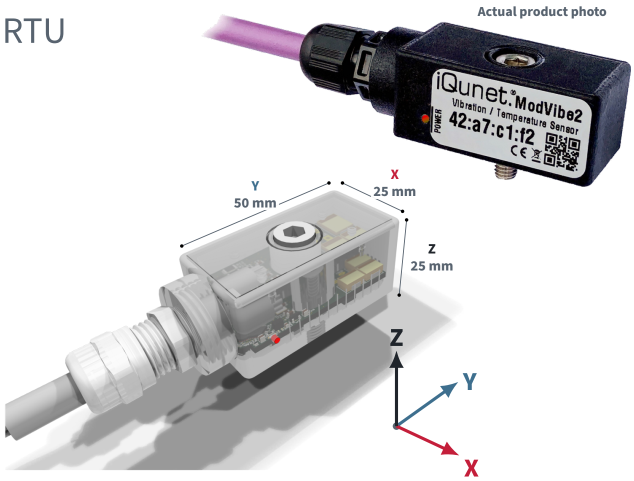
ModVibe 2.0

Dual-path triaxial vibration sensor with Modbus RTU

ModVibe is an IP67/IP68-rated industrial vibration sensor with two triaxial accelerometers and integrated temperature monitoring. It records acceleration waveforms and transfers them over Modbus RTU for continuous or periodic machine-condition monitoring.



SENSING ARCHITECTURE
2 × 3-axis
1 low-noise ADXL380
1 wideband ADXL382

NOISE DENSITY
$26\,\mu\mathrm{g}/\sqrt{\mathrm{Hz}}$
Characterized
Low-noise path

WIDEBAND PATH
8 kHz
ADXL382
-3 dB sensor bandwidth

Key features

- Triaxial acceleration waveform acquisition
- Selectable low-noise ranges of ± 4, ± 8, and $\pm 16\,\mathrm{g}$
- Selectable wideband ranges of ± 15, ± 30, and $\pm 60\,\mathrm{g}$
- 8 kS/s low-noise path or 16 kS/s wideband path, selectable for each capture
- On-board dual-core Arm Cortex-M33 processor with DSP and floating-point support for complex filtering operations
- On-board Type I low-pass FIR decimation to 125 S/s for triaxial capture windows of approximately 1 min
- Integrated MEMS sensor temperature monitoring and firmware health diagnostics
- Wide 12–30 VDC input range; 24 VDC nominal
- IP67/IP68-rated enclosure for industrial installation
- 2-wire RS-485 with Modbus RTU at 115.2k baud; optional 230.4k or 460.8k baud transfer boost
- Integrated bootloader for firmware updates over Modbus RTU
- Engineering option: application-specific firmware available on request

Applications

- Predictive maintenance for motors, pumps, fans, gearboxes, and compressors
- Permanently installed acquisition for slow-speed and broadband machine diagnostics

Vibration sensor characteristics

Characteristic	Low-noise	Wideband
Sensor	ADXL380	ADXL382
Measurement axes	X/Y/Z	X/Y/Z
Selectable range	$\pm 4/8/16\,\mathrm{g}$	$\pm 15/30/60\,\mathrm{g}$
Noise density, X/Y/Z*	$26\,\mu\mathrm{g}/\sqrt{\mathrm{Hz}}$	$58\,\mu\mathrm{g}/\sqrt{\mathrm{Hz}}$
Sensor bandwidth (-3 dB)†	4 kHz	8 kHz
Nominal counts/g, lowest range	7500	2000
PDM stream	1-bit, 32 kS/s	1-bit, 64 kS/s
TDM stream	16-bit, 8 kS/s	16-bit, 16 kS/s

* Characteristic values measured during finished-device characterization.

† -3 dB corner in high-performance mode with default sensor filters.

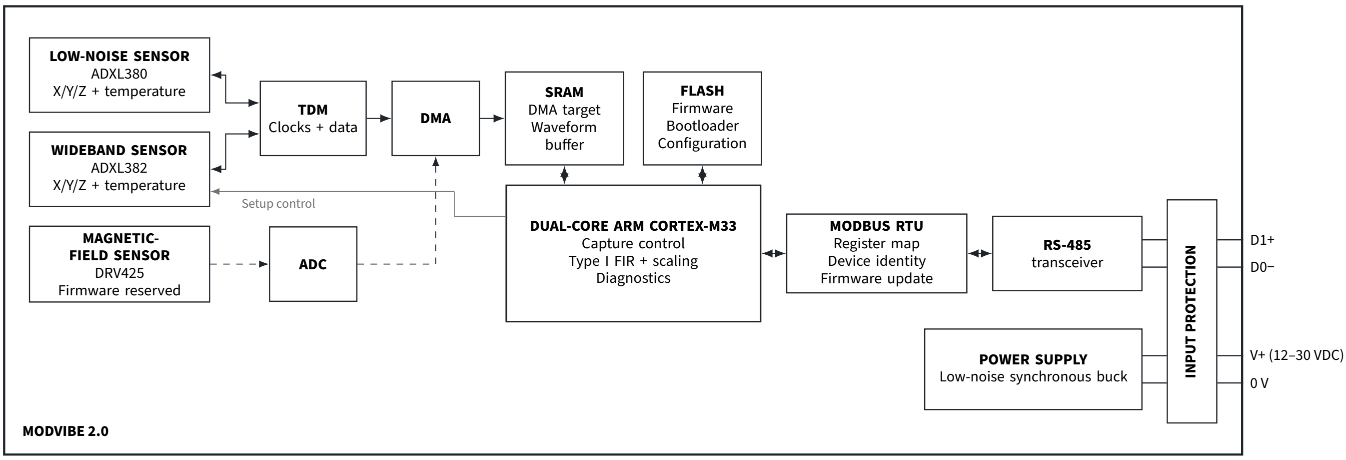
System overview

ModVibe acquires triaxial acceleration time waveforms using either its low-noise or wideband vibration sensor. It filters, buffers, and transfers each waveform over Modbus RTU.

Both on-board MEMS sensors generate a 1-bit PDM stream at up to 64 kS/s. Third-order sinc decimation integrates the complete stream into 16-bit acceleration samples at 8 kS/s for the ADXL380 and 16 kS/s for the ADXL382. These source streams feed the Modbus waveform interface. Firmware applies FIR decimation when required, buffers the completed waveform in SRAM, and returns the X, Y, and Z axis blocks over Modbus RTU. The interface also reports sensor temperatures, device identity, and diagnostics.

Populated magnetic-field hardware is reserved for future rotational-speed measurement and other magnetic-field applications.

Functional block diagram



Contents

This datasheet follows the complete ModVibe measurement chain, from defining the required vibration content and selecting the sensing path to waveform transfer and mechanical mounting. Sections 1 and 2 provide hands-on guidance for configuring and retrieving a measurement.

The supporting concepts are introduced along the way, where they are needed. Sections 3–6 then cover temperature and diagnostic information, electrical integration, and device installation.

1 Capture setup

ModVibe combines two triaxial vibration sensors with complementary measurement roles. The ADXL380 low-noise path targets lower-range measurements; the ADXL382 wideband path covers higher frequencies and acceleration levels. A *capture setup* is the combination of sensor, full-scale range, output rate, and samples per axis used for one measurement.

> **⚠ Firmware compatibility**
>
> For this document, register-map contract `0x03`, capture API version 4 (register 200), and application firmware version 1.03 or later are required. Registers 9–10 report the 32-bit firmware version, high word first; version 1.03 is `0x00000103`.

1.1 Define the measurement requirements

Define the vibration content by answering three questions: What is the highest relevant frequency? What is the largest expected peak acceleration? How long must the observation be to capture the slowest behavior or a complete transient? The table summarizes the main configuration trade-offs [8]. Section 1.5 examines sample rate, record duration, and noise together in detail.

