_PROFILE	3	FIR decimation
211	DOWNLOAD_POLICY	1	Enforce transfer-time budget
212	MAX_DOWNLOAD_MS	30,000	30,000 ms budget
213	FULL_SCALE_G	8	±8 g

Example configuration request (FC16)

TX bytes	Addr.	Meaning
1C		Unit ID 28
10		FC16, write multiple holding registers
00 CD		Start at register 205
00 09		Write 9 registers
12		18 data bytes follow; CRC excluded
00 02	205	SOURCE = 2, ADXL380
00 07	206	CHANNEL_MASK = 0x0007, X/Y/Z
03 E8	207	OUTPUT_RATE_HZ = 1,000
00 00	208	SAMPLE_COUNT_HI = 0
04 00	209	SAMPLE_COUNT_LO = 1,024
00 03	210	FILTER_PROFILE = 3
00 01	211	DOWNLOAD_POLICY = 1
75 30	212	MAX_DOWNLOAD_MS = 30,000
00 08	213	FULL_SCALE_G = 8
71 32		Request CRC, low byte first

Example response

RX bytes	Meaning
1C	Unit ID 28
10	FC16 response
00 CD	Start register 205 accepted
00 09	9 registers written
92 7D	Response CRC, low byte first

Frames are examples, not constants

Recalculate CRC after changing unit ID, address, length, or data. A normal Modbus library constructs these frames and validates responses for you.

B.3 Example START and status poll

After the configuration response, read registers 202–220 together and require CONFIGURED, NONE, the requested values at 205–213, and waveform ID zero. Then send START once and poll registers 202–203 together. The decoded frames below show READY with no error for unit ID 28.

See Sections A.7.2 and A.7.3 for all states and production retry rules.

Example START request (FC06)

TX bytes	Addr.	Meaning
1C		Unit ID 28
06		FC06, write single holding register
00 CC	204	CONTROL
00 01		START = 1
8B B8		CRC, low byte first

Example START response (FC06)

RX bytes	Addr.	Meaning
1C		Unit ID 28
06		FC06 response
00 CC	204	CONTROL accepted
00 01		START = 1 accepted
8B B8		CRC, low byte first

Example status poll (FC03)

TX bytes	Addr.	Meaning
1C		Unit ID 28
03		FC03, read holding registers
00 CA	202	Start at CAPTURE_STATUS
00 02		Read 2 registers
E7 B8		Request CRC, low byte first

Repeat this poll every few seconds until CAPTURE_STATUS reports READY or ERROR.

Valid status values are 0 through 5. An aborted capture reports ERROR (5) with ERROR set to ABORTED (12). Treat any status value above 5 as an incompatible firmware state.

Example READY response (FC03)

RX bytes	Addr.	READY/NONE meaning
1C		Unit ID 28
03		FC03 response
04		4 data bytes follow; CRC excluded
00 04	202	CAPTURE_STATUS = READY
00 00	203	ERROR = NONE
76 F3		Response CRC, low byte first

B.4 Validate and download the example

After READY, read registers 202–224 together and use:

Addr.	Field	Check / role
202	CAPTURE_STATUS	READY
203	ERROR	NONE
204–213	Require 205–213 to match at READY and before download	
214–215	OUTPUT_WORDS	3,072
216–217	CHUNK_COUNT	26
218–219	EST_DOWNLOAD_MS	Informational
220	WAVEFORM_ID	Nonzero
221–222	MAX_OUTPUT_WORDS	At least 3,072
223	CHUNK_PAYLOAD_WORDS	122
224	CHUNK_HEADER_WORDS	3

Use the reported values for paging. This request returns 3,072 signed payload words.

Example page seek (FC16)

TX bytes	Addr.	Meaning
1C		Unit ID 28
10		FC16, write multiple holding registers
00 E4	228	Start at WINDOW_OFFSET
00 02		Write 2 registers
04		4 data bytes follow; CRC excluded
00 00	228	Offset high word = 0
00 00	229	Offset low word = 0
93 78		Request CRC, low byte first

Example page read (FC03)

TX bytes	Addr.	Meaning
1C		Unit ID 28
03		FC03, read holding registers
03 E8	1000	Start of waveform-data page
00 7D		Read 125 registers
06 16		Request CRC, low byte first

Page response layout at offset 0

RX bytes	Addr.	Meaning
1C		Unit ID 28
03		FC03 response
FA		250 data bytes follow; CRC excluded
xx xx	1000	Current waveform ID
00 00	1001	Returned offset high word = 0
00 00	1002	Returned offset low word = 0
...	1003–1124	122 payload words
xx xx		Response CRC, low byte first

Verify waveform ID and offset before appending payload. xx marks variable bytes. Convert ADXL380 ±8 g samples at 3,750 LSB/g; see Section A.8.3 for other scales.

