

Multi-channel Analog to Digital Recorder (MADRE) User Manual



Description

The MADRE board is an embedded system used for analog sampling, sensor interface, data output and storage. It uses a low energy micro controller to interface with 24-bit Analog-to-Digital Converters (ADC), process data and control serial interfaces.

The MAP (Multi-Channel Analog Prototype) board connects to a pair of headers on the MADRE. The MAP is a flexible platform for analog front-ends whose output is connected through the header to the MADRE ADCs.

The MADRE can stream processed data to an external host PC. The MADRE can also store data to an onboard SD card.

In its current configuration, the MADRE microcontroller's core clock is 40MHz.

The microcontroller synthesizes a 625KHz clock for the ADC sigma-delta modulators. Configuration of the ADC sinc⁴ filter establishes the 320Hz sample word rate and implicit filter roll-off. The ADCs are configured for unity gain and unipolar (single-ended) mode.

The Counts/Volts conversion is:

$$Counts = (2^N \times AIN \times Gain) / VREF$$

with Gain = 1, N=24 bits, VREF= 2.5 Volts and AIN=Signal Input Voltage

Data Streaming and Data Storage

The MADRE begins producing output samples within seconds of power-up. Depending on configuration, samples will be available as a serial output stream or on the embedded SD card.

Sample Record structure

A sample record is generated with the completion of each sample. Sample records are produced at the base ADC sample rate (320 samples per second)

Each ADC outputs a three-byte (24-bit) sample.

Each sample record is comprised of:

- 2 temperature samples
- 2 shear samples
- 3 accelerometer samples.

The length of an EPSI sample record is $7 * 3 \text{ bytes} = 21 \text{ bytes}$.

The length of an EPSI sample record will change with the addition of micro-conductivity and other sensors.

A block is defined as 160 EPSI sample records (0.5 seconds)

Data Streaming

The data is streamed in 160 sample record blocks. Each block starts with an ASCII header followed by 0, 1 or 2 blocks of ASCII samples from auxiliary devices and one block of 160 binary EPSI sample records.

There will be no ASCII blocks, if no auxiliary devices are plugged into the MADRE board.

Header:

The Header is a 63 byte word:

"\r\n\$MADRE00000000,00000000,00000000,00000000,00000000,00000000\r\n"

- Begins with "\r\n" to establish a new block.
- "\$MADRE" are the first characters in the MADRE Header followed by:
- 8 bytes + "," : Number of EPSI samples since power up
- 8 bytes + "," : Number of 32.768 kHz RTC since power up
- 8 bytes + "," : first auxiliary device checksum (Stand alone EPSI: checksum =0)
- 8 bytes + "," : Second auxiliary device checksum (Stand alone EPSI: checksum =0)
- 8 bytes + "," : EPSI sample checksum (uint8_t)
- "\r\n" : end of the header.

The checksums is define as ;

```
for (int i=0;i<length(Epsi sample block);i++){
    chcksum^= block[i]
}
end
```

chcksum is a uint32_t and block is a uint8_t array containing data in of a AUXblock or EPSI block. These blocks are defined in the following sections.

Auxiliary device blocks:

The length depends on the length of of one auxiliary sample and the streaming frequency. A block from the first auxiliary device is defined as follows:

- Header: "\$AUX1".
- an EPSI samples timestamp (EPSI sample counts)
- " , "
- the actual device sample (in ASCII).

The EPSI sample block:

- a header: "\$EPSI".
- the 160 EPSIsample in binary (3360 bytes for the default 7 analog channels)

We do provide a python script that opens a serial port and reads the output of the MADRE board https://github.com/modscripps/MADRE_git

SD card recording:

The data are stored in a file that includes:

- 1 main file header with variable length. This main header contains the date, the mission name, the vehicle name, the deployment number, the file number, the serial number of the MADRE board, the serial number of the MAP board, the recording method, the sampling frequency, the name of the ftdi device if streaming, the duration of a block in seconds, the number of blocks in the file, the number of EPSI sample records per block, the baud rate if streaming, the power type, the kind of vehicle and the number of auxiliary sensors.
- 1 EPSI header with variable length. The EPSI header corresponds to the information describing the analog board plugged on the MADRE. This header contains the number of sensors, the serial number of the sensors, the calibration number of the sensors, the sensor order and the number of bytes per analog to digital convertor.
- 1 or 2 auxiliary device headers with variable length. The number of headers is defined in the main header file. It includes the serial number of the auxiliary instrument, the baud rate of the communication, the calibration of the instruments and the format of the instrument sample.
- Data blocks include a block header defining the block number, the number of auxiliary samples and error flags.