Setting	Choice	Result
Sensor	ADXL380	Lower noise; 3.8 kHz usable bypass bandwidth and $\pm 16\,g$ range
Sensor	ADXL382	7.6 kHz usable bypass bandwidth and $\pm 60\,g$ range
Output rate	Lower	Longer observation and lower bin noise; reduced usable bandwidth
Full-scale range	Lower	Finer nominal scaling; reduced clipping margin
Sample count	Higher	Finer frequency resolution and lower bin noise; longer capture and transfer

1.2 Select the vibration sensor

ADXL380 LOW-NOISE [1]

Select this sensor when the required measurement range does not exceed $\pm 16\,g$ and content above 4 kHz is not required.

Typical uses include shaft-speed harmonics on slow-running motors, paper-machine rollers, and conveyors. At 125 S/s and $\pm 4\,g$, the characterized noise-density value corresponds, under a white-noise model, to an estimated noise-only full-scale sine SNR of 84 dB (13.7-bit ideal-ADC equivalent).

ADXL382 WIDEBAND [2]

Select this sensor when the required range is $\pm 30\,g$ or $\pm 60\,g$, or when relevant content above 4 kHz may be present.

Typical uses include bearing-impact, gear-mesh, and pump-cavitation measurements.

1.3 Range selection: SNR versus clipping

Select the lowest full-scale range that accommodates the largest expected peak acceleration, including transient shocks and gravity.

> **ⓘ Gravity component**
>
> The returned waveform is DC-coupled, so each axis contains both vibration and the projected gravity component. Depending on mounting orientation, gravity can contribute up to 1 g on an axis.

Clipping distorts the time waveform and introduces false harmonic content into the spectrum. As a practical starting point, use $\pm 16\,g$ on the ADXL380 or $\pm 15\,g$ on the ADXL382. These adjacent ranges form the crossover between the low-noise and wideband paths. Increase the range if peaks may exceed this initial limit.

For the ADXL380, select $\pm 8\,g$ or $\pm 4\,g$ only after a capture confirms sufficient peak margin. The lower ranges are justified mainly for long, reduced-bandwidth measurements, where filtering lowers integrated noise. For the raw bypass ADXL380 vibration data, MEMS noise remains above quantization noise at every range.

Figure 1 compares every range for a 1 g RMS signal in a 1 kHz equivalent noise bandwidth, using the Table 4 characterization values under a white-noise model.

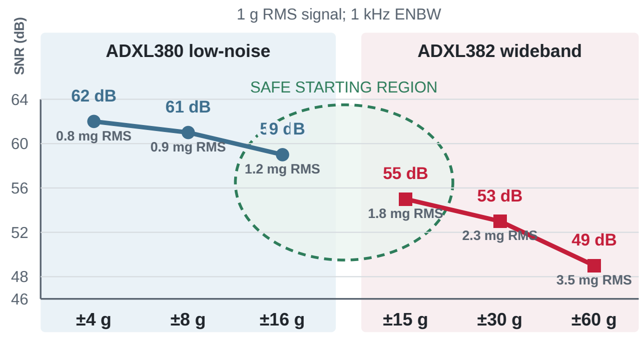


Figure 1: SNR and integrated RMS noise at 1 kHz ENBW.

1.4 FIR response and usable bandwidth

ModVibe 2 applies an embedded FIR low-pass filter before decimation. Reduced output rates use fixed profiles; full-rate ADXL380 (8 kS/s) and ADXL382 (16 kS/s) captures bypass the filter.

The Modbus waveform interface supports two analysis paths:

- **Shaft orders and low-frequency motion:** retain characteristic harmonics for low-noise, high-resolution analysis of imbalance, misalignment, and looseness.
- **Impacts and envelopes:** capture high-frequency resonances excited by early bearing defects, localized cracking, and other impacts.

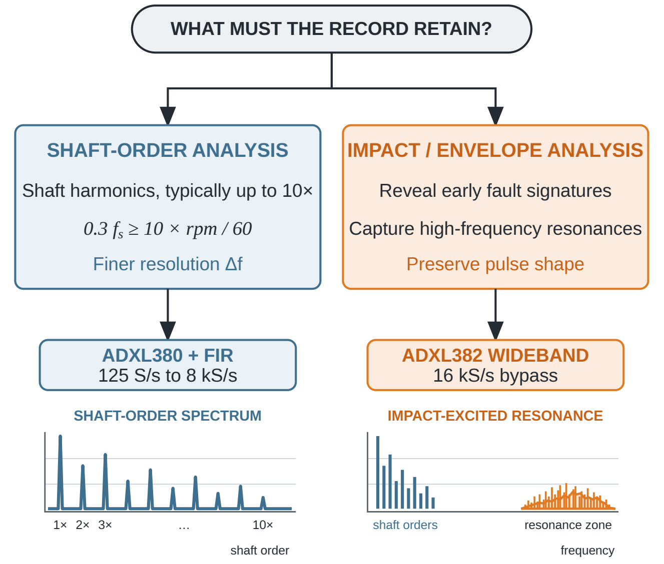


Figure 2: The two internal sensors target complementary applications: ADXL380 for low-noise shaft-order analysis and ADXL382 for wideband impact and envelope analysis.

380 + FIR Typical shaft-order signatures include dominant radial 1× vibration from imbalance, elevated axial 1× or radial 2× vibration from misalignment, and running-speed harmonic trains from mechanical looseness. For this analysis, use the ADXL380 with the lowest waveform rate that preserves the required orders with adequate bandwidth margin.

382 Bearing and gear faults excite high-frequency machine resonances. The higher sample rate of the ADXL382 captures these resonances and preserves the impact waveform. Envelope analysis then demodulates the resonance band to recover the baseband fault frequency. Use the ADXL382 when 16 kS/s waveform capture is required.

The linear-phase FIR profiles preserve waveform shape, reach -3 dB near $0.36 f_s$, and fall below -60 dB at $f_s/2$; see Figure 3. The FIR -3 dB passband listed in Table 1, not the output Nyquist frequency, defines the usable analysis bandwidth.

Slow-speed machinery

At a fixed number of samples N, a lower waveform rate extends the record so it spans more shaft revolutions. This gives finer FFT frequency resolution without increasing the waveform transfer payload. Section 1.5 applies this trade to representative machinery.

Output-rate selection

For envelope analysis, use the upper edge of the resonance carrier band. In practice, select the ADXL382 at 16 kS/s bypass and $\pm 15\,g$, increasing the range only when peak acceleration requires more headroom. An ADXL382 capture can also augment an ADXL380 measurement by revealing significant content above 4 kHz.

1.5 Balancing sample rate, duration, and noise

For a fixed sample count N, FIR filtering and decimation link usable bandwidth, record duration T, and FFT-bin spacing Δf:

$$T = \frac{N}{f_s}, \qquad \Delta f = \frac{f_s}{N}.$$

A lower output rate f_s therefore gives a longer observation and narrower FFT bins, while a higher rate preserves higher-frequency content. For approximately white noise and a fixed FFT window, halving the FFT-bin equivalent noise bandwidth (ENBW) reduces the noise power per FFT bin by 3 dB, making narrow spectral lines easier to detect.

