Voltage logger with SD-card

0. What is it?

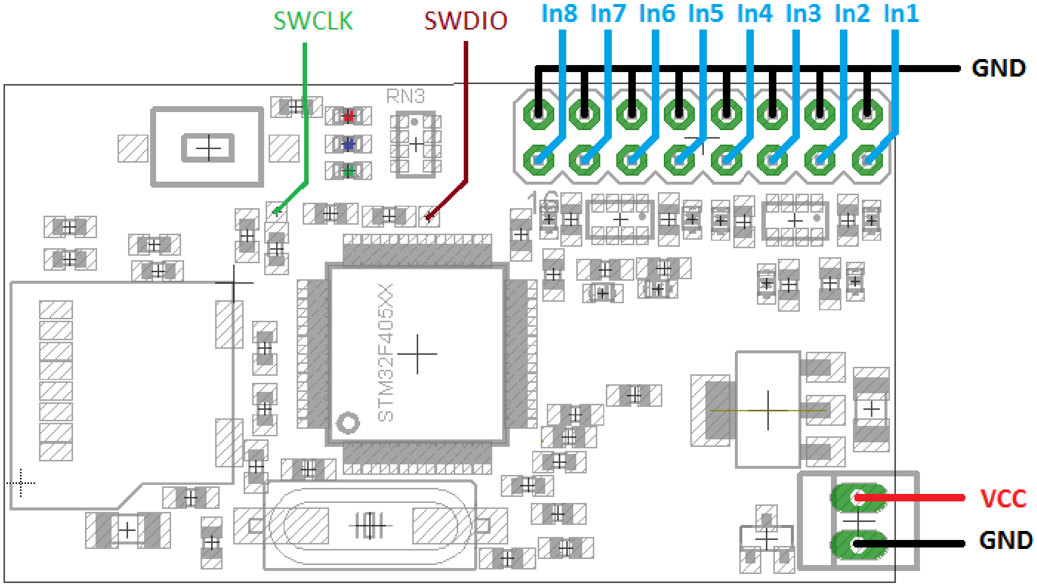
This is just a simple voltage logger which writes 8 voltages to the text file on a micro SD card. It has the following features:

- Easy to use: Only one start/stop button and all the settings are stored in the configuration text file on the SD card.
- The recorded data is stored in comma separated text file (CSV) and each entry (measurement) has a time stamp in milliseconds.
- Configurable calibration coefficients (gain and zero offset) and moving average filter for each channel.
- Three LEDs for indication of logger state.

Device specification:

Parameter	Value
Power supply voltage	5V-20V
Current consumption	60mA at 5V input
Number of channels	8
Channel input type	Single-ended
Input voltage range	0 … +3.3V
Sample time	0.5 ms … 5000 ms (5 sec), 0.2 Hz … 2 kHz
Measurement accuracy (3σ)	3.3 mV (0.1% of full scale) with 4th order moving average filter
Input impedance (max)	50 kOhm
Microcontroller	STM32F405RGT6
PCB size	48.26 mm x 27.0 mm (1.9 in x 1.063 in)

Board connections:



LEDs:

- Green: power on, also toggles eachtime the ADC samples input signals.
- Blue: blinks each time when a block of data has been written to the SD card.
- Red: fault indication (see below).

1. How to start

- Input signals, make sure that each input signal is single-ended and in range from 0V to 3.3V.
- Connect power supply (make sure the voltage range is correct).
- Place **ADC.txt** file to the root folder of SD card (here is an example of the file for ODB). It is recommended to choose the fastest SD card (UHS Speed Class 1 / U1) and format the SD card before use in logger.
- Insert SD card.
- Press "START" button to start log
- The blue LED should blink periodically (with speed dependentonwriting rate).
- Press "START" button again to stop the log.
- The recorded data file is savedto a root folder and isnamed in the format: **HH-MM-SS.csv**, where HH-MM-SS denotestime from power cycling of the device.

2. Configuration file format

All numbers in configuration text should be in decimals or floating point separated by a dot '.'