B.5 Executable Python host example

This datasheet example uses the PyModbus 3.15.0 synchronous serial client. On Linux, ftdi_sio exposes the FTDI adapter as a serial port; on Windows, install the FTDI virtual COM-port driver.

Install once; run with the serial port and ModVibe unit ID:

Install	`python -m pip install pymodbus[serial]==3.15.0`
	`python -m pip install matplotlib==3.11.1`
Linux	`python modvibe_capture.py /dev/ttyUSB0 28`
Windows	`python modvibe_capture.py COM3 28`

Replace 28 with the ModVibe unit ID. The script validates contracts, performs the fixed ±8 g capture, and plots the converted X/Y/Z acceleration traces in modvibe_waveform.png.

```python
#!/usr/bin/env python3
"""Capture the fixed Appendix B waveform and plot the result."""

import argparse
import time
from types import SimpleNamespace

import matplotlib.pyplot as plt
from pymodbus.client import ModbusSerialClient
from pymodbus.exceptions import ConnectionException
from pymodbus.exceptions import ModbusIOException

UNIT_ID = 1
SOURCE = 2                  # ADXL380
CHANNEL_MASK = 0x0007       # X, Y, Z
OUTPUT_RATE_HZ = 1000       # samples/s per axis
SAMPLES_PER_CHANNEL = 1024
FILTER_PROFILE = 3          # FIR decimation
DOWNLOAD_POLICY = 1         # enforce transfer budget
MAX_DOWNLOAD_MS = 30000
FULL_SCALE_G = 8
LSB_PER_G = 3750.0
CONFIGURED, ACQUIRING, PROCESSING, READY, FAILED = range(1, 6)
REQUEST = [SOURCE, CHANNEL_MASK, OUTPUT_RATE_HZ, 0,
           SAMPLES_PER_CHANNEL, FILTER_PROFILE, DOWNLOAD_POLICY,
           MAX_DOWNLOAD_MS, FULL_SCALE_G]
TRANSPORT_ERRORS = (ConnectionException, ModbusIOException)

def u32(high, low):
    return (high << 16) | low

def i16(word):
    return word - 0x10000 if word & 0x8000 else word

def open_modvibe(port, unit_id):
    global UNIT_ID
    UNIT_ID = unit_id
    mb = ModbusSerialClient(
        port, baudrate=115200, timeout=1.0, retries=0,
    )
    if not mb.connect():
        raise RuntimeError(f"cannot open {port}")
    return mb

def check(reply):
    if isinstance(reply, ModbusIOException):
        raise reply
    if reply.isError():
        raise RuntimeError(f"Modbus exception: {reply}")
    return reply

def read_regs(mb, address, count):
    reply = mb.read_holding_registers(
        address, count=count, device_id=UNIT_ID,
    )
    words = check(reply).registers
    if words is None or len(words) != count:
        actual = 0 if words is None else len(words)
        raise RuntimeError(
            f"short register read at {address}: expected {count},
      got {actual}"
        )
    return words

def read_state(mb):
    words = read_regs(mb, 202, 23)
    return SimpleNamespace(
        status=words[0], error=words[1], request=words[3:12],
        output_words=u32(*words[12:14]),
        page_count=u32(*words[14:16]),
        waveform_id=words[18], maximum_words=u32(*words[19:21]),
        payload_words=words[21], header_words=words[22])

def write_regs(mb, address, values):
    reply = mb.write_registers(address, values, device_id=UNIT_ID)
    check(reply)

def verify_device(mb):
    identity = read_regs(mb, 0, 14)
    if identity[:3] != [0x4649, 0x5642, 0x02]:
        raise RuntimeError("incompatible identity/map")
    release_contract = (
        u32(identity[9], identity[10]), identity[3],
        *read_regs(mb, 200, 2),
        read_regs(mb, 1200, 1)[0],
    )
    if release_contract == (0x00000102, 2, 4, 3, 2):
        return False
    if release_contract == (0x00000103, 3, 5, 3, 3):
        return True
    raise RuntimeError("incompatible firmware/contract tuple")
def configure(mb, require_cleared_id=True):
    write_regs(mb, 205, REQUEST)
    state = read_state(mb)
    if ((state.status, state.error) != (CONFIGURED, 0)
            or state.request != REQUEST):
        raise RuntimeError("configuration rejected")
    if require_cleared_id and state.waveform_id != 0:
        raise RuntimeError("configuration retained stale waveform
      ID")
    return state.waveform_id

def start_once(mb, previous_id, invalidates_id):
    for attempt in range(2):
        try:
            check(mb.write_register(204, 1, device_id=UNIT_ID))
            return
        except TRANSPORT_ERRORS:
            state = read_state(mb)
            status, error = state.status, state.error
            waveform_id = state.waveform_id
            if error == 0 and status in (ACQUIRING, PROCESSING):
                return
            ready_id_matches = (
                waveform_id != 0 if invalidates_id
                else waveform_id == (1 if previous_id == 0xffff
                                     else previous_id + 1)
            )
            if (error == 0 and status == READY and state.request ==
      REQUEST