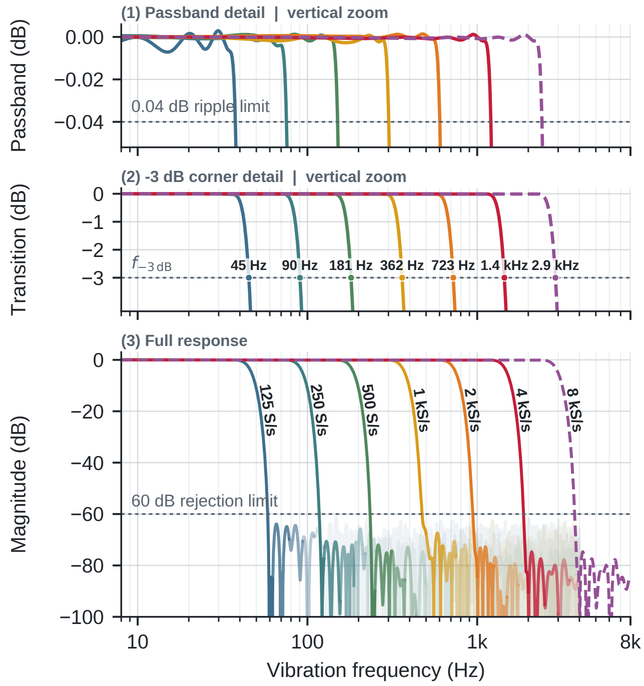


Figure 3: FIR response by output rate. Panels 1 and 2 enlarge the passband and -3 dB regions of the full response in panel 3. The dashed 8 kS/s profile is ADXL382 only.

For shaft-order analysis, the highest required frequency $f_{\max}$ is

$$f_{\max} = H_{\max} \frac{\mathrm{rpm}}{60}.$$

Here, $H_{\max}$ is the highest shaft order to retain.

Select the lowest mode in Table 1 whose FIR -3 dB band contains $f_{\max}$.

Table 1. FIR bandwidth and recommended output rate.

Rate	FIR -3 dB	FIR -60 dB	ADXL380	ADXL382
125	45 Hz	62.5 Hz	FIR	← (FIR)
250	90 Hz	125 Hz	FIR	← (FIR)
500	181 Hz	250 Hz	FIR	← (FIR)
1k	362 Hz	500 Hz	FIR	← (FIR)
2k	723 Hz	1 kHz	FIR	← (FIR)
4k	1.4 kHz	2 kHz	FIR	← (FIR)
8k	2.9 kHz	4 kHz	bypass 3.8 kHz	FIR
16k	–	–	–	bypass 7.6 kHz

Rate is the waveform sample rate f_s [S/s]; bandwidth columns apply only to FIR modes. Parentheses mark a supported but nonrecommended FIR mode. Bypass bandwidth follows the typical equalized-flatness limit specified in the ADXL380 and ADXL382 data sheets [1, 2].

For a 300 rpm shaft retaining orders through $H_{\max} = 10$, the highest required frequency is $f_{\max} = 50$ Hz. The 125 S/s profile is too narrow because its -3 dB bandwidth is 45 Hz. Select 250 S/s, whose 90 Hz bandwidth provides 40 Hz of margin.

Impact-excited bearing and gear resonance bands lie outside the 90 Hz -3 dB passband of the 250 S/s FIR and still require ADXL382 at 16 kS/s for envelope analysis.

Why downsampling matters

At $N = 8192$, the 250 S/s capture lasts 32.8 s, has $\Delta f = 0.0305$ Hz, and spans about 164 shaft revolutions. A 16 kS/s capture with the same payload lasts only 0.512 s and spans about 2.6 revolutions.

A record containing only two complete revolutions provides too little repeated motion for stable shaft-order amplitudes, fine spectral separation, or resolving slow amplitude modulation of the 1× component. A lower-rate recording observes the motion over many revolutions, while the waveform payload size and download time remain unchanged.

Zone	Representative application	rpm	ODR mode	1× noise (μm/s RMS)	T_{rec}
A	Wind-turbine rotor	< 100	125 S/s FIR	> 3.7	66 s
B	Conveyor shaft	300	250 S/s FIR	1.7	33 s
C	Fan or pump	600	500 S/s FIR	1.2	16 s
D	4-pole motor	1500	1 kS/s FIR	0.69	8 s
E	2-pole motor	3000	2 kS/s FIR	0.49	4 s
F	Compressor shaft	6000	4 kS/s FIR	0.35	2 s
G	High-speed compressor	up to 46k	16 kS/s bypass	0.20	0.5 s

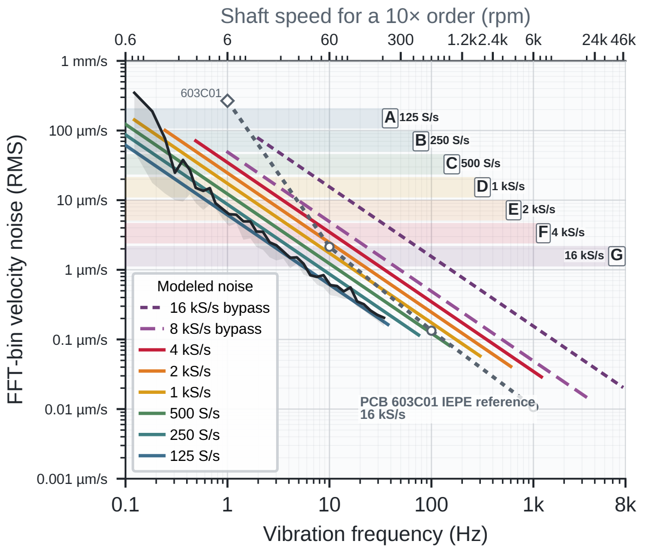


Figure 4: Application guide and FFT-bin noise. The table assigns each application to an ODR and graph zone. Zones A–F end at the FIR -3 dB bandwidth; Zone G ends at the ADXL382 16 kS/s bypass limit. Curves compare the ModVibe response with the widely used PCB 603C01 piezoelectric sensor.

Figure 4 places this rule in an application context. Start with the application table above the graph and select a close operating case.

Each row links an example application to a zone (A–G) and recommended ODR mode. At $N = 8192$, it also gives record duration and modeled FFT-bin velocity noise at the application's $1\times$ frequency, in μm/s RMS. For another spectral line, read the graph at the required frequency to estimate detection sensitivity.

Comparison with piezo sensors

Figure 4 compares modeled ModVibe FFT-bin velocity noise with published PCB 603C01 sensor noise [3, 4]. The 603C01 curve excludes signal-conditioning and digitizer noise.

For a fair comparison, the 603C01 reference assumes an external 16 kS/s acquisition with $N = 8192$, matching the ADXL382 record duration and Hann RBW. Lower-rate ModVibe modes retain the same payload and transfer time while FIR decimation lengthens the record and narrows its RBW.

The modeled FFT-bin velocity-noise performance is similar through the 1 kS/s ModVibe FIR mode. At higher rates, the PCB 603C01 has the lower modeled noise floor. ModVibe additionally provides dc response, synchronized triaxial acquisition, and long low-rate records.

PIEZOELECTRIC

Flat acceleration noise appears as $1/f$-shaped equivalent velocity noise because the conversion divides by $2\pi f$. Below its specified 0.5 Hz (30 rpm) low-frequency limit, the PCB 603C01 response rolls off.

MEMS

ModVibe retains dc response. The preliminary 125 S/s measurement shows increasing colored noise and drift below approximately 0.5 Hz, with additional influence from bias drift and temperature sensitivity. The black trace in Figure 4 shows this measured behavior.

1.6 ModVibe waveform configuration

With the sensor, range, ODR, and record length selected as described in Sections 1.2–1.5, write the waveform configuration to registers 205–213.

> ⓘ All registers referenced in this section are listed in Table 2 on page 5.

Sensor and axes. Set register 205 to 2 for the ADXL380 or 3 for the ADXL382. Set the axis bitmask in register 206 to 0x07 (all axes enabled).