Parameter	Format	Default	Meaning
`sample`	float	no	Sampling time in milliseconds, all channels are sampled simultaneously
`ch`***X***`_en`	1 or 0	0	If 1 then data from channel ***X*** is included to log file (X is from 1 to 8)
`ch`***X***`_zero`	float	0	ADC zero calibration coefficient for channel ***X*** (X is from 1 to 8)
`ch`***X***`_gain`	float	1	Gain calibration coefficient for channel ***X*** (X is from 1 to 8)
`ch`***X***`_filt`	float	4	Moving average filter order, value greater or equal to 1 (X is from 1 to 8)
`format_str`	string	%f	format of values in output file (as printf format specifies)
`timestamp`	1 or 0	1	If 1 then every record in output file has a timestamp (in milliseconds)

The recorded value is calculated from ADC code using the following calibration equation:

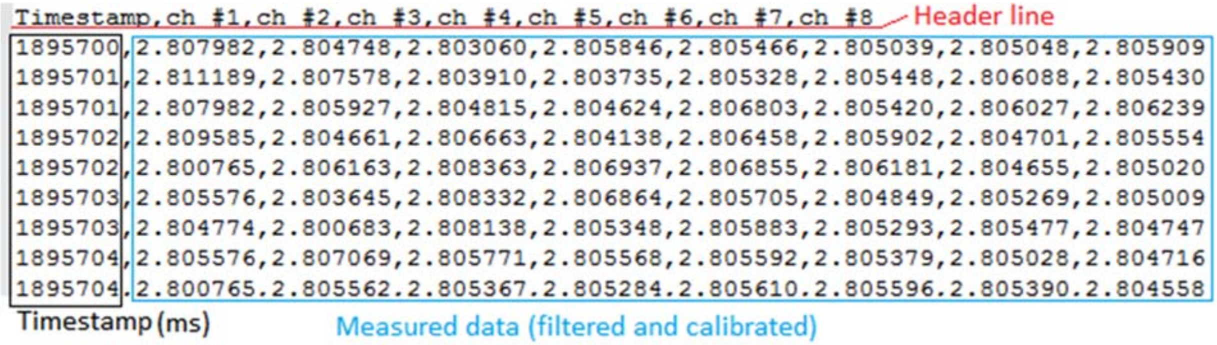
Recorded X = (ADC X - chX_zero) * chX_gain

The moving average is applied to all channels independently from sample time, every 187 us using the following equation:

Filtered X = Filtered X *((chX_filt - 1)/chX_filt) + ADC X/chX_filt

The unit step response time of filter order N is (0.187*N) ms.

3. Recorded data file format



```
Timestamp,ch #1,ch #2,ch #3,ch #4,ch #5,ch #6,ch #7,ch #8
1895700,2.807982,2.804748,2.803060,2.805846,2.805466,2.805039,2.805048,2.805909
1895701,2.811189,2.807578,2.803910,2.803735,2.805328,2.805448,2.806088,2.805430
1895701,2.807982,2.805927,2.804815,2.804624,2.806803,2.805420,2.806027,2.806239
1895702,2.809585,2.804661,2.806663,2.804138,2.806458,2.805902,2.804701,2.805554
1895702,2.800765,2.806163,2.808363,2.806937,2.806855,2.806181,2.804655,2.805020
1895703,2.805576,2.803645,2.808332,2.806864,2.805705,2.804849,2.805269,2.805009
1895703,2.804774,2.800683,2.808138,2.805348,2.805883,2.805293,2.805477,2.804747
1895704,2.805576,2.807069,2.805771,2.805568,2.805592,2.805379,2.805028,2.804716
1895704.2.800765.2.805562.2.805367.2.805284.2.805610.2.805596.2.805390.2.804558
```

4. Faults and indication

- If red LED and blue LED are both on just after pressing the "START" button, then this is a configuration text file problem; check configuration file.
- If red LED is on during logging, then this is either a data buffer overflow or SD card problem. Check if there is enough free space on SD card or whether SD card has acceptable writing speed rate.

5. How to calibrate zero

- Put this ADC.txt to SD card (it has `chX_zero = 0` and `chX_gain = 1`).
- Short inputs to ground with wires.
- Start logging to collect about 1000 samples.
- Calculate average values of every channel, it will be zero offsets.
- Modify all `chX_zero` parameters in ADC.txt by calculated mean values.

6. How to calibrate gain

- Calibrate zero offsets.
- Connect stable voltage source with known voltage to all inputs. The best voltage source is a battery with voltage about 3V (make sure that the voltage doesnot exceed 3.3V to prevent input saturation)
- Start logging to collect about 1000 samples.
- Calculate gain value for channel by equation: input voltage / mean(all channel samples)
- Modify `chX_gain` parameters by calculated gain values. Make sure that you copyat least 5 significant digits (for voltage, for example, it should be at least 9 digits after decimal point).