                    and ready_id_matches):
                return
            not_started = status == CONFIGURED and error == 0
            same_request = state.request == REQUEST
            unchanged = waveform_id == previous_id and same_request
            if attempt == 0 and not_started and unchanged:
                continue
            raise RuntimeError("ambiguous START outcome")

def wait_ready(mb, deadline_s, previous_id, invalidates_id):
    time.sleep(SAMPLES_PER_CHANNEL / OUTPUT_RATE_HZ)
    deadline = time.monotonic() + deadline_s
    while time.monotonic() < deadline:
        state = read_state(mb)
        status, error = state.status, state.error
        ready_id_matches = (
            state.waveform_id != 0 if invalidates_id
            else state.waveform_id == (1 if previous_id == 0xffff
                                       else previous_id + 1)
        )
        if (status == READY and error == 0 and state.request ==
      REQUEST
                and ready_id_matches):
            return state
        if status == FAILED:
            raise RuntimeError(f"capture error {error}")
        if status not in (ACQUIRING, PROCESSING) or error != 0:
            raise RuntimeError(f"unexpected state {status}/{error}")
        time.sleep(0.1)
    raise TimeoutError("capture deadline exceeded")

def download(mb, state):
    if read_state(mb).request != REQUEST:
        raise RuntimeError("capture changed before download")
    if state.output_words != 3072 or state.maximum_words < 3072:
        raise RuntimeError("unexpected output size")
    if (state.payload_words, state.header_words) != (122, 3):
        raise RuntimeError("unsupported page format")
    if state.page_count != (state.output_words + 121) // 122:
        raise RuntimeError("inconsistent page count")

    words = []
    while len(words) < state.output_words:
        offset = len(words)
        for _ in range(3):
            try:
                seek = [(offset >> 16) & 0xFFFF, offset & 0xFFFF]
                write_regs(mb, 228, seek)
                page = read_regs(mb, 1000, 125)
            except TRANSPORT_ERRORS:
                continue
            if page[0] != state.waveform_id:
                raise RuntimeError("waveform ID changed")
            if u32(page[1], page[2]) == offset:
                break
        else:
            raise RuntimeError("page retry exhausted")
        count = min(122, state.output_words - offset)
        payload = page[3:3 + count]
        words.extend(i16(word) for word in payload)
    return state.waveform_id, words

def plot_waveform(filename, waveform_id, words):
    count = SAMPLES_PER_CHANNEL
    time_s = [sample / OUTPUT_RATE_HZ for sample in range(count)]
    figure, axis = plt.subplots(layout="constrained")
    for number, label in enumerate("XYZ"):
        data = words[number * count:(number + 1) * count]
        axis.plot(time_s, [value / LSB_PER_G for value in data],
                  label=label)
    axis.set(xlabel="Time (s)", ylabel="Acceleration (g)",
             title=f"ModVibe waveform {waveform_id}")
    axis.grid(alpha=0.25)
    axis.legend()
    figure.savefig(filename, dpi=150)
    plt.close(figure)

def main():
    parser = argparse.ArgumentParser(description=__doc__)
    parser.add_argument("port")
    parser.add_argument("unit_id", type=int)
    args = parser.parse_args()
    mb = open_modvibe(args.port, args.unit_id)
    invalidates_id = verify_device(mb)
    previous_id = configure(mb, invalidates_id)
    start_once(mb, previous_id, invalidates_id)
    state = wait_ready(mb, 10.0, previous_id, invalidates_id)
    waveform_id, words = download(mb, state)
    plot_waveform("modvibe_waveform.png", waveform_id, words)
    mb.close()
if __name__ == "__main__": main()
```

Important notice

Information in this document is provided to support product selection, evaluation, and integration. This information reflects the product information available to iQunet BV as of the issue date. Future product versions and document revisions may differ in specifications, features, interfaces, or availability. Specifications incorporated into an existing written agreement remain governed by that agreement. Before use, verify that this document revision applies to the product and firmware version concerned.

Customers are responsible for confirming that ModVibe is suitable for the intended application and for applying appropriate installation, safety, and system-level engineering practices. ModVibe must be used in accordance with the applicable specifications and instructions.

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Current information and support: info@iqunet.com | www.iqunet.com