Write the full-scale range. Set register 213 to 4, 8, or 16 for the ADXL380, or to 15, 30, or 60 for the ADXL382. The written value specifies the positive full-scale magnitude; for example, 8 selects a range of $\pm 8\,g$.

Output rate and processing. Write the selected output rate in S/s to register 207. Set register 210 to 0x03 so firmware selects the FIR or bypass path corresponding to the selected sensor and output rate, as shown in Figure 5.

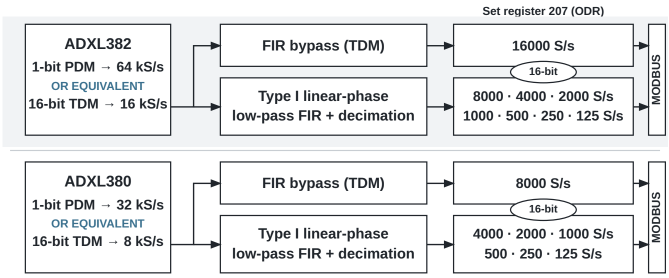


Figure 5: MEMS source rates and Modbus waveform processing. Register 207 (ODR) selects the delivered waveform rate. Firmware routes the selected sensor's 16-bit TDM stream through the corresponding FIR decimator or full-rate bypass.

Samples per axis. Write the 32-bit sample count to registers 208–209, high word first. Register 208 is 0, and register 209 contains the selected count. Supported counts are $N = 64$, 128, 256, 512, 1024, 2048, 4096, and 8192 samples per axis.

With N samples per axis and output sampling frequency f_s, the nominal record duration is $T_{rec} = N/f_s$. Table 3 gives example configurations and their resulting duration and bandwidth. X/Y/Z are acquired simultaneously, so the axis count does not multiply the record duration.

Table 3. Example settings: FIR -3 dB; bypass flatness.

Application	Sensor	rpm (10×)	ODR [S/s]	N	T_{rec}	Analysis BW
Slow shaft order	ADXL380	≤ 500	250	8192	33 s	90 Hz
General shaft order	ADXL380	500–4000	2k	8192	4 s	723 Hz
Impact / envelope	ADXL382	–	16k	8192	0.5 s	7.6 kHz

Download-time budget. Set register 211 to 1 and register 212 to 30000 ms. Section 2.1 explains how this budget is checked when a capture is started.

Write the complete configuration. Write registers 205–213 together in one Write Multiple Registers (FC16) request. This only arms the device for the next capture; Section 2.1 explains how to start it.

> ⚠ **Complete an active download before reconfiguring**
>
> Writing configuration registers 205–213 invalidates the current captured waveform in SRAM: CAPTURE_STATUS register 202 changes to CONFIGURED, the output word and page counts become zero, and subsequent page reads contain no valid waveform data.

2 Capture and download a waveform

2.1 CONTROL and CAPTURE_STATUS registers

To acquire a time waveform, the Modbus RTU client writes the complete sensor configuration described in Section 1.6 to the device, writes START (1) to the CONTROL register (204), and polls the CAPTURE_STATUS register (202) until it reports READY or ERROR (see flowchart Figure 6). Table 2 summarizes the configuration, status, and page-download registers used by this workflow.

When START is requested, firmware estimates the waveform download time before acquisition. If the estimate exceeds the 30 s budget configured in registers 211–212, acquisition does not start: CAPTURE_STATUS register 202 reports 5 (ERROR), and error-code register 203 reports 7 (DOWNLOAD_BUDGET_EXCEEDED).

The capture request sequence uses FC06 (Write Single Register) for START and FC03 (Read Holding Registers) for status and error reads.

CAPTURE_STATUS reports READY only after the complete X/Y/Z waveform has been stored in SRAM and is available for download.

Use the T_{rec} capture-duration formula in Section 1.6 to schedule the first status read. Then poll CAPTURE_STATUS (202) once per second until READY or ERROR. This reduces unnecessary bus traffic and allows the Modbus client to interleave captures across multiple sensors.

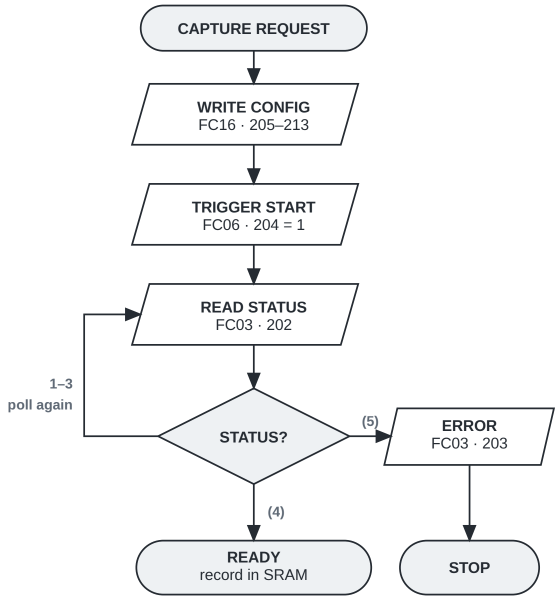


Figure 6: Modbus capture transaction sequence.

2.2 Time waveform record format

When CAPTURE_STATUS (202) reports READY, internal SRAM holds one complete X/Y/Z acceleration record. Each axis block contains N chronological samples in X, Y, Z order.

The payload contains $3N$ Modbus register words ($6N$ bytes). Each word stores one signed 16-bit two's-complement (`int16`) sample. Modbus transmits the most-significant byte first; within each byte, UART transmits the least-significant bit first. Figure 7 shows the three-axis case and the sample-byte mapping.

Table 2. Waveform capture and download registers.

PDU addr.	Setting	Access	Data type	Value / format
200	Capture API version	R/O	UINT16	4
201	Data-window version	R/O	UINT16	3
202	Capture status	R/O	UINT16 enum	0 = IDLE 1 = CONFIGURED 2 = ACQUIRING 3 = PROCESSING 4 = READY 5 = ERROR
203	Capture error	R/O	UINT16 enum	0 = NONE; 1–13 = error code; see Appendix A
204	Start/reset control	R/W	UINT16 enum	0 = IDLE/reset; 1 = START
Write setup registers 205–213 together with Modbus FC16 (Write Multiple Registers)				
205	Sensor select	R/W	UINT16 enum	2 = ADXL380; 3 = ADXL382
206	Axis bitmask	R/W	UINT16 bit field	0x07 = X/Y/Z (required)
207	Output rate	R/W	UINT16	Sensor-dependent; see Section 1.6
208–209	Samples per axis	R/W	UINT32	HI 208 | LO 209; values 64, 128, 256, 512, 1024, 2048, 4096, or 8192
210	Signal processing chain	R/W	UINT16 enum	0x03 = automatic source-rate FIR or full-rate bypass (required)
211	Enforce transfer-time budget	R/W	UINT16 enum	1 = enabled (required)
212	Waveform transfer budget	R/W	UINT16	30000 ms
213	Full-scale range	R/W	UINT16	Write 4/8/16 for ±4/±8/±16 g on ADXL380. Write 15/30/60 for ±15/±30/±60 g on ADXL382.
Read result registers 214–220 after CAPTURE_STATUS reports READY				
214–215	Total waveform words	R/O	UINT32	HI 214 | LO 215; total words in the X/Y/Z payload
216–217	Total download pages	R/O	UINT32	HI 216 | LO 217; total 122-word payload pages
218–219	Estimated download time	R/O	UINT32	HI 218 | LO 219; milliseconds at the normal transfer rate
220	Waveform ID	R/O	UINT16	Identifies the committed waveform
Download registers				
228–229	Window offset	R/W	UINT32	HI 228 | LO 229; zero-based payload-word offset; write with FC16
1000	Page waveform ID	R/O	UINT16	Copy of register 220 for page validation
1001–1002	Returned offset	R/O	UINT32	HI 1001 | LO 1002; must match registers 228–229
1003–1124	Waveform payload	R/O	INT16 array	Up to 122 waveform words; final page is zero-padded

- See Appendix A for the complete register map.
- Addresses are zero-based Modbus PDU addresses.
- Data-order conventions are defined in Section 5.6.
- This table requires ModVibe application firmware 1.03 or later.

