VoltMeter (Arduino Uno) — Command & Setup Manual

Firmware Version: VoltMeter v1.2 (Memory Optimized)

---

1. Introduction

This manual explains all available **serial commands** for the VoltMeter firmware and provides a clear step-by-step guide to set up, calibrate, and operate the system. The commands are entered through the **Serial Monitor** (or any serial terminal) at **115200 baud** with **newline** line endings.

---

2. Basic Setup Procedure

Hardware Connection

1. **Voltage Divider Wiring:**
2. Connect the input voltage (Vin) → Top resistor (RTOP)
3. Connect midpoint between RTOP and RBOT → **A0**
4. Connect bottom resistor (RBOT) → **GND**
5. Make sure A0 never exceeds **5 V** (for DEFAULT reference) or **1.1 V** (for INTERNAL reference).
6. Power the Arduino from a stable USB or regulated 5 V supply.

Software Setup

1. Upload the VoltMeter firmware to your Arduino Uno.
2. Open **Serial Monitor** at **115200 baud**.
3. Set **line ending** to **Newline**.
4. You should see the startup report and the line:

```
Type HELP for commands.
```

---

3. Command Reference Table

Command	Function	Example	Description
HELP	Show help list	`HELP`	Lists all available commands with basic usage examples.

Command	Function	Example	Description
SETREF DEFAULT	Set ADC reference to Vcc (5V)	`SETREF DEFAULT`	Use the Arduino's operating voltage as reference. Suitable for mid-to-high voltage dividers.
SETREF INTERNAL	Set ADC reference to 1.1V	`SETREF INTERNAL`	Uses the internal bandgap reference for higher accuracy when A0 voltage ≤ 1.1V.
SETREF AUTO	Auto-select reference	`SETREF AUTO`	The firmware tests the signal level and automatically picks DEFAULT or INTERNAL.
CAL <volts>	Calibrate using a known voltage	`CAL 12.000`	Runs calibration assuming the applied input is 12.000V. Calculates scale factor (K) and saves to EEPROM.
CAL <volts> RBOT <ohms>	Calibrate with known bottom resistor	`CAL 12.000 RBOT 10000`	Uses known RBOT to estimate RTOP from measured K.
CAL <volts> RTOP <ohms>	Calibrate with known top resistor	`CAL 12.000 RTOP 22000`	Uses known RTOP to estimate RBOT from measured K.
CAL <volts> [RBOT/ RTOP] SAMPLES <n>	Calibrate with custom sample size	`CAL 12.000 RBOT 10000 SAMPLES 512`	Performs calibration using <n> samples for more precision.
PRINTCAL	Print current calibration data	`PRINTCAL`	Displays stored calibration info (K, vref, resistors, stats, CRC).
CLEARCAL / RESETCAL	Erase calibration	`CLEARCAL`	Clears calibration block from EEPROM. The voltmeter will require recalibration.
MEASURE	Take one reading	`MEASURE`	Captures a single ADC measurement and prints full stats and computed Vin.
LOG ON	Enable continuous logging	`LOG ON`	Starts automatic measurement every second (default interval: 1000 ms).
LOG OFF	Disable continuous logging	`LOG OFF`	Stops periodic measurement output.

Command	Function	Example	Description
FACTORYRESET *(optional)*	Reset calibration, settings, and counters	`FACTORYRESET`	Clears EEPROM calibration and resets counters to default values. *(Only available if added to sketch)*
FULLRESET *(optional, dangerous)*	Wipe entire EEPROM	`FULLRESET`	Erases all EEPROM memory (including boot counter). Use only for recovery. *(Optional, must be added manually)*

---

4. Step-by-Step Setup & Calibration

Step 1 — Power & Verify Communication

- Open Serial Monitor at **115200 baud**.
- You should see a startup banner like:

```
================= Voltmeter Startup =================
Firmware: VoltMeter v1.2 (mem-opt)
Boot Cnt: 5
EEPROM: No valid calibration (CRC fail or empty).
Run CAL <volts> [RBOT|RTOP] to calibrate.
=====================================================
```

Step 2 — Choose Reference Mode

Depending on your divider ratio and input voltage range: - For **0–5 V ADC range**, type:

```
SETREF DEFAULT
```

- For **0–1.1 V ADC range**, type:

```
SETREF INTERNAL
```

- Or let the firmware decide automatically:

```
SETREF AUTO
```

Step 3 — Run Calibration

1. Apply a stable, known voltage (measured with a DMM) to the divider input (Vin).
2. Enter a calibration command such as:

```
CAL 12.000 RBOT 10000
```

3. The system will sample and calculate ratio `K = Vin / Vadc`, then save it to EEPROM.
4. Wait for the confirmation message:

```
[CAL] Calibration saved.
```

5. To verify calibration:

```
PRINTCAL
```

Step 4 — Start Measuring

To measure once:

```
MEASURE
```

To enable continuous measurement (logging):

```
LOG ON
```

To stop logging:

```
LOG OFF
```

---

5. Understanding Measurement Output

Example output:

```
t=10233 ms, ADC_raw_mean=682.35 (min=676, max=689), vref=5.000000,
Vadc=3.333100, Vin=11.936821 V ±0.012, Vin_IIR=11.940832, ref=DEFAULT, cal=YES
```

Explanation: - `t` — time since boot (ms) - `ADC_raw_mean` — average ADC value (trimmed) - `vref` — active ADC reference voltage - `Vadc` — measured voltage at A0 - `Vin` — actual computed input voltage

(calibrated) - `±` — uncertainty derived from ADC noise - `Vin_IIR` — filtered Vin (IIR smoothing) - `ref` — reference source (DEFAULT/INTERNAL) - `cal` — calibration status (YES = valid calibration loaded)

---

6. EEPROM & Persistence

- Calibration and counters are stored in EEPROM and loaded automatically at startup.
- If CRC fails or calibration was cleared, the system requests recalibration.
- Boot counter increments each power-up.

---

7. Factory Reset & Recovery

If calibration or EEPROM data becomes invalid: - Run:

```
CLEARCAL
```

to remove calibration only. - Or (if added):

```
FACTORYRESET
```

to restore all settings to default.

---

8. Tips for Reliable Operation

- Ensure **A0 voltage never exceeds Vref**.
- Use **metal film resistors (1% or better)** for long-term stability.
- Keep **divider impedance < 100 kΩ** total.
- Recalibrate after hardware changes or if voltage readings drift.
- Use a **stable power supply** when operating in DEFAULT mode.
- Minimize EEPROM writes — avoid frequent unnecessary calibrations.

---

9. Example Workflow Summary

1. Upload firmware and open Serial Monitor.
2. Enter `SETREF DEFAULT`.
3. Apply a known voltage (e.g., 12.000 V).
4. Type `CAL 12.000 RBOT 10000`.
5. Wait for `[CAL] Calibration saved.`
6. Type `PRINTCAL` to confirm.
7. Type `LOG ON` to begin continuous voltage readings.

10. Command Quick Reference

```
HELP                       — Show all commands.
SETREF DEFAULT|INTERNAL|AUTO — Set ADC reference mode.
CAL <volts> [RBOT|RTOP] [SAMPLES <n>] — Calibrate.
PRINTCAL                   — Show stored calibration data.
CLEARCAL / RESETCAL        — Clear calibration.
MEASURE                    — Take one measurement.
LOG ON / OFF               — Toggle periodic logging.
FACTORYRESET (optional)    — Reset calibration, counter, and settings.
FULLRESET (optional)       — Erase all EEPROM data (dangerous).
```

End of Command Manual