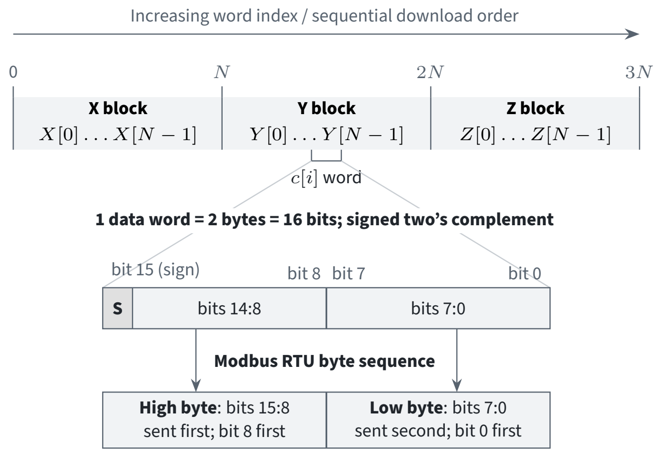


Figure 7: Modbus waveform data and big-endian sample-word order.

Use Table 4 to convert each `int16` sample code $c[i]$ to acceleration in g for the selected sensor and full-scale range.

Table 4. Nominal conversion to g. $a_i\ [\mathrm{g}] = c_i/\text{scale factor}$

Sensor	Full-scale	Scale factor (LSB/g)	Noise density* (μg/$\sqrt{\mathrm{Hz}}$)
ADXL380	± 4 g	7500	26
ADXL380	± 8 g	3750	29
ADXL380	± 16 g	1875	37
ADXL382	± 15 g	2000	58
ADXL382	± 30 g	1000	73
ADXL382	± 60 g	500	111

*Characteristic noise-density values measured during finished-device characterization. Scale factors are nominal and not shaker-calibrated.

Store the selected sensor, range, and output rate with each downloaded waveform; these values are not included in the returned data.

Samples are DC coupled and include the gravity component projected onto each axis. For zero-centered acceleration RMS, remove the record mean and apply any band limits required by the measurement. Before integrating acceleration to velocity, apply a high-pass filter with a cutoff below the lowest vibration frequency of interest; otherwise offset, drift, and low-frequency noise produce a wandering velocity baseline.

> **ModVibe 2.0 transfer boost**
>
> Where cable length and bus loading permit, a compatible Modbus client can use the optional (nonstandard) boost mode at up to 460k baud, four times the nominal baud rate. Boost mode is covered in Sections A.9–A.10 of Appendix A.

2.3 Time waveform download procedure

The Modbus client retrieves the completed record through the paged waveform data window (1000–1124). Each FC03 multi-word read uses the 125-register Modbus limit: three header registers contain the waveform ID and slice offset, followed by up to 122 waveform words.

The download procedure is as follows (Figure 8):

- Read and store the READY metadata (214–220).
- For each page, write the required offset i in the SRAM record to registers 228–229 (UINT32), then read the 125 registers of the data window (1000–1124).
- Validate the returned waveform ID (1000) and offset (1001–1002) against the READY metadata, then append up to 122 waveform words from registers 1003–1124.

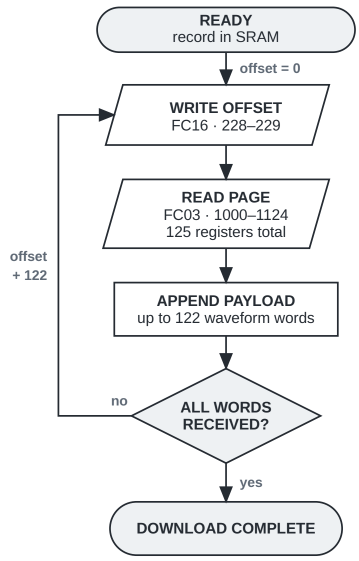


Figure 8: Modbus waveform page-download sequence.

READY metadata (214–220)

Obtain the waveform word count, page count, and waveform ID. For N samples per axis, expect $3N$ words and $\lceil 3N/122 \rceil$ pages.

Waveform ID (220)

Firmware auto-increments the waveform ID for each completed waveform recording, immediately before setting register 202 to READY. The ID wraps from `0xffff` back to `0x01`. Validate every page against the READY waveform ID.

Download duration. For $N = 8192$, the X/Y/Z payload contains $24\,576$ words. At 115.2k baud, firmware reports an estimated payload transfer time of about 24 s in registers 218–219.

Set the window offset (228–229)

The `uint32` window offset specifies the zero-based word index in the SRAM waveform record. Write the high word followed by the low word in one Write Multiple Registers (FC16) request. Use page-aligned offsets 0, 122, 244, and so on, advancing only after each validated page. Firmware rejects other offsets to prevent off-by-one errors. Page reads do not auto-advance the offset.

Read and validate a page

Read all 125 holding registers at addresses 1000–1124 in one Read Holding Registers (FC03) request. Before concatenating waveform words, verify that the header waveform ID matches the READY waveform ID and the returned offset matches the requested offset. Firmware zero-pads the final page; discard the padding.

Continue or retry the download

For a complete download, continue until the page and word counts match those in the READY metadata (214–217). If a page read times out or fails the Modbus CRC check, simply rewrite the same offset and retry, up to a fixed limit.

Partial download of one axis (optional)

X, Y, and Z begin at word offsets 0, N, and $2N$. Begin at the greatest multiple of 122 that does not exceed the selected block's first-word offset, then continue through the page containing its last word. Discard words outside the selected axis. Use the same validation and retry rules.

> **Further reading**
>
> **Appendix A: *ModVibe 2.0 Register Map*** defines paging, status, retry, boost, and recovery.
> **Appendix B: *Capturing a ModVibe Waveform: Minimal Modbus RTU application note*** is a worked direct-capture example with executable code.

3 MEMS temperature

3.1 Temperature registers

Registers 48 and 49 report the scaled internal temperatures of the ADXL380 and ADXL382. Registers 50 and 51 provide the corresponding uncalibrated TDATA codes as defined in the sensor data sheets [1, 2].

These readings indicate the on-board sensor temperatures, not the instantaneous machine-surface temperature. They follow machine temperature through the enclosure and sensor packages with some thermal delay. Continuous acquisition increases local power dissipation and may slightly elevate the readings.

Table 5. MEMS temperature registers.

PDU addr.	Register	Access	Data type	Value / format
48	ADXL380 temp.	R/O	INT16	0.1 °C/count; `0x8000` = invalid
49	ADXL382 temp.	R/O	INT16	0.1 °C/count; `0x8000` = invalid
50	ADXL380 raw	R/O	INT16	Sign-extended 12-bit TDATA code
51	ADXL382 raw	R/O	INT16	Sign-extended 12-bit TDATA code
52	Temp. status	R/O	UINT16 bit field	Validity and calibration flags; see Fig. 9

3.2 Temperature validity and freshness

Before using a temperature value, check its VALID and LIVE bits in TEMP_STATUS (52). VALID means a usable value is stored; LIVE means the latest background refresh succeeded. During normal operation, an available sensor temperature is refreshed at least once every 2 seconds. Reads return the current snapshot without triggering sensor access. Do not infer validity from the scaled or raw code alone.

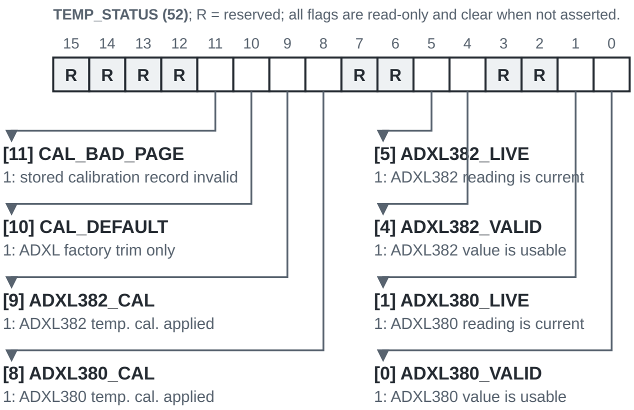


Figure 9: TEMP_STATUS (52) bit definitions.

4 Firmware diagnostics

Firmware validates the capture request, acquisition, READY record, and boost session:

- **Invalid capture request:** START rejects an unsupported request, sets CAPTURE_STATUS (202) to ERROR, and publishes no waveform; ERROR (203) gives the cause.
- **Interrupted acquisition:** READY follows a complete X/Y/Z record. Missing or discontinuous data reports SENSOR_FAULT; an FIR overrun reports PROCESS_OVERRUN.
- **READY record validation:** an ID, word or page-count, or offset mismatch withdraws READY output and sets CAPTURE_STATUS (202) to ERROR.
- **Boost recovery:** failed or abandoned sessions return to 115,200 bit/s. Routine fallback leaves no record; retained fields distinguish direct from watchdog-assisted recovery.

4.1 Health monitoring and fault response

Registers 100–110 form the firmware health block summarized in Table 6. They report the current supervisor result and retain the most recent failed check and firmware response.

Table 6. Firmware health registers.

PDU register addr.		Data type	Value / format
100	HEALTH_CONTRACT	UINT16	Require `0x01`
101	HEALTH_STATUS	UINT16 enum	0 = OK; 1 = fault
102–103	RUN_COUNT	UINT32	Supervisor run count
104–105	FAULT_COUNT	UINT32	Failed supervisor checks
106	FAULT_BITS	UINT16 bit field	Latest-cycle fault mask
107	LAST_OWNER	UINT16 code	Service subsystem code
108	LAST_VALIDATOR	UINT16 code	Service check code
109	LAST_ACTION	UINT16 enum	Retained response
110	LAST_FAULT_BITS	UINT16 bit field	Retained fault mask

HEALTH_CONTRACT (100)

The contract versions the layout and semantics of registers 101–110. Require `0x01` before interpreting them.

The 100 ms supervisor checks internal state for communication, acquisition, and transfer. Depending on the failed check, firmware:

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

HEALTH_STATUS (101) and FAULT_BITS (106)

Read registers 100–110 as one block. HEALTH_STATUS reports whether the latest supervisor cycle detected a fault. FAULT_BITS sets the corresponding subsystem bit for each fault found during that cycle. Figure 10 shows the summary status and maps each fault bit to its supervised area and firmware action.

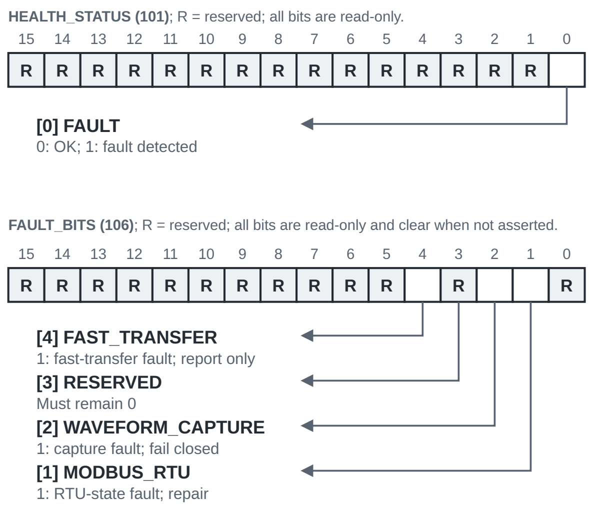


Figure 10: HEALTH_STATUS (101), FAULT_BITS (106), and corresponding firmware actions.

Use the health block

- HEALTH_STATUS and FAULT_BITS report active faults and clear after a healthy supervisor cycle.
- LAST_FAULT_BITS and LAST_ACTION preserve the most recent failure; nonzero retained values do not imply an active fault.
- Poll RUN_COUNT more than 100 ms apart to confirm supervision; within one run, a FAULT_COUNT increase reveals failed checks between reads.
- FAULT_BITS identifies the affected subsystem. Inspect the corresponding Modbus RTU, capture, or fast-transfer registers for detail; see Appendix A.5 for health semantics and recovery.

5 Electrical and communication interface

5.1 Operating limits

Parameter	Min.	Nom.	Max.	Unit
Input voltage at sensor	12	24	30	VDC
Operating temperature*	−20		+80	°C

* Applies to ambient and mounting-interface temperature.

5.2 Electrical interface summary

ModVibe connects through one fixed cable carrying 12–30 VDC power and two-wire RS-485.

Table 7. Electrical and communication interface.

Parameter	Specification
Measured supply current at 24 V	9–14 mA
Power conductors	V+ (red), 0 V (black)
Grounding	Mounting base and screw isolated
Galvanic isolation	None; power and RS-485 share 0 V
Data conductors	D1+ (blue), D0− (white)
Data physical layer	Two-wire, half-duplex RS-485
Differential drive voltage	Approx. 1 V into 60 Ω
D0/D1 load capacitance*	Approx. 2.5 nF differential
Internal termination	None; add 120 Ω at each trunk end
Protocol / format	Modbus RTU server / 8N1
Nominal baud rate	115.2k baud
Boosted baud rates	230.4k or 460.8k baud
Firmware update	Modbus RTU bootloader

* Conservative per-device bus-planning value, including the line-protection TVS diodes, RS-485 transceiver, and fixed 2 m cable [5].

5.3 Power input and protection

ModVibe operates from 12–30 VDC between red V+ and black 0 V, with 24 VDC nominal. This range applies at the sensor after voltage drop along the power conductors. The maximum continuous input voltage is 30 VDC.

Long industrial cables can couple switching noise, EFT, and lightning-induced surges into the supply. A TVS diode with a 33.3 V minimum breakdown voltage limits these disturbances before they reach the internal electronics.

Use a 24 VDC supply with overcurrent shutdown. This limits fault energy during conductor-to-conductor shorts and wiring faults. Disconnect the supply and correct the wiring before restarting.

5.4 Fixed-cable connections

ModVibe is supplied with a non-detachable 2 m HELUKABEL 81910 DeviceNet PUR cable. The factory-sealed cable entry forms part of the enclosure ingress protection. The bare drain provides access to the cable shield; it is not connected inside ModVibe and must not carry supply-return current. Maintain shield/drain continuity through the network. At the Modbus client or its tap, bond the shield/drain and black 0 V (Modbus Common) to protective earth (PE) at one central point only. Make no other Common-to-PE or shield-to-PE bonds on the bus [7].

Table 8. Fixed-cable conductor assignment.

Conductor		Host connection
V+	Red	12–30 VDC supply; 24 VDC nominal
0 V	Black	Supply return and Modbus Common
D1+	Blue	Modbus D1, positive line
D0−	White	Modbus D0, negative line
Drain	Bare	Cable-shield access; no internal connection

5.5 RS-485 bus operation

Follow Figure 11. Terminate the D1/D0 trunk with 120 Ω at each physical end. Connect each ModVibe's fixed 2 m cable as an unterminated stub. Validate alternative topologies for the intended cable length, node count, and baud rate. ModVibe requires no external idle bias. If another device requires polarization, use one bus-wide bias network, normally at the host.

Built-in termination

Some RS-485 host interfaces and adapters include switchable 120 Ω termination. At a trunk end, use either the built-in termination or an external resistor, never both. Confirm that exactly one 120 Ω termination is present at each end.

5.6 Modbus register conventions

Register addresses in this datasheet are zero-based PDU addresses, exactly as transmitted in the Modbus request. Some PLC tools display PDU address 0 as holding register 40001; in those tools, PDU address 205 appears as 40206.

For a transparent Modbus TCP-to-RTU gateway, set the Unit Identifier in the Modbus TCP header to the assigned ModVibe unit ID[6].

- R or R/O means read only; R/W means read/write; W identifies a command register whose readback is not configuration state.
- Each register is one 16-bit word transmitted most-significant byte first. INT16 values use two's complement. ModVibe UINT32 values occupy consecutive HI and LO registers, in that order.
- Transfer each grouped field and UINT32 pair in one Modbus transaction; do not update or interpret individual halves separately.
- Respect the block boundaries in Appendix A. Do not extend bulk reads through reserved or write-command-only addresses. Such a request returns exception 02 (ILLEGAL_DATA_ADDRESS).

Appendix A is normative for register access and exception behavior. Appendix B provides complete transactions, retry rules, and the waveform transfer procedure.

5.7 Firmware maintenance

The integrated bootloader supports firmware updates over Modbus RTU. The update procedure and bootloader interface are controlled maintenance functions outside Revision 1 of the public register map; contact iQunet for support.

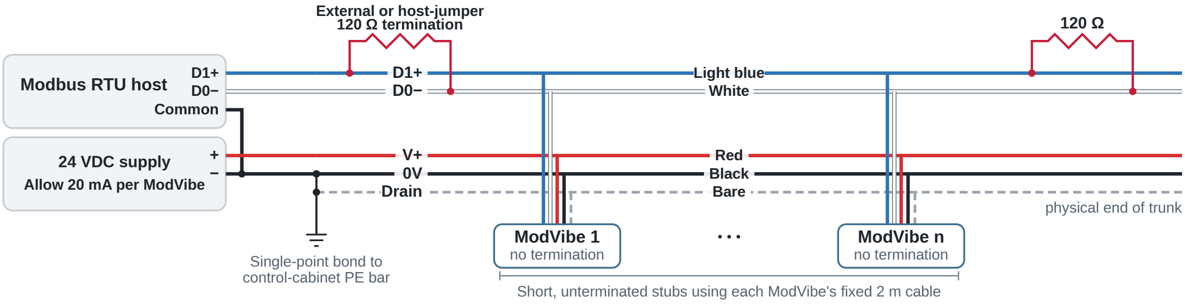


Figure 11: Recommended RS-485 multidrop wiring, termination, and grounding.

6 Mechanical outline and installation

The enclosure has a rectangular body, bottom mounting boss, and side cable gland. Dimensions are nominal and exclude the cable. Use them for installation planning.

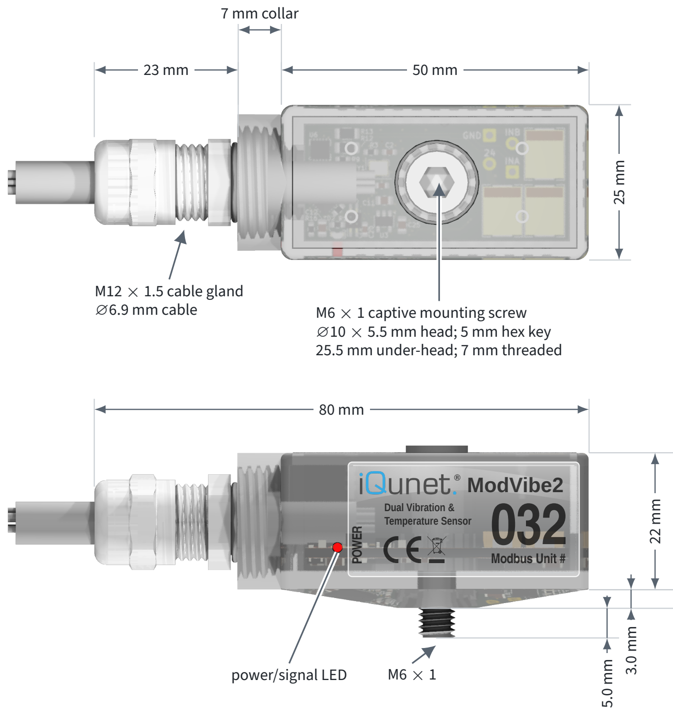


Figure 12: Top and front views with nominal body and interface dimensions.

6.1 Installation dimensions

Feature	Specification
Body envelope (L × W × H)	50 × 25 × 25 mm
Overall envelope incl. gland	80 mm
Mounting boss	⌀12.6 mm; 3.0 mm projection
Sensor body mass	50 g
Captive mounting screw	M6 × 1
Installed screw protrusion beyond sensor mounting face	5.0 mm
Installation tool	5 mm hex key
Mounting torque	1.4 N·m
Fixed cable type	HELUKABEL 81910
Cable length / diameter	Approx. 2.0 m / ⌀6.9 mm

Envelope basis: H includes the 3.0 mm mounting boss. The body L × W × H excludes the gland, cable, screw projection, and tool clearance.

6.2 Installation principles

The following practices support repeatable vibration measurements and consistent condition-monitoring data [8].

1. Select a rigid, clean, flat location that transfers machine vibration directly into the mounting boss. Do not mount on flexible covers, guards, thin plates, unsupported brackets, or other parts that can resonate independently of the machine body.
2. Choose one of the following rigid mounting methods:
   - 2.a. **Tapped hole:** Use a centered M6 × 1 tapped hole with at least 5.0 mm usable thread depth. This provides the stiffest coupling.
   - 2.b. **Bonded pad:** If drilling is not permitted, securely bond an M6 × 1 threaded mounting pad, such as the CTC MH130-6A mounting disk, to a prepared bare-metal surface, following the manufacturer's instructions.

   For either method, ensure that the mounting boss seats fully without the captive screw bottoming in the hole.
3. Tighten the captive mounting screw to 1.4 N·m. At the next scheduled machine inspection, check and restore the torque to 1.4 N·m to compensate for initial settling of the PA12-GF mounting interface. Keep the sensor orientation unchanged for consistent three-axis measurements.
4. Support the cable on the measured structure and leave a relaxed service loop near the entry. Prevent cable tension, sharp bends, and unsupported cable motion that could load the enclosure or introduce measurement artefacts.

> **Correct mounting affects measurement quality**
>
> A vibration sensor cannot compensate for a compliant bracket, loose fastener, uneven surface, or cable-induced movement. Installation guidance and mounting torque are therefore controlled installation parameters, not informal recommendations.

6.3 Enclosure and ingress protection

The factory-sealed ModVibe enclosure is rated IP67/IP68. The rating applies only to a complete, undamaged device with the factory cable entry intact. Do not loosen or modify the cable gland. Keep the free cable end dry or terminate it in a suitably ingress-protected enclosure.

Do not clean the device with a pressure washer. The IP rating does not establish resistance to oils, coolants, solvents, or cleaning agents.

References

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[3] PCB Piezotronics, *Model 603C01 Industrial ICP Accelerometer*, Product Specification 13145, Rev. J, April 2026. [Online]. Available: https://www.pcb.com/contentstore/docs/PCB_Corporate/Pressure/products/Manuals/603C01.pdf

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[7] Modbus Organization, *MODBUS over Serial Line Specification and Implementation Guide*, version 1.02, December 2006. [Online]. modbus.org.

[8] International Organization for Standardization, *Condition monitoring and diagnostics of machines: Vibration condition monitoring, Part 1: General procedures*, ISO 13373-1:2002, February 2002. [Online]. Available: https://www.iso.org/standard/21831.html

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 requires application firmware 1.03 or later. Require `APP_VERSION` `0x00000103` or later and `MAP_CONTRACT` `0x03`. Before using a feature, verify its contract register and reject unsupported values explicitly.

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, internal FIR, 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

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 verify identity/map contracts.
3. Read registers 200–229 and verify capture contract 4 and data-window 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 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)

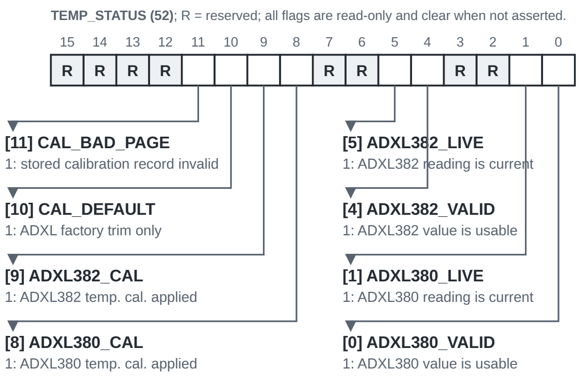


Figure 13: `TEMP_STATUS` (52) bit definitions, repeated for reference.

`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 background refresh succeeded for the corresponding sensor. During normal operation, an available sensor temperature is refreshed at least once every 2 seconds. If VALID is set while LIVE is clear, the snapshot contains the last usable stored value; `TEMP_ADXL380_AGE` (53) or `TEMP_ADXL382_AGE` (54) 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 snapshot. The Modbus read does not wake a sensor, trigger sensor access, or wait for a refresh. Polling faster does not refresh the temperatures; use a moderate monitoring interval.

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.

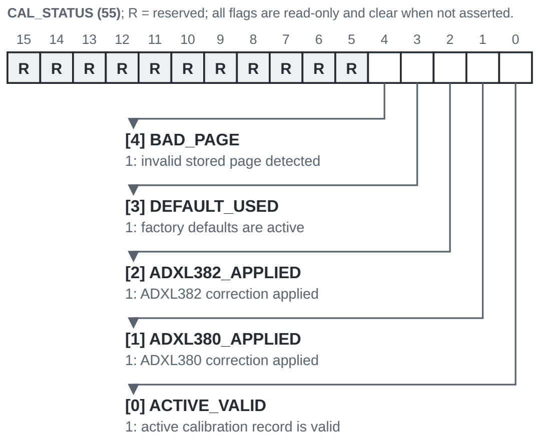


Figure 14: `CAL_STATUS` (55) bit definitions.

`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.

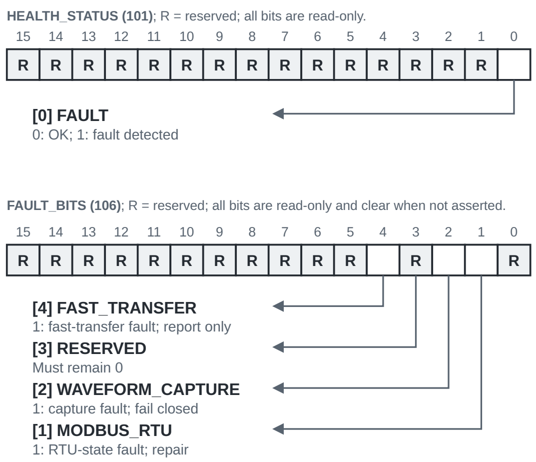


Figure 15: `HEALTH_STATUS` (101), `FAULT_BITS` (106), and firmware responses, repeated for reference.

`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.

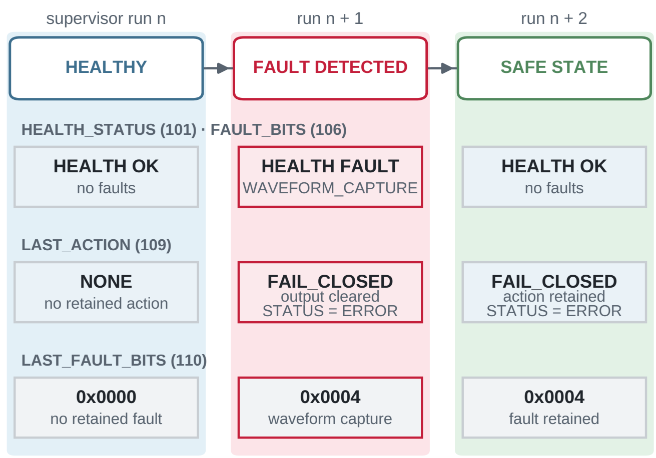


Figure 16: Latest-cycle faults clear; the retained record preserves the latest fault and response.

`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=0x0004` before interpreting registers 202–227. Section 1.6 explains the waveform configuration.

Addr.	Name	A	Format	Description
200	`CAPTURE_CONTRACT`	R	u16	Require `0x0004`
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 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; keep ID
1	START	Validate and begin acquisition

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.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

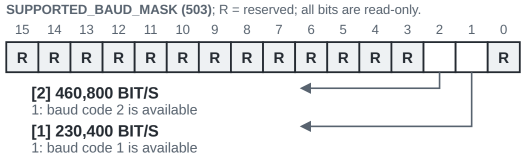
`FAST_ERROR` (502) gives the cause of a rejected command or automatic fallback and can remain nonzero after status returns to IDLE.

Table 9. `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.

SUPPORTED_BAUD_MASK (503); R = reserved; all bits are read-only.



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	WATCHDOG_RECOVERY	Watchdog reset restored 115,200 bit/s

`RECOVERY_ERROR` (514) uses the enum in Table 9. 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;
   - WATCHDOG_RECOVERY (5): watchdog 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 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:

Addr.	Register	Required
0	`ID_MAGIC_HIGH`	`0x4649`
1	`ID_MAGIC_LOW`	`0x5642`
2	`ID_CONTRACT`	`0x02`
3	`MAP_CONTRACT`	`0x02` or `0x03`

Then read registers 200–201 together and require:

Addr.	Register	Required
200	`CAPTURE_CONTRACT`	`0x0004`
201	`WINDOW_CONTRACT`	`0x0003`

Stop with a clear compatibility error if any required value differs.

> **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, send START once, then 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.

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,
    )
    return check(reply).registers

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]
            or identity[3] not in (2, 3)):
        raise RuntimeError("incompatible identity/map")
    if read_regs(mb, 200, 2) != [0x0004, 0x0003]:
        raise RuntimeError("incompatible capture/window contract")

def configure(mb):
    write_regs(mb, 205, REQUEST)
    state = read_state(mb)
    if ((state.status, state.error) != (CONFIGURED, 0)
            or state.request != REQUEST):
        raise RuntimeError("configuration rejected")
    return state.waveform_id

def start_once(mb, previous_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
            if (error == 0 and status == READY and state.request ==
  REQUEST
                    and waveform_id not in (0, previous_id)):
                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):
    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
        if (status == READY and error == 0 and state.request ==
  REQUEST
                and state.waveform_id not in (0, previous_id)):
            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)
    verify_device(mb)
    previous_id = configure(mb)
    start_once(mb, previous_id)
    state = wait_ready(mb, 10.0, previous_id)
    waveform_id, words = download(mb, state)
    plot_waveform("modvibe_waveform.png", waveform_id, words)
    mb.close()
if __name__ == "__main__": main()
```

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